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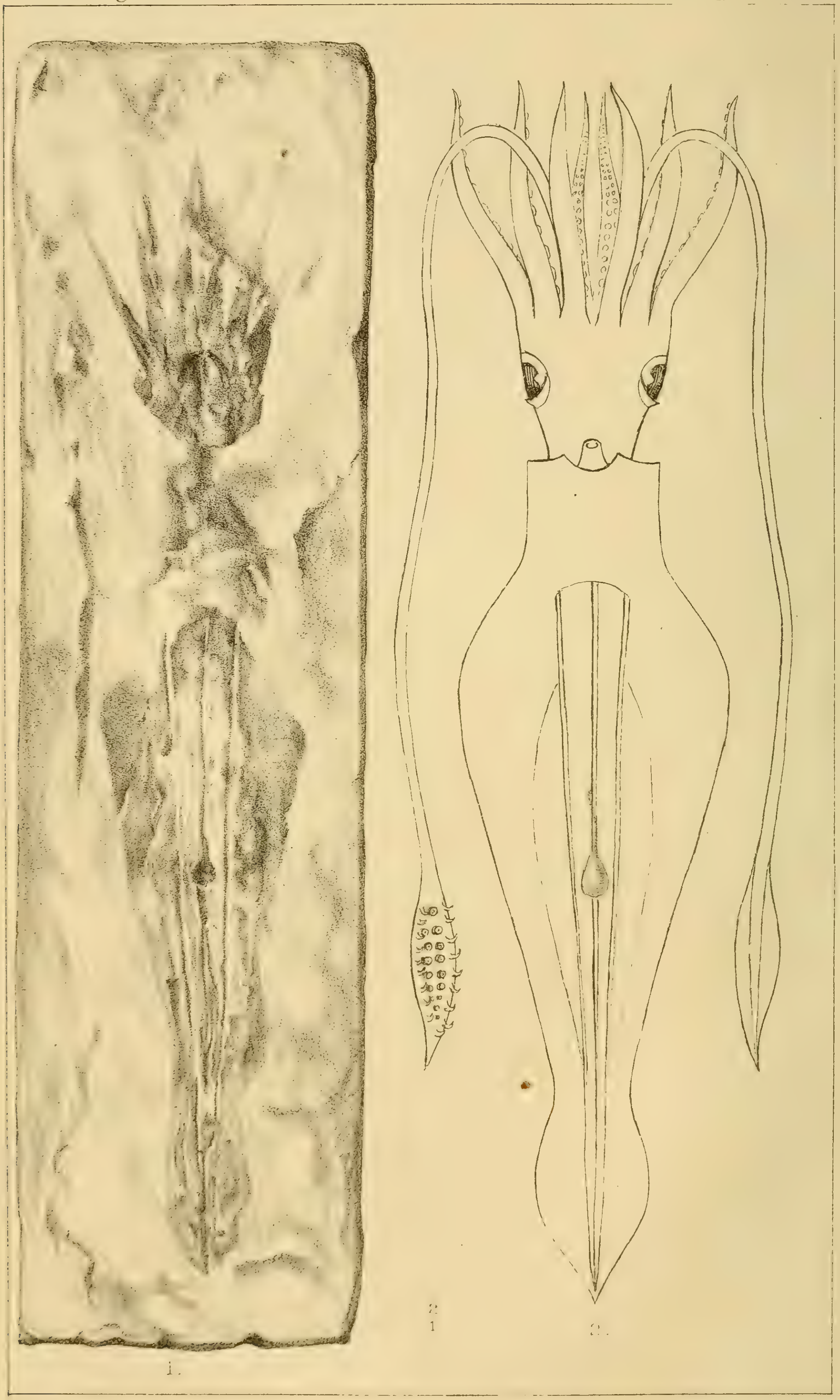


E. C. Woodward del. et lith. West Newman & Co. imp.

Dorateuthis syriaca, *H. Woodw.*
Cretaceous Lebanon.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. X.

No. I.—JANUARY, 1883.

ORIGINAL ARTICLES.

I.—On a New Genus of Fossil "Calamary," from the Cretaceous Formation of Sahel Alma, near Beirût, Lebanon, Syria.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc.

(PLATE I.)

SOME years ago my friend Mr. Robert Damon, F.G.S., of Weymouth, visited the Cretaceous deposits of the Lebanon, and when at that place he was so fortunate as to make the acquaintance of the Rev. E. R. Lewis, M.A., F.G.S., Professor in the Syrian Protestant College, Beirût, Syria.

Since that date Prof. Lewis has sent home many interesting collections of fossils from the now classical localities of Hakel and Sahel-Alma. The choicest of these palæontological treasures are to be found preserved in the British Museum, Natural History Collection, Cromwell Road.

Of the various organic remains met with in these Lebanon Cretaceous rocks, fossil Fishes are the prevalent type. Only a very few genera and species from this district, so rich in ichthyological treasures, have at present been described; it is to be hoped, however, that some expert may ere long be tempted to devote his attention to their fuller elucidation.

I have given a notice of two new and remarkably interesting types of Crustacea from Hakel, viz. *Squilla Lewisii*, and *Limulus Syriacus* (see Quart. Journ. Geol. Soc. 1879, vol. xxxv. pl. xxvi. pp. 552–556), but many more Crustaceans remain to be figured.

I propose on the present occasion to notice the occurrence of a new species of decapodous Dibranchiate Cephalopod represented by a small but nearly entire individual preserved on a slab of limestone from Sahel Alma.

"Sahel Alma," writes Prof. E. R. Lewis, "may be visited from Beirût in a single day, with an allowance of two or three hours at the locality. We leave Beirût early, pass by the traditional site of St. George's encounter with the Dragon, canter over the sandy beach of St. George's Bay, and stumble on the remains of an old Roman road which cuts through a cave, leaving exposed to this day a breccia of bone, flint flakes, etc. In specimens of this, submitted to Dr. Fraas, he has recognized *Bos priscus*, superior and inferior molar, *Rhinoceros tichorhinus*, inferior molar. We pass around the Dog River Promontory under the celebrated stone-cut inscriptions, ford Dog River, cross the next point, and reach Juneh Bay in an easy three hours from Beirût. About two-thirds the distance across the beach of this bay we strike up the steep hill-side towards the apparently vertical strata before us in the mountain. A short climb brings us to the convent, under the very walls of which, and in a fig orchard, outcrops the stratum of white chalky limestone, whence so many beautiful specimens have been obtained. The place is about 300 feet above the level of the sea, and a little more than a mile distant from the shore. The exposed stratum is steeply inclined, as are all the strata in that part, and the exposed rock abounds in specimens, which lie in all directions, some of the fish passing through an inch or more of thickness, *i.e.* the head deeper in the rock than the tail or *vice versa*. The rock is soft chalky white, easily cut or sawed, and differs entirely from the Hâkel rock, which is heavy and brittle, with a much more distinct tendency to split into layers than the Sahel Alma limestone."[1]

The Dibranchiate Cephalopods—represented by the living *Octopus* or "Devil-fish," the *Argonauta* or "Paper-nautilus," the *Loligo* or "Calamary," the *Sepia* or "Cuttle-fish," and the *Spirula*—had but comparatively few representatives in the seas of the past; the oldest known forms occurring in the Lias formation.

Even in the strata of Secondary and Tertiary age, in which the remains of the internal shells and the traces of the integument and soft parts of these two-gilled Cephalopods sometimes occur—yet nevertheless by far the greater part of the remains of the Cephalopoda found fossil belong to the Tetrabranchiate or "four-gilled" division, represented at the present day by the pearly *Nautilus*, the sole survivor of this once dominant *Molluscan* type.

The most perfectly preserved remains, hitherto met with, of the so-called "naked-cephalopods" (because the shell is *internal*), have been procured from the Oxford Clay (Middle Oolite) of Chippenham and Christian Malford, Wiltshire, and referred to the genus *Belemnoteuthis*,[2] and from the Lias of Lyme Regis, Dorset, referred by Prof. Huxley to the genus *Belemnites*, having evidence of the shell, the ink-bag, the beaks, the arms, and the hooklets with which they were provided.[3] I am not acquainted with any examples of Dibranchiate Cephalopods having the soft parts and the arms preserved as occurring in strata of Cretaceous age; hence the interest attaching to the present specimen, and to others, probably allied to *Sepia*, from the same locality (Sahel Alma) which I hope to figure in a future Number of the Geological Magazine.

I have felt considerable difficulty as to the genus to which I should refer this Lebanon Teuthid.

One sees clearly enough, through the light brown stain which marks the contour of the body, the narrow, pointed, horny, spear-shaped internal shell or 'pen,'—nearly as long as the entire body of

[1] See article on "The Fossil Fish Localities of the Lebanon," by the Rev. Prof. E. R. Lewis, M.A., F.G.S., Geol. Mag. 1878, Decade II. Vol. V. pp. 214–220.

[2] *Belemnoteuthis*, Pearce, 1842, see Proc. Geol. Soc. 2, p. 593, and on the fossil Cephalopoda constituting the genus *Belemnoteuthis*, by J. C. Pearce, F.G.S., London Geological Journal, No. 2, Feb. 1847, pl. xvi.

[3] See Mem. Geol. Surv. Mon. ii. 1864, pp. 1-14, plate i.

the animal,—the shaft of which is marked by three equidistant ridges, one median and two lateral (as in *Acanthoteuthis tricarinatus*),[1] which converge together at the very acute distal extremity;[2] two extremely delicate lateral expansions, or alæ (like the blade of a spear-head), are developed upon each side, and give rigidity to the two elliptical fins: these fins contract at $\frac{3}{4}$ths of the length of the body, and then expand again, so as to form a small distinct terminal fin, with a broadly-pointed extremity. The position of the ink-bag (placed on the median line, and distant exactly half the length of the body from the head); the impression of the horny mandibles, and the eyes, can be very well seen in the fossil.

The head is surmounted by eight arms provided with minute hooklets? and acetabula or suckers; there are also traces of the two long and slender tentacular arms.

As there is no fossil form of Teuthid, similar to this Lebanon one, in which the soft parts are preserved, we can only compare the characters of its internal shell. From these it seems at first sight proper to place it in Wagner's genus *Acanthoteuthis*, which includes quite a number of species, from the Lithographic stone (Upper Oolite) of Solenhofen, Bavaria, having narrow elongated pens marked by converging ridges,[3] like those of the living genus *Ommastrephes*.

But this genus was originally founded upon the *fossil hooks* of a Calamary from Solenhofen, the animal of which had *ten nearly equal arms*, all furnished with a double series of horny claws, throughout their length.

The fossil pens, like *Ommastrephes* from Solenhofen, have been also ascribed to these impressions of arms.

Some of these Acanthoteuthids from Solenhofen, such as *A. speciosa*, *A. Ferussacii* and *A. Lichtensteinii*, were also considered by Wagner, as having belonged to *Belemnites* or to *Belemnoteuthis*.[4]

Another series, namely, *A. angusta*, *A. lata*, *A. subovata*, *A. subconica*, *A. acuta*, *A. brevis*, *A. intermedia*, *A. rhomboidalis*, *A. semistriata*, and *A. tricarinata*,[5] have been referred by Prof. Wagner to a distinct genus, *Plesioteuthis*, on the ground that they were not found associated with hooks; but, as Prof. Huxley well observes, he (Wagner) afterwards gave the *same generic name* to the hard undigested remains of naked-bodied Cephalopods "consisting of the middle keel of the pen, crushed into many short pieces, and of the hooklets of the arms, which, sometimes large, sometimes small, lie scattered round the fragments of the pen in great numbers," found in the coprolites of reptiles in the Solenhofen slates. It would therefore appear that *Plesioteuthis had hooks*, though Wagner's statement that he had never either in Münster's Collection or any other,

[1] Münster's Beiträge zur Petrefactenkunde, 7th Heft, 1846, Bayreuth, t. vi. fig. 7.

[2] The base or proximal end of the shell is, in breadth, exactly $\frac{1}{8}$th the entire length.

[3] See Münster's Beiträge zur Petrefactenkunde, Erstes und Siebentes Heft, 1846.

[4] "Die fossilen Ueberreste von nachten Dintenfischen," 1860.

[5] See Münster's Beitrage, 7th part, Taf. 4, 5, and 6.

found hooks associated with these sword-shaped pens (*save in these coprolites*) is so far as negative evidence goes somewhat against that conclusion.[1]

Prof. Wagner furthermore separates from *Acanthoteuthis* under the genus *Kelœno*, or *Celœno*,[2] a form, named *C. conica*, displaying hooks similar to those of *Acanthoteuthis Ferussacii*, and in addition, the remains of *acetabula* or suckers.

Prof. Huxley therefore concludes that "upon the whole it becomes plain that the *Acanthoteuthes* of Münster, so far as they are known only by hooks and impressions of soft parts, may have been either *Belemnites* or *Belemnoteuthes*, or *Plesioteuthes*, or may have belonged to the genus *Celœno;* and that, with the evidence before us, it is impossible to say whether *Acanthoteuthis speciosa* and *Ferussacii* belong to *Belemnites*, or to *Belemnoteuthis*."

He further expresses his opinion that it would be better to separate *A. speciosa* and *A. Ferussacii* and place them in the genus *Belemnoteuthis*, and to retain *Acanthoteuthis* for the *Plesioteuthis* of Wagner.

As regards our Lebanon fossil, it is interesting to record that Doctors von Der Marck and Cl. Schlüter in their valuable Monograph on the New Fishes and Crustacea from the Chalk of Sendenhorst, Westphalia,[3] enumerate, among other fossil remains from this formation, "the hard parts of a naked Cephalopod which we have placed under Wagner's genus as *Plesioteuthis arcuata*." As no figure of this fossil is given, we cannot enter upon its comparison with our specimen.

Bearing in mind the fact that the genus *Acanthoteuthis* was originally established upon the fossil hooks of a Calamary, with ten nearly equal arms, all furnished with a double series of horny hooks throughout their length, we cannot refer the Sahel-Alma Teuthid to this genus, as it has eight nearly equal arms and remains of two long tentacles. We are equally disinclined to refer it to Wagner's genus *Plesioteuthis*, about which we have little certain information. There is good reason to conclude that this new Squid is near to the genus *Ommastrephes*, of D'Orbigny, judging from the general form of the animal, as well as by its pen.

There is, however, reason to conclude that although indistinctly preserved, the arms were furnished with both minute hooklets and acetabula (suckers), which would show its affinity with *Belemnoteuthis*.[4]

After carefully considering all the evidence, it seems more convenient to place it in a new genus, for which I would propose the name of *Dorateuthis*,[5] and for the only species the geographical appellation of *Syriaca*.

[1] See Professor Huxley's (Memoirs Geol. Surv. 1864), Monograph II. "On the Structure of *Belemnitidæ*, p. 21.

[2] This may have belonged to the genus *Belemnoteuthis ?*

[3] Paleontographica, Band xv. pt. 6, p. 272.

[4] The extremely chalky and friable nature of the Sahel-Alma deposit renders the preservation of minute structures such as these a task of extreme difficulty.

[5] From δόρυ, δόρατος, a spear or lance; and τευθὶς, a squid or cuttle.

I hope shortly to figure the remaining form of Cuttle-fish from this interesting locality.

EXPLANATION OF PLATE I.

Fig. 1. *Dorateuthis Syriaca*, H. Woodw., sp. nov., from the Cretaceous of Sahel Alma, Lebanon, Beirût, Syria. Twice the natural size. The original preserved in the Geological Department of the British Museum.

,, 2. An attempt at an outline restoration of Fig. 1.

II.—On Scottish Silurian Brachiopoda.

By Thomas Davidson, LL.D., F.R.S.

In the volume of the Palæontographical Society for 1883, I conclude the series of supplements to my work on British fossil Brachiopoda. Additional supplements will, no doubt, be called for every now and then. As our rocks continue to be searched, new forms will turn up, and specimens will be procured that will enable palæontologists to complete the history and illustration of a certain number of those I have been compelled to leave insufficiently made out, described and illustrated.

It has always been my desire during the preparation of my monograph to do all the justice within my power to the Brachiopoda that occur in the fossiliferous rocks of Scotland, and no trouble has been spared by many friends in the search for the necessary material.

From all the specimens that have passed through my hands for examination during the last thirty-three years, I have been able to determine, describe, and illustrate some 4 *Recent* species; 2 *Post-Tertiary*; 16 *Liassic and Oolitic*; 59 *Carboniferous*, and about 134 *Silurian*, making a grand total of 216 so-termed species,—a large number from a country that had been so long considered as scarcely fossiliferous; and especially so when it is borne in mind that it is only from the *Jurassic*, *Carboniferous*, and *Silurian* formations that Brachiopoda have been obtained.

My object, however, in this communication is to mention in as few words as possible the results of my study of the Silurian Brachiopoda that have been collected from the following eight Scottish counties, namely, *Midlothian*, *Lanarkshire*, *Peeblesshire*, *Ayrshire*, *Sutherlandshire*, *Kirkcudbrightshire*, *Dumfriesshire*, and *Berwickshire*. The Llandeilo, Caradoc, Llandovery, Wenlock, and Ludlow formations are well represented in Scotland, and all details in connexion with the subject will be found in the pages of the Palæontographical Society's volumes. I would also refer the student for much important information to Mr. R. Etheridge jun.'s able opening address to the Royal Physical Society of Edinburgh, 1881, "On the Palæozoic Conchology of Scotland." In that memoir the author recapitulates all that has been published with respect to the Carboniferous and Silurian Brachiopoda up to the period of the delivery of his address. The Silurian rocks of Scotland contain a certain number of species that have not been found in England or in Ireland. If we briefly consider the general results shown by our table, it will be seen that

SCOTTISH UPPER AND LOWER SILURIAN BRACHIOPODA.

Genera and Species.	Ludlow.	Wenlock.	Llandovery.	Caradoc.	Llandeilo.	Scottish Counties where found.
TRETENTERATA.						
Lingula Lewisii, Sow.	x	...	...	...	...	Midlothian.
,, *Sysmondi*, Salter	x	x	...	...	...	Midlothian, Ayrshire.
,, *lata*, Sow.	...	x	...	...	...	Midlothian.
,, *minima*, Sow.	x	...	...	...	...	Lanarkshire.
,, *attenuata*, Sow.	...	...	...	x	x	Ayrshire, Peeblesshire.
,, *ovata*, M'Coy?	...	...	...	x	...	Ayrshire.
,, *brevis*, Portlock	...	...	...	x	x	Ayrshire, Dumfriesshire
,, *Canadensis*, Billings	...	...	...	...	x	Ayrshire.
,, *quadrata*, Eichwald	...	...	...	x	x	Ayrshire.
,, *Ramsayi*, Salter	...	...	...	...	x	Ayrshire.
,, *granulata*, Phillips	...	...	...	...	x	Ayrshire.
Orbiculoidea Forbesii, Dav.	x	...	x	...	...	Midlothian, Ayrshire.
Discina rugata, Sow.	...	..	x	...	...	Ayrshire.
,, *Portlocki*, Geinitz	...	...	...	...	x	Dumfriesshire.
,, *perrugata*, M'Coy	...	...	...	...	x	Ayrshire, Peeblesshire.
,, *oblongata*, Portlock	...	...	...	?	x	Ayrshire, Dumfriesshire
,, *crassa*, Hall	...	...	...	...	x	Ayrshire, Dumfriesshire
,, ? *Balcletchiensis*, Dav.	...	...	...	x	x	Ayrshire.
Pholidops (*Crania*) *implicata*, Sow.	x	...	x	...	...	Midlothian, Ayrshire.
Crania Siluriana, Dav.	x	..	x	...	...	Ayrshire, Midlothian.
Obolella sagittalis, Salter	...	..	...	...	x	Dumfriesshire.
Acrotreta Nicholsoni, Dav.	...	...	...	...	x	Ayrshire, Dumfriesshire
,, ? *costata*, Dav.	...	...	...	...	...	Ayrshire.
Siphonotreta Scotica, Dav.	...	...	...	...	x	Ayrshire.
,, *nucula*, M'Coy	...	...	...	...	x	Ayrshire, Dumfriesshire
CLISTENTERATA.						
Spirifera plicatella, var. *radiata*, Sow.	...	...	x	...	...	Ayrshire.
,, *crispa*, Hisinger	...	x	...	...	...	Midlothian.
Cyrtia exporrecta, Wahl.	x	x	x	...	...	Midlothian, Ayrshire.
Nucleospira pisum, Sow.	x	...	x	...	...	Midlothian, Ayrshire.
Whitfieldia tumida, Dal.	x	...	x	...	...	Midlothian, Ayrshire.
Meristella ? *Maclareni*, Haswell.	x	...	...	...	...	Midlothian.
,, ? *angustifrons*, M'Coy	...	...	x	x	...	Ayrshire.
Athyris ? sp.	...	...	...	x	...	Ayrshire.
Glassia compressa, Sow.	x	...	...	...	...	Midlothian.
,, *obovata*, Sow.	...	...	x	..	...	Ayrshire.
Atrypa reticularis, Linné	x	...	x	...	...	Midlothian, Ayrshire.
,, *imbricata*, Sow.	...	..	x	...	...	Ayrshire.
,, ? *Scotica*, M'Coy	...	...	x	...	...	Ayrshire.
Merista ? *cymbula*, Dav.	...	...	...	x	...	Ayrshire.
Triplesia ? *Grayi*, Dav.	...	...	...	..	x	Ayrshire.
,, ? *spiriferoides*, M'Coy	...	...	...	x	x	Ayrshire.
,, ? *monolifera*, M'Coy	...	...	x	...	...	Ayrshire.
,, ? *incerta*, Dav.	...	x	...	...	...	Ayrshire.
Leptocœlia hemispherica, Sow.	...	..	x	x	...	Ayrshire.
Pentamerus oblongus, Sow.	...	...	x	...	...	Ayrshire.
,, *globosus*, Sow.	...	...	x	...	..	Ayrshire.
,, *undatus*, Sow.	...	...	x	...	...	Ayrshire.
,, *galeatus*, Sow.	...	...	x	...	...	Ayrshire.
,, *rotundatus*, Sow.	...	...	x	...	...	Ayrshire.
,, ? *Shallockiensis*, Dav.	...	...	...	x	...	Ayrshire.

Genera and Species.	Ludlow.	Wenlock.	Llandovery.	Caradoc.	Llandeilo.	Scottish Counties where found.
Stricklandinia lens, Sow.	...	...	x	..	...	Ayrshire.
,, *lirata*, Sow.	...	...	x	...	...	Ayrshire.
,, *? Balcletchiensis*, Dav. ...	...	...	...	...	x	Ayrshire.
Rhynchonella æmula, Salter	...	...	...	...	x	Ayrshire.
,, *Balcletchiensis*, Dav......	...	...	...	...	x	Ayrshire.
,, *Salteri*, Dav.	...	..	...	...	x	Ayrshire.
,, *nasuta*, M'Coy	...	...	...	...	x	Ayrshire.
,, *Thomsoni*, Dav.	...	...	...	...	x	Ayrshire.
,, *Lapworthi*, Dav.	...	...	...	...	x	Ayrshire.
,, *borealis*, Schl.	...	...	x	...	...	Ayrshire.
,, *sub-borealis*, Dav..........	...	...	...	...	x	Ayrshire.
,, *cuneata*, Dal................	...	...	x	x	?	Ayrshire.
,, *cuneatella*, Dav.	...	...	..	...	x	Ayrshire.
,, *Weaveri*, Salter ?	...	...	...	...	x	Ayrshire.
,, *Llandoveriana*, Dav. ...	...	...	x	...	...	Ayrshire.
,, (near to *Nucula*) *?*.........	...	...	...	...	x	Ayrshire.
,, *Shallockiensis*, Dav.	...	...	...	...	x	Ayrshire.
,, *Girvaniensis*, Dav.	...	...	...	...	x	Ayrshire.
,, *Scotica*, Dav................	...	...	...	...	x	Ayrshire.
,, *Peachi*, Dav.	...	...	...	...	x	Ayrshire.
,, *Wilsoni*, Sow.	x	..	x	...	...	Ayrshire, Midlothian.
,, *decemplicata*, Sow.........	...	...	x	...	...	Ayrshire.
,, *nucula*, Sow................	x	...	...	...	...	Midlothian.
,, *Jacki*, Dav.	...	...	...	x	...	Dumfriesshire.
,, *Maccoyana*, Dav..........	...	...	...	x	...	Peeblesshire.
,, *? Pentlandica*, Haswell..	x	...	...	...	...	Midlothian.
,, sp.	x	...	..	...	...	Lanarkshire.
Skenidium Lewisii, Dav.	x	...	...	...	...	Midlothian.
,, ,, var. *Woodlandiana*, Dav.	...	...	x	...	...	Ayrshire.
,, *Grayi*, Dav.	...	...	...	x	...	Ayrshire.
,, *? Shallockiensis*, Dav. ...	..	...	...	x	...	Ayrshire.
Orthis biloba, Linné	x	...	...	x	...	Midlothian, Ayrshire.
,, *elegantula*, Linné	x	...	x	x	x	Midlothian, Ayrshire.
,, *calligramma*, Dalman ...	...	x	x	x	x	Dumfriesshire, Peeblesshire, Lanarkshire, Ayrshire.
,, *polygramma*, var. *Pentlandica*, Dav.............	x	...	x	x	...	Midlothian, Ayrshire, Dumfriesshire.
,, *turgida*, M'Coy...........	...	...	...	...	x	Ayrshire.
,, *Balcletchiensis*, Dav.....	...	...	...	x	x	Ayrshire.
,, *Rankini*, Dav.	...	...	...	x	x	Ayrshire.
,, *biforata*, Schl.	...	...	.	x	x	Ayrshire, Dumfriesshire
,, *plicata*, Sow...............	...	...	x	...	x	Ayrshire.
,, *Mullockiensis*, Dav.	...	...	x	x	...	Ayrshire.
,, *confinis*, Salter	...	...	?	...	x	Ayrshire.
,, *vespertilio*, Sow.	...	...	...	x	x	Ayrshire.
,, *intercostata*, Portlock ...	...	...	...	...	x	Ayrshire.
,, *tricinalia*, Conrad.........	...	...	..	x	x	Ayrshire.
,, *Lapworthi*, Dav.	...	...	...	x	x	Ayrshire.
,, *testudinaria*, Dalman ...	...	...	...	x		Ayrshire, Lanarkshire, Sutherlandshire.
,, *flabellulum*, Sow.	...	...	...	x	x	Ayrshire.
,, *crispa*, M'Coy	...	...	...	x	x	Ayrshire, Peeblesshire, Lanarkshire.

Genera and Species.	Ludlow.	Wenlock.	Llandovery.	Caradoc.	Llandeilo.	Scottish Counties where found.
Orthis Sowerbiana, Dav.	...	...	x	x	x	Ayrshire, Peeblesshire.
,, *saggittifera*, M'Coy	...	...	x	...	...	Ayrshire.
,, *nina*, Dav.	...	...	...	x	...	Ayrshire.
,, *rustica*, Sow.	...	..	x	...	...	Ayrshire.
,, *Actoniæ*, Sow. ?	...	...	...	x	...	Ayrshire.
,, *reversa*, Salter	...	...	x	...	...	Ayrshire.
,, *protensa*, Sow.	...	...	x	...	...	Ayrshire, Peeblesshire, Lanarkshire.
,, ? *Kelbucoensis*, Dav.	...	...	...	x	...	Peeblesshire.
Strophomena rhomboidalis, Dalm.	x	x	x	x	x	Midlothian, Peeblesshire, Ayrshire.
,, *antiquata*, Sow.	x	...	x	...	...	Midlothian, Ayrshire.
,, *Walmstedti*, Lindstrom	x	...	..	...	...	Midlothian, Ayrshire.
,, *pecten*, Linné	x	...	x	...	...	Midlothian, Ayrshire.
,, *applanata*, Salter	x	...	x	...	...	Midlothian, Ayrshire.
,, *Hendersoni*, Dav.	x	...	...	...	...	Midlothian.
,, *grandis*, Sow.	...	...	...	x	...	Dumfriesshire, Ayrshire
,, *alternata*, Salter	...	...	...	x	...	Dumfriesshire, Peeblesshire, Ayrshire.
,, *expansa*, Sow.	...	...	x	x	x	Dumfriesshire, Lanarkshire, Ayrshire.
,, *corrugatella*, Dav.	...	x	x	x	x	Dumfriesshire, Ayrshire
,, *imbrex*, var. *semiglobosina*, Dav.	..	...	...	...	x	Ayrshire.
,, *Llandeiloensis*, Dav.	...	...	...	...	x	Ayrshire.
,, *retroflexa*, Salter	...	...	...	...	x	Ayrshire.
,, *Waltoni*, Dav.	...	...	x	..	...	Ayrshire.
,, *Shallockiensis*, Dav.	...	...	..	x	x	Ayrshire.
,, *deltoidea*, Conrad	...	...	...	x	...	Ayrshire.
Leptæna transversalis, Sow.	x	...	x	...	..	Midlothian, Ayrshire.
,, *sericea*, Sow.	...	...	...	x	x	Peeblesshire, Lanarkshire, Ayrshire, Kirkcudbrightshire, Berwickshire, Dumfriesshire.
,, ,, var. *rhombica*, M'Coy	...	...	...	x	x	Dumfriesshire, Ayrshire
,, *tenuicincta*, M'Coy	...	...	...	x	x	Dumfriesshire, Peeblesshire, Lanarkshire.
,, *quinquecostata*, M'Coy	...	...	...	x	x	Ayrshire.
,, *segmentum*, Angelin	...	...	...	...	x	Ayrshire.
,, *Youngiana*, Dav.	...	..	...	...	x	Ayrshire.
,, *Etheridgi*, Dav.	...	..	...	...	x	Ayrshire.
,, *Llandeiloensis*, Dav.	...	...	...	...	x	Ayrshire.
,, *Grayi*, Dav.	...	...	...	...	x	Ayrshire.
,, *scissa*, M'Coy	...	...	x	...	...	Ayrshire.
Chonetes striatella, Dalman	x	...	...	...	...	Midlothian.

the 134 so-termed Silurian species have been referred to about 25 genera, and that about—

64 species are recorded from the *Llandeilo* (including much of the Lower Caradoc of Murchison, Ramsay and Geikie).
44 from the Lower, Middle, and Upper *Caradoc* (including beds from a little below the Caradoc Limestone to the base of the Lower Llandovery).
47 from the Lower, Middle, and Upper *Llandovery*.
8 from the *Wenlock*.
28 from the *Ludlow*.

It is also evident that in Scotland the largest number of species have been obtained from the *Llandeilo;* of these about 22 are common to the *Caradoc,* 7 pass into the *Llandovery,* 3 into the *Wenlock,* and 1 into the *Ludlow.*

Of the *Caradoc* species 11 pass into the *Llandovery* (chiefly the Lower Llandovery), 17 from the *Llandovery* (chiefly Middle and Upper Llandovery) into the *Wenlock* and *Ludlow.*

It is also evident from these approximate and provisional estimates, that in Scotland the larger number of species are restricted to their formation. The Llandeilo is extremely rich, and although only about a third of its species are found in the Caradoc of Scotland, some more of them occur in the Caradoc of England, but the exact line of separation between the Lower Caradoc and Upper Llandeilo has still to be correctly defined, as also the different horizons of the Llandeilo itself.

I have followed in my table the classification of the Silurian rocks of Scotland as recently proposed by Prof. C. Lapworth, F.G.S.

More collecting and further study of the species will no doubt tend to modify the numbers we have given, and which are provisional and the result of our personal investigation. The larger portion of my material with respect to Scottish Silurian Brachiopoda has been contributed by Mrs. R. Gray, and by the Director-General of the Survey of Great Britain, or Museum of the Geological Survey of Scotland. The Pentland Hill series was kindly sent to me by Mr. J. Haswell, Mr. J Henderson, and Mr. D. J. Brown.

III.—Traces of a Great Post-Glacial Flood.

5. Evidence of the Marine Drift.

By Henry H. Howorth, F.S.A.

(*Continued from* Decade II. Vol. IX. 1882, p. 559.)

ANOTHER series of beds, comprising those which are raised a considerable height above the sea, contain a congeries of mixed shells, often broken, and clearly, as we shall show presently, not *in situ* ; sometimes the shells are imbedded in sand and sometimes in clay. They contain generally a larger proportion of species, and belong to a more temperate condition of things. The fact that Arctic shells are found in these higher beds is undoubted ; but, as I contend, the meaning of this is very different to what is often supposed,—the proportion of purely Arctic shells being by no means large, and under any circumstances the mollusca clearly pointing to a condition of things very different indeed to that which must have existed when the great boulder heaps of Smaland and Finland, which I have travelled across for scores of miles with amazement, were being fashioned,—when our azoic Boulder-clays were being manufactured, and when the mollusca which prevail in high latitudes were driven far to the south, to the Mediterranean and elsewhere, where a few of their descendants are still found in very deep water and sporadically. During the Glacial period proper it is exceedingly probable that the sea was in fact as denuded of life as the land is.

But let us continue. We must remember that not only is the number of purely Arctic shells in these beds as compared with the whole number comparatively small, but that the fact of finding a few distinctly Arctic shells is balanced by the occurrence in certain of the beds of another class which tells an entirely different story, namely, shells characteristic of a more southern latitude than our own, southern forms which occur beside these Arctic forms.

In the thirtieth volume of the Journal of the Geological Society, Mr. Mellard Reade describes the marine shells from the Lancashire drifts in the neighbourhood of Liverpool and Warrington. In this paper, pp. 34 and 35, he says, "Though all, with the exception of *Astarte borealis, Leda pernula,* and *Saxicava norvegica* (which are of course northern shells), may be described as Irish sea shells, yet, if we make a fair comparison, we shall find that the Boulder-clay assemblage possesses a more northern facies than the present fauna of the British Seas." Notwithstanding this sentence, Mr. Reade very frankly points to the presence of *Venus Chione, Dentalium tarentinum* and *Cardium tuberculatum,* as distinctly southern shells, and adds, "The presence of *Venus Chione* in the low level Boulder-clays as well as in the Macclesfield drift, where it was first discovered by Mr. Darbishire, is certainly a remarkable fact; but it is not an isolated one; for *Cardium aculeatum* and *Cardium pygmæum,* both Lusitanian forms, are found in the Scotch drift, and in the Irish drift southern forms also occur," adding in a note, "Forbes notes the discovery by Captain James of *Turritella incrassata,* a Crag fossil, a southern form of *Fusus,* and a *Mitra* allied to the Spanish species in the Wexford gravels."

In a paper by Mr. Darbishire, on the Shell-drift at Leyland, which was published in the same volume of the Geological Journal, the author says, "The list, although containing a few names of species of a northern character (*Astarte* and *Fusus*), contains also several shells of markedly southern origin. *Venus* (*Cytherea*) *Chione,* which has been identified at Macclesfield, and in several of Mr. Reade's Liverpool localities, may almost be called a characteristic fossil at Leyland. *Cardium tuberculatum* (*rusticum,* F. and H.) occurs not unfrequently. One perfect and characteristic hinge of *Mactra glauca* (*helvacea,* F. and H.) was found. All these are essentially southern species. The only shell which is peculiarly Arctic in character is *Fusus* (*Trophon*) *craticulatus,* Fabr., a species now living in Greenland, of which one fine and (for drift) fairly fresh-looking shell has been found. The same species was identified at Moel Tryfaen" (*op. cit.* p. 39). The presence of these southern forms is surely just as eloquent and just as forcible evidence as that of the northern species, and when these two papers were discussed, Mr. G. Jeffreys said, "All the shells found in these Lancashire beds were just such as might have been thrown up on the shore, though the matrix in which some of them are found is not sandy. . . . He did not regard any of the shells as truly Arctic, and doubted whether any of them afforded clear evidence of climate." Mr. Prestwich said, "In the overlying Boulder-clay the fragments of shells were all of species still existing in the neighbouring seas of the present day; and he did not think that at the time of its deposit the climate was of necessity intensely cold." While Prof. Hughes was so much struck with this that he submitted that the shells belonged to an age succeeding the true Glacial period (*id.* p. 41).

Mr. Darbishire says of the drift shells from Leyland, with the exception of the *Fusus* (*Trophon*) *craticulatus*, Fabr., "The series from Leyland must be described as very similar to that of the fauna of the present seas along the western shores of Britain" (Journ. Geol. Soc. vol. xxx. p. 39). In a paper on the drift deposits found near Blackpool, by the late Mr. Binney, published in the 10th volume of the Memoirs of the Manc. Lit. and Phil. Soc. p. 127, etc., he has described the shells found in the Till there, to the number of 19, all of them being shells still found on the Lancashire coast. A similar assortment of shells were found by Mr. Harkness in the Till near Ormskirk (*id.* p. 130). These shells assuredly witness no glacial climate. A more remarkable find, because of its locality, 50 miles from the sea, 568 feet above the sea-level, and right up in the gorges of the English Appenines, which, in the Glacial period, must have been choked with permanent ice, were found by Mr. Bateman, the engineer, in making the reservoir at Hollingworth, in Mottram in Longdendale. These included the *Turritella terebra, Fusus Bamfius, Purpura lapillus*, two species of *Tellina* and *Cardium edule* (Proceedings Lit. and Phil. Soc. of Manchester, vol. iii. pp. 15 and 16).

Let us now turn to the famous beds found near Macclesfield, and which occur there as much as 1200 feet above the sea-level. On these shells Mr. Darbishire wrote a valuable paper in the 3rd volume of the 3rd series of the Memoirs of the Lit. and Phil. Soc. of Manchester. See also Geol. Mag. 1865, Vol. II. p. 293.

Mr. Darbishire describes 49 shells from this locality, all except 7 occurring in Forbes's list already quoted.

Of the 42 named by Forbes, 4 reach their limit within the British seas, 6 entered southwards as far as the British Channel, while "of the remaining 32 species, the whole now range considerably southward of the British Isles, but, as a set, present a characteristically British aspect." The 7 shells not named by Forbes are *Pholas candida, Cytherea Chione, Cardium rusticum, Cardium aculeatum* (?), *Arca lactea, Littorina littoralis*, and *Dentalium abyssorum.* None of these appear, says Mr. Darbishire, "in McAndrew's list of Mollusca, observed between Drontheim and the North Cape, and only one, *Littorina littoralis*, in Danielsen's Zoological Notes of the Scandinavian coast. The remaining 6 are all shells of species which at present reach their *northern limit* within the British seas, extending on our western shores from the Spanish province. *Cytherea Chione, Cardium rusticum, Cardium aculeatum*, and *Arca lactea* are characteristic shells of a Spanish or southern type. The *Cytherea* is not found north of Carnarvon Bay nor in the German Ocean, it is essentially a southern species. The *Cardia* rarely frequent the coasts of Devonshire and Cornwall. *Cardium aculeatum* is said to have been dredged off Bergen; but *Cardium rusticum* is not known east of the Channel" (*op. cit.* p. 62). Mr. Sainter says of the two *Cardia*, the *Cardium rusticum* is also essentially southern and Spanish, Bantry Bay being now its most northerly and authentic distribution. The *Cardium aculeatum* reaches its highest northern range in the south or west of England and Ireland. The *Arca lactea* is also a southern shell, ranging northwards as far as Berwick Bay and Oban (Scientific Rambles about Macclesfield, pp. 57 and 58).

Not far from the deposits just described, but at a level 600 feet higher, Mr. Prestwich found fragments of shells. This spot is situated near the Buxton New Road, about a mile eastward of the first toll-bar out of Macclesfield, and, according to Mr. Darbishire, is from 1120 to 1160 feet above the sea-level. Here the latter gentleman found fragments of 12 species of shells, namely, *Psammodia ferroensis*, *Tellina solidula*, *Mactra*, *Cytherea Chione* (a characteristic hinge-fragment and another), *Artemis lincta*, *Astarte arctica*, *Cardium echinatum*, *Cardium edule*, *Mytilus*, *Turritella communis*, *Fusus antiquus*, and *Trophon*. After enumerating these shells, Mr. Darbishire adds the striking comment, "The occurrence of the *Cytherea* in this bed at a height of 600 feet above the beds examined on the west of Macclesfield is very curious, and adds a formidable consideration to the many difficulties which seem as yet to delay the solution of the 'Drift' problem" (*id.* pp. 64-5).

If we turn from these high beds in Cheshire, to the famous beds at Moel Tryfaen, in Carnarvonshire, we shall find that, although the Lusitanian species which are found at Macclesfield are absent, the general facies of the deposit is the same. Of fifty species found there, as many as 37 are still found living in the Irish Sea, while 11 only are typical of a more northern habitat. The evidence on the whole pointing no doubt to a colder sea, such as is known on the Scandinavian coasts and those of Boreal America, but in no way justifying the notion that it was like that of the Polar regions.

The Irish drift-beds were treated in a compendious paper by Mr. Bell in the 10th volume of the Geological Magazine. The evidence they furnish is like that of the beds on the opposite side of St. George's Channel. In the well-known Wexford beds 69 species of shells have occurred, of which as many as 52 still live in the British seas. Ten, that is, barely one-seventh, are northern forms, viz. *Astarte borealis*, *Leda hyperborea*, *Leda oblonga*, *Nucula proxima*, *Natica affinis*, *Pleurotoma Vahlii*? *Scalaria Grœnlandica*, *Trophon Fabricii*, *T. clathratus*, *Volumitra*, sp. *Grœnlandica*. These northern forms, however, are balanced by the occurrence with them of the southern forms *Leda pusio*? *Fusus crispus*? *Nassa semistriata*, *Turritella incrassata*, one Japanese species, *Nucula Cobboldiæ*, and two others whose habitat is unknown, *Melampus pyramidalis* and *Fusus Bailyi* (*op. cit.* pp. 451 and 452). In the Dublin drifts 33 species have occurred, of which 29 still live in our waters. Of the other four, two, namely, *Loripes divaricatus* and *Woodia digitaria*, are Lusitanian forms, and found on the East Atlantic coasts of Spain (Jeffreys' British Conchology, vol. v. p. 179).

On the banks of the Logan and the southern shores of Belfast

Lough 37 species of shells have been found in the drift clays by Messrs. Bryce and Hyndman. Of these, only two, *Leda oblonga* and *Trophon clathratum*, are not now found in the British seas, but only in the seas further north (Geol. Mag. Vol. X. p. 449).

Mr. Bell has also shown that a bank of shells, now submerged, off the mouth of Belfast Lough, and known as the Turbot Bank, consists largely of drift shells. Speaking of these latter shells he says, "Amongst the species, all of which are small, *intermixed with Celtic* and *southern forms*, are nine or ten whose congeners now live in the northern seas," adding, "The intermixture of southern forms with those of higher latitudes does not interfere with the placing of these beds in the Post-Tertiary Series, since they are equally present in the Killiney drifts, the Lancashire drifts, and in some of the Scottish Clyde beds, especially the one near Greenock. Indeed, amongst a parcel of minute shells and shelly clay from the latter place, I detected the fry or extreme young of some living Mediterranean forms, *Conus Mediterraneus* and *Cardita trapezia*" (*id.* p. 450).

Let us now go beyond our own land. "At Lillehersstehagen, which lies about an English mile east of Uddevalla, an extensive deposit of shells is partially exposed. Here the upper layer gives a singular result. Mixed with the universal *Trophon clathratus* (which is a high northern species, and found living only within the Arctic circle), are many shells of rather a southern type, such as *Ostrea edulis, Tapes pullastra, Corbula gibba,* and *Aporrhais pes-pelicani.* All these species, however, have been recorded by Sars as inhabiting the coast of Finmark, although they are also natives of the Mediterranean. According to Dr. Torell, a living oyster has never been found in the seas of North Greenland and Spitzbergen" (Jeffreys' Report on Upper Tertiary fossils of Sweden, Brit. Assoc. Report, 1863, 1874, and 1875). This is paralleled in Norway, where southern forms of shells have occurred mixed with Northern ones in the raised beaches.

No doubt both in Norway and Sweden we find raised beds of shells showing different climatic conditions, some presenting a more Arctic facies than others, but all of them prove the existence of open water and not of ice-bound coasts when they were deposited; but the difference of the contents of the beds may have its lessons exaggerated. "It is true that in some districts the Post-Tertiary fauna differs from that of another, at no great distance, in its apparently more northerly or southerly aspects, which unquestionably might arise from local causes, independently of climatal changes. The same thing holds good at the present time. For instance, *Fusus Turtoni, Fusus Norvegicus, Fusus Berniciensis,* and *Saxicava* (*Panopæa*) *Norvegica,* all northern species, have been taken living on the coasts of Durham and Northumberland, while no trace of them has been found on the western coasts of Scotland. We may reasonably infer that similar variations occurred in the seas of ancient times, yet no one would ascribe them to change of climate" (Robertson, Notes on Raised Beach at Cumbrae, Trans. Geol. Soc. of Glasgow, vol. v. p. 193).

Messrs. Crosskey and Robertson most aptly say: "A species may be rare at one part of a clay pit, and within a hundred yards or less, and in precisely the same clay, be abundant and characteristic, so that a fresh excavation may give a new aspect to the apparent grouping of the various forms. Exactly the same method of distribution prevails with these fossils from Post-Tertiary beds as with the inhabitants of the sea-bottom of the present day. Different species have their peculiar individualities of habitat, often within very short distances of each other. *Solen ensis*, e.g. is plentiful round Cumbrae in all the banks of muddy sand, but upon one bank *S. siliqua* occurs, and there scarcely an example of *S. ensis* has yet been found, although the banks are as nearly as possible similar in composition and not a quarter of a mile from each other. In the same way, *Pecten Islandicus* is abundant in the glacial clay in one locality, and will be replaced in the immediate neighbourhood by a different characteristic shell. *Cytheridea punctillata* (to give another example) — an abundant fossil form — is plentiful living in Loch Fyne, but rare in every other part of the west coast. The collector of glacial fossils is thus in exactly the position of the marine naturalist—he has to deal with an elevated sea-bottom in which many forms had their own especial dwelling-places" (Trans. Geol. Soc. of Glasgow, vol. ii. p. 269).

The fact is, the distribution of the mollusca is in all probability ruled by the same laws as that of the land fauna. It depends a great deal more on a sufficient supply of suitable food than on merely climatic conditions, and when we find Southern and Northern forms mixed together in so-called glacial beds, as they have been so clearly shown by Mr. Searles Wood to be mixed in a larger degree in the beds of the Crag, we ought to feel no more surprise than we do when we meet with the remains of the Reindeer and the Hippopotamus lying together in the Brick-earths of the Thames Valley, or the Reindeer and the Tiger living together, at this moment, in Manchuria, and the Camel and Mountain-sheep in Tibet. This analogy points another moral. As we have tried to urge, during the Glacial period proper the sea was probably as azoic as the land; when the glacial conditions began to mitigate, the land was first occupied by the Reindeer, the Marmot, the Lemming, etc., and presently by a fauna requiring more genial conditions. The sea must have had precisely the same rôle of climatic surroundings, and the earlier terrestrial beds are matched by the more arctic marine beds of Caithness and of Scandinavia. The two sets of marine and subaerial beds were contemporaneous. Of this we have remarkable evidence in certain situations where the debris of the land-life and of the sea-life have been mingled together. Thus in Western Sweden, in the black clays, the following list of shells mark the molluscan fauna: *Mytilus edulis, Mya truncata, Modiola modiolus, Solen ensis, Cyprina islandica, Nucula nucleus, Leda pernula, L. caudata, Cardium edule, C. echinatum, C. fasciatum, C. norvegicum, Lucina borealis, Montacuta bidentata, Isocardia cor, Pecten islandicus, P. maximus, P. septemradiatus, P. striatus, Saxicava rugosa, S. arctica, Tellina proxima, T. solidula, Astarte elliptica, A. sulcata, A. compressa, Thracia villosiuscula, Mactra subtruncata, Tapes pullastra, Venus* *striatula, V. ovata, Scrobicularia piperata, Ostrea edulis, Anomia patelliformis, A. aculeata, Littorina littorea, L. rudis, L. littoralis, Trochus cinerarius, Natica nitida, N. Montagui, Lacuna pallidula, L. vincta, Turritella communis, Cerithium reticulatum, C. adversum, Purpura lapillus, Nassa reticulata, N. pygmæa, Aporrhais pes-pelicani, Buccinum undatum, Fusus despectus, F. Turtoni, Trophon clathratus,* var. *minor, Mangelia linearis, Patella vulgata, Acmæa virginea, Lepeta cæca, Dentalium entale, Balanus porcatus, B. crenatus, B. Hameri* (Exposé des formations Quaternaires de la Suede, by A. Erdmann, pp. 92 and 93). The collocation of these forms is itself curious. The greater part of them still live on the coasts of Sweden, others now live further north, but the specimens from the beds are larger and finer than those now living in the same neighbourhood, proving that the conditions of life were then more favourable. Having examined the shells, we shall do well to turn to a notice, furnished by the author just quoted, of the remains of land plants found in the upper parts of this black clay, where exposed in a typical section at Enköping. Here he says is a quantity of vegetable debris of very different kinds, as, for example, stalks of *Equisetum limosum* mixed with fragments of Conifers and of leaves of the Oak, Willow and the Aspen, leaves and cones of the Pine, twigs, branches and bark of the Fir, the Aspen, etc. With them are found the epidermous coverings of the *Mytilus edulis*, of which all traces of the shells have disappeared. These debris assuredly point a very important lesson. Oaks would not be growing, nor Pine trees bearing cones, in contiguity with a Glacial sea.

If we come nearer home, we have a remarkable example in the marine drift at Kelsea Hill, at the mouth of the Humber, described by Mr. Prestwich in the 17th volume of the Geological Journal. From these beds Mr. Prestwich collected 40 species of shells. It is not necessary to enumerate them here, but I may add the conclusion arrived at by Mr. G. Jeffreys. He says, "Although nearly all of the species comprised in the foregoing list still exist in the German Ocean, there are some which are only known as living in more northern seas." Mr. Prestwich himself says, "The number of shells now obtained from these beds show, however, a more northern character than was at first apparent, and tend therefore, taken in conjunction with the occasional capping of thin seams of clay like a Boulder-clay, and the fact of a general development of gravels to the westward, to incline me to believe that these beds are to be referred to the upper part of the Boulder-clay. The shells are all of recent species, and 33 out of the 40 are still found on the Yorkshire coast. Nevertheless the presence of such species as the *Natica clausa, N. Grœnlandica, Trophon Gunneri, T. scalariforme, Mangelia pyramidalis* and *Littorina squalida*, which have a wide northern and Arctic range, indicates colder conditions than those now prevailing on these shores, and more in accordance with what we know of the fauna of this portion of the Post-Pliocene series (*op. cit.* pp. 455, 456). What is very curious, however, is to find this same northern fauna associated not with individual sporadic shells, but with thousands of examples of the freshwater shell *Cyrena fluminalis*, now confined to the Nile and the southern latitudes of Asia, and in all probability also associated with the Mammoths' tusks which have been found in the estuary of the Humber, the *Cyrena* and the Mammoth being companions in the Thames Valley and elsewhere. Again, during the construction of the Forth and Clyde Canal, some beds were met with at Croftamie (Drymen Station). In a bed of blue clay the following shells were found: *Cyprina islandica, Astarte compressa, Fusus antiquus, Littorina litorea,* and *Balanus*, and in the same bed was a *fragment of Deer's horn* $11\frac{1}{2}$ *inches* long, which was declared by Professor Owen to be that of a young or female Reindeer of the existing species (Trans. Geol. Soc. of Glasgow, vol. v. p. 16). These shells, says Mr. Jack, indicate a climate not severe, though probably a little colder than the present climate of these latitudes. All the shells specifically distinguished are living in the British seas (*id.* p. 25). This deposit was more than 100 feet above the sea-level. In other deposits near Loch Lomond, also described by Mr. Jack, and situated up to as high as from 120 to 262 feet above the sea-level, were beds of shells, which he describes as water-worn marine shells of species almost all now living in the British seas. The deposit, therefore, indicating a climate little more severe than our own (*id.*).

In concluding this part of my argument, I would strengthen it by two quotations from the opinions of Sir Roderick Murchison, based on his continental experience.

"But," he says, "some of the very marine shells on which we have been insisting as proofs of the aqueous formation of this Boulder drift, are said to be Arctic species, and have therefore been quoted as indicating the prevalence of a colder climate in our latitudes in those days than at present. Hence, glaciers, it is supposed, may have been adjacent to such arctic animals. But what are the species of shells associated with the great Boulder drift in Denmark? Why, in many tracts, the very same which now live *in the adjacent seas.* And though several of the latter are Arctic species, no glaciers occur within several hundred miles of the sea in which they live. Again, the researches of Prof. E. Forbes in the Ægean and of Prof. Loven in the North Sea have taugh tus, that the more or less Arctic character of shells essentially depends upon the depth of the submarine zone at which the animals lived" (Russia and Ural Mountains, i. 551).

Again, "We were at one time disposed to think that the presence of sub-fossil shells of Arctic character naturally indicated the former presence of a much colder climate in those latitudes where they have been found; but, independent of discoveries in submarine life, we now hold that it is unnecessary to have recourse to such an argument, in relation to any phenomena in the British Isles or similar latitudes; for we can easily imagine, that when very different physical features prevailed, and when lands now above the sea were beneath it, cold currents may have extended very far southward of the arctic circle, and have been inhabited by species now restricted (through geographical changes) to a less horizontal range" (*id.* note 2).

(To be continued.)

IV.—Woodwardian Laboratory Notes—N. Wales Rocks IV.

By E. B. Tawney, M.A., F.G.S.

(*Continued from* Dec. II. Vol. IX. 1882, p. 553.)

[Cl. 41], Sedgwick Collection, from near the top of Bwlch Mawr, is a rock of greenish-grey colour, with rather fewer felspars than the last. In the microscope the ground is seen to be largely occupied by squarish crystals of felspar, between which is some crypto-crystalline matter. The larger felspars seem all plagioclase, but they are all much decomposed, some of the smaller ones are perhaps orthoclase. There is no pyroxenic mineral preserved; calcite aggregations result, and also viridite extinguishing in no position. There are many minute quartz grains in the ground, which have the appearance of being secondary. Apatite is abundant; there are also black and brown crystals of iron oxides (ilmenite). A few crystals of epidote have been formed. No hornblende is to be found, and amorphous matter in the ground is uncertain, yet the rock may most conveniently be placed among the porphyrites. It has not, however, the andesitic structure of the Carn Boduan rock. The dark colour would be due to the chloritic matter and iron oxide scattered through the ground.

The hills Bwlch Mawr, Girn Goch, Girn Ddu, and Moel Penllech, form one continuous mass as mapped by the Geological Survey, their line is about parallel to that of the coast. They all belong to one series of igneous action, being lithologically allied. Some of the stone in the "set" quarries on Girn Ddu is almost exactly like that of Bwlch Mawr, while in the same quarry it assumes sometimes quite a different colour and appearance, instead of dark grey, being pale pinkish or greenish. There is no trace of conglomerate or of inclosed fragments of them in the Cambrian shales which surround them. Their appearance, therefore, is later, their intrusive nature being inferred from their relations to the shales which surround them.

Girn Goch, summit.—The rock here is of pinkish-grey colour, much weathered, as is natural on the top of an exposed peak. Under the microscope the ground is granulo-crystalline, consisting of quartz and felspar; the quartz abundant, among its inclusions are fluid-cavities with moving bubbles. Scattered through the ground are aggregates of viridite which under crossed Nicols depolarizes feebly; with it are mixed up numerous epidote particles; these may be inferred to be the remains of hornblende which has entirely disappeared. The felspars of the rock, from the value of the extinction angles, and their streaky nature, are indicated as chiefly microcline. The rock may be classed as granite-porphyry.

Girn Ddu, summit [Cl. 47], Sedgwick Collection.—Very like the prevailing rock of Bwlch Mawr, a dark grey ground, from which stand out numerous greenish-white felspars. Segregations of epidote visible to the unassisted eye; the triclinic nature of many felspars is detected with a hand lens. Under the microscope the ground is seen to consist chiefly of decomposing felspar crystals. The small felspars are much decomposed, they are often margined by decomposition products stained ferruginously. There is a little augite in a fresh condition, its extinction angle being 37°, but hornblende has entirely disappeared; parallel bars of ferric oxide perhaps indicate its pseudomorphs, the interior being entirely rearranged and unrecognizable, while chloritic matter and epidote, scattered abundantly through the ground, may also be considered indications of its presence. The rock may be classed as epidiorite, rather than porphyrite, since amorphous matter seems to be absent from among the decomposing elements of the ground.

A specimen taken from the new set-quarries on the N. side of Girn Ddu was also microscopically examined. It is a grey rock, in appearance like that of Bwlch Mawr, but the same quarry yields within a few yards quite light varieties, with a pinkish or slightly greenish hue. The rock is not yet deeply quarried, and under the microscope decomposition is seen at work. The large felspars are chiefly plagioclase, but are much attacked. No hornblende preserved; scattered augite crystals are preserved, but are seen changing into a green substance with aggregate polarization; specks of this are scattered through the ground. Magnetite is present, connected with the chloritic tracts which also inclose apatite rather frequently. The ground is chiefly crystalline, consisting of squarish felspar crystals, and occasionally a small quartz grain, with some cryptocrystalline tracts. The smaller felspars may possibly be orthoclase, they mostly show no building up of hemitrope laminæ, some few extinguish parallel to their length, others do not. It is the augite and magnetite which give the dark colour to the rock in this part of the quarry, but the felspathic element of the ground is far in excess. The rock may be classed as a variety of the epidiorite-group, though augite-syenite-porphyry would come also near to its constitution, if monoclinic felspar predominated.

A little further south of these hills are other igneous masses marked on the Geological Survey Map in an almost parallel line to the above. Two of these form the hills Penygaer and Moel bron-y-miod. Penygaer is mapped as greenstone and described as diorite in the text (*l.c.* p. 219). On ascending to the encampment at the top of the hill, I found it apparently a felsite, so that some error has crept into the colouring of the map here.

This rock is light grey, with a more compact ground than have the preceding rocks, but with similar felspars about one-eighth of an inch in length scattered through it. A microscopic examination shows that it differs somewhat from the preceding; the ground is microcrystalline, a minutely granular mixture of quartz and felspar apparently, the felspathic portions much decomposed and a micropegmatitic structure is set up in spots. Chloritic or viridite matter in aggregates is scattered about, but a fragment of augite left undecomposed in the centre of one of the patches points to what the green mineral originated from. Apatite is abundant. Some of the larger felspars are again plagioclase. In the minute quartz of the ground were fluid-inclusions with moving bubbles. The rock may be classed with the felsites.

[Cl. 1.] Sedgwick collection (*l.c.* p. 458).—The mass E. of Llanaellaiarn has been already described by Prof. Bonney as rhyolite.

It has been stated above that this group of igneous rocks has been mapped by the Geological Survey with the same colour as the Eifl hills, which are indicated as "syenitic-felspar-porphyry," and designated as intrusive. Dr. Hicks has, however, in his sketch-map and description of the Pre-Cambrian outcrops (*l.c.* p. 297, 299), considered all these not as intrusive, but as Pre-Cambrian rocks.

We have now to add that our observations led us to note an alteration of Cambrian slates at different spots round the hills, where the shales can be seen sufficiently close. We traced the indurated shales S.E. of Bwlch Mawr, again N. of Girn Goch, while similar indurated beds may be found in the narrow col between the two Eifl hills.

Guided by Sedgwick's MS. Journal of 1831, I found the junction of porphyry with the slates on N. side of Girn Goch, above and to the right of a small waterfall, viz. at the top of the screes; the two rocks are here within a foot of each other; the slates are much indurated and crushed, being converted to a hard greenish-grey hornstone-like rock scarred by ferruginous veinlets.

There is therefore little doubt that the Geological Survey are perfectly correct in their mapping. The igneous rock must be later than the slates into which it is intrusive. As to age, it is probably Post-Arenig; but not having found fossils, I cannot give any exact date.

Continuing in a southward direction, we come to the Eifl and Nevin groups. The rocks of the Eifl hills were described by Prof. Bonney (*l.c.* p. 305), from Dr. Hicks's specimens, as quartz-felsite on S.E. side, rhyolite on E. side, and N.W. of the Eifl near the coast (Trevor quarry) as possibly a granite-porphyry. The rock of the smaller Eifl (Tre'r Ceiri) encampment hill is also a felsite of pinkish-grey colour and minutely granular ground. Under the microscope it is seen to consist of a microcrystalline mosaic, with larger patches of quartz of irregular outline, never rounded crystals; the few larger felspars are chiefly plagioclase however.

Dr. Hicks's specimen [III. *l.c.* p. 305] seems to have come from the Trevor so-called granite-quarries. The rock there varies; I have one darkish grey variety outwardly similar to that of Bwlch Mawr, except that there are dark greenish specks in it; others are of lighter tints, some pinkish, some light grey. The larger felspars are about $\frac{1}{8}$ inch long; no separate quartz is visible to the eye.

Though a granite-porphyry, there is a good deal of plagioclase in my slice among the larger crystals. A detached mass S. of Vortigern's valley (Nant Gwrtheyrin) is a rock with slightly different aspect. Its colour is pale grey, it has fewer separate felspars, but a finely granular texture throughout; it is well seen in the "set" quarries.

Microscopic examination shows it to be quite akin to the Trevor rock, the ground crystalline with abundance of small clear quartz grains mixed with felspar. Being less decomposed, we are able to see that hornblende is present in small quantities; some of the bisilicate is, however, passing into chloritic matter; magnetite is connected especially with these tracts.

In two cases hornblende crystals inclose an augite centre, though set with axes parallel the value of the extinction angle is quite different at the centre and outside, the latter only being dichroic. The rock may be classed as granite-prophyry slightly hornblendic, rather than quartz-diorite, though many of the larger felspars are plagioclase.

The mass is mapped as surrounded with shale; evidence of induration of the adjacent shales as if by heat may be seen near Tir Gwyn.

The set-quarries at Moel Gwyn, between Pistyll and Nevin, yield a rock with dark grey ground and white felspar, much like that of Girn Ddu; no quartz is visible in the lens, but many of the felspars are seen to be triclinic.

[P. 56], Sedgwick Collection, from hill one-half mile S.S.E. of Pistyll, would perhaps be from Moel Gwyn; it is a similar darkish grey porphyry. Microscopic examination shows a ground consisting chiefly of rectangular crystals of felspar; most of the larger felspars are certainly triclinic. Those of the ground are somewhat quadrangular, but mostly the length is about twice that of the breadth. They mostly extinguish very nearly in the direction of their length, and are therefore probably chiefly oligoclase. Some are probably orthoclase, but the limits of error in the present case make it uncertain; these small felspars do not show twinning. Both hornblende and augite are present in small quantities, accompanied by decomposition products, chloritic matter and magnetite. Apatite is also abundant. The augite is recognized both by basal sections showing cleavage and a high extinction angle in clinodiagonal sections. The hornblende has nearly all decomposed. The rock may be classed as epidiorite.

[P. 3], Sedgwick Collection, from sea-side between Pistyll and Nevin, one-half mile from Pistyll.—This must be from the igneous mass of which Nevin occupies the centre; it has the appearance of a syenite-porphyry, the dark green patches being almost equal to the felspathic portion of the rock.

Microscopic examination shows that the separate felspars are chiefly plagioclase, which is more abundant than orthoclase. They are much decomposed. Quartz is abundantly crystallized out in the spaces between the felspars, and the ground often shows a micropegmatitic structure. The hornblende is green and fibrous, and forms sometimes groups of actinolite-like crystals, which are at times inclosed in quartz; the further state of change is that of chloritic aggregates. The quartz is probably partly of secondary origin. The rock may be classed as quartz-diorite, rather than granite-porphyry, from the nature of the felspars.

The Gwylfa rock, near by, is also described in the Survey Memoir [ed. 2, p. 219] as diorite.

The rock of Mynydd Nevin, which is the hill nearest to Carn

Boduan, is again a porphyry with greenish-grey ground; it is much like that of Moel Gwyn.

The microscope shows that the separate felspars are chiefly plagioclase; some are so decomposed that they are doubtful; the alteration is that so often described: the smaller felspathic portions of the ground mosaic are also much attached, they do not show twinning. Hornblende is present, mostly changing to chlorite of chrome-green colour, but portions of the original crystal are preserved; it occurs as separate crystals, and minuter grains in the ground, but is far less in quantity than the felspar. Quartz grains are abundantly scattered throughout the ground, which is minutely crystalline. Apatite is abundant in largish crystals, usually connected with the hornblende or chloritic areas, but sometimes included in felspar. One portion of augite was observed. Since the larger felspars are triclinic, the rock may be classed as quartz-diorite, or quartz-epidiorite of some authors.

The relation of these Nevin rocks to the Cambrian shales which lie around them makes it extremely probable that they are intrusive; indeed, the area of shales confined between two arms of the igneous rock at Pistyll shows evidence of the action of the latter in induration, *e.g.* near Pen y nant and on the east side of Tany foel.

In view of these circumstances, which moreover have been previously indicated by Sir A. C. Ramsay, in the Survey Memoir [ed. 2, p. 218], one cannot but adopt his conclusion, viz. that these rocks are intrusive in Cambrian beds mostly of the age Arenig to Bala. No reasons have been given by Dr. Hicks why the term Arvonian should be given to them, nor is the meaning of this correlation explained.

Certainly the variety of rock in the same igneous mass is a little perplexing; this is specially noticeable in the Nevin tract, which is described generally by the Survey as syenitic-felspar-porphyry, but at Gwlfa quarry is called "a fine-grained diorite." At one part quartz will be abundant, and at another time absent. Carn Boduan, Carn Madryn, Carn Fach, and some other detached bosses are respectively fairly uniform throughout.

Doubtless, the same speculation will occur to many, as is so well expressed by Sir A. C. Ramsay [*l.c.* p. 220], that these dome-like masses are parts of deep-seated material, above which rose craters from which the lavas and ashes of adjacent parts of N. Wales were ejected.

This variation in composition of these old rocks may further possibly be explained by their being supplied from time to time with melted matter of different constitution, which might become more or less fused together, though the pulsations of fresh material were added at considerable interval, and even after the crater had ceased its emissions at the surface from gradual decline of energy.

(*To be continued.*)

V.—The Red Chalk of Norfolk.

By William Whitaker, B.A., F.G.S.,
of the Geological Survey of England.

(Part of his Presidential Address to the Norwich Geological Society, 7 Nov. 1882.)

My remarks will have to be limited to Norfolk; because personally I know very little of the Red Chalk of Yorkshire, and nothing of that of Lincolnshire. Of course the subject would be better treated as a whole; but Norfolk geologists will forgive me for not waiting until that time (perhaps never to come) when I may know all the English Red Chalk. Perfection may be devoutly prayed for; but to wait for it would be to do nothing.

The plan I have adopted is to notice the various papers, etc., on the Norfolk Red Chalk in the order of the years in which they were published; then to review the arguments brought forward in them; and then to conclude with a few remarks of my own, which are meant to be suggestive rather than dogmatic.

[An account was then given of the various works on the subject, from 1816 to 1882.]

The result of an examination of our Red Chalk literature probably astonishes you, from the variety of the opinions evolved; and indeed, to make a bull, the unanimity of geologists in getting different conclusions from like premises, is certainly surprising. However, on thinking over the matter, it seems to me that we ought to be thankful for not having had more theories as to the age of our Red Chalk.

Let us examine the possibilities of the case, and firstly from the purely stratigraphical point of view. Speaking in general terms of Hunstanton Cliff we have the following regular succession:—White Chalk, Red Chalk, and Carstone (Neocomian). Now there is nothing like the ordinary Upper Greensand or Gault, the space usually filled by one or both of those formations being taken up by the four feet of Red Chalk. Again, there is nothing to show that the lowest beds of the Chalk are present (and I believe that they may not be) or the highest beds of the Neocomian, though geologists seem to have quietly *assumed* both these occurrences, or at all events the former. We have, therefore, four formations to deal with: Chalk (part), Upper Greensand, Gault, and Neocomian (part). Speaking simply on stratigraphical grounds, the Red Chalk might therefore belong to any one of these four, or it might be a combination of any two of them (adding six alternatives), or a combination of any three (adding four alternatives), or it might represent all four. We have therefore fifteen views to choose from so far! Calling in, however, palæontology to our aid, we may get rid of the Neocomian, leaving us with either of the other three, a combination of any two of them (three alternatives), or a combination of all, giving us still seven views. Of these seven two have escaped as yet, no geologist, as far as I know, having advocated either a mixture of Chalk and Upper

Greensand, or of Chalk and Gault. Mayhap there will be volunteers to rush into "the imminent deadly breach," and appropriate these views, or so much as I may leave of them.

We may now turn to the various statements that have been put before us, and see what can be made of them, and in what our later knowledge may affect them. Fortunately it is not needful to begin at the beginning, for Prof. Seeley, in his first paper,[1] has cleared the way for us. Although the Professor has shown the illogical character of some of the conclusions of geologists, yet it seems to me that he has not quite avoided some like mistakes himself. His illustration of the Red Crag with its abundance of Recent species, and which nevertheless is not a raised recent beach, is hardly to the point: we know that the Crag *everywhere* yields these species, and not in comparatively few peculiar places. Moreover, they are contained in the ordinary Crag, and not in a deposit of exceptional character that happens to occur locally in the geological horizon where Crag is elsewhere found. Besides, this illustration, if strictly to the point, would go further than its author carries it; for it might just as well point to the extension downwards of Chalk species into Gault as into Upper Greensand, and so might be claimed by Mr. Wiltshire as in favour of the Gault theory. I do not see either the force of the argument that the difficulty of separating the Red from the White Chalk is in favour of the former being classed as Upper Greensand, it would seem rather in favour of classing it as Chalk. The chief objection, however, to Seeley's view is one that he could not have foreseen,—founded, as it is, on later researches. What is the Upper Greensand to which he refers the Red Rock? Clearly, from frequent references, it is the so-called Upper Greensand of Cambridge, the "coprolite-bed," or thin layer of phosphatic nodules in green marly sand that has been so largely worked in Cambridgeshire. Now this really insignificant layer—for it is generally thinner even than the Red Chalk at Hunstanton—has been the subject of careful research, and my colleague, Mr. Jukes-Browne,[2] has, I think, conclusively shown that it does not really belong to the Upper Greensand; but is nothing more than the base of the Chalk Marl, the greater number of its fossils having been derived from the destruction of other beds, Upper Gault to wit. Therefore, by our present lights Prof. Seeley's arguments would tend to show that the Red Rock is Chalk rather than Upper Greensand, though I fear he still holds to the older view as regards the age of the nodule-bed. As so great a number of the Cambridge fossils are Gault species, and derived from the Gault, the Professor's tables, showing so large a proportion of Upper Greensand fossils in the Red Rock, are invalidated.

With regard to the same observer's idea[3] that the sponge-bed (of

[1] Ann. Nat. Hist. ser. 3, vol. vii. pp. 233-244 (1861).

[2] Quart. Journ. Geol. Soc. vol. xxxi. p. 256 (1875), and The Geology of the Neighbourhood of Cambridge, pp. 24, 25, 29-31, 132, 149-154. Geological Survey Memoir, 8vo. London, 1881.

[3] Quart. Journ. Geol. Soc. vol. xx. pp. 327–332 (1864), and Ann. Nat. Hist. ser. 3, vol. xiv. p. 276.

the White Chalk) is linked to the top bed of the Red Chalk, surely we may as well put it the other way up, and look on the top bed of the Red as linked to the bottom of the White. From my own observations, I think it an untenable view to regard the sponge-bed as being Upper Greensand, or even Chalk Marl. How the Hunstanton Rock, which is only four feet thick, can have the slightest pretence to be "the most perfect exhibition of the Upper Greensand that is known," I cannot see; but then, being a field geologist, I cannot look on the subject from a purely palæontological point of view: besides, too, even my comparative blindness in this matter does not hinder me from seeing that Upper Greensand species are not remarkable for their great abundance in the Red Rock, whilst Gault species are plentiful, and Chalk species not rare.

I can find no good reasons given for the opinion of Mr. Rose [1] and others that the sponge-bed, the base of the White Chalk at Hunstanton, should be classed as Upper Greensand. Its fossils are not quoted as showing this, neither does its lithological character help, for it is simply chalk. The idea seems indeed to have been put forward for the purpose of satisfying the strange greed for correlation that possesses the souls of geologists! Under the Chalk there ought to be Upper Greensand, and under that Gault; so if we cannot see anything like these, we must needs worry about to find something that may be taken as representing them!

With reference to Prof. Judd's remark that all palæontologists who have examined the subject regard our red rock as not newer than Upper Greensand, and perhaps as being of the age of the Gault,[2] I would say that the question is by no means one to be decided by an appeal to fossils alone, and, even if it were, I fail to see how such a conclusion could logically be got at, for it utterly ignores the large number of Chalk fossils that occur in the red rock.

The same remark as made above to the correlation of the sponge-bed with Upper Greensand applies also to Mr. Wiltshire's correlation of the next bed of the White Chalk (the *Inoceramus*-bed) with the Chalk Marl, in his paper of 1869.[3] Nothing, as far as I can see, but the presumed necessity of getting in Chalk Marl somewhere in the section, justifies this. Against another remark of the same observer I must raise my voice in protest, and the more so as it is one of a kind not by any means peculiar to him, alas! but common to most geologists, to the effect that "if the Folkestone section be taken as *typical* of English Gault," etc. What right have we thus to limit Nature, and of what avail can be our attempts to fix her to our so-called types? Is there any reason to expect that Nature, the ever-varying, should deposit a world-wide mass of clay, 100 feet thick or so, and with certain shells in it, just because she has done so at Folkestone, or any other place? And if Nature has been bountiful enough not to treat us in this monotonous way, but to

[1] Geol. Mag. Vol. IV. p. 30 (1867), and his earlier papers, Phil. Mag.
[2] Quart. Journ. Geol. Soc. vol. xxiv. p. 223 (1868).
[3] Quart. Journ. Geol. Soc. vol. xxv. p. 185.

give us that variety without which our science would be nowhere, are we to stamp her work as not being *typical* when it happens not to agree with what, from our small point of view, seems to us the right thing? Why should Folkestone, or any other British town or district, be taken as a *typical* spot, rather than Russia, or India, or America? Moreover, who is to decide what is *typical* Gault (or anything else)? The fact is that these attempts at squaring Nature depend wholly on the mere accident of place and person. By *typical*, geologists generally mean as seen at the place where, to their minds, any bed is most correctly developed. One man's type, therefore, may be another man's exception.

Mr. Wiltshire's illustration of the argument that the lithological difference between Red Chalk and Gault is no bar to considering them as the same, is unfortunate, for the Carstone at Sandringham is not so different from the same bed at Hunstanton as he thinks. There is Carstone at both places, and in the same geological position: the pure white sand near Sandringham, which he thinks represents the Carstone of Hunstanton, does not do so; for the sand is at a lower geological level, and separated from the Carstone by a thin mass of clay, all three however being parts of one formation.

Prof. Bonney's[1] notice, in 1875, seems marked by an absence of dogmatism and by philosophical conclusions.

I cannot agree with Dr. Barrois[2] in separating the Norfolk Chalk, etc., from its more southerly kin, as not being connected with the London Basin, and not dipping under the Tertiary beds thereof. Our Norfolk Chalk is just as much connected with the London Basin as any other Chalk, and it does dip under the Tertiary beds, though certainly there is a very wide area in which no such beds occur. Neither can I agree with the classification proposed, which seems to be founded on fossil evidence only, a dangerous thing. If there be any gap between the sponge-bed and the Red Chalk, it is strange that the same peculiar sponge occurs in both. The evidence, too, that I have gathered in Norfolk makes the sponge-bed higher than the Chloritic Marl, or even than the whole of the Chalk Marl. In the name of Norfolk geologists I may thank Dr. Barrois for his lists of fossils from these and the overlying chalk, no such detailed information having been given us before.

The short notes of Mr. Gunn[3] have, I think, hit a weak point of most authors, by his argument that the newest fossils should have the chief weight in fixing the age of the bed.

I may now allude to the few ideas that have occurred to me on the subject of the Red Chalk whilst working in West Norfolk, and in the first place will take rather a pet notion that, alas! I can make nothing of. It occurred to me that, considering the treacherous nature of the red colouring of many beds, and the

[1] Cambridgeshire Geology. Appendix iii.

[2] Recherches sur le Terrain Crétacé supérieur de l'Angleterre, ... pp. 156-158 (1876).

[3] Proc. Norwich Geol. Soc. pt. i. p. 23 (1878).

mistakes that geologists had been led into thereby (such as taking reddish Carboniferous Sandstone for Permian, solely on account of its colour), some such mistake might have been made as to our particular red friend; and that whilst we had been thinking that we were dealing with a bed we might really have been misled by what might be merely a colour-line. Unfortunately there are in Norfolk no other sections showing the junction of the White and Red Chalk than those of the Hunstanton cliff and of a pit near by the railway-station, and therefore no great way from the cliff. These sections certainly do not aid my notion, for in them the sponge-bed invariably overlies the Red Chalk, and it is unlikely that a colour-stain should be confined so strictly to one geological horizon for a long distance. Prof. Judd moreover has noted the same succession in Lincolnshire, as aforesaid, so that my colour-line idea must be put aside.

As to the cliff-section there is probably little to be added to the detailed descriptions that have been published, except that from the nature of such a section there is a constant chance of something fresh being shown. In regard to the softer and more sandy base of the red rock (which contains grains of glauconite not decomposed) passing down into the Carstone in places, I think little is proved by it, for such a passage may be apparent rather than real, through having been caused partly perhaps by the working up of a little of the lower bed during the deposit of the upper, but partly also to the slight carrying down of particles of the upper into the lower through the infiltration of water downwards after the deposition and consolidation of the Chalk, an action which there is nothing to hinder, and which would result in carrying away part of the calcareous matter in solution. With reference to planes of jointing being stopped at the top of the red rock, as noticed by Mr. Seeley, when I saw the section in 1880, the joints stopped rather at the top of the *Inoceramus*-bed, though some went through to its base; so that little is proved by them, for they have been seen to stop at three different levels.

In the course of my survey work in West Norfolk, as yet very incomplete, I have traced the Chalk Marl northwards from within a few miles of Lynn. It has the clayey character so usual to this bottom division of the Chalk in Cambridgeshire, Hertfordshire, etc., giving rise to a belt of country covered with oaks and elms, and not having the usual look of an ordinary Chalk tract; but it is of far less thickness than in Cambridgeshire, perhaps eastward of Lynn some 20 feet only; whilst going north it gets thinner still, until at last it disappears, the last I have seen of it being at Sandringham. In this part of Norfolk this clayey Chalk Marl is characterized by having some layers of a very pale pinkish colour, an occurrence that I do not remember having noticed to the south.

In the tract to which I have alluded Gault clay also occurs; but to a less extent than the Chalk Marl, being only a few feet thick, and last seen in the neighbourhood of Castle Rising.

The argument, therefore, that the Red Chalk represents the Gault because it comes on where the latter has thinned out, the one being replaced by the other, might be just as well put forward in favour of the theory that Red Chalk represents the Chalk Marl—even more strongly, for the vanishing points of these two are nearer than those of the Gault and of the Red Chalk.

It was the absence of these two clayey beds in tbe north-western corner of Norfolk that led me to think of the possibility of the Red Chalk being a colour-line rather than a bed, and I am not yet sure that this absence may not have something to do with the red colour that co-exists with it. The Chalk Marl stops the infiltration of water downwards through the Chalk, of which there is good evidence in the springs thrown out at the outcrop of the former; whilst the Gault would stop any upward rise of water that might occur through the underlying sands, under different physical conditions from those we now see, shutting the water up in those sands, as in deep wells through Gault to Lower Greensand. It is quite possible, therefore, that the absence of these clayey beds may have something to do with the presence of that redness, which is owing perhaps to the per-oxidation of some salt of iron, a process that would be made more easy by freedom of percolation by water.

Though perhaps beyond our subject, I may notice another bed of clay, which differs from the two just noticed in being peculiar to our district—I mean the bed that occurs in the Neocomian Sands (towards their upper part) from Hunstanton southwards to Flitcham, first noticed I believe by Mr. J. H. Teall,[1] whose essay gives the best account of the Norfolk Neocomian that we have. It is perhaps, the presence of this bed which has caused the formation of the Carstone, a stone which is merely a sand or grit cemented by brown iron-oxide; at all events the Carstone is best developed where this clay exists and where the Chalk Marl and Gault are absent, whilst elsewhere it ceases to exist as a marked bed. The clay seems to have stopped any further sinking of water with iron-salt in solution, and to have held it in the upper part of the sands. It should be noted too that it is in the same district that our Red Chalk occurs, and thus, whilst in that district ferruginous water could sink no great way below the horizon of the Red Chalk, but could easily go thus far, a little to the south, where Chalk Marl comes in, no such water could get to that horizon at all.

Having just travelled geologically a little way from our subject I will now, for a short time, take you away from our district. As you know, Red Chalk is not confined to Norfolk; occurring also, and to a greater extent, in Lincolnshire and Yorkshire. But we find in those counties that there is not simply one Red Chalk, but another, and a thicker, bed comes on many feet up in the Chalk. This upper red bed must therefore belong to the Chalk, and, on the supposition that the lower bed does not, we are faced with the strange anomaly of two members of the Cretaceous Series, elsewhere distinct, putting on together the same exceptional character. I do

[1] The Potton and Wicken Phosphatic Deposits, pp. 16 –23. 8vo. *Cambridge* and *London,* 1875.

not know whether any attempt has been made to examine the upper bed palæontologically, but if not, I trust that our Lincolnshire and Yorkshire friends will set about it.

There is a stratigraphical argument in favour of classing the Red with the White Chalk that I fancy has not been noticed; it is the fact of the parallelism of the Red Chalk and the two lowest beds of the White Chalk (the sponge-bed and the *Inoceramus*-bed) not only along the Hunstanton section; but also in Lincolnshire, according to Judd. Now, if these three belong to two distinct formations, it is passing strange that such extreme regularity should occur!

You will probably agree with me, after what has been said, that the question of the age of the Red Chalk is not to be settled by an examination of the Hunstanton cliffs, even were that examination of the most detailed and searching kind. It is needful also to trace the bed along its outcrop, and, more than this, to carry our researches to the beds both above and below its horizon, by which I mean not only where its outcrop can be seen, but also southward, where the red rock does not occur. The Red Chalk indeed must be studied as part of a series, and not as an independent bed.

Let us now pass to a consideration of the evidence of the fossils. Though the kindness of my colleague Mr. Jukes-Browne, who has revised the published lists and brought them up to date for me, I am enabled to lay before you the accompanying list, and also to quote these remarks, with which my friend has favoured me. "Palæontologically the Hunstanton Limestone has stronger affinities with the Gault than with any other formation; 35 of its fossils occur in the Gault and three others occur as derived fossils in the Cambridge nodule-bed, thus making 38 altogether. Its affinities with the Chalk Marl are less strong, but nevertheless remarkable. It must be remarked however that none of the specially characteristic Chalk Marl fossils are found. Its affinities with the Upper Greensand (exclusive of the Blackdown Beds) are still weaker, and none of the characteristic Upper Greensand Brachiopoda or Cephalopoda occur. Generally speaking the commonest fossils are Gault species, which do not range up into the Chalk."

I have made the following analysis of the list of fossils, omitting unnamed species and doubtful species and occurrences:—

	Total.	Mollusca only.
Number of species (and varieties) in the Hunstanton Red Rock......	77	44
,, ,, these that occur in the Gault	35	26
,, ,, ,, ,, Upper Greensand	23	16
,, ,, ,, ,, Cambridge nodule-bed	29	22
,, ,, ,, ,, Chalk	32	18
,, ,, ,, peculiar to the Red Rock	20	6
,, ,, ,, that occur elsewhere in Gault only	5	5
,, ,, ,, ,, ,, Gault and Cambridge nodule-bed only	10	7
,, ,, ,, ,, ,, Upper Greensand only...	1	0
,, ,, ,, ,, ,, Chalk only	11	6
,, ,, ,, range above the Gault	37	22
,, ,, ,, do not occur in Gault (or in the Cambridge nodule bed), but do occur in U.G.S or Chalk ...	15	9

Although no very definite conclusion seems allowable from this table, it will be seen that more than half of the Gault species are such as are not peculiar to that formation, but range above it, whilst there is only a single species that is peculiar to the Upper Greensand. By disregarding everything but the Mollusca the Gault gets an advantage.

As to the number of Gault fossils! Does it prove that the Red Rock must be Gault? How so? There are also Upper Greensand fossils, though in less number, and there is a goodly proportion of Chalk fossils. If the rock represent Gault, and Gault only, how are we to account for the occurrence of these fossils belonging to higher beds, and some of which have nowhere been found in undoubted Gault? It seems to me that this is fatal to the Gault theory, as also to the Upper Greensand one; for whilst we can understand how Gault fossils may occur in Chalk (either by derivation, or extension of range), it is not so easy to see how a lot of Chalk species can have managed to get down into the Gault. It should be remembered that this is not a question of a few stray specimens; but one of many specimens and of a number of species, known elsewhere as characteristic of the Chalk, and some of which have not even been found in the Upper Greensand. It seems to me that, knowing certain species existed in the Gault, we need feel no great surprise at their *continuing* to exist in places after the time of the Gault, even though in most places that is not the case; whilst to suddenly antedate the appearance of a number of species known only as occurring in the Chalk, is a different matter.

Let me give a chronological illustration. We are now in the latter part of the 19th century, and the majority of the men now living are 19th century men. There are, however, a good many 18th century men still living; but no one can say that there are any of the 20th century! It is not until the 20th century comes that we can have 20th century beings, and what will be the case in the earliest part of that century? Why, the great majority of people will be 19th century creatures, but few will belong to the 20th century, and there may be a few survivals from the 18th.

It may be objected to this, that our divisions of time are arbitrary —What then are our geological divisions? are not many of them arbitrary too? and has not a large amount of arbitrary division been exercised at Hunstanton?

The possibility of any of the Gault fossils in the Red Chalk having been derived has been alluded to I believe by only two of the authors quoted, Seeley and Gunn. I must own to a sort of surprise that fossils from older beds are not more often found worked up again in newer beds; but strangely enough one of the best marked of such occurrences (outside of that *omnium gatherum*, the Drift) is one in which Gault fossils are largely found in a newer deposit—and that deposit is the nodule-bed *at the base of the Chalk*, in our neighbouring county, Cambridgeshire. How is it, we may ask, that so great a number of Gault fossils occur in the base bed of the Chalk in Cambridgeshire, etc.? It is because the upper part of the Gault there (where there is no Upper Greensand) was worn away before the deposition of the Chalk Marl, and the hard nodules and fossils were left behind, to form part of the overlying deposit. Now we may infer that in Norfolk the Gault clay has been worn away also, and even to a greater extent, for that clay thins northward from Cambridgeshire through Norfolk. We might therefore expect to find some remains of Gault in the latter county, as in the former, in the overlying deposit. I would suggest, therefore, to those geologists who may visit Hunstanton that they should examine the fossils of the Red Chalk in order to see whether any of them show signs of having been derived, either from having worn surfaces, from their contents differing from the surrounding matrix, or, if there be no such difference, from anything that may tend to show alteration or replacement of the original earthy contents. As far as I know no evidence of this sort has been recorded.

The rarity of species elsewhere confined to the Upper Greensand need not surprise us. That division is probably the least constant in the Cretaceous Series, and is not known to occur for many miles from our Red Rock.

Neither am I much surprised at the non-occurrence of the characteristic Chalk Marl species, noticed by Mr. Jukes-Browne, for, as stated above, the Chalk Marl seems to have thinned out some miles south of Hunstanton, and it has not yet proved very fossiliferous in Norfolk.

I have now reached the last stage of this address, and am sorry to say the most difficult one. From the data we have, I cannot see the way to a definite conclusion as to the precise age of the Hunstanton Red Rock, nor do I see from what quarter we are to expect fresh help.

The stratigraphical evidence, taken alone, seems to me to be in favour of the Chalk theory, as may be seen from what has gone before; but the palæontological evidence seems to put a veto on this, unless we can explain the occurrence of the many Gault forms, either by derivation (of which we have had no evidence) or by local survival to later times, and something of this sort may have occurred: at all events I have found numbers of what appears to be the Gault form *Belemnites minimus* in the Chalk Marl of Norfolk.

The palæontological evidence is really vague; but it does, to my mind, lead to certain negative conclusions, thus clearing the way. I think it shows that the rock is neither Gault only, nor Upper Greensand only, nor a mixture of the two; for how either of these three theories can hold against the number of Chalk fossils that occur passes my understanding.

Arguing from its contained fossils, indeed, we seem to be left two alternatives only, as to the geological age of the rock. Firstly, that it represents the lowest part of the Chalk, the Upper Greensand, and the upper part of the Gault, having been laid down at the same time as those deposits, but under different conditions,

Fossils of the Hunstanton Red Rock.	Occur in Gault.	Occur in Upper Greensand.	Occur in the Cambridge Nodule Bed.	Occur in Chalk and Chalk Marl.
PROTOZOA.				
Cristellaria rotulata, Lam.	x	—	—	x
Globigerina cretacea, D'Orb.	—	—	—	x
Berenicea contracta, Seeley	—	—	—	—
——— *regularis*, D'Orb.	—	—	—	—
Cellulipora sulcata, Seeley	—	—	—	—
Proboscina dilata, D'Orb.	—	—	—	—
Reptomulticava mamilla, Reuss.	—	—	—	—
Scyphia tenuis, Roem.	—	—	—	—
? *Siphonia pyriformis*, Goldf.	—	x	—	—
Spongia paradoxica, Woodw.	—	—	—	x
Stomatopora longiscuta, D'Orb.	—	—	—	—
Ventriculites texturatus, T. Smith	—	—	x	—
ACTINOZOA.				
Cyclolites polymorpha, Goldf.	—	—	—	—
Micrabacia coronula, Goldf.	x	x	—	x
Podoseris elongata, Dunc.	—	—	—	—
——— *mamilliformis*, Dunc.	—	—	—	—
ECHINODERMATA.				
Bourgetocrinus rugosus, Ag.	—	—	—	—
Cidaris gaultina, Forbes	x	—	x	—
——— *sceptrifera*, Mant., or *dissimilis*, Forbes (spine)	—	—	—	x
——— new sp. (spines)	—	—	—	—
Holaster suborbicularis, Ag.	—	x	—	x
Pentacrinus Fittoni, Austin	x	x	x	x
Pseudodiadema Brongniarti, Ag.	—	—	—	x
——— *ornatum*, Goldf.	x	—	x	x
Salenia Wiltshirei, Seeley	—	—	—	—
Torynocrinus canon, Seeley	—	—	—	—
ANNULOSA.				
Pollicipes unguis, Sby.	x	—	?	x
Serpula antiquata, Sby	x	x	x	x
——— *cristata*, Duj	—	—	—	—
——— *depressa*, Goldf.	—	—	—	—
——— *rustica*, Sby.	—	x	—	—
Vermicularia umbonata, Mant.	—	—	—	x
MOLLUSCA.				
Brachiopoda.				
Kingena lima, Defr.	x	x	x	x
Rhynchonella Cuvieri, D'Orb.	—	—	—	x
——— *sulcata*, Park.	—	—	x	—
Terebratula biplicata, Sby.	x	x	x	x
——— ——— var. *Dutempleana*	x	—	x	—
——— *capillata*, D'Arch.	—	—	—	—
——— *semiglobosa*, Sby.	—	—	—	x
——— *sulcifera*, Mor.	—	—	—	x
Terebratulina striata, var. *triangularis*	—	—	—	x
Lamellibranchiata.				
Avicula gryphæoides, Sby.	x	x	x	x
Exogyra conica, Sby.	x	x	x	—
——— *haliotidea*, Sby.	x	x	—	x
——— ——— var. *laciniata*, Nils.	x	—	x	—
——— ——— *Rauliniana*, D'Orb.	x	x	x	x
Hinnites trilinearis, Seeley	x	—	x	—

Fossils of the Hunstanton Red Rock.	Occur in Gault.	Occur in Upper Greensand.	Occur in the Cambridge Nodule Bed.	Occur in Chalk and Chalk Marl.
Inoceramus concentricus, Park.	x	—	x	—
——— *Crispii*, Mant.	x	—	—	—
——— *sulcatus*, Sby.	x	—	x	—
——— *tenuis*, Mant.	—	—	—	x
——— (*Perna*) *lissa*, Seeley	—	—	—	—
——— ——— *transversa*, Seeley	—	—	—	—
Lima globosa, Sby.	x	x	x	x
——— *Iteriana*, Pictet and Roux	—	—	—	—
Ostrea frons, Park.	x	x	x	x
——— *Normanniana*, D'Orb.	—	x	—	x
——— *vesicularis*, Lam.	x	x	x	x
Pecten Beaveri, Sby.	—	x	—	x
Plicatula minuta, Seeley	—	—	—	x
——— *pectenoides*, Sby.	x	x	x	x
Spondylus gibbosus, D'Orb.	x	—	x	—
——— *striatus*, Sby.	—	x	—	x
Trigonia Hunstantonensis, Seeley	—	—	—	—
Gasteropoda.				
Cerithium mosense, Buv.	x	—	—	—
Natica gaultina, D'Orb.	x	—	x	—
Pleurotomaria, sp.	—	—	—	—
Cephalopoda.				
Ammonites auritus, Sby.	x	x	x	—
——— *Beudanti*, Brong.	x	—	—	—
——— *lautus*, Sby.	x	—	—	—
——— *ochetonotus*, Seeley	?	—	—	—
——— *rostratus*, Sby.	x	x	x	—
——— *sphærotus*, Seeley	—	—	—	—
——— *splendens*, Sby.	x	x	x	—
Belemnites minimus, Nyst	x	—	x	?
Nautilus albensis, D'Orb.	—	—	x	—
——— *Bouchardianus*, D'Orb.	x	—	—	—
Fish.				
Ischyodus, sp.	—	—	—	—
Notidanus, sp.	—	—	—	—
Otodus appendiculatus, Ag.	x	x	x	x
Reptiles.				
Ichthyosaurus campylodon, Carter	x	x	x	x
Plesiosaurus latispinus, Owen (?)	—	—	?	—

which seems to be something like what Mr. Wiltshire first suggested (though rather vaguely) in 1859, what Mr. Gunn was half inclined to think in 1864, what Prof. Seeley made an approach to in his second paper of the same year, and nearly what Prof. Bonney suggested in 1875. Secondly, it seems open to us to discard the Upper Greensand, and for two reasons, the palæontological reason that all the Hunstanton species that occur also in the Upper Greensand range either down into the Gault, or up into the Chalk, with only one exception, and the structural reason that in the neighbouring country to the south the Upper Greensand is absent and the Chalk rests on the Gault. This view, which seems to me more probable than the triple one last noticed, is one of the two that has hitherto escaped note.

I have now done my best with a difficult subject, and, if unable to absolutely clear it up, I trust that what has been said may at all events be a step towards that result. From the evidence before us it seems to me that our Red Chalk is probably one of two things: either it is a part of the Lower Chalk, or else it is a representative of that and of the upper part of the Gault. It is certainly Chalk to some extent. Consequently, were I obliged to confess my belief in any one formation, I should simply say that Red Chalk is—Red Chalk.

VI.—On the So-called "Plant Fossils" from the Silurian of Central Wales.

By Dr. A. G. Nathorst,

of the Geological Survey of Sweden, Stockholm.

In the Geological Magazine, Dec. II. Vol. IX. November, 1882, my esteemed friend, Mr. W. Keeping, describes (pp. 485-491) some markings from the Silurian beds of Central Wales, which he considers to be fossil plants. The description of those markings, however, so far from supporting the correctness of Mr. Keeping's views, seem, on the contrary, to put it quite beyond doubt that the objects referred to are only trails and burrows of Annelids. It is indeed most surprising that Mr. Keeping, although referring to my paper on trails of different animals, etc.,[1] seems to have taken no notice whatever of the statements which are there brought forward as to the mode of occurrence and structure of the worm trails. For if this had been done, I think that the objects referred to would never have been described as fossil plants.

First, let us consider the branching, which, according to the views expressed by Mr. Keeping, should be *per se* sufficient to demonstrate the plant-nature of the markings. Now this statement is indeed most surprising, since I long ago (in my work referred to) demonstrated not only that branched trails *can* be produced by worms, but also that there are some species of these animals the trails of which are *always* branched. The branching affords consequently *per se, no proof whatever* as to the plant-nature of the markings. Secondly, the regularity of the branching, shown in the figures 1 and 2 of Mr. Keeping's paper, cannot be regarded as any support for the supposed plant-nature, as precisely the same alternating position of the branches is sometimes very conspicuous in the branched worm trails (vide plate 9, fig. 1, of my memoir). Further, it ought not to be forgotten that the worms referred to not only produce branched trails on the surface of the sediment, but also *in* the mud, and when such branched tunnels are filled with sediment or by mineral matter, they appear like cylindrical branched stems, a transverse section of which precisely "resembles rain pittings."

[1] Om spår af några evertebrerade djur m.m. och deras paleontologiska betydelse. With a French translation: Mémoire sur quelques traces d'animaux sans vertèbres etc. et de leur portée paléontologique. (Svenska Vetenskaps Akademiens Handlingar Bd. 18, No. 7, Stockholm, 1881.)

The different manner in which the supposed "seaweeds," described by Mr. Keeping, occur in the rock, harmonizes most perfectly with the opinion that they are worm trails. That this opinion is correct is finally put beyond doubt by Mr. Keeping's statement, "that it is noteworthy that these structures usually project as convex bodies upon the *under* surfaces of the grit beds." Or, to speak in other words, the markings referred to *are casts of furrows or depressions, produced in the surface of the underlying beds when still soft.* True plant fossils *never* occur in this way, but it is, on the other hand, quite clear that this is the mode of occurrence, in which trails of animals *must* present themselves. As far as I can understand, this single statement is thus quite sufficient to prove that the markings in question cannot have been plants. *Buthotrephis major, B. minor, Palæochorda tardifurcata, Nematolites Edwardsii,* should consequently be erased from the lists of fossil plants.

As to *Retiofucus* Mr. Keeping certainly states, that "the vegetable nature of this structure cannot however be doubted," but for what reasons the reader is not informed. I should however think, that every one has a right to claim that such a statement should be based on comparison with living plants, and until it has been shown that any relation between the structure of *Retiofucus* and some modern alga really exists, there is no reason why one should regard the former as being of organic origin. Not having examined the specimen myself, I cannot express any decided opinion as to its mode of formation, but I will not omit to mention, that I have seen a pretty analogous structure on the sea-beach between Mundesley and Cromer, when visiting England in 1872. The water of the sea, being very much troubled with mud, had given rise to a dark and dirty foam, and this, when left on the sandy shore at low water, produced, in bursting, a net-like structure, the meshes of which, corresponding to the air-bubbles of the foam, were formed by loamy ridges. This structure if hardened would have very much resembled the *Retiofucus* although it is highly probable that this might have been formed in some different way.

Thus much as to the supposed plant-fossils described by Mr. Keeping. Before ending I should however like to give a hint to any one working with such doubtful bodies. First examine closely their manner of occurrence, and do not compare them with plants, if this examination has not shown that their being fossil-plants is really possible.

As to *Myrianites Lapworthii,* Mr. Keeping might be quite right in comparing it with the trail of a worm, although it is by no means impossible that it may have been produced by a crustacean. But why should one give names at all to such objects, since I have elsewhere shown that different animals might produce very similar trails, while the same animal under different conditions may give rise to very different ones?

NOTICES OF MEMOIRS.

I.—Bidrag till Japans Fossila Flora af A. G. Nathorst. Härtill sexton Taflor. (Ur "Vega-Expeditionens Vetenskapliga Iattagelser." Bd. II. Stockholm, 1882.) [Contribution to the Fossil Flora of Japan. By Dr. A. G. Nathorst. With 16 Plates. From the Scientific Observations of the Vega Expedition, Vol. II., Stockholm, 1882.]

On the homeward voyage of the *Vega*, after successfully accomplishing the north-east passage, Prof. Nordenskiöld called at Japan, and at a place named Moji, in the neighbourhood of Nangasaki, in 33° N. Lat., discovered a rich flora of late Tertiary or Post-Tertiary age. The collections made at this place were entrusted to Dr. Nathorst, who, in this memoir, fully describes and figures the plants, and draws from them some interesting conclusions respecting the climatal conditions of this region during the period when they flourished.

The plants were found in strata of fine clay, exposed at the sea-level, and they were covered by beds of volcanic tuff and ashes several hundred feet in thickness. With the exception of a fruit of *Carpinus* and fragments of beech-bark, the remains consist exclusively of well-preserved impressions of leaves. From 80 to 90 per cent. of these leaves belong to a species of beech which cannot be distinguished from the existing *Fagus ferruginea*, Ait., which now grows in North America from Lake Winnipeg to Florida; at the same time there is an existing species of beech in Japan which is very closely allied to the fossil form. The remaining 10 to 20 per cent. of the leaves in the collections made, belong to about 70 different species of trees and shrubs, which are referred to 42 genera. The principal of these are *Taxites*, *Salix* (?), *Betula* (?), *Juglans*, *Carpinus*, *Ostrya*, *Quercus*, *Ulmus*, *Exoecaria*, *Styrax*, *Vaccinium*, *Viburnum*, *Liquidambar*, *Deutzia*, *Prunus*, *Rhus*, *Acer*, *Vitis*, *Tilia*, *Magnolia*, and *Clematis*.

The peculiar feature of this flora consists in the fact that it does not correspond with that now growing in the same position and locality, but that it closely resembles the flora now inhabiting the forest regions in the mountain districts of the northern portions of Japan, at heights varying between 4500 and 7000 feet above the sea-level. It is therefore evident that when this fossil flora grew in the extreme south of Japan at the sea-level, the climate must have been considerably colder than that now prevailing. Judging from the number of species which are either identical with or closely allied to those of the northern hilly districts of Japan, Dr. Nathorst concludes that the age of these leaf-beds does not date further back than late Tertiary or Post-Tertiary times, and that most probably it coincides with the Glacial period. These fossil plants furnish the only evidence hitherto discovered of the former prevalence of a colder climate in Japan. There is every probability that in *Miocene* times the climate of Japan was warmer than at present, and the subtropical flora which then existed must have been driven southwards during the colder period when the flora at Moji flourished at the sea-level, whilst at the same time Northern Japan was probably invaded by plants from Amourland and Kamtchatka, some of which still exist in the Alpine flora of the tops of the mountains.

Dr. Nathorst believes that a former land surface extended from Japan to the south-west, thus connecting it with Formosa and the Philippine Islands, and that the present flora of Japan is derived from that which lived on this now submerged area during the colder interval represented by the fossil flora of Moji, and that with the return of a warmer climate this flora again advanced northwards.

G. J. H.

II.—La Struttura Microscopica delle Spugne silicee del Miocene Medio della Provincia di Bologna e di Modena. Per A. Manzoni. Con 7 tavole. Bologna, Fratelli Treves, 1882. [The Microscopic Structure of the Siliceous Sponges of the Middle Miocene of the Provinces of Bologna and Modena. By A. Manzoni. With 7 plates. 4to., pp. 24.]

In this interesting memoir Dr. Manzoni gives a very full and detailed description of the minute structure, the mineral state, and the conditions of deposition, of several species of siliceous sponges which he has discovered in the Italian Miocene. The sponges were derived from two localities, one in the neighbourhood of Montese, where they occurred in beds of dark argillaceous marls, intercalated in strata of coarse molasse or sandstone; in the other locality, in the hills of Zola, Guidoni, and Maserna, the sponges were imbedded in deposits of disintegrated siliceous, ochraceous material, traversed by layers and amygdaloidal masses of flint, which, like the Montese marls, intervene in the strata of the prevailing molasse sandstone. The sponges are so numerous in the siliceous and flinty layers that these may fairly be regarded as sponge beds. The author notices the occurrence of the siliceous sponges in conjunction with the flinty masses, which bear a great resemblance to the flints in the Upper Chalk, but as he has been unable to discover any traces of sponge structure in the amorphous masses of flint, he thinks that they cannot be derived, like the chalk flints, from siliceous sponges. He is, perhaps, unaware of the fact that in many places the flints in the chalk are quite destitute of any traces of the sponge spicules, and therefore the absence of structure in the Miocene flints by no means invalidates the probability that they have originated from siliceous sponges.

The same species of Lithistid and Hexactinellid sponges occur in both the above-mentioned localities, but whilst those from the siliceous deposit retain a siliceous structure, though modified by secondary depositions of silica during fossilization, the sponges from the marly strata at Montese have had the silica replaced by calcite in the same manner as so many of the Hexactinellid sponges in the Jurassic Limestone of Germany. Another remarkable feature of these Miocene Hexactinellid sponges is the fact of their occurrence in a deposit, which, from its mechanical character and the included fossil Mollusca and Echinoderms, is clearly proved to be of comparatively shallow-water origin, whereas the habitat of the existing Hexactinellids is distinctly in deep water, though an exception to this rule is known in the occurrence of a species of *Cystispongia* in the Gulf of Mexico at no greater depth than 120 feet.

These Miocene Hexactinellids are referred to the genus *Craticularia*, in which the nodes of the spicules are solid. There are excellent illustrations of the structure of the surface layers and of the interior mesh of the sponge-wall, as well as of the secondary changes due to fossilization. The Lithistid sponges are less perfectly preserved, and are referred to the genera *Astrocladia*, *Siphonia*, *Jerea*, *Meta*, and *Chenendopora*. These sponges are probably closely related to the Miocene sponges, from the province of Oran in Algeria, discovered by Pomel,[1] but as this author has only described the outer form and canal structure, disregarding the all-important features of the minute spicular structure, it is impossible to make an exact comparison with them. The presence of fossil Hexactinellids in the Miocene strata to the north and south of the Mediterranean is of special interest from the recent discovery of existing sponges of this order in deep water off the south-east coast of Sardinia.

G. J. H.

III.—Recent Opinions on Interglacial and Pre-glacial Man in Britain.

In the first part of his paper on "The Newer Pliocene Period in England" (Quart. Journ. Geol. Soc. vol. xxxvi. 1880, p. 497) Mr. S. V. Wood gives his reasons for concluding "that the Hoxne palæolithic brickearth, so well known to geologists by the description of Prof. Prestwich, is of the age of the Chalky [Boulder] Clay itself, though of the latest part of it." In fact (to quote from the second part of his paper, *Ibid.* vol. xxxviii. 1882, p. 669), he "described how the ice of the Chalky Clay at its greatest extension in East Anglia (and probably as the first step in the general recession of the ice of the great glaciation), by receding from the plateaux and uncovering the moraine there for vegetation to spring up on it, but still occupying the valleys, had intercepted the drainage from the plateaux, and so given rise to the lagoon deposit of Hoxne, with its palæolithic implements, mammalian and arboreal remains."

Referring also to "the bed of brickearth at Mildenhall, which is overlain by the Chalky Clay as well as underlain by it (and in which Mr. Skertchly has found palæolithic implements)," Mr. Wood has expressed his opinion that it "was formed by the drainage issuing westwards from the inosculating valleys of the Little Ouse and Waveney and from the valley of the Lark, when, though the ice was wasting and had withdrawn from those valleys, a large body of it still remained" (*Ibid.*, vols. xxxvi. p. 499, xxxviii. pp, 672, 673).

On the other hand, in the last number of the Proceedings of the Norwich Geological Society (vol. i. part vi. 1882), Mr. H. Prigg, in describing the implement-bearing beds in the Valley of the Lark,

[1] Paléontologie de la Province d'Oran, Spongiares, 1872.

Little Ouse, and other places, says (p. 165), that "A vast antiquity must be assigned to the implements; at the same time, the evidence thus far, fairly interpreted, will not allow us to assign to any of the beds containing them a greater age than those usually classed as Quaternary or Post-Glacial." In the discussion that followed the reading of this paper, Mr. J. H. Blake stated "he was well acquainted with many of the localities mentioned in the paper, where implements had been found; and, so far as his own investigations had gone, he considered there was no reliable evidence whatever of any flint-implement-bearing-bed in the East of England, being of greater antiquity than that generally known as the Post-Glacial Period."

In conjunction with these opinions, it is interesting to read that expressed by Prof. W. Boyd Dawkins in his address to the Department of Anthropology of the British Association (Southampton, 1882). After noting the discoveries of palæolithic implements at Crayford and Erith, he asks, "To what stage in the Pleistocene period are we to refer these traces of the River-drift hunter? The only answer which I am able to give is that the associated animals are intermediate between the Forest-bed group and that which characterises the late Pleistocene division in the region extending from the Alps and the Pyrenees as far north as Yorkshire. Nor am I able to form an opinion about their relation to the submergence of Middle or Northern Britain under the waves of the glacial sea. They are quite as likely to be pre- as post-glacial."

IV.—Report on the Rocks of the Fintona and Curlew Mountain Districts. By G. H. Kinahan, M.R.I.A., with Palæontological Remarks by W. H. Baily, F.G.S.

THIS report commences with a discussion of the age of the Pomeroy and Lisbellaw fossiliferous rocks. Near the former place, in County Tyrone, three distinct groups of rocks (neglecting the Carboniferous) are developed, namely:—

3. "Lower Old Red Sandstone" (Silurian).
2. Pomeroy Series.
1. Arenig Group.

Attention is now directed to the rocks of the Pomeroy series, which are evidently much newer than the metamorphic rocks north of them (Arenig Group), although both groups are called Lower Silurian in the Geological Survey Memoir descriptive of the district. The fossils indicate an age similar to the Caradoc-Bala series. The "Lower Old Red Sandstone," it was thought, rested unconformably on the Pomeroy Series.

In his palæontological notes, Mr. Baily remarks that the Pomeroy district is celebrated for the beauty and variety of its fossils, 111 species having been recorded from a comparatively small area of strata.

A portion of the report is devoted to a discussion of the Silurian rocks, commonly called "Lower Old Red Sandstone," of Tyrone, Fermanagh, and the Curlew Mountains, with their relations to the

Silurian rocks of S.W. Mayo and N.W. Galway. One group of these beds was called by Jukes the "Dingle or Glengariff Grits," and they comprise a red arenaceous type of accumulation, coarse in nature. Mr. Kinahan points out that this type is no indication of relative age, for although the rocks are more often above the other group of finer accumulations, of a green and grey argillaceous type, yet this is not always the case; and he endeavours to show, with the aid of sections, that the Silurian strata having been deposited in separate basins, the littoral rocks usually coarse, must be on different horizons. Referring to Dr. Archibald Geikie's paper "On the Old Red Sandstone of Western Europe," and the five "Basins of Deposition" therein suggested, Mr. Kinahan observes that, if extended into Ireland, the Lake Caledonia or Middle Scottish Basin might be called the *Ulster and Connaught Basin*, and the Welsh Lake Basin the *South Munster Basin.*

The evidence brought forward in this Report goes to show that these Silurian rocks [Lower Old Red Sandstone] rest unconformably on Cambrian or Cambro-Silurian [Lower Silurian] rocks, and are overlain unconformably by Carboniferous rocks. H. B. W.

REVIEWS.

I.—TEXTBOOK OF GEOLOGY. By ARCHIBALD GEIKIE, F.R.S., LL.D., Director-General of the Geological Survey of Great Britain and Ireland. (London: Macmillan & Co., 1882.)

THE absence of a general Text-book in which all the departments of the science receive a fairly equal amount of attention has long been felt to be a great want in British Geology. Of late years we have had nothing on this side of the Atlantic that could be compared for a moment in general interest and completeness with the American Manual of Dana. The classical "Elements" of Lyell were excellent in their original form, but as transformed into the later "Student's Elements," they have lost much of their former attraction, while the order of description of the formations has always appeared to us to be unnatural. The well-known manual of Page, which has made many a geologist in its day, is, on the whole, too much of a compilation for the ambitious student of the present time, and too small as a work of reference. The manual of the late Professor Jukes was all round the fairest and best work upon the subject. Jukes's manner was irresistibly attractive. His absorbing love for his subject glowed through every page. He had a way of taking his reader into his confidence which made the pupil regard him less as a master than as a hearty friend. In the sunshine of his presence, in his utter unconsciousness of personal dignity, in his carelessness of authority as such, in his honesty of purpose in the search for truth, and his belief in that of his pupil, the reader was impelled swiftly forward, and was inspired, if not with a fruitful love of the science itself, at any rate with a profound respect for its methods, and a confidence in the perfect reliability of its widest conclusions that never left him.

The recent Physical Geology of Green has much of the old spirit and fire of Jukes, and in its original mode of arrangement, and in its purely stratigraphical sections, it stands to-day unapproached in the entire range of geological literature. But, unfortunately, it covers only half the ground. The student who desires to study the science as a whole is compelled to supplement it by the works of other and inferior hands.

Ever since the publication of the last edition of Jukes's "Manual of Geology," to which such important and valuable additions were made by Dr. Geikie, British geologists have naturally felt that here was the authority, who could, if he chose, compile what should become a standard work upon the science. Materials were plentiful. the petrological and dynamical departments of the subject had become crowded with an array of new and important discoveries, and in both these departments Dr. Geikie was known to stand in the very first rank. But not only was he known to be an enthusiastic and successful geologist. He had already taken the highest position in Britain as a brilliant and fascinating writer upon the science itself. When, therefore, it was known that he was engaged upon the article "Geology" for the new edition of the "Encyclopædia Britannica," the expectation of those in the secret was raised to the highest pitch, for it was felt that the article would be not only a *vade mecum* for the student, but an apology for the science itself. It would disarm the prejudices of the unscientific, and win for geology many a disciple from among the ranks of educated men. Upon its appearance it was at once acknowledged by all unprejudiced geologists that, at last, we possessed a text-book in which all the departments had a fairly equal share of attention, and in which the diverse sections and branches had been grouped into definite and intelligible order. To many besides ourselves we have no doubt the article in question has been a treasure-house of valuable material, into which we could enter at all times, and where we could lay our hands upon the thing wanted without a moment's doubt or hesitation.

Since that time we have waited very patiently for the appearance of the present volume, knowing perfectly well that Dr. Geikie would make it even more worthy of his great reputation and more fully suited to the needs of the general public. In both these respects we feel that our confident anticipations have been more than justified, and that the volume before us, as a standard work of reference upon all the main branches of geological science, is unquestionably the finest in the English language. But, in saying this, we by no means intend to imply that the work is equally perfect throughout. But there is less inequality of treatment than in any other work of the kind, and from beginning to end there is evidence of a conscientious endeavour to give every department its fair share of notice. Even when we feel that the author is dealing with a part of the subject with which he has no personal sympathy, he never allows his want of interest to stand in the way of making his work complete. If the materials are extant and accessible, they are collected and grouped into order for the benefit of the student; and every name and number is so arranged as to lead to some definite conclusion, which is either that already accepted among geologists in general, or is that which the geological insight or personal bias of the author deems it desirable that his readers shall draw for themselves.

In his preface Dr. Geikie assures us that the book is intended primarily for the ordinary student of the science, but trusts that it will not repel the general reader. If we know anything of the habits of students and the desires of the so-called general reader, we feel pretty confident that the majority of those who will value the work will not be college students, but those who come to the examination of the science from without. The young student usually desires to rush into *medias res*, and is impatient of everything that has not an immediate bearing upon the matter in hand. He is willing to accept any assertion which he can test for himself by means of a hand specimen, or put into instant practice in the field. The growth of his knowledge to be natural must be essentially synthetic. The grand all-embracing theories of the cosmogonist appear to him like idle dreams, the study of which is a mere waste of valuable time. Until his mind has been thoroughly well grounded in the elements of the science, these theories only excite his contempt and scorn. To such an one the Manual of Green appears to be the perfection of method, and in this case we cannot help thinking his instinct is perfectly correct.

To commend it to the tastes of the ordinary member of society, Geology demands an entirely different style of treatment. When, as it happens upon the very rarest of occasions, the educated man thinks it advisable to take the opinion of his geological brother, he quotes it as a matter of course, as he would that of any other dry specialist, if it happens to coincide with his own, without note or comment. If, on the other hand, it tends in a different direction, he either ignores it altogether, or passes it by with an easy smile of assured and conscious superiority. He cannot conceive that there can be any attraction in the science itself. Of all sciences it seems to him to be the most harsh and inharmonious, wholly devoid of the possibility of anything like artistic treatment, and allowing of no scope for the exercise of the imaginative faculty. It appears a bewildering chaos of disjointed facts and hazy conclusions, possessing only the faintest bond of union among themselves, and having no relation whatever to the needs or the philosophies of the day.

The attempt to uproot this old and apparently well-grounded conviction, and to prove to demonstration that the science of geology is second to none in the interest of its details, and in the scope it affords for the exercise of order, of taste, and of imagination, while at the same time that it is indissolubly linked with the older sciences and the higher philosophies, were a task that only the most daring intellect could hope to accomplish. But to unite this with the endeavour to command at the same time also the attention and the respect of the youthful student and the grey devotee of the science, is a labour so gigantic that no one less ambitious than Dr.

Geikie would ever have ventured upon it. That he has not wholly succeeded is due to the inherent impossibility of this double task: we doubt if any other living authority could have accomplished so much and succeeded so well.

Dr. Geikie is not only an enthusiastic physical geologist, but he is also a born artist, a man of brilliant imagination, a master of English, and a thorough man of the world. Many of his sympathies lie with the earnest student burning to pierce to the heart of things, but his normal view of the science is that of an artist, a disciplinarian, and an educated man of society. His instincts of order and artistic feeling are extraordinary. In his hands the most heterogenous materials group themselves into the most orderly arrangement, and are explained with charming clearness and beauty of description. He instinctively seizes at once upon some central idea of classification, and groups his facts around it stage by stage. His arrangement is not always natural, but it is always plausible, and it is always certain to lead to a symmetrical and picturesque effect. Unlike the ordinary compiler of geological text-books, he is not content to hide away the purely speculative parts of his science in an obscure corner. He boldly places them in the fore-front of his work, lights them up with all the glow of his own imagination, and compels the attention and sympathy of all those who take an interest in the speculative philosophy of the time. Under his rule the heterogeneous facts and conclusions of the science are marshalled together into a vast army, in which all degrees of subordination have their regulated place, an army deliberately intended to overwhelm all doubt and opposition, and to win for their leader the awe and respect of all those who dwell within and around the borderland of his science.

(*To be continued.*)

II.—The Palæozoic Conchology of Scotland. Opening Address delivered before the Royal Physical Society of Edinburgh, 16th November, 1881. By R. Etheridge, jun., President of the Society. (Edinburgh, 1882.)

THIS address is mainly devoted to the general consideration of the present state of the fossil conchology of the older rocks of Scotland. Even in this restricted sense, it is an important contribution, for the intimate acquaintance of the author with the Palæozoic invertebrata of this country and of Australia fully qualified him to prepare this excellent *resumé.* It is not, however, a mere compilation, but a valuable compendium of facts, carefully selected, and critically examined, with many suggestive observations bearing on one branch, and that probably the most important of Palæontology, that is, Fossil Conchology, for "of all life groups used by the geologist to assist him in working out the successive epochs of the earth's history, none, perhaps, have played so important a part, or yielded so satisfactory and valuable results, as the Mollusca."

The Palæozoic Conchology of Scotland is restricted as far as at present known to the Silurian and Carboniferous rocks, for no shells have been described from any deposits referable to the Cld Red Sandstone period, although rich in the remains of Fish and some Crustacea, while the few casts of Mollusca from the Permian beds of the County of Dumfries are regarded as no more than mere derived Carboniferous fossils.

The history and progress of Scottish Silurian Conchology is successively treated from the first record of fossil shells by Dr. Hutton in 1795 to the present time, a critical analysis being given of the relative importance of the works relating to the subject. Much, however, remains to be done in the systematic description of the shells from the N.W. Highlands, the Pentlands, Kirkcudbrightshire, and Girvan, the latter locality yielding to the researches of Mrs. Gray during some years the most complete series of Silurian fossils ever brought together in Scotland, some of which have been noticed by Messrs. Gray, Young, and Davidson. A monograph also on the Girvan fossils has been partly published by Prof. Nicholson and the author (see GEOL. MAG. 1880, p. 139), which important work Mr. Etheridge has the modesty not to allude to in his address.

By far the larger portion of the address (pp. 29-90) is occupied with the conchology of the Carboniferous strata, which has been studied in Scotland with much greater assiduity than that of her Silurian rocks. This may be partly due to the greater and varied facilities which the Carboniferous rocks afford for obtaining fossils, and their better state of preservation. A detailed notice of the various contributions connected with the literature of the Carboniferous mollusca, from the earliest published remarkable work of Ure in 1793, is followed by a systematic review of the different classes of Mollusca. This portion of the address is full of valuable information, and, while fully acknowledging the labours of other authors, Mr. Etheridge brings his own practical experience as to the nomenclature, modifications, and affinities of the different generic forms, and thus affords an exhaustive analysis of the present state of the Carboniferous Mollusca of Scotland, while remarking, "There is really more good work to be done amongst the Bivalves and Univalves than in any other group of fossil organic remains known to us." Among the interesting notices are those relating to the Pectenidæ, Aviculopectenidæ, Mytilidæ, and Anatinidæ among the Bivalves; the Naticidæ, Loxonema group, Euomphalidæ, Pleurotomariidæ and Bellerophontidæ among the Univalves; with regard to the latter family, including *Bellerophon* and *Porcellia*, Mr. Etheridge concurs with De Koninck and Meek in placing it near Haliotidæ rather than under the Heteropoda. Under Pteropoda the structure, affinities and zoological position of *Conularia* are fully noticed. The characters and subdivisions of *Orthoceras, Goniatites* and *Nautilus* are severally described. Many interesting points are noticed as to the grouping, abundance and rarity of species in certain zones, the varietal tendency of some forms, the continuity of species, their geographical distribution, colour markings, and stunted growth in some localities.

The geological distribution of the Mollusca is a subject of some importance, to which only a brief reference could be made. "We are taught by the researches of the various writers quoted the rapid extinction of the Carboniferous Molluscan fauna after the final deposition of the Upper Limestone Group, its struggle on through the Millstone Grit, its occasional appearance in the Coal-measures, and final extinction before the deposition of the Upper Red Sandstones."

In alluding to the papers published to prove the marine deposition of the Coal-measures, Mr. Etheridge remarks "that the special occurrence of marine bands in the measures prove only, and specially, the occasional occurrence of truly marine conditions. We must look upon the sediments in which *Anthracosia*, *Anthracoptera*, *Anthracomya*, appear as either of brackish or freshwater origin. The probability appears to be, speaking purely from personal experience in a climate where creek and brackish vegetation attains a luxuriant growth, accompanied by a rapid humus-accumulation of soil, that the brackish-water theory deserves more attention than any other which has yet been advanced."

This address will be a valuable addition to palæontological literature, and of practical assistance to those interested in the study of the fossil Carboniferous Mollusca. J. M.

III.—A Catalogue of Works, Papers, Reports, and Maps, on the Geology, Palæontology, Mining, Metallurgy, etc., of the Australian Continent and Tasmania. Compiled by R. Etheridge, Junr., and R. L. Jack, F.G.S. (London, 1881: Stanford, Charing Cross.)

A CATALOGUE like the present, when carefully compiled, is of considerable value, for the bibliography of geology and allied sciences has of late years reached such formidable proportions that any attempt to master the literature, without such aid as the above work, would be futile.

The work is evidently the result of much conscientious labour on the part of the authors, and those persons interested in the geology and mining of the Australian continent will be grateful to Mr. R. Etheridge, and his colleague, Mr. R. L. Jack, for a list of works relating to that country and the adjacent Tasmanian land.

The present volume may be partly considered as a further expansion of the list of references given at the end of the valuable "Catalogue of Australian Fossils," by the first-named author some years since, and noticed in this Magazine (Dec. 2, Vol. V. p. 567). Scattered through so many periodicals or in separate works, the information relating to the above subjects is rendered easily accessible as now collected in one volume, while at the same time it shows the large amount of work already completed, bearing on the geology and mining industries of our Australian colonies.

More than 2000 references, which are alphabetically arranged under the authors' names, except when the work is anonymous, and then usually under the name of the subject, are given in the present catalogue, the publication of which is in a great measure due to the liberality of the Government of New South Wales. J. M.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 15, 1882.—Dr. J. Gwyn Jeffreys, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "The Drift-beds of the North-west of England and North Wales. —Part 2. Their Nature, Stratigraphy, and Distribution." By T. Mellard Reade, Esq., C.E., F.G.S.

The author stated that the first part of this paper, read in 1873, treated of the low-level Boulder-clay and sands, specially in relation to the contained shells. Since that time he has been diligently collecting information to enable him to treat of the nature, origin, and stratigraphy of the Drift lying between Liverpool and St. Bees and Liverpool and Caernarvonshire. He finds that, in the basin of the River Mersey, the Triassic rocks underlying the low-level Boulder-clay and sands are cut up by a system of pre-glacial valleys, in some cases presenting very precipitous sides and not in all cases following the present course of the rivers. If the mantle of clay and sands could be stripped off, we should have scenery differing considerably from the present surface-features. These pre-glacial valleys are, in parts of their courses, considerably below the present low-water level.

Where the rock has been bared and it is of a nature capable of retaining striations, we almost invariably find it planed and grooved in a direction approximately from N.W.; and when the rock is soft, it is broken up into rubble and red sand.

Upon this débris of the Trias lie the low-level Boulder-clay and sands of the plains, the clay lying immediately on the rock being frequently, but not invariably, of a sandier and harder nature than the upper beds. Lines of erosion of a local nature, but often of considerable extent, often occur at the top of this clay and then die out; or there are thin or thick beds of sand and gravel intercalated at the junction and also dying out. Sometimes sand and gravels underlie this harder clay; but the larger mass of the low-level clay is of a more plastic nature, and is used in brickmaking. Intercalated sand-beds also occur in this, and sometimes the clay gets stonier again near the top.

If we trace the drift from the sea up each river-valley to the high lands, we see at once that the nature of the clay gets more intimately connected with the rocks in the basin above. This is specially noticeable in the Ribble valley, where the brown marine Boulder-clay gradually, above Milton Bridge, gets replaced by a drift composed almost wholly of the débris and grindings of the Carboniferous Limestone and grits above. In the mountain-districts, also, the drift becomes more localized both in Cumberland and Wales.

The author's conclusions are that an ice-sheet, radiating from the mountain-district of the English lakes and the south of Scotland, produced the planing and grooving of the rock and the red sand and rubble débris; then the ice melted back into local glaciers, and the submergence began. The low-level Boulder-clay and sands were, during a slow submergence, laid down probably at depths of from 200 to 300 feet; and the author considers that all the phenomena can be satisfactorily accounted for by ordinary river-action and fraying of the coasts by the sea, combined with frost and ice due to a severer climate bringing down the materials of such river-basins to the sea, while icebergs and coast-ice sailed over, dropping on the sea-bottom their burdens of erratic stones and other materials from the mountain-districts of the north. He pointed out, also, that the great majority of the well-glaciated rocks were specially those that could be traced to the high lands. This fact was forced upon his notice after making a large collection of glaciated boulders and pebbles. Among the rocks he had been able to identify, with the help of Professor Bonney and Mr. P. Dudgeon, of Dumfries, Scawfell granite (Eskdale, of Mackintosh) was the most abundant granite; then came grey granites from Dumfries; syenite from Buttermere, which occurred all over the area described, and up to 1200 feet on the Macclesfield Hills, and syenite from Cannockfell. Other probable identifications were also named. The whole series of rocks from the Silurian to the New Red Marl were represented in the low-level Boulder-clay; a few flints also occurred, and one piece of what was believed to be chalk.

The paper concluded with an Appendix by Mr. David Robertson, giving a list of the Foraminifera and other organisms found in the various beds of Boulder-clay in the Atlantic Docks, Liverpool.

2. "On the Evidences of Glacial Action in South Brecknockshire and East Glamorganshire." By T. W. Edgeworth David, Esq. Communicated by Professor J. Prestwich, F.G.S., F.R.S.

The area which is included in this paper is about 200 square miles, extending north and south from the Brecknockshire Beacons to a line between Cowbridge and the mouth of the Rhymney, of which the Ely valley has been more particularly studied. Most of the rocks in this district, and particularly the Millstone Grit, retain traces of glacial markings. The whole area has a *moutonnée* aspect. The evidence of glacial action is classified under the following heads:—(1) erratics; (2) Boulder-clay; (3) shattered and contorted rock-surfaces; (4) grooved and striated rock-surfaces. The first three obtain everywhere; but the last is confined to the coal-basin sandstones in certain localities, to the Millstone Grit at its northern outcrop, and to a small extent of Carboniferous Limestone to the north of the latter.

(1) The erratics consist of Old Red Sandstone, of various members of the Carboniferous series, of dolomite conglomerate, Lias, and Chalk flints. These, in one district, are derived from Brecknockshire rocks, in another from Glamorganshire.

(2) The Boulder-clay contains boulders which are sometimes 5 feet in diameter, generally smoothed, rounded, and striated. It is sometimes 100 feet thick, and is found as high as 1200 feet above the sea. Many sections are described, and percentages of their contents given.

(3) In certain districts the rocks are much shattered, so as to resemble a breccia, and Boulder-clay has been forced into this—as, for example, near St. Fagans.

(4) Grooved and striated surfaces are preserved under favourable circumstances. A full description is given of a number of instances, the direction of the striæ being recorded, as well as the fall in feet per mile from the summit of the Beacons. The author in summing up his observations comes to the conclusion that the erratics in the Eglwysilan and Caerau group were probably, as a rule, transported by floating ice, but that some may be the relics of old moraines; that the Boulder-clay of South Brecknockshire is chiefly the product of land-ice; and that the striated rock-surfaces are in some cases the result of glaciers which have descended existing valleys. In other cases they may have been produced by an ice-sheet, which it is possible may have come from the N.W.

CORRESPONDENCE.

TEXT-BOOK OF GEOLOGY BY ARCHIBALD GEIKIE, LL.D.

Sir,—It is very far from my desire to write a word in derogation of the high merits which this work possesses; but I may be allowed to draw the attention of its author to a few points personally affecting myself, and to some extent my colleague, Dr. Rowney.

Dr. Geikie has incorrectly represented the view we hold as to the origin of the "canal system" of "*Eozoon Canadense.*" Coupling our names with that of Professor Möbius, the readers of the *Text-Book* are informed that we "have endeavoured to show that the supposed canals and passages are merely infiltration veinings of serpentine in the calcite" (p. 639). This remark may be correctly applied to Dr. Möbius; but in none of *our* publications is there the least indication of any endeavour of the kind to be found. We have, on the contrary, maintained that the "canal system" has originated, in many cases, from the wasting action of carbonated solutions on clotules of "flocculite," or, it may be, saponite—a disintegrated variety of serpentine, and, in others, from a similar action on crystalloids of malacolite ("white pyroxene"). In both cases there are produced residual "figures of corrosion," or arborescent configurations, having often a "regular disposition," even to the extent of a sheaf-like symmetry.[1] This, in which we certainly agree with Dr. W. B. Carpenter, is "quite unlike any mineral infiltration;" for, as stated in our *Old Chapter of the Geological Record*, p. xviii, we had palpable evidence that it had been determined by mineral cleavage—a divisional structure, which is essentially *regular* and correspondingly *symmetrical* in malacolite and its monoclinic allies.[2]

While on the subject of Eozoonal structures, it behoves me to mention that the *Text-Book* contains no reference to our views,

[1] Formerly, I held with Dr. Rowney, that the "canal system" is in general *irregularly* arranged; but having been lately favoured by Dr. Carpenter with an inspection of his numerous beautiful preparations, besides having examined some specimens that have lately come into my possession, I feel bound, and in agreement with my colleague, to give expression to the terms stated in the text.

[2] The mineral origin of the "canal system" is demonstrable by the clearest evidences, hereafter to be published, abounding in specimens of hemithrene, intermixed with ordinary gneiss, which I have lately received from Ceylon.

published at intervals running over sixteen years, on the origin of, and on changes in, serpentine, chrysotile, and other related minerals.

Nor is there the least notice of any of the phenomena which we ascribe to chemical changes (methylosis) in rocks.

My Memoir on Jointing and Slaty Cleavage, published in the Transactions of the *Royal Irish Academy*, vol. xxv. pp. 605–662, 1875, is altogether unnoticed.

I have in the last place to mention that all reference to my *Monograph of the Permian Fossils of England*, also some subjects introduced, are omitted in the *Text-Book*; although the latter contains (p. 752) some figures of shells copied from it, but without acknowledgment.

Under the conviction that Dr. Geikie doubtless desires his *Text-Book* to contain fair and correct references to the labours of his colleagues on the subjects he has touched upon, I am disposed to believe that he will not overlook these notes when preparing, as pretty certainly will be the case, another edition of his valuable work.

William King.

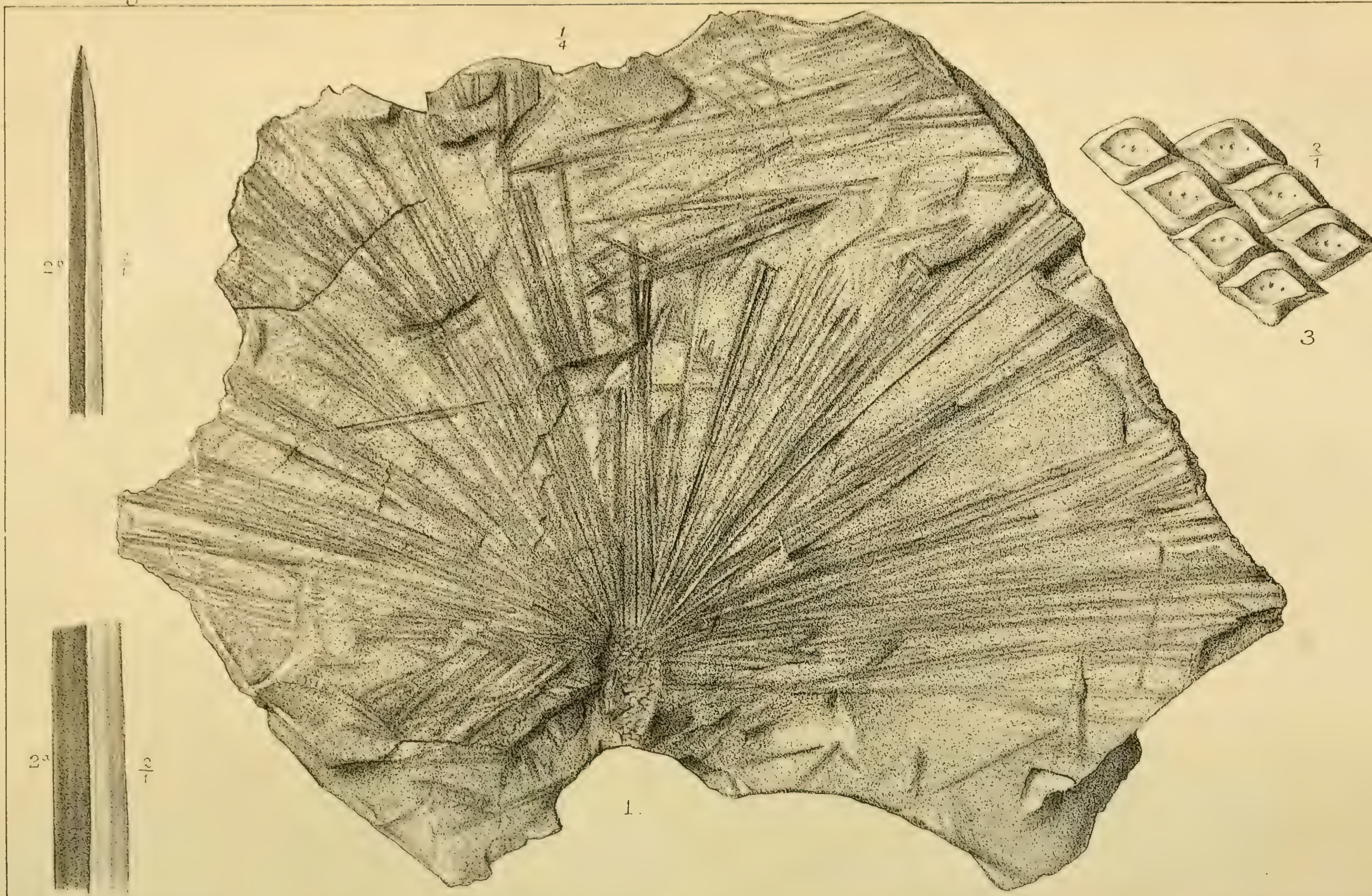
Glenoir, near Galway, *Nov.* 5, 1882.

THE RIGIDITY OF THE EARTH.

Sir,—In his letter in the November No., 1882, "On the Depression of Ice-loaded Lands," the Rev. O. Fisher laments the disagreement between the mathematical physicists and the geologists respecting the rigidity of the body of the earth. But if the earth have a *viscous* rigidity, there need be no incompatibility between their respective contentions. The character of a viscous solid is that, though it may seem to be quite rigid when tested by a short-lasting stress, it may be capable of yielding very considerably, in some cases almost indefinitely, to a much smaller stress continued for a sufficiently long time. Sir William Thomson's conclusion as to the steel-rigidity of the earth is founded upon the magnitude of the short-period ocean tides, classing with these even the monthly tides due to the ellipticity of the moon's orbit (he has given up the argument from precession). But he himself declared in his Address to the Physical Section of the British Association, at Glasgow, in 1876, that the absence of any indication of a 18·6-year ocean tide, depending on the revolution of the moon's nodes, could not be easily explained without assuming or admitting a considerable degree of yielding in the body of the earth. That is to say, our earth, as a whole, is a viscous, or practically viscous, solid, which, notwithstanding its apparently very high rigidity when tried by reciprocating stresses of short period, may be able to yield to the full satisfaction of geologists to a sufficiently long-continued pressure, such as that of a great depth of ice in high latitudes during the Glacial period. I omit some other considerations which go to strengthen this conclusion.

M. H. Close.

University Club, Dublin, *Nov.* 7, 1882.



G. M. Woodward del. et lith. West Newman & Co. imp.

Sigillaria Serlii, *Brong.* Coal Measures, Radstock.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. X.

No. II.—FEBRUARY, 1883.

ORIGINAL ARTICLES.

I.—On the Foliage of *Sigillaria Serlii*, Brongn.

By Wm. Carruthers, F.R.S., F.G.S.;
Keeper of the Botanical Department, British Museum (Natural History).

(PLATE II.)

THE rarity of specimens of *Sigillaria* with foliage attached makes the specimen figured on Plate II. of great value. Since Lindley and Hutton figured a fragment of Sigillarian leaf, and from its nervation referred it to *Cyperaceæ* under the designation of *Cyperites bicarinata* (plate 43), not a little has been done to elucidate the foliage of this important genus.

Brongniart, in one of the latest plates (161) of his great work, figures the bases of long parallel-sided leaves proceeding from the fragment of a large stem marked with ridges and furrows, and belonging to the restricted genus *Sigillaria*. To this plant he gave the name *S. lepidodendrifolia*. Other figures of species of the same group have been published (see Geinitz, Steink. Form. in Sachs., etc.). Long linear leaves are considered to be characteristic of the genus *Sigillaria*. And in support of this generalization we are able to figure a singularly beautiful specimen of *Sigillaria Serlii*, Brongn., which belongs to the group of species to which Brongniart gave the name *Clathraria*, and which is characterized by the absence of furrows on the stem, the bases of the leaves being contiguous, rhomboidal, longest in the transverse diameter, and placed in regular alternating verticils. The leaf separates at some distance from the stem, leaving a short cushion or permanent leaf-base adhering to the stem. The cicatrix produced by the separation of the leaf is smaller than the cushion, and is marked by three small vascular scars across the largest diameter. I have been unable to discover any reason for considering that the lateral scars in these or any other species of *Sigillaria* are indications of gum canals.

In the species figured, *S. Serlii*, Brongn., the scar caused by the separation of the leaf is ovoid-rhomboidal, and the three vascular scars are of nearly uniform size. The leaves are very long, but though several extend to a little over twelve inches from their origin on the branch to the edge of the slab, they are there broken across. On the upper portion of the slab are the apices of some leaves from another branch, and one of these presents what I believe to be the true apex. The sides of the leaves are nearly parallel, sloping very gently towards the apex. From the decrease in width it appears to me certain that the leaves were not less than two feet long. One leaf shows quite clearly the attachment to the cushion or permanent base. There is a slight constriction at the base of the leaf, and the three vascular scars of the cicatrix are seen to pass into the leaf as three similar nerves, which gradually approach each other as the leaf narrows until they reach the summit, where they are so close that they appear to be a single nerve.

The elevated cushion and alternating verticils of the leaf-bases suggested to Goldenberg the placing of *Sigillaria Serlii*, Brongn., in the genus *Lepidophloios*. The fossils included under this designation have cushions or permanent bases to the leaves, sometimes very much elongated, as in *L. crassicaulis*, Brongn.; the cicatrix is more or less rhomboidal, and the three vascular scars are arranged as in *Sigillaria Serlii*, Brongn. The arrangement of the leaves on the stem is also the same as in the Clathrate Sigillarias, that is, in alternating verticils, the bases of the leaves in the first, third, and fifth rows being perpendicular to each other, those of the intervening verticils, the second, fourth, sixth, and so on, are perpendicular or opposite to each other. The leaves of several species of *Lepidophloios* have been figured, and they are of precisely the same structure as those of *Sigillaria*. Whether the two groups can be separated generically is of less importance than the bearing these facts have upon the question of the affinities of *Sigillaria* with *Lepidodendron*. There has never been any question as to the affinities of *Lepidophloios* with *Lepidodendron*, nor of the propriety of classing the Clathrate Sigillarias in the same genus with the fluted species. But the affinity between the fossils of the type of *Sigillaria Serlii*, Brongn. and *Lepidophloios*, or rather the identity in all essential points between the two as far as the points we have specified are concerned, strengthens the view generally entertained that *Sigillaria* is a Lycopodiaceous plant. And this view is further established by what is known of the internal structure of the stem when properly understood, and by the little we know of the fructification.

The specimen which forms the subject of Plate II. was obtained by the late Mr. Charles Moore, F.G.S., of Bath, from the Coal-measures of Radstock, Somerset, and has been obligingly sent up for examination by the Rev. H. H. Winwood, M.A., F.G.S., the Hon. Sec. Bath Field Club, to whose efforts the city of Bath is mainly indebted for the preservation of Mr. Charles Moore's admirable Palæontological Museum within the walls of its Literary and Scientific Institution, where for so many years it had been deposited by Mr. Moore, and formed one of the principal attractions of his native city.

EXPLANATION OF PLATE II.

FIG. 1. *Sigillaria Serlii*, Brongn. One-fourth nat. size.
,, 2. Portions of leaf twice the nat. size, *a*. from near the base, *b*. the apex.
,, 3. Leaf scars from the specimen figured, twice the nat. size.

II.—The Fauna of Cenrtal Europe during the Period of the Loess.—A Rejoinder to Mr. H. H. Howorth.

By Dr. A. Nehring,
Professor of Zoology at Berlin.

In the last volume of the Geological Magazine the question concerning the origin of the Loess has been discussed by several authors in a minute and rather excited manner. Mr. Howorth has firstly expressed his opinion on that question in the Magazine for January and February, 1882, and he there combats the theory of the formation of the Loess as set forth by Baron Richthofen (China, Bd. I., Berlin 1877). This distinguished geographer and geologist found himself compelled to explain and defend his theory in a detailed letter to the Editor of the Geological Magazine for July last, in which he enumerates and discusses the most important arguments of his theory.

To these arguments belongs one based on the fauna which has been expressed in the following form (Geol. Mag. 1882, p. 296): "The great quantity of bones of mammals found in the Loess, the genera and mostly the species, or the next relatives of which, are known to abound at present in Steppes and on grassy plains."

And concerning the molluscs of the Loess, Baron Richthofen in the preceding lines, calls our attention to "the fact, that land-shells are imbedded in immense numbers throughout the Loess, and that the most delicate shells are perfectly preserved. Fresh-water shells are of extremely rare occurrence, as has been correctly pointed out by Mr. Howorth."

In the subsequent explanation of his arguments Baron Richthofen refers to my researches concerning the Diluvial Fauna of Central Europe, of which he says as follows (*op. cit.* p. 301): "At the same time, when I published these arguments regarding the mode of origin of the Loess of Europe, Dr. Nehring, of Wolfenbüttel, came in the course of his admirable researches on the bones found in the Loess of Northern Germany to the well-known result, that the mammals which lived there at the time of the formation of that earth, were identical with, or nearly related to, those which are living now on the Steppes of Arctic regions, as well as in Siberia and Central Asia, and he concluded, that Germany must then have had the character of a Steppe and been subjected to a climate similar to that which prevails at present in Western Siberia.

"Thus, Dr. Nehring, who, at that time, had no knowledge of my researches, was led through the study of the fossil remains to precisely the same conclusion regarding a limited region in Europe, at which I had arrived with respect to a large portion of the continent by arguing on the structure and mode of occurrence of the Loess. Since then, the continued studies of the bones of mammals contained in the Loess, which have been made by Dr. Nehring and others, have yielded an overwhelming amount of evidence in the same direction, and have enabled us to extend the first conclusions to the whole of Germany, including the Rhine valley, Bohemia, and the vicinity of Vienna, and also in Hungary."

Mr. Howorth has answered to the detailed letter of Baron Richthofen in the number of August (pp. 343-356). He has in this answer attacked firstly and principally the above-cited statement of Baron Richthofen concerning the mammals of the Loess; he says (p. 345): "The first point to which I would call attention is that we are completely at issue about the kind of surroundings which the *debris* of the Loess fauna show must have existed when that fauna was living. Baron Richthofen says, 'The genera and mostly the species of mammals found in the Loess, or their next relatives, are known to abound at present in Steppes and on grassy plains.' Is this so? The Mammoth, it has been well said, would starve in a few days on the richest Craven pasture. The Elephant and his nearest relatives cannot browse upon the herbage of Steppes or grassy plains. Its natural habitat is the forest, its natural food—the succulent branches of trees, and we actually know, as is most familiar to Baron Richthofen, that both the Mammoth and the *Rhinoceros tichorhinus* did live upon the softer portions of trees, for remains of their food have been preserved and examined. *These are the characteristic quadrupeds of the Loess*, and with them occur other forest animals."

Afterwards Mr. Howorth recurs once more to the Fauna of the Loess period, and drawing my name into the discussion, he says (*op. cit.* p. 350): "In Europe therefore, so far as we know, there is no area, whence the dust could come, and there is abundant evidence that the dry Steppe-climate of Baron Richthofen is virtually out of the regions of possibility. But he makes still greater demands on our faith when, not content with speaking of a Steppe climate, he speaks of such Steppes as if they were the equivalents of or had any analogy with the Siberian tundras, and treats the two as if they were the same thing. The tundras are as different to Steppes as anything can be; they are covered with thick moss, and can neither be denuded by winds nor have their substance increased by them. They are essentially exceedingly humid and quite different to the dry areas he otherwise speaks of. Surely we require some explanations of these extraordinary statements. Here let me say parenthetically, that Baron Richthofen cannot be serious in urging that the proof of the identity of the Pleistocene fauna of Europe, including that of the Loess, with that buried under the tundras, was reserved for Dr. Nehring. Has he forgotten the name of Cuvier, to select only a very big name from a large crowd, who proved this elementary position long before Dr. Nehring was born?"

The ironical manner in which Mr. Howorth mentions my researches, and his absolute ignorance of my publications, compels me to make the following communication, from which I would have otherwise abstained, if Mr. Howorth had taken the trouble to read any of the numerous papers concerning the Loess and the Fauna of of the Post-Glacial Steppes of Central Europe, which I have published since 1875 in several well-known journals.[1]

[1] Cf. Verhandlungen d. k. k. geol. Reichsanst. in Wien, 1878, No. 12. 1880, No. 12. Zeitschr. f. d. gesammten Naturwiss. 1875, Bd. 45, pp. 1-28 mit Taf. 1876, Bd. 47, pp. 1-68, mit Taf. Bd. 48, pp. 177-236, mit Tafel. "Gaea," 1877,

In August, 1874, I found in the Loess-like layers of the gypseous quarries of Westeregeln (situated between Magdeburg and Halberstadt), beside numerous remains of wild horses, a great number of bones of small rodents, that excited my particular attention. A minute study of those bones proved that most of them belong to such genera and species which live at present in the Steppes of South-east Russia and South-west Siberia; and a minute study of the layers, which contained the numerous remains of Steppe-animals, proved that they belong to the first epoch of the Post-Glacial period, and are identical with or equivalent of the typical Loess.

Already at the general meeting of the Society for Natural History of Saxony and Thuringia, held at Quedlinburg, Whitsuntide, 1876, I expressed in a public lecture [1] the well-founded opinion, that the region of Westeregeln during the period in which the Steppe-rodents lived there, and where their bones were imbedded in the Loess-like diluvium, must have exhibited the character of a landscape like the present Steppes in South-east Russia and South-west Siberia.

Those species of animals, on which I principally founded the above-mentioned hypothesis, are the following:—

1. *Alactaga jaculus* (=*Dipus jaculus*), represented by 150-160 fossil bones, which belong to 21 specimens.[2]

2. Two species of *Spermophilus* (also represented by numerous specimens), of which I have identified the larger one with *Spermoph. altaicus*, Eversm., the other with *Spermoph. guttatus*, Temm.[2] My friend Wilh. Blasius, Professor of Zoology and Director of the Ducal Museum for Natural History in Brunswick, has lately, it is true, published a short paper,[3] in which he affirms the fossil *Spermophilus*, that I have identified with *Sp. altaicus*, to agree still better with *Sp. rufescens*, Keys. et Blas., than with that species. But this does not alter the conclusion I have drawn; for *Spermoph. rufescens*, living in the Steppes of Orenburg, is still more a characteristic native of the Steppes than *Spermoph. altaicus*.

3. *Arctomys bobac.* (Two specimens, a young and an old one.)

4. *Lagomys pusillus.* (Two specimens, a young and an old one.)

5. Several species of the genus *Arvicola*, as *Arvicola gregalis*, *A. ratticeps*, *A. amphibius*, *A. arvalis*, *A. alliarius*, represented by numerous specimens.

6. *Wild horses*, represented by many remains of old and young specimens.

pp. 218-223; 1879, pp. 663-671, u. 712-726; "Globus," 1878, Bd. 34, No. 6 u. 7, 1880, Bd. 37, No. 1 u. No. 20. "Ausland," 1876, p. 937 ss. 1877, p. 594 ss. 1878, p. 114 ss. 1880, No, 26. Archiv f. Anthropologie, 1877, pp. 359-398, 1878, pp. 1-24. Zeitschr. f. Ethnologie, 1879, p. 137 ss. mit Taf. and numerous reports in the Sitzungsberichten der Berliner Ges. f. Urgeschichte since 1876.—Neues Jahrb. f. Mineralogie, 1880, p. 118 ss. mit. 2 Tafeln. Ibidem numerous briefl. Mittheilungen.—Zeitschr. d. deutschen geol. Gesellsch. 1880, pp. 468-509. Jahresbericht d. Vereins f. Naturw. in Braunschweig, 1879–1880, pp. 11 ss., 1880–81, pp. 28 ss. "Natur," 1879, No. 45.

[1] Cf. Zeitschr. f. d. ges. Naturwiss. 1876, Bd. 47, s. 537.

[2] Zeitschr. f. d. ges. Naturwiss. 1876, Bd. 47, p. 18 ss. Bd. 48, p. 191 ss. Arch. f. Anthropol. 1877, p. 380 ss.

[3] Zoolog. Anzeiger, 1882, No. 125, p. 610 ss.

Every zoologist knows that the *Jerboas* (Dipodidæ) are characteristic animals of the Steppes, and that especially *Alactaga jaculus* is a species characteristic of the Steppes of South-east Europe, South-west Siberia, and Central Asia.

Almost all species of the genus *Spermophilus* are also true natives of Steppes; those species, whose remains were imbedded in the diluvium of Central Europe, and particularly in the deposits of the Loess period, are identical with several species existing at present in the Steppes situated between the Volga and Upper Obi.

That *Arctomys bobac* is an animal peculiar to the European and Asiatic Steppes, Mr. Howorth cannot dispute; I remark that all species of Marmots (as *Arctomys marmota, A. monax*, etc.) shun the forests.

Lagomys pusillus inhabits at present the Steppes between the Volga and the Upper Obi; also the other species of *Lagomys* live either in Steppes (*Lag. ogotona*) or in rocky forestless mountains (*Lag. alpinus, Lag. nepalensis, Lag. princeps*, etc.).

The species of the genus *Arvicola* are generally considered by all zoogeographers to be inhabitants of open forestless regions; they appear most numerously in the real Steppes. Some species, it is true, live at present in Central—and even in West—Europe, but mostly in such districts, in which man, by extensive agriculture, has destroyed the woods and has produced Steppe-like tracts.

That wild horses are inhabitants of the Steppes, and that even the domesticated horses best thrive and increase in open Steppe-like districts, Mr. Howorth cannot deny.

After having stated the above-mentioned hypothesis concerning the former Steppe-like character of the neighbourhood of Westeregeln, I could readily suppose not only this small district, but also a considerable part of Germany or Central Europe to have had a Steppe-like vegetation, and have been inhabited by Steppe-animals during the Post-Glacial period. For it seemed to me *extremely improbable* that a small district of some few square miles only could have shown a characteristic Steppe-fauna within great and abundant forests.[1]

I therefore continued my researches not only at Westeregeln, but extended them, animated by Baron Richthofen, Rud. Virchow, Hauchecorne, Beyrich, and other authorities of German science, as far as possible. I made excavations in many places, as in Thiede, near Wolfenbüttel, in the Seveckenberg, near Quedlinburg, in several caves of the Franconian Jura (between Nürnberg and Baireuth), and in other places.[2] I visited many public and private collections in Germany, which contain Pleistocene fossils. I determined many thousands of fossil bones, which were sent to me for examination,[3] and I followed up the discoveries in other countries by corresponding with all those interested in and pursuing this branch of palæontological inquiry.

[1] See my essay in the "Gaea," 1877, p. 222.

[2] Mr. Howorth and every one can examine my collections of fossil bones, which are preserved in the Zoological Museum of the Roy. Acad. for Agriculture at Berlin.

[3] Cf. Zeitschr. f. Ethnologie, 1881, p. 97 ss.

Supported by these extensive researches, I am able to maintain that real Steppe-animals can be investigated from many points of the Pleistocene deposits, and especially in the Loess of Central Europe, and that these Steppe-animals have inhabited this region in the greatest number and extent during the first epoch of the Post-Glacial period. A Steppe-fauna therefore has been in a great part of Central Europe interposed between the Arctic fauna of the Glacial period, and the forest-fauna of the Neolithic epoch.[1]

In the following passage I have enumerated the most important species of Steppe-animals or forest-shunning animals, and the places where their remains have been found in Central or even Western Europe :—

1. *Alactaga jaculus* at Westeregeln, Thiede near Wolfenbüttel, Quedlinburg near the Hercynian mountain, at Gera, Poesneck and Saalfeld in Thuringia, at Wurzburgh in Franconia.

2. Remains of *Spermophili*, most of which belong to *Sp. rufescens*, others to *Sp. fulvus* and *Sp. guttatus*, were found at Westeregeln, Thiede, Quedlinburg, Gera, Poesneck, Jena, in some caves of the Franconian Jura, at Wurzburgh, Tubingen (Wurtemberg), Eppelsheim (Rhine-Hessia), Steeten-on-the-Lahn, in some Belgian caves, at Montmorency near Paris and in other places of France, in the Mendip Hills and other localities of Southern England, in one place in Denmark, in Bohemia, in Moravia, at Nussdorf near Vienna, etc.

3. *Arctomys bobac* and other Marmots at Westeregeln, Gera, Oelsnitz (Saxony), Saalfeld, in a cave of the Franconian Jura, at Wurzburgh, Langenbrunn-on-the-Danube, Biberach (South Wurtemberg), Thayingen near Schaffhausen, Eppelsheim, Mayen in the Eifel Mountain, Aachen, Remagen on the Rhine, in Belgium and France, at Prague (Bohemia), etc., etc.

4. *Lagomys pusillus* at Westeregeln, Thiede, Goslar, Poesneck, in the Franconian Jura, at Biberach (Wurtemberg), at Steeten, Balve (Westphalia), in some Belgian, French and English caves, at Nussdorf near Vienna, in Bohemia, Moravia and Upper Hungary.

5. Species of *Arvicola* at Westeregeln, Thiede, Goslar, Gera, Poesneck, Saalfeld, Wurzburgh, Steeten, and in most of the above-mentioned places.

6. *Cricetus frumentarius*, very numerous specimens at Saalfeld, in the Franconian Jura, at Wurzburgh, at Montmorency, at Dinant-sur-Meuse, in Bohemia, Moravia, Upper Hungary, etc.

7. *Cricetus phœus* at Saalfeld, at O-Ruzsin near Kaschau (Upper Hungary), and at Beremend in South Hungary.[2]

8. *Hystrix hirsutirostris* (the porcupine of the Eastern Steppes) at Saalfeld, and in two caves of the Franconian Jura.

[1] Other naturalists, as Prof. Liebe at Gera, Prof. Woldrich at Vienna, Prof. Laube at Prague, who examined my hypothesis by their own researches, have come to the same result. Cf. Liebe, Arch. f. Anthrop. ix. p. 162. Zoolog. Garten, 1878, No. 2. Woldrich, Sitzgsber. d. Acad. d. Wiss. in Wien, 1880 u. 1881.

[2] See my essay in the Jahrbuch of the K. K. Geol. Reichsanst. in Wien, 1879, p. 491, and Zeitschr. f. Ethnologie, 1881, p. 107.

9. *Equus caballus ferus* at Westeregeln, Thiede, Quedlinburg, Gera, and in innumerable other places of Central Europe.

10. *Equus hemionus* at Westeregeln, Quedlinburg, Gera, Langenbrunn on the Danube, and probably in other places, where fossil remains of Asses are mentioned to have been found.

11. *Antilope saiga* in Belgium, in France, and probably at Westeregeln, Quedlinburg, and in some other places of Germany.

I think this enumeration of animals and places will be sufficient to convince Mr. Howorth, that there has positively existed at a certain time a Steppe-fauna in Central Europe in spite of Mr. Howorth's contradictory assertions.

I notice that the other animals, whose remains were found in the same horizon, together with the above enumerated Steppe-animals, belong mostly to such species, as, although not being exclusive natives of forestless and Steppe-like regions, however prefer these regions or visit them at certain seasons, as *Lepus timidus, Canis lupus, Fœtorius putorius, Elephants, Rhinocerosses,* etc.

At Westeregeln, at Thiede, in the Franconian Jura, and in other places, where I made excavations myself, I did not find the slightest trace of a characteristic forest-animal side by side with the Steppe-animals; I never observed there, for instance, a fossil bone of *Sciurus, Pteromys, Myoxus, Muscardinus, Mustela martes, Cervus elaphus, Cervus alces, Cerv. capreolus, Bison europæus,* etc.

Mr. Howorth regards only the Mammoth and *Rhinoceros tichorhinus* as characteristic quadrupeds of the Loess; these species I do not at all consider to be characteristic representatives of the Loess-fauna. The Mammoth is, as Prof. Boyd Dawkins has already pointed out, Pre-Glacial, Glacial and Post-Glacial; his remains occur not only in the Loess, but in the most varied deposits of Europe, as in the Forest Bed, in Glacial gravel layers, in clay and loam, in Tuff deposits. This is similarly the case with *Rhinoceros tichorhinus.* How can Mr. Howorth designate those animals as the characteristic quadrupeds of the Loess?

At Westeregeln and Thiede, where the deposits are of the purest and distinctest nature, and where I made very careful excavations during six to eight years, I never found the remains of the Mammoth in close association with those of decided Steppe-animals. I know, however, very well that Mammoth and Rhinoceros remains are often found in the Loess, and I have already attempted in several publications to explain, by pointing to the migrations of the present African Elephants and Rhinocerosses, how the remains of their Pleistocene relatives could be buried together with the remains of Steppe-animals.[1]

Concerning the molluscs, Mr. Howorth maintains (p. 346), that "those conchologists who are best able to decide such a question agree that the *Helices* and other shells of the Loess lived in the recesses of damp woods, and their abundance proves the conditions to have been singularly favourable to them, namely, those of a humid atmosphere and of a deep shade."

[1] Sitzungsber. d. Berl. Ges. f. Urgesch. v. 11. März, 1882. Archiv f. Anthrop. 1878, S. 14 ff.

I regret also in this point to be obliged to refute the affirmations of Mr. Howorth, although he has quoted European and American authorities. E. von Martens, Professor of Zoology at Berlin, who is also an European authority in conchology, has proved in several publications, that the *Helices* and *Succineas*, which Mr. Howorth and his correspondent Prof. Todd believe to require a moist climate and a deep shade, live very numerously in the Steppe-regions of Central Asia, and that many species of Loess molluscs occur at present living in East Russia, in South-west Siberia, and even in the prairies of the Little Missouri in North America.[1] I state further, that the molluscs found by me at Westeregeln and Thiede together with the Steppe-animals require by no means a moist forest climate, but are on the contrary always or at least very often natives of dry and forestless districts.[2]

In referring Mr. Howorth to my publications, I may in conclusion state:—

1. During the first epoch of the Post-Glacial period, where the Loess and many Loess-like deposits were formed, there lived in Central Europe a Steppe-fauna, the principal representatives of which were *Alactaga jaculus*, several species of *Spermophilus*, *Arctomys bobac*, *Lagomys pusillus*, numerous species of *Arvicola*, *Cricetus phœus*, Wild Horses, Wild Asses, *Antilope saiga*.

2. This Steppe-fauna (excepting some extinct or extirpated species) is identical with the fauna of the South-east European and South-west Siberian Steppes.

3. The first exhaustive exploration of that fossil-fauna was, I am glad to state, reserved for me; I do not know where Cuvier or other palæontologists before me have published exact researches about *Alactaga jaculus* foss., *Spermophilus altaicus* foss., *Arctomys bobac* foss., etc., or where they have previously published the well-founded conclusions at which I have arrived.

4. The former existence of Steppe-regions in Central Europe is also supported by the most recent researches both of botany and geology.[3]

5. A Steppe-fauna requires a corresponding Steppe-flora and a Steppe-climate. Forests were reduced during that epoch to the borders of the streams, to the slopes of the mountains, and other well-irrigated tracts. Inland-lakes were as numerous in the Post-Glacial Steppe-regions of Central Europe, as they are now in the North-west of Central Asia.

[1] E. v. Martens, Sitzgsber. d. Gesellsch. naturforsch. Freunde in Berlin, vom 20 Nov. 1877, vom 19 März 1878, vom 21 Oct. 1879, vom 18 Juli 1882, vom 21 Nov. 1882.

[2] *Pupa muscorum*, *Helix pulchella*, *Chondrula tridens*, *Succinea oblonga* are abundant in the steppe-like surroundings of the Altai. *Helix striata*, which species at Westeregeln is most prevalent, occurs at present always on dry grassy slopes of loamy or sandy hills. *Helix tenuilabris* is found living on the woodless heights of the Swabian Alp, and *Helix hispida* I found abundant on the nettles of dry sandy hills far distant from any wood.

[3] Engler, Versuch einer Entwicklungsgesch. d. Pflanzenwelt, etc., I. p. 161 ss. Engler, Botan. Jahrb. I. p. 75.—Tietze, Die geognost. Verh. d. Gegend von Lemberg im Jahrb. d. K. K. geol. Reichsanst. in Wien, 1882, Heft I.

6. We may assume that Europe at that time had a different configuration from its present one, and that Germany was more distant from the Atlantic Ocean than now.[1] There exist also other proofs, which admit the supposition that Europe, during that epoch, extended itself further west and north-west, that there existed even an isthmus between North-west Europe and North-east America.[2]

7. It is virtually not "out of the regions of possibility," that during the Loess-epoch similar meteorological conditions prevailed in Central Europe, as Baron Richthofen requires for his Loess theory, and as I supposed for the neighbourhood of Westergeln and a great part of Germany as long ago as in 1876. It is not necessary to suppose that the climate of the Post-Glacial Steppes of Central Europe was so extremely dry, and the vegetation so sterile and so wanting in trees, as they are now in the Mongolian Steppes of Central Asia; it is sufficient to suppose a climate and a flora like that of East-Russia and West-Siberia.

8. That all deposits of Loess have been caused by subaërial means, I do not venture to maintain;[3] but at any rate, the wind has played an important part in the formation of the Loess-like deposits of Westeregeln, Thiede, and many other places in Central Europe.

9. I have never confounded the Arctic Tundras with the sub-Arctic grassy *herbed* Steppes of South-west Siberia, as Mr. Howorth seems to believe. Although the Tundras are often designated by the geographers as moss-steppes, or Arctic steppes, and although they are not throughout so exceedingly humid as Mr. Howorth maintains, I know, however, very well, that they display both a different fauna and different climatic conditions as compared with the southern grassy Steppes. During the Glacial period there were, no doubt, also Tundra-like districts in Germany between the extended glaciers and fields of inland-ice, that covered great parts of our country.

The characteristic animals of those Tundra-like districts in Germany were the same, which at present live in the Tundras of Siberia, and in the Barren Grounds of North-America, viz. *Myodes torquatus* (=*M. hudsonius*), *Myodes obensis*, *Lepus glacialis*, *Cervus tarandus*, *Ovibos moschatus*, *Canis lagopus*, *Lagopus mutus*, *Lagopus albus*, *Strix nivea*, as I have shown in many publications.

10. This *Arctic fauna* of Central Europe, after the melting of the glaciers and ice-fields, was by degrees displaced and dispossessed by the above-mentioned *sub-Arctic Steppe-fauna*, and this fauna was afterwards displaced and pushed Eastward by the *forest fauna*, which had been reduced during the Glacial period to those parts of Europe where the forests had not been destroyed by the ice-streams of the mountains and the ice-fields of the plains.

[1] See my essay in the "Gaea," 1877, p. 223.

[2] See my essay in the "Tägliche Rundschau," Berlin, 17 Mai, 1882, No. 114.

[3] See my essay in the "Globus," 1880, Bd. 37, No. 1.

III.—Supplement to a Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.

(*Continued from* Dec. II. Vol. IX. p. 509.)

Found 1854.—Cranbourne, near Melbourne, Victoria, S. Australia.[1]

Two masses of meteoric iron were discovered in Victoria in 1854, and they were first reported upon by the late W. Haidinger in the *Sitzungsberichte Akad. Wiss.*[2] in 1861. The smaller block became the property of Mr. Abel, the engineer; the larger one was purchased by Mr. A. Bruce, now of Chislehurst. It appears that Mr. Bruce had seen a piece of iron, which had the appearance of being meteoric iron, in the fireplace of a squatter there, and he asked the man if any more of that kind was to be met with in that neighbourhood. He was conducted to a spot in the adjoining parish of Sherwood, where an irregular spur of iron projected from the surface, and he there and then purchased it with the intention of presenting it to the British Museum. Later on, when they proceeded to dig round it and uncover its sides, they were astonished at its large size. Various sums of money were offered Mr. Bruce for the splendid block, but his one answer to all such offers was, "No; I have bought it for a sovereign; and I am going to give it to the British Museum." As has been stated, a point only of the iron was above the surface. A photograph was taken on the spot by my late friend, Mr. R. Daintree, the Agent-General for Queensland, after the tertiary sandstone inclosing it had been removed. It is the same sandstone which crops out at Broughton, with basalt from 12–15 feet below, as on the coast at Western Port. Bruce states that the lower bed is Silurian, and that the block of iron penetrated a foot or more into it.

Early in 1861 the spot was visited by Dr. Neumayer and Mr. Abel. One mass was found to weigh several hundredweight; the other from three to four tons. Their relative positions is shown in an accompanying small sketch-map of the district. They were found to be beyond all question native, or rather meteoric, iron covered with a crust of the usual characters, in which the customary hollows were not wanting. This statement is, however, somewhat misleading. No crust corresponding to that of magnetite, such as is presented by the Rowton siderite (which see), is met with; but, in place, a layer of considerable thickness of hydrated oxides and magnetite, indicating a long period during which the blocks had lain in the earth. The relative position of the two masses was S. 30° W. and N. 34° E. (magnetic declination), and they were 3·6 miles (60 miles to a degree at the equator) apart. Both lay close to the surface, and were only so deeply imbedded that a point protruded from the soil. The latitude of the smaller block, which lies north of the other, is 38° 8′ and long. 145° 22′ E.; that of the larger being 38° 11′ or long. 145° 20′ E. of Greenwich. The height above sea-level of the former was 107 feet, and of the latter 127 feet.

[1] Walter Flight, *Philosophical Transactions*, 1882.

[2] W. Haidinger, *Sitzungsberichte Akad. Wiss.* xliv. 18th April, 6th June, and 17th October, 1861; xlv. 65, 9th January, 1862.

They showed no polarity beyond that due to the action of the earth. The underside of each mass was strongly south magnetic, and on the upper side north magnetic. The longer axis of the Bruce meteorite, the larger mass, is about 5 English feet, and it lay exactly in the magnetic meridian of the place.

Neumayer made a number of determinations of the specific gravity of the nickel-iron of the smaller mass, in the possession of Mr. Abel, ranging from 7·12 to 7·6, the crust being 3·66. This block was sent to the International Exhibition in London in 1862. The larger was brought down to Melbourne and placed in the University Grounds there, near the shore, and unfortunately exposed to the action of the sea-water. Efforts were made to delay the shipment of the Bruce meteorite to England, but eventually the smaller block was bought by the Trustees of the British Museum for £300, and it was presented to the Colonial Museum; the Bruce meteorite was then sent to this country. When it reached the British Museum, some holes were drilled into its under surface, and it was fixed on a turntable in the first room of the Mineral Gallery. It was found to decay to a considerable extent; fragments oxidised and crumbled off, and drops of iron chloride exuded here and there. This, however, was stopped to a very great extent by injecting it with clear shellac varnish, and keeping it in a glass case provided with trays containing caustic lime. By this means the destruction has been reduced to a minimum. It was noticed that the part of the meteorite which was so rapidly decaying presented a very marked crystalline character: that the tetrahedral structure broke up into plates, and between them were very thin plates of another constituent, which less readily underwent change. The action of moisture on these series of plates was like the exciting liquid of a galvanic cell, and caused the oxidation to proceed very rapidly. Many of the fragments which came off at this time were selected and reduced again to the firm solid original condition and present beautiful structure. Of this I shall have more to say later on.

It was at once noticed that the meteorite consisted entirely of metallic minerals, that it contained no rocky matter whatever. One of the first experiments which suggested itself was to determine whether the iron was alloyed with nickel, cobalt, copper, etc., or whether it contained combined carbon. A weighed portion was suspended by a platinum wire, carefully covered up in caoutchouc, in a solution of recrystallized salt, and connected with a Bunsen cell. The positive cell was kept slightly acid from time to time as it grew alkaline. Nickel-iron weighing 5·9989 grms. was dissolved in this way, and the greater part of the insoluble ingredients was found to consist of very minute bright apparently square prisms, which pervade all the nickel-iron, and apparently constitute nearly 1 per cent. of its mass. These prisms are acted upon slowly and with considerable difficulty by hydrogen chloride, but go readily in hydrogen nitrate. But I shall return to the consideration of the characters and composition of the prisms later on. The absence of all combined carbon was fully established. The nickel-iron thus dissolved was found to contain of:—

Prisms	0·932 per cent.
Nickel	7·651 ,,
Cobalt	0·501 ,,
Copper	0·0156 ,,
Silicium	0·172 ,,

Some of the largest nickel-iron crystals, and cleavages of them, were examined for other constituents than iron with the following results:—I. was a tetrahedron of iron with cleavages parallel to the faces of the tetrahedron; II. was similar to I. but thinner; III. were several examples of cleavage plates, firm not pliant, thicker than the paper-like plates which will be described later on; IV. were thinner plates, but not pliant ones; V. were thick cleavage plates; and VI. some borings. The following ingredients were met with:

	I.	II.	III.	IV.	V.	VI.
Insoluble part ...	1·405	0·072	0·103, 0·106, 0·724	none	none	0·137
Nickel	—	7·837, 7·712, 7·529, 7·504	9·764, 6·476	—	—	—
Nickel and Cobalt	8·057	—	—	9·801	9·046	—
Cobalt...	—	0·601	0·756	—	—	—
Phosphorus ...	—	0·187	0·018	0·059	—	—
Sulphur	—	—	— 0·023	—	—	—

The rusted fragments of the meteorite, which were very carefully picked over, yielded many very good crystals of nickel-iron. These were reduced in porcelain tubes in hydrogen, a large quantity of hydrogen chloride was extracted from them, and dozens of perfectly complete tetrahedra of nickel-iron as well as many cleavage pieces with sharp edges were safely preserved.

In one of the early notes on the Bruce meteorite published by W. Haidinger, in 1862, he wrote "Vielleicht finden sich in der That innerhalb der Meteorisenmassen . . . selbst manche Sättigungspunkte, welche wirklich verschiendene Mineralspecies darstellen." Such an instance presents itself in the thin paper-like pliant plates which lie on the faces of the tetrahedra of nickel-iron and between the large plates of the crystals of nickel-iron; they are in the form of equilateral triangles or are lozenge-shaped, have the thickness of stout writing paper, and, unlike the plates of nickel-iron, are quite pliant. They are strongly magnetic, are of a pure white colour, and have evidently been extruded from the nickel-iron at the time of formation. They are soluble in hydrogen chloride and nitrate. As the examination of them was made in the case of some which had been reduced in hydrogen, a further portion picked direct from the fragments which had come off the meteorite was taken; both kinds were found to be equally pliant. The fresh plates taken direct from the meteorite contained 0·688 per cent. of phosphorus. Analysis of the plates showed them to consist of:—

Iron	70·138 ÷ 28 = 2·504 : 5	
Nickel	29·744 ÷ 29·5 = 1·008 : 2	
	99·882	

This is evidently an alloy of very well defined composition, which has been extruded from the nickel-iron under special conditions when the latter was saturated with it and ready to expel it. It is the constituent of nickel-iron which forms the fine lines constituting the Wiedmannstädtian figure, and not schreibersite, as usually stated in writings on the etched figures of meteoric iron. Tänite is the name Professor Gustav Rose gave to leaves containing 13·2 per cent. of nickel, and which he stated to form the figures on an etched surface. Dr. K. G. Zimmermann, in a letter to one of the editors of the *Jahrbuch für Mineralogie*, 1861, p. 557, proposed the name "meteorine" for a new metal occurring in the Cranbourne meteorite which he found to contain no copper, nickel, or cobalt. The substance referred to in both cases was evidently the little plates above described. As the composition of this mineral has now for the first time been definitely made out, I propose to call it Edmondsonite, in memory of the late George Edmondson, the Head Master of Queenwood College, Hampshire, a great lover of science, a man with whom I had the honour to be long and intimately connected.

A curious accident should here be described which established the fact that the alloy is a definite chemical compound. A number of pieces of nickel-iron from this meteorite, which had become rusty, were heated in a porcelain tube in a current of hydrogen. During the experiment, which was conducted out of doors, it came on to rain, and some drops touched the hot tube and cracked it. Air slowly entered the crack and oxidised the iron, till it acquired a bright blue colour; while the little plate of edmondsonite remained colourless. This result accords with the conclusion arrived at by Stodart and Faraday some sixty years ago,[1] on the oxidation of alloys of iron and nickel. An alloy of iron, or rather of the best Bombay wootz, with 10 per cent. of nickel, made by them in 1820, in imitation of the Siberian meteoric iron, in which Children found as a mean of three analyses 8·96 per cent.[2] of nickel, was compared, as regards its powers of undergoing oxidation, with pure iron. And the authors say: "The colour, when polished, had a yellow tinge. A piece of the alloy has been exposed to moist air for a considerable time together with a piece of pure iron; they are both a little rusty, not, however, to the same extent, that with the nickel being but slightly acted upon comparatively to the action on the pure iron; it thus appears that nickel, when combined with iron, has some effect in preventing oxidation, though certainly not to the extent that has at times been attributed to it. It is a curious fact that the same quantity of the nickel alloyed with steel instead of preventing its rusting, appeared to accelerate it very rapidly."

The Bruce meteorite contains many nodules of troilite lying here and there amongst the plates and crystals of nickel-iron, always in rounded masses, only very occasionally an ill-defined cleavage plane

[1] Faraday's Experimental Researches in Chemistry and Physics. Taylor and Francis, 1859, p. 63.

[2] Berzelius found nickel 10·73 per cent., and copper 0·46 per cent. in the Krasnojarsk nickel-iron from Siberia.

being met with. They vary in size from half an inch to more than two inches in length, are usually covered with a thin layer of graphite, sometimes with some daubreelite surrounding them, and one nodule, consisting of graphite, was found to inclose troilite, which had aggregated inside the graphite in a curious way, so that the section of the nodule suggested the outline of a holly-leaf. A sketch appended represents a section of the nodule of graphite, the shaded inclosed part representing the sulphide. Troilite is the only sulphide found in this meteorite, and, it need hardly be said, was not in the slightest degree magnetic. A specimen of pounded and dried mineral was digested with a quantity of carbon disulphide, which had been twice distilled, for a day and a half, and sulphur amounting to 0·0207 per cent. was dissolved. A portion chosen for analysis was found to possess the following composition:—

	I.	II.	III.	IV.
Insoluble part ...	0·215	2·297	—	—
Iron...	—	62·150	63·613	—
Sulphur	36·543	—	36·207	36·250
Nickel	—	0·446	—	—
Copper	—	0·076	—	—
Chlorine	—	1·130	—	—

or, as the mean of these determinations:—

		Fe S requires
Iron	= 63·613	63·64
Sulphur ...	= 36·333	36·36
Copper... ...	= 0·079	—
Chlorine ...	= 0·130	—
	100·155	100·00

The next mineral, the composition of which we have to consider, is that forming the prisms which, as we have already seen, are scattered throughout the mass of the nickel-iron, and form nearly one per cent. of its mass. They resist the action of hydrogen chloride and are only dissolved after long treatment with very strong acid; they dissolve, on the other hand, easily in hydrogen nitrate.

They exhibit strong magnetic characters. They seem to be identical with the mineral to which Gustav Rose gave the name of rhabdite. They appear to form square prisms, and the terminal faces of the prism could rarely be met with.

The prisms were exceedingly brittle, and were rarely, if ever, of their normal length. It was a difficult matter to obtain the prisms quite free from organic matter (dried varnish, etc.), but the following very pure material was at last obtained:—

	I.	II.	III.	Mean.	$(Fe_4Ni_3)P$.
Nickel	49·715	—	48·955	49·335	48·38
Iron	36·666	39·519	38·540	38·242	38·23
Phosphorus	(13·619)	12·586	12·645	12·950	13·39
					100·000

The specific gravity of several specimens of the prisms gave numbers varying from 6·326 to 6·78.

A few years ago Professor Daubrée[1] pointed out the great resem-

[1] G. A. Daubrée, *Comptes rendus*, lxxiv., 1427; and M. Sidot, *Comptes rendus*, lxxiv., 1425.

blance which he had traced between the artificial phosphide of iron, Fe_8P, which M. Sidot had succeeded in preparing, and the rhabdite of meteoric iron. I have to offer my hearty thanks to Professor Daubrée for permitting me to inspect some of M. Sidot's crystals, which bore the closest resemblance to the above crystals. More recently, in the spring of last year, M. E. Mallard [1] communicated a note to the Comptes rendus, on phosphide of iron found among the products of the spontaneous fires in the coal-mines at Commentry. The crystals are square prisms, terminated by a pyramid, are strongly magnetic, have a specific gravity of 6·71 and the composition indicated by the formula Fe_7P. They, of course, contain no trace of nickel; in all other respects, however, they bear the closest resemblance to the above body.

When the crude nickel-iron of the meteorite was treated with hydrogen chloride till action ceased, coarse insoluble particles, mixed with a black powder, and the needles remained; they could both be removed by decantation and repeated washings. It was then subjected to a thorough cleansing with hydrogen chloride, with dilute nitric acid, with water, with a mixture of ether, alcohol, benzol, and chloroform, and finally, when dried, with the magnet. In this way the coarse powder was obtained in a pure state; it consisted of a very brittle, very magnetic, coarse powder, which dissolved easily in strong hydrogen nitrate. Analyses gave the following results:—

	I.	II.	Mean.		
Iron	56·245	55·990	56·117	÷ 28 = 2·004	} 2·993
Nickel	29·176	—	29·176	÷ 29·5 = 0·989	}
Phosphorus	13·505	—	13·505	÷ 31 = 0·435 × 7 = 3·045	
			98·798		

This is, doubtless, the mineral Schreibersite which appears to have the composition indicated by the formula $(Fe_2Ni)_7P$. The material, as already stated, consisted of a coarse powder, of faceless irregular fragments of a very brittle constituent of the meteorite.

Search was accordingly made for crystals, and occasionally, but very rarely, larger bodies which might when broken up have formed this powder were hit upon. One was met with, a large brass-coloured oblique crystal which readily cleaved across the base; it was but slightly acted upon by hydrogen chloride or nitrate, both of which, however, on long-continued boiling, dissolve it slowly; in *aqua regia*, on the other hand, it quickly disappears. When heated a fragment of one of these crystals quickly became of a dark brown. Analyses of these crystals gave the following results:—

	I.	II.			
Iron	69·251	69·843	69·547	÷ 28 = 2·484 =	} 2·972
Nickel [2]	—	—	14·410	÷ 29·5 = 0·488 =	}
Phosphorus ...	15·420	16·666	16·043	÷ 31 = 0·517 =	0·517
			100·000		

[1] M. E. Mallard, "Sur la production d'un phosphure de fer cristallisé et du feldspath anorthite, dans les incendies des houillères de Commentry," *Comptes rendus*, 1881, xcii. 933.

[2] Both determinations were lost.

which results point to $(Fe_9Ni_2)P_2$ as the true representative of its composition. It does not accord very well with the analysis of the powder, and the relation of one body to the other must be left till fresh material comes to hand.

Mention should here be made of a curious crystal which on two or three occasions was met with while searching through the *débris* of the meteorite. It consisted apparently of a square prism, which, while the sides were quite bright and metallic, had a square centre of a dull almost black colour; it very readily broke across the prism.

In the paper there is represented such a prism broken across, showing the dark centre. An analysis of this compound gave the following results:—

Iron	67·480 ÷ 28	2·410
Nickel	20·318 ÷ 29·5	0·688
Phosphorus	12·317 ÷ 31	0·387
	100·115	

which numbers agree with the formula $(Fe_7Ni_2)_8P$.

Graphite occurs occasionally, but rarely, as nodules; sometimes as nodules inclosing troilite, like the one already referred to; sometimes in large sheet-like masses, in one case about four inches in length and two inches wide. A specimen was carefully dried and pounded and burnt in a current of oxygen and gave numbers which show it to have the composition:—

Carbon	89·661
Hydrogen	0·257
Residue (iron, etc.)	10·412
	100·330

The nickel-iron was further examined for occluded gases. A portion of the nickel-iron borings removed from the under surface was selected and was heated in a porcelain tube connected with a Sprengel pump. Gas amounting in bulk to 3·59 times the volume of the iron was extracted, and was found on analysis to have the following composition:—

Carbonic acid	0·12
Carbonic oxide	31·88
Hydrogen	45·79
Marsh gas	4·55
Nitrogen	17·66
	100·00

The paper is illustrated by a plate of drawings and several woodcuts.

IV.—Woodwardian Laboratory Notes—N. Wales Rocks V.

By E. B. Tawney, M.A., F.G.S.

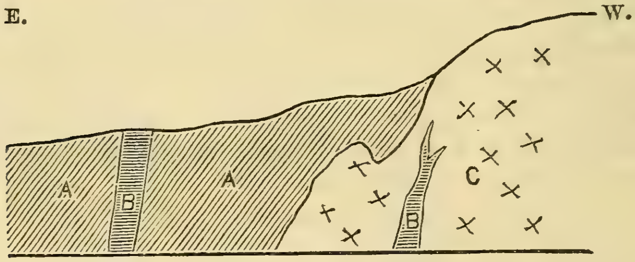
(*Continued from* p. 21.)

We may pass next to the Sarn Meylltern district, to examine the patch which Dr. Hicks on his sketch-map [Q.J.G.S. vol. xxxv. p. 297] has indicated as Dimetian with a strip of Arvonian along the north side. We read [*l.c.* p. 300], "Eastward (*sic*) of this, and as we approach the so-called altered Cambrian, rocks of a more felsitic character come in abruptly, and it is probable that these are of Arvonian age." At the north end of the patch, by the Cromlech and Amwlch Lodge, the rock is however of the type which Dr. Hicks has termed Dimetian, and as it varies much in character at different parts of its course, I think we must ask for further proof that there is a second bed of rock of different age in this area.

In fact the rock in the quarry by Amwlch Lodge, which the Geological Survey has here mapped as syenite, is somewhat like that of Twt Hill, Carnarvon; it is a mixture of dirty white felspars, crystals, and equally large milky quartz, the two interlacing together, while in some of the interstices are specks of dark greenish-grey material.

The contact with the dark grey Cambrian shales is an interesting one. It is not at all surprising from the character of the junction that the Geological Surveyors considered it an igneous rock.

Section near Amwlch Lodge, Sarn.



A Cambrian Shale. B Intrusive Dykes. C Metamorphic.

In the accompanying diagram, compiled from two sides of the quarry, I have sought to represent the relative position of the beds. The shales seem in one place caught up between branches of the so-called syenite, since in the shale appears a projection of syenite. The shales are somewhat a paler grey near the junction, as if partly discoloured: this is not necessarily a sign of heat-action. There are two veins of decomposed trap-rock, one traversing the shales on the east side, the other ramifies in the so-called syenite. If this is not the contact of an igneous rock, it will be noticed at once that the steepness of the dip of the shales and absence of any shore deposit are against the notion that these deep-sea shales were deposited directly against an old Pre-Cambrian land. A fault would have to be inferred. There is, however, no clear line of junction. The contact is an irregular surface and the shales are joined on as tightly to the Dimetian as if they had been cemented by heat. Perhaps we may suppose that after the fault occurred further lateral pressure and movements had partly broken up the rocks at the junction and forced the hard rock as projecting processes into the shale. This would scarcely be synchronous with the intrusion of the igneous dykes, as lateral pressure would have tended to prevent or close any vertical fissures. Dr. Hicks's specimens from this same area, which he terms Dimetian at Tymawr nearer Sarn, were described by Prof. Bonney [Q.J.G.S. vol. xxxv. p. 306].

Comparing a slice of the Amwlch rock, we notice the same powdery-looking state of the quartz; this arises from the great multitude of inclusions—liquid inclusions with bubbles, many spontaneously moving; these are often in lines which stretch sometimes continuously across from one crystal to another. The quartz has formed evidently in presence of abundant vapours; its outlines are not always marked out by powdery matter; there seems to have been a thorough recrystallization. The felspars, both orthoclase and triclinic, are much decomposed. The dark substance in the intervals between the other minerals is not resolvable into any definite mineral, it seems a mixture of opacite and grey powder, sometimes coloured greenish from a trace of chloritoid matter; a little secondary epidote has been formed.

Microscopic examination therefore shows that this is the same type of rock described by Prof. Bonney from Rhos Hirwain, Twt Hill, etc. It varies, however, in different parts of the area; thus the rock which one sees in Penygopan quarry, about 1½ miles south-west of Sarn, appears more like a grey granite, since a dark hornblendic material is abundantly present.

A microscopic examination shows the quartz rather full of inclusions, sometimes in lines roughly parallel, or even with two systems of lines transverse to each other. Among these are some with spontaneously moving bubbles, but bubbles seem not very abundant in these inclusions; the outlines of the quartzes are margined sometimes by kaolinized matter, but not always. The felspars are about as abundant as the quartz; most of them show multiple twinning, many are so decomposed that its absence may be due to conversion of the felspar into secondary aggregates, but probably some orthoclase may be inferred. The hornblende is also in a state of transition, a little of the original cleavage is left, but most of it has lost its dichroic property, and is a pale greenish substance, partly actinolite from its optic properties, and partly chlorite or viridite in masses much grouped together. A few scales of brown mica are seen, and brown iron oxide, probably formed at expense of the hornblende. Apatite is present. We may class it as hornblendic gneiss (if igneous, it would best be called quartz-diorite rather than syenite). The constitution of the rock, however, is against its being igneous, and its great variability within short distances also. Owing to the absence of openings, I was unable to find a contact with adjacent beds, except in the case above described.

At Penllech, near by, the rock looks something like a fine-grained granite with minute ill-characterized mica.

By the aid of the microscope it is seen that the quartzes are rather full of inclusions, among which a few spontaneously moving bubbles may be observed. The outlines of the quartz elements are often not to be distinguished except by the aid of polarized light. Of the felspars a large proportion is plagioclase; they contain similar inclusions, but I could not detect any bubbles. Some biotite is present, but it gradually loses its strong absorptive and dichroic characters, becomes green, finally loses its cleavage, and so passes to chloritoid or viridite substance. Ferruginous and chloritic strings traverse the rock. There is no parallelism in the arrangement of the constituents in the hand specimen to determine its being called gneiss. The difference between this type of rock and granite is a difficult subject. Some distinctions have been already mentioned by Professor Bonney [*l.c.* p. 306]. It may be remarked that in igneous rocks, so far as I have observed, triclinic felspars and quartz do not occur together in nearly equal abundance.

As mentioned by Dr. Hicks [*l.c.* p. 300], the boundaries on the Survey Map are not quite correct here, since these last two places are within the greenstone area on the map.

West of Mynydd Rhiw, near Sarn, is a patch of so-called syenite from which Sedgwick, in 1831, collected what he terms in his MS. Journal "gneiss," remarking that it was the only place in Lleyn where gneiss occurred. He found it in a roadside quarry near the back of Meillionydd House, about three miles N.E. of Aberdaron. To the eye it is a mixture of rectangular portions of opaque white felspar, with milky quartz, and in places much blackish-brown mica, the mica irregularly distributed usually, but occasionally, in layers.

[P. 52.] Under the microscope the quartz, which forms large mosaic patches, is seen to be fairly clear, the outlines usually only visible in polarized light; inclusions sometimes in lines; where bubbles are seen, they are often spontaneously moveable. The felspar seems chiefly plagioclase; it is much attacked by decomposition, which results in thorough change of its nature.

Of all the areas of rock in the Lleyn promontory which Dr. Hicks claims as Pre-Cambrian, this patch of metamorphic rocks near Sarn seems to be the only one with any claim. It is, however, unfortunate that we have not been able to find any fragments of it inclosed in Cambrian beds.

The range of hills east of this area called Mynydd Rhiw, consists of greenstone. The summit of Mynydd Rhiw is a more or less cellular diabase, rather fine-grained; some vesicles are filled with calcite, some with delessite. The conical hill by Clip y Cilfinhir of the map, is also of this rock, though mapped as within the syenite boundary. Castell Carron, a boss to the north of Mynydd Rhiw, is quarried, and the solid diabase is well exposed here.

The microscope shows large augites, which are penetrated by the narrow plagioclases; many tracts of secondary chloritoid matter result from decomposition of the augite; secondary quartz grains also occur in the same connection. Magnetite is abundant in single and branched forms.

All observers admit these greenstones to be igneous.

We may notice next the rock of the finely-shaped hill of Carn Madryn, some four miles S.S.W. of Nevin. In Dr. Hicks's map it stands as Arvonian. It is a rock of the Bwlch Mawr type (noticed previously); the ground is darker grey than most of the Nevin porphyries, but the greenish-white felspars are of about the same size averaging 3–5 mm.; many can be seen with a hand lens to be triclinic. Under the microscope it is seen that the larger felspars are much decomposed, being full of secondary products, scales and needles in groups at irregular angles, calcareous specks, etc.; most of them show remains of repeated twinning. The ground is microcrystalline, consisting largely of minute grains of quartz, the rest being felspathic, of indistinct outline, with a little pale-greenish granulated matter in the interstices optically almost inert. Hornblende in remnants only, pale brownish-yellow, feebly dichroic, and mostly converted to a yellowish-green chloritic substance, which is feebly doubly refracting and sometimes fibrous. Apatite is abundant, piercing both the felspars and the chloritic portions. Black oxide in hexagonal form is abundant (ilmenite). A few bright crystals of secondary epidote have been formed. From the character of the felspars, the rock takes its place among the porphyrites, or more particularly quartziferous porphyrite. The hill is mapped as surrounded by shale, said to be much covered by drift. In my cursory examination I did not succeed in finding any opening to show a junction.

Immediately south of this hill—distant about a quarter of a mile —is another hill, Carn Fach, or Carn Fadrin of the map. It is similar to that of the Llanbedrog mass, but of a pale, quite light-grey colour, and compact ground; ferruginous spots in it are signs of decomposition. It is impossible to obtain a perfectly unweathered specimen; with the hand lens some of the felspars are seen to be triclinic.

The shales round this hill are noticed as being fossiliferous [Survey Memoirs, vol. iii. (ed. 2), p. 218]. Under the microscope the ground is found to be microcrystalline, consisting of minute quartz and turbid felspar grains. It is difficult to be certain that there is no amorphous matter among the granulated products of felspar decomposition, but there can be but little. The separate felspar crystals are chiefly plagioclase, often in groups set at various angles to each other, and much decomposed. They are fairly riddled frequently with branching veins of ferric oxide ramifying through them; larger ferric patches are abundant in the ground, and the veins often proceed from them, but minute specks are scattered throughout the ground; some opaque patches are perhaps limonite. Calcite occurs as decomposition product. Apatite is not abundant, but is inclosed in felspar. Notwithstanding the quantity of plagioclase, we may put this rock among the felsites; bisilicates seem absent.

East of these two detached hills is a large area of igneous rocks, also with them mapped as Arvonian by Dr. Hicks. Two specimens from the Nanhoron quarries in this tract, collected by Dr. Hicks, have been already described by Professor Bonney [*l.c.* p. 306] as intrusive types. From a look at the area between Llanbedrog and Llanfihangel Bachellaeth I find the rock to be orthoclase-felsite for the most part. At the top of Y Foel Fawr the rock has a darkish-grey ground with not many separate felspars; at Mynydd Manetho it is much the same as at Llanbedrog, viz. a greyish felsite with abundant felspars, with ferruginous spots from decomposition.

Ascending Carn Neddol, the rock is here Orthoclase-felsite, the ground being paler and rather closer in texture. There is an irregular columnar appearance in the rock produced by cross joints at small intervals. A thin slice under the microscope shows that the black spots 2–3 mm. across are coloured by viridite and ferruginous material, and represent perhaps pyroxene; no cleavage, etc., is however preserved. The felspar is orthoclase, and is more or less minutely streaky, as if permeated by another felspar not extinguishing at the same time. One small quartz crystal in the slice. The ground is microfelsitic for the most part, but in places is microcrystalline with some imperfect spherulites.

At the village called Pig Street, near Llanbedrog, is a quarry, of which the rock looks like a coarse tuff (ash) made up of felsite fragments. These fragments are of different colours, their outlines stand out quite sharply in places; they seem all of the same type of rock, but of redder colour, while the paste contains scattered felspars, etc., so as to have much the same appearance as the included fragments. An exposure of the rock a few score of paces away shows merely scattered included portions of different colour, and may perhaps not belong to this tuff. A thin slice from the quarry near the old windmill, Pig Street, confirms the conclusions drawn from the inspection of the rock *in situ.* Some of the included fragments look like porphyrite of dark red colour, others are felsite containing spherulites; the fragments of felspar are often triclinic, and are surrounded by dark red ground, almost opaque, from colouring by iron oxides, and serving to make the outlines of the fragments very distinct. This is not the only case in Lleyn of ash, as bedded ash has been already mentioned at Pwllheli by Sir A. C. Ramsay, in the Survey Memoir on N. Wales [p. 207, ed. 2].

The southern point on the sea-coast at Foxhall, Llanbedrog, is a pale grey orthoclase-felsite, with dull white felspars about 4 mm. diameter, with ochry centres due to decomposition [Sedgw. Coll. p. 107]. The microscope shows a micropegmatitic structure very prevalent in in the ground; the minute quartz grains in the ground contain fluid inclusions, some with spontaneously moving bubbles. The larger felspars are chiefly orthoclase, but some plagioclase is present; patches of dark-brown iron oxide and secondary epidote crystals are results of decomposition.

Though unable to offer any proof of the age of irruption of these igneous masses, or of the relation of the ash, etc., to the Cambrian beds of the district, I scarcely think that Dr. Hicks's view of their Pre-Cambrian age is probable; their similar position to that of the rocks mentioned above as intrusive among Cambrian shales renders it at least desirable that some evidence should be brought forward to show why the results of the Geological Survey are not to be received; till this is done one had best adopt the most natural solution of the structure of the country, viz. that offered by Sir A. C. Ramsay in the Survey Memoir on N. Wales.

To the north-east of Madryn are some peculiar sedimentary beds, viz. those seen in the road-cutting where Y Gledrydd stands on the map. Here is a whitey-brown thick-bedded felspathic rock inclosed between olive-green indurated beds, with ochry and grey shales, grits and conchoidal marls. The felspathic bed exhibits felspar crystals averaging 1 mm. in length. Under the microscope it is seen to consist of rounded quartz grains, angular fragments of felspar, others dull grains of whitish-yellow felsite; spherulitic portions in the ground seem also derived, but the outlines are not always distinct from the interstitial felspathic ground.

One would suspect this bed to be a fine-grained tuff connected with some of the adjacent igneous rocks. I had no opportunity to trace these beds, which are so different from the ordinary shale of the district; it would be, I fear, a difficult task, as exposures seem so scarce. No fossils were seen here.

V.—Traces of a Great Post-Glacial Flood.

5. Evidence of the Marine Drift.

By Henry H. Howorth, F.S.A.

(*Continued from page* 16.)

WHAT is the burden of all these facts? Why, assuredly that the shells found in our higher marine drifts, or at least in nearly all of them, far from bespeaking conditions of climate such as can alone be fairly described as Glacial, on the contrary, speak to us of a time when the general temperature was perhaps somewhat lower than it is now, but when the North Sea and North Atlantic were filled with open water, and bathed a land where the Mammoth and the Rhinoceros could find abundant food, where the Oak and the Pine flourished, and where the rivers could sustain such molluscs as the *Cyrena fluminalis.* This conclusion destroys at once the basis of those who have argued that our high-level marine drifts were left where they are found by ice—either by floating bergs or a creeping ice-foot. But apart from the general conclusion which the particular collocation of shells enables us to make, quite a number of facts may be collected going to show the impossibility of ice having been the motive power which deposited such beds as those at Moel Tryfaen.

Icebergs, if they ground, naturally crush to powder such fragile things as a great many shells are. This is a perfectly obvious *à priori* criticism, but it is abundantly supported. Dr. Robert Brown, in describing the life near the ice fiords of Greenland, says, "In the immediate vicinity of the Jakobshavn ice fiord (and I take it as a type of the whole) animals living on the bottom were rare, except on the immediate shore, or in deep water; for the bergs grazed the bottom in moderately deep water to such an extent as almost to destroy animal and vegetable life rooted to the bottom. In this vicinity bunches of Algæ were floating about, uprooted by the grounding bergs, and the dredge brought up so little material for the zoologist's examination that unless in deep water his time was almost thrown away (Journ. Geol. Soc. vol. xxvi. p. 688). . . . . Again, in shallow inlets, except for Crustacea and other free-swimming animals, the bottom continually disturbed by the dropping of moraines or the ploughing up of bergs, would be unfavourable for life" (*id.*). It is, indeed, quite obvious that no icebergs could pass over ground containing shells without reducing them to powder; yet without passing along the bottom or grounding, how are they to collect the shells? Again, speaking of the shells from various zones found together, Mr. Mellard Reade well says, "Had the confusion (*i.e.* the confusion of the shells) been due to the ploughing up of icebergs, as suggested by Forbes, the disturbance at each stage of subsidence would not have reached beyond a certain depth below the surface of the sea, and all below that depth would have been free" (Journ. Geol. Soc. vol. xxx. p. 32). It must be remembered that the shells found in the high-level marine drifts are not *in situ* as they were when living, but are, as we shall show presently, a mixed assemblage of littoral and deep-water shells. They would need, therefore, to be collected together; how could icebergs perform this task? Why, again, should icebergs leave them in such isolated positions as we now find them? What special reason why Vale Royal and Moel Tryfaen should be selected for them to discharge their loads? The fact is, the position is not arguable. Let us now turn from icebergs to ice in another form, to the creeping of the foot of a vast ice-cap filling the British seas, which it has been gravely urged might have pushed these marine beds into their present position. This theory was, I believe, first pressed by Dr. Croll, and the view is concisely stated by one of its supporters, Mr. Tiddeman, who says: "It is a point insisted on by some geologists, that wherever rolled stones or marine shells are found in the Boulder-clay, it must be of marine origin. I do not think either of these characters is infallible. Mr. Croll has shown that the Caithness Till, which contains shells, need not necessarily be marine, but may have been formed by the ice-sheet working over a previous sea-bed, and pushing the shells on to the land. In this way shells scratched and broken may be found at very much higher levels than the sea in which they lived and died. They are as much boulders as the scratched stones alongside of them, and are no more evidence of the drift in which they lie having been formed under the sea than Spirifers and Producti found in limestone river gravel would be proof of its being marine. In very many places the ice-sheet must have passed over what had previously been the sea-bed, and if its course took it thence inland, we should be surprised not to find sea-shells mixed with the drift formed by it" (Journ. Geol. Soc. vol. xxviii. p. 471.)

Mr. Belt has adopted the same view. Thus he says of the shells at Moel Tryfaen: "They are just where they ought to be found, on the supposition that an immense body of ice coming down from Northern Ireland, from Scotland, and from Cumberland and Westmoreland, filled the basin of the Irish Sea, scooped out the sand with the shells that had lived and died there, and thrust them far up amongst the Welsh hills that opposed its course southward and around the great height of which Liverpool forms the apex" (*Nature*, vol. x. p. 26).

In regard to this theory, one can hardly approach it seriously. Where, in glaciated regions like Greenland, do we find the ice being thrust up into the country from the sea in this fashion to the extent of 1400 feet? How could molluscs live at all in a sea occupied by such an ice-sheet which was scouring the bottom? How could very delicate shells be found entire and unbroken, as Mr. Etheridge affirms they were, at Moel Tryfaen (Geol. Journ. vol. xxxvi. p. 355), after such a journey and under the foot of such a crushing mass? How could the shells from various depths and habitats be brought together just at one spot in this fashion? How could they live along shores lined with immense masses of ground ice engaged in making boulders and boulder-clay? For most of these shells are not deep-sea species, but lived in shallow water. Thus Forbes, speaking of the genera *Littorina, Purpura, Patella,* and *Lacuna,* says they "definitely indicate not merely shallow water, but in the first three cases a shore-line. . . . All the forms of *Littorina* live only at *water-mark* or between tides" (*id.* p. 370). Forbes then goes on to show that the absence of deep-sea forms proves that the waters in which these shells lived were shallow. "We find no traces," he says, "of the great *Oculina prolifera,* still living in the depths of the Zetland Seas and off the coast of Norway; nor of the characteristic *Turbinolia, Cariophylleæ, Celleporæ,* and smaller corals; nor of the great northern Asteroids, such as *Primnoa lepadifera* and *Alcyonium arboreum,* which, from their gigantic size, being equal in dimensions to small trees, would certainly have left some evidence of their existence behind. Instead of these, we get an association of species, which, if we proceed sufficiently far north, we may still find living in the shallows of colder seas. . . . So far as I have seen, there is no British case of an upheaved stratum of the glacial formation containing organic remains evidently untransported which may not have been formed at a less depth than 25 fathoms, and as the *Millepora* occasionally occurs in the deeper beds, to which belong most of the clays and marls, it is probable that between 10 and 15 fathoms would more frequently approach the truth" (*id.* p. 376). How could littoral shells live if the coast was lined with an ice-sheet, or if ice existed there on the scale that Ross found it in the Antarctic Sea?

I might go on with my comments, but I prefer to conclude with some observations of Prof. Bonney, who has put this view, as it seems to me, *hors de combat* in some characteristically incisive phrases: "Apart," he says, "from the difficulties of a glacier thus walking so far up-hill, and of shells having escaped utter smashing in this uncomfortable mode of transport, Mr. Belt has forgotten that Wales was a centre from which radiated glaciers, and at one time an ice-sheet, which surely would have warded off from its own hills the northern intruder" (*Nature,* x.). Again, he says, "Mr. Belt appears to forget that shells have been found not only at Moel Tryfaen, but also near Llyn Ffynnon-y-gwas, about two miles west of the peaks of Snowdon. Does Mr. Belt mean to say that Snowdon could not protect itself in the heart of its own domain better than this? If the lake mountains had an ice-sheet, surely Snowdonia." "I think it in the highest degree improbable that the Vale Royal shells could be brought to their present position (more than 1100 feet above the sea) by any ice-sheet without the cold being enough to cover *all* the higher ground in Britain with ice, and so protect it." Again, "My contention was that the enormous force which would be exerted on beds scooped out as described and shoved some 1500 feet up-hill for miles over broken ground would crush the shells to a far more comminuted state than they are now in" (*id.* p. 85). Mr. A. H. Green adds to these arguments that the shell-bearing drift gravels are stratified: "I can speak," he says, "to those in the neighbourhood of Macclesfield, which run up to 1100 feet above the sea, being also very delicately current-laminated. I am puzzled to imagine how this structure could be obtained, if the gravels were brought to their present position in the way Mr. Belt supposes; indeed, its presence seems to me fatal to his hypothesis" (*id.* p. 105).

Lastly, as Mr. Macintosh says, "An intimate acquaintance with the character of the Moel Tryfaen deposits precludes the idea that all the shells, together with the erratic stones, were pushed out of the beds of the Irish Sea as far south as Moel Tryfaen; for, if it were a true explanation, the shells and erratic stones would have diminished in number the higher up they were pushed. But, on the contrary, the shells and erratics in the drifts near the sea are fewer in number than on Moel Tryfaen. This theory would likewise require to invest the land-ice with the power of rounding the pebbles derived from the upper part of the hill, and laminating the sand and fine gravel; for it ought to be remembered that though the sand and gravel are, in places, much contorted on Moel Tryfaen, the contortion was evidently in many instances produced after their accumulation" (Journ. Geol. Soc. vol. xxxvii. p. 351). The same experienced geologist again says: "The idea of shell fragments having been pushed up-hill along with portions of existing sea-beds is opposed by so many facts as to render it altogether untenable" (*id.* vol. xxxviii. p. 195).

Having decided that ice has had no part in the transport or deposit of the Marine Drift, we must now go elsewhere, and we naturally turn to the theory which has the support of a large number of geologists, and which may be said to be the dominant theory. This accepts the beds of marine drift which occur at the height of several hundred feet in several localities in England and elsewhere as evidence that the land was submerged *for a considerable time*, at least to that depth when the beds were deposited, and thus invokes a gigantic oscillation of the earth's crust to the extent of at least 1400 feet down and up again, in order to account for these sporadic deposits. The actual conclusions based on the premiss are so enormous and so striking, that it is well to quote them in the words of a typical supporter of the theory, and we can find none better for the purpose than Sir Charles Lyell himself. The following paragraph occurs in his Antiquity of Man (pp. 334-5): "The submergence of Wales to the extent of 1400 feet, as proved by glacial shells, would require 56,000 years, at the rate of 2½ feet per century; but taking Professor Ramsay's estimate of 800 feet more, that depression being implied by the position of some of the stratified drift, we must demand an additional period of 32,000 years, amounting in all to 88,000; and the same time would be required for the re-elevation of the tract to its present height. But if the land rose in the second continental period as much as 600 feet above its present level, as in map, p. 328, this 600 feet, first of rising, then of sinking, would require 48,000 years more; the whole of the grand oscillation, comprising the submergence and re-emergence, having taken about 224,000 years for its completion; and this, even if there were no pause or stationary period, when the downward movement ceased, and before it was converted into an upward one." Here assuredly we have abundant matter to arrest attention, and even to take away our breath. Here we have the great apostle of Uniformity, at whose feet the modern school of geology in England sits, postulating a movement of a vast extent, covering a very huge period, and basing his calculations on purely hypothetical grounds. So far as we know, this part of the world is now stationary. So far as we know, it has remained stationary at least since Roman times. There is no evidence whatever of any gradual movement going on at present either up or down, while the submerged forests show that the last movement on these Western coasts was downwards, not upwards; and yet the argument is used by one who will not have any appeals to forces not in progress now, and not only so, but we also have an elaborate calculation as to the rate of movements based literally, so far as we can judge, upon no data whatever. But let us proceed. It is not England alone to which the main argument is applied. Speaking of Ireland, and of the fact that marine shell-beds have been found there to a height of 1000 to 1200 feet above the sea-level, Sir Charles Lyell says: "The great elevation of these shells, and the still greater height to which the rocks in the mountainous regions of Ireland have been smoothed and striated, has led geologists to the opinion that that island was in great part submerged during a portion of the Glacial period." The same arguments would apply to Scandinavia. Now it will be granted that before we accept the gigantic figures presented to us by Sir Charles Lyell, we ought to inquire very carefully whether the cause he appeals to is competent to explain the facts.

The first thing that strikes a critic at once is the extremely local character of these high-level marine drifts. They are found in isolated places, and only found also in places bordering on the present sea. This very important factor in the problem has not escaped Sir Charles Lyell. Speaking of the shell-beds at Moel Tryfaen and those in Vale Royal, he says: "The two localities are about eighty miles distant from each other in a straight line, and the Vale Royal shelly drift is near the watershed of the centre of England. Intermediate between these points there are areas varying greatly in height above the sea, composed of every description of rock, sometimes covered with drift, but often free from it, and where proofs of marine submergence are entirely wanting. These have been surveyed with such care, that, but for the occasional patches before mentioned, in which the shelly remains occur, a geologist who relied on negative evidence might have confidently affirmed that the land had not been covered during the formation of the drift by salt water (*Antiquity of Man*, p. 318). But this is looking at the difficulty through the wrong end of the telescope, which only minimizes it exceedingly. If w· are to gauge its real proportions, we must go much further afield. We must inquire how it is that these drifts with shells are not found in the interior of Great Britain, and only in isolated patches along the shore. Surely if the land were generally submerged, as is generally assumed, even for a comparatively short time only, we should find shell-beds in various parts of England, and not merely in the Severn Valley and on points near the coast. "Mr. Trimmer, who devoted much attention to the superficial accumulations of England, and sought to explain them chiefly by the action of the seas and floating-ice, was yet unable to overlook the remarkable fact that there is a general absence of marine remains and of regular beds of these remains, in what he termed the upper erratics, not only in Norfolk, which he had specially studied, but also in every district of England, Wales and Ireland he had examined" (Jamieson, Journ. Geol. Soc. vol. xxx. p. 320).

In regard to this absence, Mr. Geikie says: "If arctic shelly clays ever occurred in as thick beds in the inland as in the maritime districts, surely we should have found some notable trace of them. It will not do to lay the blame of their disappearance on that geological scapegoat *denudation.* Denudation has not run off with the Kames. Why should it have been less considerate with the clays? The Kames have come down to us almost, if not quite, in the same state as the sea-god left them; but if shelly clays ever existed in the interior parts of the country, they would appear to have vanished, and left not a wreck behind. If it was in Scotland only where the marine shell clays were confined to the maritime districts, there might be some excuse for dragging in denudation to account for their absence at the higher levels reached by the Kame drift, but in Norway and Labrador and Maine the shelly clays are restricted precisely as in Scotland to the vicinity of the sea-coast" (Geol. Mag. Vol. IX. p. 28).

Mr. Reade says: "It is a striking fact that though the whole of the Pennine chain has been under water, only at one place, near Macclesfield, 1200 feet above the sea, have marine shells been found, and those mostly fragmentary. The same with Wales, the same with the lake district; these organic evidences of subsidences are only sporadic" (Trans. Geol. Soc. Glasgow, p. 275).

Another argument has been used effectively by Mr. Belt in the following sentence, in which, although he has somewhat minimized the proportion of unbroken shells in the drifts, of which a few certainly occur, yet the main contention seems to me most just. "Where," he says, "was the shore of that mythical sea under which England nearly to the Thames is supposed to have been submerged? How is it that not a single undisturbed bed of Glacial shells has been found, that nearly all are broken to pieces, that many fragments of *Cyprina* exhibit Glacial scratchings (scratchings certainly, but assuredly not Glacial, H. H. H.), and that not a single instance has been recorded of the two valves of a Lamellibranch having been found together? Was there no friendly cliff or cavern able to preserve a single shell from the ruthless second advance of the ice? Mr. James Geikie finds the fragile bones of water rats and frogs in his 'interglacial' beds, and uninjured land and fresh-water shells occur in abundance, but not one marine shell has been found in the uplands that does not show proof of having been transported, by being broken, worn or scratched" (Nature, vol. x. p. 63).

What is true of England is also true of Ireland.

Mr. Bell, speaking of Ireland, says: "The greater part of the country is covered with drift, local in its origin," and adds, "It is singular that no fossils have been noticed in the gravels of so great a part of Ireland. A few *Mytili* in Sligo, a *Buccinum* in Moate, Co. Westmeath, and a few fragments in Tipperary, appear to be all that have been seen." Yet "at Boreragh, in Derry, the clay rises to a height of 1150 feet above the sea, and contains many fossils of few species. These are *Turritella terebra, Cyprina,* and *Leda oblonga*" (Geol. Mag. Vol. X. pp. 448–9).

Ireland, therefore, shares with England in having the greatest part of its surface free from traces of marine organisms. But this again is only a small part of our problem. How comes it that no marine shells, except near the coast, are found in the drifts of the continent? How is it that they should be universally barren, except on the shores of Scandinavia? Here Mr. Belt has made some very judicious observations: "Excepting around the northern border of the Baltic," he says, "and just so far as, and no farther than, the Scandinavian glaciers reached and carried up fragmentary shells from the arms of the sea they had crossed, the northern drift does not contain sea-shells or any other marine organism. For thousands of square miles, south of the irregular line I have indicated, up to and around the Carpathians, the northern drift is spread out, and not a trace of marine life, not even a diatom, has been recorded from it, while at its base, between the Oder and the Elbe, freshwater shells abound. To believe that Europe gradually sank down below the level of the sea until the latter had its shore-line more than 1000 feet up the flanks of the mountains, and that it rose again without the sea leaving behind it any traces of life excepting freshwater shells, is such an extreme hypothesis, and so contrary to all we know respecting the composition of existing sea-bottoms, that it is probable that its present acceptance is simply a survival from the time when there was no other way of explaining the existence of water up to such a height. . . . There is much evidence to show that vast continental areas were never below the sea-level from the close of the Palæozoic period up to the end of the Tertiary period. Yet after this stability of surface over such an immense period of time no hesitation is felt, in the comparatively insignificant Glacial period, in sending the surface of the land thousands of feet higher that ice may accumulate on the now low ranges, and thousands of feet lower, that icebergs may float over the submerged lands; and no difficulty is experienced in believing that it should finish its wonderful oscillations by regaining the level it had before the Glacial period commenced. It seems a burlesque on science that such theories should be prevalent amongst our geologists, and if they were not held by philosophers, they would be ridiculed as unphilosophical. Those who advocate the former existence of these oscillations of the surface are those who urge that we should not call in the aid of any but existing agencies; yet where do they now find a shore-less and a shell-less sea? Put down a dredge anywhere in the ocean within depths of less than 2000 feet, and in the small quantity of clay, mud, sand, or gravel scraped up, it will be scarcely possible to take out a teacupful that shall not teem with marine organisms; yet we are taught that an immense area in Europe and America has been a sea-bottom, and every part of it a sea-beach as the land rose again, without any existence of marine life having been left behind" (Quart. Journ. of Science, vol. vii. pp. 82–83). This admirable passage, as it seems to me, is conclusive, but I will supplement it by another by the same talented author, the value of whose ingenious work has not been sufficiently recognized. In this case he refers to Siberia, which is so continuous in regard to its physical aspects with the great plains of Russia, that it is hardly credible the latter should have been submerged for any length of time beneath the sea without it also having been subjected to the same influence. In answer to Professor Bernhard von Cotta, who postulated a submarine origin for the surface of Siberia, Mr. Belt says, "I believe that the absence of sea-shells is fatal to the marine theory: I searched diligently for them and could find none; and excepting in the extreme north, around the present coast, I believe none have been found by other observers. The mollusca exist all over the present ocean; they abound around Greenland even within a short distance of the foot of the great glaciers. I do not contend that the presence of shells of *Cyrena fluminalis* is a proof that the waters in which the sands were deposited were not marine, as they might have been (and I believe were) brought down by streams from the south; but their preservation in the sands proves that marine shells did not exist there, or their remains would also be found. I have worked most of the coasts of the world, and dredged in northern waters, and everywhere found marine molluscs to abound, and I believe that the absence of sea-shells in any Tertiary or Post-Tertiary strata, excepting in some muddy deposits in which they could not well live, is a proof that these strata were not deposited in the great ocean" (Journ. Geol. Soc. vol. xxx. p. 495).

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—On the Orbitoidal Strata near Auspitz, Moravia. By M. A. Rzehak. [Proceed. Imp. Geol. Instit. Vienna, July 31, 1882.] (Communicated by Count Marschall, F.C.G.S., etc.)

THE prevailing deposits are soft sandstones and blue marls, distinctly stratified, and resting on menilitic shales. The marls include in one locality remains of *Meletta*, and in another some few Foraminifera, probably referable to a late Oligocene horizon ("Tongrian-Aquitanian"). A deposit lithologically and chronologically distinct from the "soft sandstones" appears on the Steinberg and on the south slope of the Haidenberg. It is a highly calcareous sandstone, with intermediate conglomerates, including fragments of crystalline, massive, and schistose rocks, and with occasional layers of green clay containing Foraminifera, on the whole of older Oligocene type. A fine-grained bed of the sandstone contains Foraminifera, including a large *Dentalina*, possibly *Dentalina Herculea*, Gümbel, a "Nummulitic" form. Other organic remains in the sandstone are fragments of Shells, Corals, Polyzoa, and rarely teeth of Squalidæ. Nummulite-like shells are very frequent in some strata. These lenticular shells, beset with small tubercules, are *Orbitoides*. They are identical with, or, at least, very near to *Orbitoides aspera*, Gümbel; and equal in size to those from the Buda Marls, though smaller than the Bavarian specimens. These Orbitoidal beds are evidently the most ancient member of the Tertiaries in the Auspitz district, being coeval, isotopic, and partly isopic, with those of Kirchberg, in Lower Austria, and of Stokerau, north of Vienna. They are of the same age as the upper strata of Priabona, and Hoffmann's "Orbitoidal Horizon" in Hungary.

The Foraminiferal clay of Rikolschiz is, in some respects, allied to that of the Hungarian Middle Oligocene (*Clavulina Szaboi* beds). Their Foraminiferal fauna, especially the *Orbitoides*, imparts to them more of the "Alpine" than of the "Carpathian" types. Possibly, together with the analogous Hungarian deposits, they may constitute a special geological province, connecting the "Alpine" with the "Carpathian Sandstone Zone."

II.—Glacial Sections at York, and their Relation to other Deposits. By J. Edmund Clark. [Geol. and Polytechnic Soc. W. Riding of Yorks, vol. vii. pp. 421–439.]

IN this paper details are given of a number of sections of Glacial and Alluvial deposits in the neighbourhood of York. The occurrence of *Ursus spelœus* (identified by Mr. W. Davies, F.G.S.) in the valley gravel appears to be the first record of a carnivorous mammal in this deposit near York. Mr. Clark mentions that in the deposits at Overton, Mammoth, Hippopotamus, etc., have been found.

REVIEWS.

I.—Textbook of Geology. By Archibald Geikie, F.R.S., LL.D., Director-General of the Geological Survey of Great Britain and Ireland. (London: Macmillan & Co., 1882.)

(*Continued from p.* 42.)

IN the body of his work Dr. Geikie arranges his subject-matter under the following heads: 1. The Cosmical Aspects of Geology. 2. Geognosy. 3. Dynamical Geology. 4. Structural Geology. 5. Palæontological Geology. 6. Stratigraphical Geology. 7. Physiographical Geology. Thus, in his mode of presentation of the subject, the author has, either with unconscious natural proclivity, or with well-considered art, selected that especial method of treatment which of all others commends his work to the prejudices of educated men in general, and he repeats in his plan the natural method of history itself. Feeling, doubtless, how incapable are the unimaginative and inelastic ideas of the old empirical school of British geology, of popular and artistic treatment, he deliberately cuts himself adrift from its society at the outset, and sails triumphantly away into the ranks of the new cosmologists. He points out how, in the infancy of the science, men commenced the study of geology by the adoption of some fanciful hypothesis of the origin of our planet, or of the universe, of which it is a part. He gracefully acknowledges that, thanks to the teaching of the illustrious Hutton and to the labours of the Geological Society of London, geologists learnt that it is no part of the province of their science to discuss the origin of things. But in this the Doctor sees nothing more than a very natural reaction. He owns that geology is never likely to discover even so much as a fragment of the first crust of the earth. But if geology has not yet attempted a cosmology, other sciences have done so. The average mind, he seems to imply, naturally desires a cosmology, and we must provide one.

Founding upon the nebular hypothesis of Kant and Laplace, the author therefore gradually developes, before the eyes of the reader, a consistent scheme of earth-evolution, buttressing every stage either with acknowledged facts, or with authoritative theories gathered from the most recent literature in speculative physics, chemistry, and astronomy. The manifold mathematical and physical conclusions of Sir W. Thomson, the latest guesses of Mr. Lockyer, the tidal hypotheses of Mr. G. F. Darwin, and the attractive speculations of Dr. Croll, are all laid under contribution. Interspersed with numerous and well-selected astronomical or physical facts, these are employed by the author as factors of almost equal value with the latter in the construction of an introductory cosmical section of wonderful symmetry and plausibility. It is impossible for the reader to refuse his admiration of the skill which could thus group such heterogeneous elements into so complete and consistent a whole. It is graceful and harmonious as a rainbow, and destined, alas! by the very nature of things to be almost equally evanescent. But, aerial as it is, it serves several purposes. It permits of the grouping of the more imposing points in the forefront of the book. It appeals to the intellect and imagination of the educated reader, and that upon his most vulnerable side, and compels his keen interest in the subject at the very commencement.

In the second division of the volume (Book II.) the author treats of the fully developed earth of the present; here, as everywhere throughout the work, following invariably the same order in his descriptions;—proceeding from the general to the special, from without, inwards. In the first section of this Book, he carries the reader in imagination through the outer coverings of air, water, and visible earth-crust, until he stands with him once more peering curiously into the mists of recent speculation respecting the actual state of the earth's interior. Nearly one-half of this sub-section is devoted to the discussion of the various theories hitherto advanced as to subterranean heat and pressure, and the probable extent of geological time. The diverse results of Hopkins, Delaunay, Thomson, Mallet, Darwin, and Fisher, are all passed in review. One can hardly avoid the inference that the author has a leaning towards the views of the Scottish authorities, and one would personally have preferred a much fuller treatment of the views of Fisher and Le Conte; but upon the whole this sub-section is the best summary of opinion we actually possess.

The second section of the Book (Book II. Part 2) is devoted to a description of the minerals and rocks which constitute the accessible earth-crust. From beginning to end of this part we feel that we are in the presence of a master of his subject, one who is familiar with every stage, and knows how to smooth over every difficulty. After a brief glance at the main chemical rock-forming elements, the author passes on rapidly to the chief rock-forming minerals, giving just such descriptions as are generally capable of verification by hand-specimens, and carefully avoiding all mineralogical terms but such as are actually necessary. While we heartily sympathize with him in his avoidance of long definitions of crystalline forms, we can hardly help regretting that at least a short sketch of the chief crystalline types and their major derivatives had been inserted for the benefit of those private students of the science who have no leisure to follow out a complete mineralogical course, and to whom, as a consequence, many of the definitions on pages 63 to 85 will be partly incomprehensible.

To the sub-section which follows (Sect. IV.) treating chiefly of the microscopic characters of rocks, and which is essentially a new feature in geological text-books, no exception can be taken; it is excellent throughout.

But in the next section (Section V.), which is devoted to lithology, it does not appear to us that the Author is quite so successful. He classifies rocks under the two main heads—crystalline and clastic, dividing the former into stratified, foliated, and massive; and the latter into sands, clays, tuffs, and fragmental organic rocks. As a consequence of this arrangement, compact limestone finds a place at one end of the entire rock-series, and chalk almost at the other;

quartzite, under one form or another, makes several distinct appearances; clay-slate and shale are divided from each other by the entire group of volcanic rocks; and so on. Surely the old-fashioned arrangement of rocks into aqueous, igneous, and metamorphic was much more manageable than this; and it is hardly likely that such a thorough-going believer in the power of metamorphism as Dr. Geikie would have found any insurmountable difficulty in classifying the individuals in his major groups according to their degree of alteration, and making them teach the special lesson which it is clear he desires them to convey.

The third division (Book III.) of the volume is devoted to an account of the agencies at present engaged in geological evolution. These agencies are classed as hypogene and epigene, and the subject is treated with an exhaustiveness that leaves nothing to be desired. Geologists have long been aware of the interest Dr. Geikie has taken in this special branch of his science, but we were hardly prepared for such a masterly command of the entire subject as he has developed in these pages. In selection and arrangement of material, in sequence and proportion, this section appears to us to leave everything hitherto attempted in geological text-books in this special department far behind. Every conspicuous fact and conclusion having a geological bearing hitherto published has its proper place in the compilation. It covers the ground embraced generally within the limits of Lyell's "Principles," and bespeaks an enthusiastic student of that immortal work. But the student has now become a master in his turn and has his own story to tell: and admirably he tells it. Every word falls with its proper weight and has its due effect.

Having fully discussed the great earth-crust-builders and sculptors, Dr. Geikie next takes the reader to the study of the architecture of the great building itself, and treats in succession of the phenomena of stratification, fracture, protrusion, and metamorphism. As a whole this section is most extended and complete; but it is very unequal in parts, and when contrasted with the foregoing sections appears to us to be most decidedly inferior. For the unavoidable drudgery of mapping and sectioning the author appears to have lost much of his former zest. Some instructive examples of inversion are inserted from Heim's magnificent memoir, but we trust that in a future edition we shall see corresponding examples from British localities. They are plentiful enough in some areas in our islands, and display almost every phenomenon illustrated by Heim.

In his description of intrusive and volcanic rocks, however, Dr. Geikie is himself again, and both in description and illustration the paragraphs are admirable.

But it is in the sub-section upon metamorphism that the author's interest becomes fully aroused. He very carefully distinguishes between *local* and *regional* metamorphism, tracing the effects of the former, by means of well-authenticated examples stage by stage until he demonstrates the possible transformation of ordinary clastic into actual crystalline rocks. But where he treats of regional metamorphism his arguments are much weaker, and some of them will have no weight whatever with many British geologists. In effect, so far as Britain is concerned, his argument rests largely upon the asserted fact that the Highland metamorphic rocks of the north-west of Sutherland and Ross "demonstrably overlie fossiliferous Lower Silurian rocks." Now we are not among those who deny the possibility of the transformation of aqueous into crystalline rocks by means of regional metamorphism, or the probability that altered equivalents of some of the S. Scottish Silurian rocks do actually occur in the Highland region. But we so distinctly believe the fact that the truly metamorphic rocks of the north-west do *not* overlie and follow the fossil-bearing rocks in natural sequence can be so fully proved in the field, that we feel this threadbare argument ought soon to wholly disappear from the controversy. We hope that the timid little section on page 584 of Dr. Geikie's work, by which this specious, but moribund, view is illustrated, is destined to be the last of its race to be pressed into this unnatural service.

The fifth section of the work (Book V.), on Palæontological Geology, may be looked upon as an introduction to the purely stratigraphical and theoretical division of the subject. It contains some well-considered paragraphs, but the author chafes visibly under the curb imposed by the doctrine of geological contemporaneity; and the instinct of self-preservation leads him to make much of the handy theory of colonies—that convenient refuge for the stratigraphic destitute. He parallels the famous colonies of Bohemia with the well-known fossil-bearing bands in the Silurian of South Scotland. We believe this comparison to be the best that could be made. In both areas the disputed successions are founded upon corresponding appearances, and in both cases the belief in the orthodox view is probably destined soon to be confined solely to its authors. Both are, however, valuable warnings, with which the future student of historical geology could ill afford to dispense. One is the fruit of palæontology without stratigraphy—the other of stratigraphy without palæontology.

In Book VI. we enter upon the subject of Historical Geology itself. Although the author is careful to impress the student with the fact that this is unquestionably the highest branch of the science, yet it is evident enough that, in his own eyes, as in those of the vast majority of modern physical geologists in sympathy with him, it has rather the appearance of an oppressive nightmare of piles of undigestible facts and meaningless strings of names. Since the death of Edward Forbes, the breath of British genius has never swept over this valley of dry bones, and the man has yet to arise who shall summon them again into life, and demand from them the final solution of the great riddle of evolution, which the patient embryologists and dreamy cosmogonists of the present are vainly seeking for elsewhere. These facts in themselves have clearly little attraction for the author, except in so far as they are connected with his own life-work and with former supposed phases of earth development. For the purely palæontological department of the subject, he does not attempt to disguise his own want of sympathy. On the stratigraphical side he generally coincides with the majority of the day.

Nevertheless he has compiled a section of some 300 pages on palæontological and historical geology, which for extent and completeness is unequalled by anything yet published in Britain. Among the older rocks he is heavily handicapped by his intense anxiety to defend the peculiar position he has adopted with respect to the age of the Metamorphic rocks of the Highlands, and the sequence in the Southern Uplands, and by his amusing reluctance to admit that any British-born subject who has not been, or is not, a member of H. M. Geological Survey, can possibly produce anything worthy of notice in Geology. But when he once gets fairly out of the Silurian maze, his work is excellent. Every system in the ascending scale is described as a whole, the essential features of its rocks, and its special life types. Next, the local variations in its rock formations are noticed in order, commencing with Britain, and passing thence to Europe, America, Asia and Australia. Every page bears the impress of intense labour and care. No pains appear to have been spared to make the section a complete summary of our present knowledge of the subject, and the student of comparative geology will find it an excellent work of reference, easy of search, and as a general rule thoroughly reliable.

Finally, we have a comparatively brief section (Book VII.) restricted to the discussion of the evolution of the present land and water contour, or—as the author prefers to call it—to Physiographical Geology. This is merely a short summary of the broader facts and of the accepted theories of elevation and denudation, and is very modest and temperate in tone throughout.

Looking back over the work as a whole, we see no reason for modifying the opinion expressed in the earlier paragraphs of this notice. Dr. Geikie's "Handbook" is the most readable and complete work upon the entire subject yet issued to the public, and will prove of great value not only to the earnest student, but to all who are interested in the science of geology. To the practised geologist it has an especial value, from the fact that it is a very accurate presentation of what may be called the prevalent shade of geological opinion in Britain. It is an exponent of the ideas of that increasing number of geologists, who, whatever may be their professed tenets, unquestionably act and live as if the study of the materials and outward aspect of the great earth-building were the be-all and the end-all in geology. The moral the non-geological reader is certain to draw from a first perusal of the work is that while the study of rock-specimens and of the effects of geological agencies demands and is worthy of the life-long devotion of the geologist, and that at the last he is but a simple student, whose accumulated knowledge is but the merest fraction of the great sum of truth; yet, in the domain of historical and palæontological geology, any one who can take a dip or a strike, or can make a rough identification of a fossil from some standard monograph, is as good as the best. In the physical half of the work the author is himself a student among students, all aglow with interest and enthusiasm, so full of his subject, and so anxious for light and knowledge, as to be able to recognize at a glance the import and value of the work of others, and willing to allow that the humblest observer may arrive at a part of the truth. In the stratigraphical half his interest is less living and personal, and his work occasionally becomes perfunctory, didactic and defensive. His official position as Director-General of the Geological Survey, and the traditions of his school, forbid his calm presentation of the views of all sections, and force him into the position of an exponent and apologist of the views of his office and party; and he becomes the grave teacher and the infallible authority, cold and unsympathetic, whose *ipse dixit* is final and conclusive. We feel assured that in both departments his work will bear its natural fruits. For one who will painfully wade through his elaborate section on Stratigraphical geology, hundreds will study the physical chapters with pleasure and with profit.

The veterans of the old British school of Hutton, Lyell, and William Smith, will hail the appearance of this volume with unalloyed pleasure. The finest and most attractive portion of the work—that upon Dynamical Geology—is filled with the very spirit of Lyell himself. In the elaborate paragraphs of his stratigraphical sections, and in his strenuous advocacy of the Colonial theory, the author is preparing a magnificent tribute to the memory of William Smith. In the vague and nebulous beauty of his own provisional cosmogony he affords us a new and striking demonstration of the fact that there is no rest for the sole of the foot but upon the great principle of Hutton. The spirit of restless inquiry, of search after absolute truth, raised in the first half of the work will not be stilled by anything in its later pages. These earlier portions are certain to attract students, and will form the very best possible training for the thorough investigation of those higher branches of the science, which, of late years, have been so sadly neglected in Britain. The straining after picturesque provisional generalizations, the confusion of fact and opinion, and the affectation of non-recognition of all but properly constituted authority, rarely, but occasionally met with in its pages, and which jar upon the feelings of the modest and conscientious worker in the science, constitute a fresh proof, if any were required, of the necessity for the members of the Geological Society of the present to hold fast and firm to their fundamental rule of "collecting facts, instead of fighting over hypotheses."

In the light of these facts, as they gradually develope themselves in the immediate future, the rising race of young geologists will see for themselves that our science is still in its very infancy—and that some of the mightiest problems in British geology yet await solution. Out in the wholesome air of individual liberty of opinion, free from the stifling restrictions of party or office, it will be theirs to solve them as did their fathers in the past. In the earlier pages of Dr. Geikie's charmingly written volume they will find the means of doing this work. In its later pages they see before them the present horizon of authoritative opinion in Britain in advancing from which they have an unfailing means of estimating their onward progress.

Chas. Lapworth.

II.—Obersilurische Korallen von Tshau-Tiën im Nordöstlichen Theil der Provinz Sz-Tshwan. Von Herrn G. Lindström, in Stockholm. [Upper Silurian Corals from Tshau-Tien in the North-Eastern Part of the Province Sz-Tshwan. By Dr. G. Lindström. 4to. pp. 24, with Three Plates.]

IN this treatise, which will be included in the forthcoming volume of the Baron von Richthofen's great work on China, Prof. Lindström describes a series of corals entrusted to him for this purpose, by that distinguished traveller, who collected them in the course of one of his journeys in Northern China. The corals are of Silurian age; the beds containing them are regarded by Lindström as homotaxial with the English Wenlock and the Wisby series of Gotland. There are in all eighteen species belonging to eleven genera. Ten of the species are new forms, and three new genera are defined. It is interesting to observe in this outlying Silurian area, the occurrence of such familiar genera as *Favosites*, *Heliolites*, *Plasmopora*, *Halysites*, *Amplexus*, *Cyathophyllum*, *Ptychophyllum*, and *Cystiphyllum*. Of the new genera, the most interesting is a compound coral, named *Somphopora*, with completely perforate walls and six short spinous septa in each corallite. It appears to be closely allied to the existing genus *Alveopora*, and furnishes another example of the occurrence of corals of the order Perforata in the Palæozoic rocks.

Another genus, named *Ceriaster*, in exterior appearance resembles *Columnaria*, but it possesses interior dissepiments and increases by intracalicular budding. We may remark that the figures of this coral very strongly remind us of the *Columnaria alveolata*, Goldfuss, and in another species, *C. calicina*, Nicholson, the increase is partly by calicular gemmation, of an apparently similar character to that which takes place in *Ceriaster*.

The remaining new genus, *Platyphyllum*, is, in the form of the cup, like *Calceola* or *Rhizophyllum*, and in the interior structure, closely similar to *Goniophyllum*. The summit appears to have possessed a single operculum-plate like *Calceola*, but up to the present the operculum of this coral has not been discovered.

In addition to the description of the new forms, Professor Lindström discusses some disputed points touching the structure, affinities, and synonyms of some of the long-known Silurian corals. We can here only refer to one or two of these points, and the first relates to the characters of the small tubular structures which intervene between the cylindrical corallites in the genus *Heliolites*. Up to a recent period these tabulated tubes were regarded as cœnenchymal in character, but lately Prof. Nicholson[1] described them as "probably

[1] Palæont. 2nd ed. vol. i. p. 221.

occupied in the living state by rudimentary or imperfect polypes." Prof. Moseley [1] has also recently made a similar statement respecting the interstitial tubules in the existing *Heliopora*, that it is "by no means improbable that the cœnenchyma here is composed of the tubes of aborted zooids (siphonozooids)." We may here, *en parenthèse*, reiterate our opinion that there is no true relationship between *Heliolites* and *Heliopora;* the true distinct septa of the former genus cannot be compared with the pseudo-septa of the latter. Professor Lindström is totally opposed to the views of Nicholson, and believes that the tubules in *Heliolites* are produced by the extension outwards of the ends of the septa of the coral. In his view the tubules consist of the intergrowth of the borders of the individual corallites, and from these extended borders new corallites are produced by budding. Lindström regards the structure of *Heliolites* as homologous with that of *Acervularia*; so that the cylindrical corallites of *Heliolites* are equivalent to the central portion of the corallites of *Acervularia*, and the tubules are merely the exterior borders of the corallites. It may, however, be stated that, altogether apart from the correctness of Nicholson's views as to the tenants of the interstitial tubules, the walls of the cylindrical corallite in *Heliolites* are too distinct and well defined to be compared with the pseudo-walls of the interior portion of the corallites in *Acervularia*. In the beautiful representations of the microscopic structure of *Heliolites* and its allied genera *Propora*, *Lyellia*, and *Plasmopora* given by Nicholson in plates xi. and xii. of his "Palæozoic Tabulate Corals," we fail to see any indication that the cœnenchyma of these genera, whether tubular or cellular, has been produced by an outward extension of the septa of the individual corallites.

Prof. Lindström also proposes to abolish the genus *Streptelasma*, Hall, on account of the insufficient and unsatisfactory definition of its characters by its author, and the various interpretations of the genus introduced by subsequent writers, and he places the species usually included in the genus under *Ptychophyllum*, Ed. and H., and he also embraces therein the genera *Strephodes*, M'Coy, *Polycœlia*, Dybowski, and *Grewingia*, Dybowski.

Our space only allows us to refer to one other subject, touching the authorship of the dissertation "Corallia Baltica," in which several of the Silurian corals are mentioned for the first time. It is a question which is very desirable to clear up, and therefore we cannot do better than give the explanation of Lindström in full. He says: "It is generally believed by non-Swedish authors that Henric Fougt composed this treatise. It is, however, positively certain that Linnæus is himself the author of it. The circumstance that Fougt's name, though not as author, is upon the title-page, has given rise to this belief. Now it was, till very recently, the custom in the Swedish Universities, that candidates for the degree of Doctor, or, as it was then styled, Master of Philosophy, should publicly defend a Treatise or Dissertation—therefore the words on

[1] Report of the Scientific Results of the "Challenger," p. 123.

the title 'publice defendit.' This dissertation was frequently not composed by the candidates themselves, but by one of the Professors, who in the disputation acted as President. It was thus an opportunity for the Professors to get their own works printed. As a confirmation of the above, there is an original letter from Linnæus to his friend Dr. A. Bäck, dated Upsala, 7 March, 1745, in which he says: 'I have prepared a disputation, *De coralliis Balthicis*, with 30 figures, in which I arrange most of the corals of Bromell as varieties, and describe many new ones.' The contents of the treatise, moreover, show that it could in no wise have been composed by a young student of mining. The part which Fougt had in its preparation consisted merely in drawing the figures, and in paying the costs of the publication." G. J. H.

III.—A Primer of Physical Geography. By P. Martin Duncan, M.B. (Lond.), F.R.S. (London, 1882: Ward, Lock & Co.)

THIS little book forms one of a series of Science Primers for the people, which the publishers have undertaken to produce at a very low price, while aiming to supply valuable introductions to the subjects of which they respectively treat.

In the above work Prof. Duncan has endeavoured to comprise the leading facts of Physical Geography, systematically arranged in nine chapters. The globe and its physical peculiarities, the land and sea, the atmosphere and the phenomena connected with it, snow and ice and their effects, river valleys and lakes, volcanos and their correlated phenomena, climate and the distribution of animals and plants.

A great deal of information is given in a very limited space (128 pages), the subject-matter of each chapter and its bearings being concisely described, thus forming a good elementary hand-book to the science. J. M.

IV.—Traité de Géologie. Par A. De Lapparent, Professeur à l'Institut Catholique de Paris. Fascicules 7–8. (Paris, 1883: F. Savy.)

THIS excellent treatise of Geology (which has been previously noticed in this Magazine, Dec. II. Vol. IX. p. 122) is now completed by the publication of the 7th and 8th parts, and forms a volume of 1280 pages, including an alphabetical index.

These last two parts complete the Cretaceous rocks, which are followed by the description of the Tertiary and Quaternary periods. The third book treats of the origin and characters of the eruptive rocks, and of mineral and metalliferous veins. The last and concluding book contains a general account of terrestrial dislocations and their distribution, as well as on the theoretical considerations on the earth's structure. J. M.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 6, 1882.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Note on a Wealden Fern, *Oleandridium* (*Tæniopteris*) *Beyrichii*, Schenk, new to Britain." By John E. H. Peyton, Esq., F.G.S.

This fern, figured by Schenk in the "Palæontographica" (vol. xix. plate xxix. figs. 6, 7), was discovered near Minden, in the North-west German Wealden-beds, and appears to have been hitherto unknown in England. It was first discovered in the Wadhurst Clay ("Tillgate stone" of Mantell) of the cliffs east of Hastings, by Mr. Charles Dawson, of Warrior Terrace, St. Leonards, who has a fine collection of Wealden fossils, and was brought to my notice by Professor Augusto de Linares, of the Valladolid University, who has lately discovered the Wealden in the North of Spain.

This specimen,[1] which I have much pleasure in presenting to the Society for their Museum, I found about a fortnight ago, also in our local "blue-stone" from the Wadhurst Clay of the Hastings cliffs.

In connexion with the flora of the Wealden, I may perhaps mention that, besides the ordinary ferns recorded by Mantell, Fitton, Topley, and others, viz. *Lonchopteris Mantelli*, *Sphenopteris gracilis*, *S. Mantelli*, *S. Phillipsii*, *S. Sillimani*, etc., I have been fortunate enough to discover the following North-German forms:—*Pecopteris Geinitzii*, *Pecopteris Murchisoni*, *Pterophyllum schaumburgense* (Dunker), and an undetermined one, which I think is *Sphenopteris Gœpperti*. They all occur in the beds of stone in the Wadhurst Clay, which are locally used for building and road-metal.

2. "On the Mechanics of Glaciers, more especially with Relation to their Supposed Power of Excavation." By Rev. A. Irving, B.A.

1. The author commenced by showing that ice is comparable in some respects with *glass*, with which (at temperatures not far removed from their several points of liquidation) it has many points of physical resemblance, the chief point of difference between the two bodies being the absence in ice of the great ductility which characterizes glass. Ice may therefore be regarded as a near approximation to the "vitreous condition" of water.

2. The remarkable yielding property ("plasticity," "Nachgiebigkeit") of ice as it exists in glaciers (which constitutes its most important point of resemblance to heated glass) being recognized as a fact of observation (the experiments of Tyndall and Helmholtz, and the measurements of glacier-movements by the former being referred to), the deduction drawn from these *facts* (irrespectively of the theoretical explanation of the facts themselves) in the light of the simple *law of conservation of energy*, is that in the movement of glaciers only a small residuum of "energy of motion" of the glacial mass is avail-

[1] It varies slightly from the one figured by Schenk in the nervures; and the midrib is "herring-boned." It bears a strong resemblance to *Tæniopteris vittata* (Brongn.) of the Trias (Geikie's 'Text-Book of Geology,' fig. 358); compare also *T. scitamineæ-folia* (Sternberg), from the Stonesfield beds (Phillips's 'Geology of Oxford,' Diagram xxx. fig. 8).

able for the work of *erosion;* most of the energy is expended *within the mass of the glacier* in overcoming *cohesion.*

3. If the ice, though *flowing* really in a way comparable to the motion of a river-current (the upper layers moving faster than the lower, the median portions faster than the lateral), retained its *continuity,* the strain against the rocks might be great enough to do much that is required of it by the "erosion-theory;" but here comes in the remarkable *absence of ductility* of ice, giving birth to *crevasses,* the varieties of which are all referable to one common principle, and adverse to erosion.

4. Prof. Tyndall was quoted as an authority for the fact that there is a gradual transfer of ice-particles from the bed towards the surface of the glacier, a fact which the author attempted to explain later on in the paper by reasoning adopted from Helmholtz. The fact itself is directly opposed to erosive action.

5. The instance of the Morteratsch glacier was more particularly considered; and an attempt was made to show that the assumptions which underlie the reasoning by which Professor Tyndall has endeavoured to meet the objections which have been raised to the erosion-theory from observations of the Morteratsch, are incompatible with sound mechanical principles.

6. The important law of the *lowering of the freezing-point of water by pressure* was next discussed, and reasoning adopted from Helmholtz, which leads to the remarkable conclusion that within the glacier water at 0° C. exists in contact with ice below 0° C. This was accepted by the author as the explanation of the otherwise unintelligible fact referred to in 4.

7. The last point led to the discussion of Dr. Croll's views on glacier-movement. The author gave reasons for rejecting Dr. Croll's so-called "molecular theory" of the movement of glaciers (it is really little more than a restatement of the regelation theory disguised by a misuse of the terms "molecule" and "molecular"), and for not sharing his feeling of "mystery" about the theory of regelation.

8. A real work of *erosion* was shown to go on in connexion with glaciers, by the direct action of the glacier-streams; but the same objections apply to these as to streams flowing in an open valley, as agents capable of excavating basin-like hollows.

9. The remainder of the paper was mainly occupied with a consideration of "tarns" among the mountains. Here it was admitted that a glacier may work in a different manner from a glacier moving down a valley; and so it was thought many small rock-basins (now tarns) may have been formed at the foot of precipices. On the other hand, it was maintained that many tarns occupy hollows formed by earth-movements on the mountain-slopes, or by moraines.

10. In conclusion, the author strengthened his position by pointing to the rejection of the erosion-theory by such high authorities as Professors Bonney, Helmholtz, and Credner, and Mr. John Ball; and expressed his regret at finding himself at issue with Sir A. Ramsay, to whose geological writings we all owe so much.

Generally, the author concluded, from mechanical and physical considerations, that far too much *erosive* power has been attributed by some writers to glaciers, and that it is doubtful if the work of actual *excavation* has been accomplished by them at all. The *differential movement* of glaciers he attributed to three causes: (1) cracking and regelation (Tyndall and Helmholtz); (2) generation of heat by friction within the glacier (Helmholtz); (3) the penetration of the glacier by *luminous solar energy*, the absorption of this by opaque bodies contained in the ice (stones, earth, organic germs, etc.), and the transformation of it in this way into *heat*. To this last he attributed the greater differential movement of the glacier (a) by day than by night, (b) in summer than in winter.

II.—December 20, 1882.—1. "On Generic Characters in the Order Sauropterygia." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

After referring to the subdivision of De la Beche's group of Enaliosauria into the orders Ichthyopterygia and Sauropterygia, the author indicated that the latter showed differences in the proportional length of the neck and the number and form of its vertebræ bearing relation to the size of the head, together with modifications of the teeth, to the sterno-coraco-scapular frame and of the paddle-bones, leading to the formation of two genera, namely, *Plesiosaurus* and *Pliosaurus*, the latter so called to indicate the nearer approach made by it to a generalized Saurian type. In Crocodilia the crowns of the teeth show a pair of strong enamel ridges, placed on opposite sides of the teeth, and these occur also in *Pliosaurus*; while in *Plesiosaurus* they are not present. *Pliosaurus* further approaches the fresh-water Saurians by the large size of the head and the shortness of the neck.

The author described the sterno-coraco-scapular frame in the Sauropterygia generally as consisting chiefly of a pair of large caracoid bones meeting in the middle in a straight suture, but separated by a notch anteriorly and posteriorly; in front of these is an episternum, also notched in front; and attached to this on each side is a scapula, directed outward and backward, joined at its distal part by suture to the antero-lateral margin of the caracoid, and forming the outer border of the "caraco-scapular vacuity," a rounded aperture which exists on each side in the fore part of the sterno-coraco-scapular mass. The humeral articulation is formed by the outer margin of the fore part of the caracoid and the extremity of the scapula on each side. The chief distinctive character in *Pliosaurus*, consists in the retention of a typical character of the scapula which is lost in the more specialized Pleisosaurian forms, namely, the production of part of the blade-bone laterad and dorsad, where it terminates freely, this portion representing the main body of the scapula in the higher vertebrates. In *Pliosaurus* this portion is separated by a large notch from that which in both genera joins the caracoid and assists to form the glenoid cavity. The latter portion also extends further mesiad than in the Plesiosaurs, so that its sutural border unites with the fore end of the caracoid, which is much produced forward. The author finds the true homology of the constituents of this sterno-coraco-scapular mass in the endo-skeleton of the Chelonia; *Pliosaurus* shows characters resembling those of contemporary Crocodilia. A third modification of the Sauropterygian type is indicated by teeth and a portion of the skull upon which the genus *Polyptychodon* has been founded.

2. "On the Origin of Valley-Lakes, mainly with reference to the Lakes of the Northern Alps." By the Rev. A. Irving, B.A., B.Sc.

The author, having given reasons for considering this question still an open one, proceeded to criticize Prof. Ramsay's theory as it was expounded by him in 1862. The defects in Prof. Ramsay's argument are, he considers:—(1) the non-recognition of the fact that many lakes in the Northern Alps lie in *longitudinal valleys*; (2) the omission, in the discussion of the relation of valleys to lines of fracture, of the consideration of *anticlinal* lines of fracture, which can be shown to be very common in the Alps; (3) the illogical inference from conditions existing in *crystalline metamorphosed rocks* as to what could or could not appear in the *stratified sedimentary deposits of the Alps, among which the Alpine lakes chiefly occur*; (4) the rejection of the hypothesis of *subsidence* on the mere ground of the number of instances. The author proceeded to show that the lakes of the Northern Alps are found, as a rule, just among those strata where subsidence would be most likely to occur. In this way it was shown that we are *not shut up*, by Prof. Ramsay's reasoning, to the hypothesis of *glacial excavation*.

Further, other agencies than those discussed by Prof. Ramsay may have co-operated to form lakes, such as:—

(a) *Alterations in the relative levels* of different parts of a floor of a valley, connected with movements of parts of a mountain-system on a large scale. The effects of (1) lines of flexure crossing older lines of valley-erosion, (2) of lateral thrusts closing in a valley (partly), were here considered.

(b) *Upthrust* of the more yielding strata (as in the "creeps" of coal-mines) by resolution of forces due to pressure of the mountain-masses at the side of a valley.

(c) The *dead weight of the huge glaciers* which filled the Alpine valleys, and *crushed in the floor*, in places where extensive under-ground erosion had gone on in preglacial times.

(d) The partial *damming up of valleys*, (1) by *diluvial detritus*, (2) by *moraines*, (3) by *Bergstürze* (recently investigated by Prof. Heim of Zürich).

(e) *Faults*.

(f) *Chemical solution*, by Alpine waters derived from the melting of the snow, which has undergone long exposure to the atmosphere.

It was shown that the very situation of the great majority of the lakes of the Northern Alps is distinctly favourable to the operation of one or more of these agencies. The Königsee was mentioned as a special instance of *subsidence;* the Achensee of a lake lying in a *faulted* line of dislocation; L. Alleghe and L. Derborence as lakes formed by Bergstürze during the last century; the prehistoric delta of the Arve as the most conspicuous instance in the Alps of the partial damming-up of a valley by diluvial detritus; the *quondam* Lake of Reutte as an instance connected with violent inversion of strata; and the ancient lakes of the Grödner and Oetz Thals as instances of the action of moraines.

The common fact of observation that lakes are more numerous in glaciated than in non-glaciated countries, the author thought, was partly explained by some of the foregoing principles, partly by the better preservation of lake-basins in glaciated countries from silting up and from becoming thus obliterated, while in some glaciated regions lakes are wanting.

CORRESPONDENCE.

THE BRIDLINGTON CRAG.

SIR,—There seems to be some misapprehension about the Bridlington Crag.

In the Geological Record for 1878, on page 3, there occurs the following passage: "Confirms the succession given by Mr. Lamplugh that the 'Crag' bed lies on the blue clay or basement bed, but is below the snuff-coloured laminated clay, while the purple clay is above the last."

Now Mr. Lamplugh has conclusively shown that the Bridlington Crag is not a bed at all, but a series of patches, boulders in fact, included *in* the so-called Basement Clay.

The bed or beds whence the shells were originally derived, if still existing, has never yet been seen. I say "or beds" because shells that lived at different depths have been brought together at Bridlington. J. R. DAKYNS.

MELMERBY, PENRITH.

DR. RICKETTS.—ON SUBSIDENCE AND ACCUMULATION.

SIR,—In connexion with the subject of Mr. Jamieson's paper on the Cause of the Depression and Re-elevation of the Land during the Glacial Period (GEOL. MAG. Sept. and Oct. 1882), it may be interesting to re-direct attention to a paper by Dr. Charles Ricketts, On Subsidence as the Effect of Accumulation (GEOL. MAG. Dec. I. Vol. IX. p. 119); and to his presidential address to the Liverpool Geological Society in 1872, on Valleys, Deltas, Bays, and Estuaries. He has, in the latter paper, expressed his opinion that during the Glacial period the combined weight of ice and boulder-clay would produce subsidence of the land; and again, in speaking of deltas, he concluded that the steady accumulation of mud would in the end cause subsidence, gradual and imperceptible at first, but under certain conditions perhaps sudden.

The observations of Messrs. G. and H. Darwin, noticed in a late number of the GEOLOGICAL MAGAZINE, by Prof. Milne, show that the crust of our earth is more susceptible than we imagined when, ten years ago (GEOL. MAG. Vol. X. pp. 88 and 141), we ventured to criticize somewhat unfavourably the views then put forward by Dr. Ricketts. H. B. W.

TERRACES IN DORSET.

SIR,—There are to be seen on the sides of the valleys in Dorset a number of terraces, which are, I believe, a peculiar geological feature of that and a neighbouring county. I have never yet seen a satisfactory theory as to their origin. It has been asserted that they are old fortifications; also that they have been formed by the plough. Whether the sea-beach or lake-beach theory has ever been advanced I cannot say; but all, I maintain, would be found wanting by a careful and competent judge. If any of your readers can throw light on the subject, it would be interesting to those geologists who happen to have observed the peculiarity to which I refer.

CLEVELAND LODGE, LOWER SYDENHAM. S. H. WRIGHT.

The nature and origin of these Terraces is, we think, now generally very well understood by geologists.

We recommend to Mr. S. H. Wright's consideration an excellent little article upon them which appeared in the GEOLOGICAL MAGAZINE for 1866, Vol. III. p. 293, by the late G. Poulett Scrope, Esq., F.R.S., F.G.S., than whom we could hardly cite a more competent observer or more trustworthy geological guide.—EDIT. GEOL. MAG.

THE RIGIDITY (?) OF THE EARTH.

SIR,—It has given me much pleasure to read Mr. Close's remarks referring to my lament over the disagreement between mathematical physicists and geologists touching the condition of the interior of the earth. His letter gives promise that a further discussion of the question with him may serve to elucidate it.

Mr. Close has not, I think, exactly apprehended my meaning. I wrote of the conclusion arrived at by mathematicians, "that the earth is excessively rigid from its centre to its surface." Mr. Close, on the other hand, writes of the disagreement between them and geologists respecting "the rigidity of the body of the earth." It is important to be precise as to what we are discussing. As a physical geologist I seek to explain the phenomena exhibited by the masses which constitute the *surface;* its continents, mountains, plains, valleys, oceans, and volcanos. Still, these phenomena require us to speculate upon the condition of the interior down to a considerable depth; yet not necessarily to a depth which bears any large proportion to the entire radius. In short, I am willing to relegate the "body of the earth" to the physicist pure and simple, as a region beyond my province, and respectfully to accept his conclusion that it is extremely rigid. Possibly this rigidity may be no more than that *viscous* rigidity which Mr. Close so accurately describes, showing in his letter how such a condition of the interior would be capable of explaining many of the facts relied upon to establish rigidity. It certainly also appears to suit, better than absolute rigidity, with one to which he has not alluded; namely, that the *present* ellipticity of the earth agrees so well with the present period of diurnal rotation.

I will now state some objections, which, on geological grounds, I would offer against the contention of Mr. Close, that a general viscous rigidity, such as I understand him to advocate, would meet the requirements of the problem; and I will point out one instance of the neglect of geological phenomena by a mathematician. I maintain that the surface phenomena require that the cooled crust of the earth should be far more rigid than what it rests upon. For instance, they require that the substratum should be sufficiently fluid to admit of the crust being shifted over it towards the mountain ranges; that it should likewise be in a condition to flow upwards into narrow chasms, and form igneous dykes, and to furnish the ejectamenta of volcanos. These and other phenomena, such as that which I shall shortly mention, have been too much ignored by mathematicians in treating of the subject. To suit the exigencies of the calculus, they assume the earth to be homogeneous throughout, and either fluid, viscous, or elastic, and take no account of any greater rigidity existing in the surface than in the parts beneath it. Mr. Darwin, for example, in his paper on the Stresses of Continents and Mountains, assumes that the earth must be strong enough to bear the stress arising from their weight. But it is a fact well known to geologists that the parts of the earth's surface which have a tendency to sink are not the mountains, but the sedimented areas, the river plains, and the bottoms of shallow seas. The tendency of the mountains, on the other hand, is to rise, so as partially to compensate for what they lose by denudation. In short, the crust of the earth bears a close analogy to a floating field of ice, broken up, crushed together, and refrozen; and no one would argue that there could be no fluid stratum beneath it, because some blocks of ice stood higher than others; for he would know they would receive sufficient support from their under sides sinking deeper into the water.

The above facts show that the substratum must have a less viscosity than the crust. But if the substratum be as rigid as glass or steel, then the crust must be much *more* rigid than glass or steel, which is a *reductio ad absurdum.* For my own part I believe it to be what may without impropriety be called liquid. And if it be asked how it can remain liquid under the pressure of between 20 and 30 miles of superincumbent solid rock, I answer, that recent experiments have tended to show that igneous rocks are denser when melted than when solid at the melting temperature. Consequently we may expect their melting-point to be lowered rather than raised by pressure. If that be the case, solidity would not be induced in such molten rocks by the pressure of the superincumbent crust.

HARLTON, CAMBRIDGE, O. FISHER.
5th January.

PERMIAN AND TRIAS OF SOUTH-WEST LANCASHIRE.

SIR,—Having read the recent articles on the Permian and Trias by the Rev. A. Irving, F.G.S., and the letters referring to the Permian strata of South-west Lancashire, I beg to offer some further information more recent than that available to Prof. Hull, Mr. De Rance, or Mr. Strahan. During the last week I visited St. Helen's Junction, and in consequence of a fall of *débris* at the side of a pit, found an exposure of ten feet of red marl, containing a layer, a few inches thick, of a greenish colour which effervesces strongly in acid. I and Mr. Strahan saw the sandstone at the base of this section in 1881, but at that time only one foot of the overlying marl was visible. No fossils have been found, or searched for, it being dangerous to approach the spot for fear of falling into the pit. The marl must belong to the beds described in the wells of the brewery many years ago, and most likely represents the Permian.

However, a section of much more importance has just been obtained from a boring now in progress at Hunt's Cross, Wootton, much nearer Liverpool than St. Helen's Junction, for the particulars of which I am indebted to Mr. A. Timmins, C.E., who is conducting the operation. The spot is near a doubtful boundary-line between the Pebble-beds and the Upper Mottled Sandstone, on the Geological Survey Map. After passing through 137 feet of drift a bed of marl was found, which has been penetrated to the thickness of 200 feet —337 feet from the surface—without reaching the bottom of it. It would be absurd to call this marl Lower Mottled Sandstone, and most likely it is Permian, just below the Pebble-beds, which is the usual succession in the country to the east of the boring. Before the age of this marl is finally decided, it is very desirable that fossils should be obtained, if any occur in it, but the stuff comes up the bore-hole in the condition of powdered dust, so that there is little chance of finding any at present. Now that attention has been directed to the importance of finding fossils, it is to be hoped that they will soon be found in some of the localities where the marl occurs. Meantime it seems probable that the marl occurs between the Pebble-beds and the Lower Mottled Sandstone, and that all the strata below the former belong to the Permian in the country around Liverpool, as I understand to be the case about Manchester.

G. H. Morton.

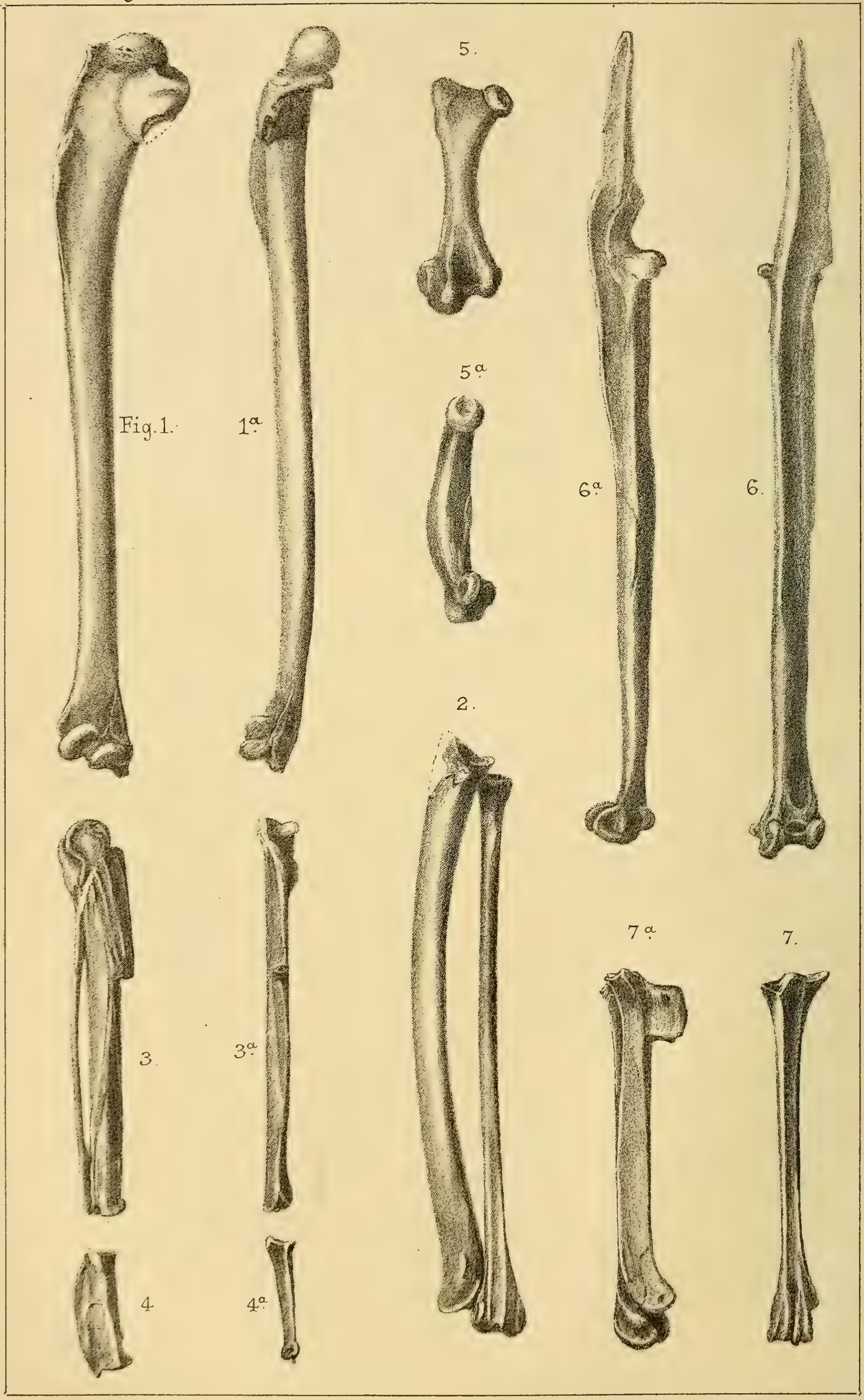
P.S.—From the great thickness of the marl at Hunt's Cross, it is just possible that the boring may be in the Keuper Marl, but even that would be very extraordinary.

THE PERMIAN QUESTION.

Sir,—May I be permitted to point out an ambiguity which has crept into the discussion of the Permian-Trias question in this Magazine? The term "Upper Permian" has been used by me consistently to indicate beds (marls and sandstones) which occur *above* the Magnesian Limestone series, which Murchison designated "Bunter Schiefer." Such a use of the term implies that the Magnesian Limestone series would, in a threefold classification, fall into the place of Middle Permian, as in the "Student's Elements." The sense in which I have used the term "Upper Permian" is that in which it was formerly and recently used by Prof. Hull, and by Mr. De Rance in the table of the Lancashire Permian Strata which appeared in my paper of last month. The latter gentleman, in last month's Number, uses "Upper Permian" for what (in the classification I originally ventured to criticize) would be called Middle Permian. Of course, if the threefold division be given up, these become the upper member of a dual series, the existence of which I have not called in question. All therefore that Mr. De Rance has recently urged, as well as the evidence put forward quite recently by Prof. Hull, is beside the point at issue.

Wellington College, A. Irving.
Dec. 9th, 1882.

We regret to record the death of one of our contributors to this Magazine, Mr. Edward B. Tawney, M.A., F.G.S., Conservator of the Woodwardian Museum, Cambridge. We shall give a full notice of his work next month.



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Colymbus septentrionalis.

from the "Mundesley River Bed."

All the figures 2/3 nat. size.

THE
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No. III.—MARCH, 1883.

ORIGINAL ARTICLES.

I.—On the Remains of a Red-throated Diver, *Colymbus septentrionalis*, Linn., from the "Mundesley River Bed."

By E. T. Newton, F.G.S.,
of H. M. Geological Survey, Museum of Practical Geology.
(Published by permission.)

[PLATE III.]

THE remains of Birds from Quaternary deposits in this country have been so rarely recorded, that any fresh evidence, throwing light upon our Pleistocene avian fauna, cannot but be of interest. The specimen about to be described was found in the "Mundesley River Bed," from whence was obtained the *Emys lutaria* described in this Magazine in 1879 (Dec. II. Vol. VI. p. 304). In a note appended to that paper, Mr. H. B. Woodward has given a short account of this Mundesley deposit, and it will be found fully described in the Geological Survey Memoir, by Mr. C. Reid, "On the Geology of the Country around Cromer," pp. 119 and 126.

Some time ago, the last-named gentleman was fortunate enough to find in this deposit a number of well-preserved bird's bones, evidently belonging to one individual. The specimen is now in the Museum of the Geological Survey, and comprises a number of bones entirely freed from the matrix and for the most part perfect; and a block of indurated sandy marl, containing a somewhat crushed pelvis, some vertebræ, a right femur with a tibia and fibula; these parts remaining in their natural relations. The separate bones are, a scapula, coracoid, humerus, radius, ulna, metacarpal, middle phalanx of wing, tibio-tarsus, fibula, and tarso-metatarsus; also fragments of sternum, vertebræ and ribs.

The relatively small and strongly curved femur, the large size of the rotula-process of the tibia, which extends far above the femoral articulation, and the remarkably flattened tarso-metatarsus, show at once that these remains are referable to the genus *Colymbus*.

Through the kindness of Prof. Flower, and of Mr. A. D. Bartlett, of the Zoological Society, I have been able to compare these fossils with several recent skeletons of *Colymbus septentrionalis*, the red-throated diver, and of *C. torquatus*, the great northern diver. The measurements given below are taken from some of these specimens. The *C. torquatus* is much larger than the fossil bird, which evidently does not belong to this species. Most of the skeletons of *C. septentrionalis* are rather larger than the fossil; but one of them, labelled as a young specimen (Roy. Coll. Surgeons, No. 1166a), is a little smaller, and in other respects agrees with it so exactly, that I have no doubt whatever of their specific identity. I have not been able to compare the skeleton of a black-throated diver, *Colymbus arcticus*; but this species is said to be larger than *C. septentrionalis*, and consequently would not so nearly resemble the Mundesley fossil bird. The comparison of this specimen with the recent skeleton of *C. septentrionalis* showing such a close agreement between them, it will only be necessary to point out the chief peculiarities of the more important of these fossil bones which are characteristic of the *Divers*. The size of the specimen, as will be seen by the table of comparative measurements, shows that it comes nearest to the *C. septentrionalis*.

The humerus is comparatively a long bone, with a rounded shaft and small proximal articular head. The pectoral ridge is strongly developed, and there is no pneumatic orifice. The distal end is widened out, and has twice the transverse extent of the shaft.

The ulna is curved, and has its inner surface flattened, especially towards the distal extremity. The radius is slender and more nearly cylindrical, but with both ends enlarged; the outer surface of the distal extremity having two well-marked grooves.

The ankylosed metacarpals are flattened, and the first one is much longer than is usual in birds, occupying quite one-third of the length of the middle or second metacarpal.

The femur is remarkably short, has the upper surface strongly arched, and the ends of the bone much laterally expanded. The crest of the outer condyle, which plays between the tibia and fibula, is strongly developed.

Measurements in millimètres of the bones of the Mundesley fossil *Colymbus*.

	Greatest length.	Greatest extent proximal end.	Greatest extent distal end.	Smallest diameter of shaft.
Femur...............	39·5	12·5	14·5	6·3
Tibio-tarsus	149·0	15·0 *	11·0	4·5
Tarso-metatarsus	68·0	12·0	11·0 *	4·0
Humerus	137·0	23·0	15·0	6·3
Radius	107·0	6·0	8·5	3·5
Ulna	107·0	——	12·0	4·6
Metacarpals	70·0	12·0	8·0	4·0

* Antero-posterior extent.

Comparative measurements of different specimens of *Colymbus*.

	C. torquatus (=*C. glacialis*.)	*C. septentrionalis.*			Mundesley Fossil.	*Colymboides minutus*, M. Edwards.
		A.†	B.	C.		
Femur...............	59·0	37·5	39·0	37·0	39·5	30·0
Tibio-tarsus	200·0	...	165·0	149·0	149·0	...
Tarso-metatarsus	91·0	...	70·0	67·0	68·0	...
Humerus	200·0	135·0	143·0	132·0	137·0	62·0
Radius and Ulna	160·0	109·5	114·0	106·0	107·0	50·2
Metacarpals	107·0	...	76·0	68·0	70·0	...

† Measurements given by M. M. Edwards.

The tibio-tarsus is chiefly remarkable for the manner in which the cnemial crest extends upwards beyond the femoral articular surface, so as to form a cnemial, or rotula-process, which occupies more than one-fourth of the entire length of the bone.

The tarso-metatarsus is much compressed, and is on this account a most characteristic bone. The articulation for the outer toe is placed almost entirely behind the one for the middle toe.

The recent species of *Colymbus* have a very wide range, being distributed throughout the Northern hemisphere. The genus—and indeed each species—thus exhibits in a marked degree a capability of adaptation to a great variety of circumstances; and as it is frequently found that animals possessing this plastic constitution extend far back in geological time, one is led to inquire, with the greater interest, into the past history of this genus.

I have been unable to find any account of the *Colymbus* occurring in a fossil state in England; but the late Dr. A. Leith Adams has recorded the occurrence of the *C. septentrionalis*, among a number of other birds, from the Shandon Cave, Co. Waterford, Ireland (Trans. Roy. Irish Acad. vol. xxvi. p. 187). He hesitated however to admit these remains "as contemporaneous with those of the mammoth and the mammals found in the breccia." The avian coracoid from Kirkdale cave noticed by Dr. Buckland (Reliq. Diluv. p. 35, tab. 11, f. 28) seems to have been regarded by some persons as belonging to a Diver; but M. M. Edwards (Oiseaux Fossiles, vol. i. p. 297) has already pointed out that this is evidently a mistake; and it appears, therefore, that Mr. Clement Reid's specimen is the only known instance of the genus *Colymbus* occurring as a fossil in England.

The remains of a bird from the Miocene of Allier are described by M. M. Edwards (*loc. cit.*) as *Colymboides minutus*. Although the bird is considered by that eminent naturalist to possess characters which justify his placing it in a separate genus, yet it was evidently closely allied to the Divers and Grebes.

The bird-bones from the Cambridge Greensand, described by Prof. H. G. Seeley as *Enalornis* (Quart. Journ. Geol. Soc., vol. xxxii. p. 496), show a very close resemblance to the bones of *Colymbus* in several points of their structure. The arching of the femora being so extremely like what obtains in the latter genus, that it is difficult to believe they are not generically identical. The tibiæ, on the other hand, in their much shorter rotula-process, more nearly resemble those of the Grebes (*Podiceps*).

To what extent these Cambridge Cretaceous Birds were allied to the American Odontornithes, is difficult to say, for we have no evidence at present to show whether the British forms had teeth or not. The fact that the London Clay *Odontopteryx* had teeth, or something very like them, renders it highly probable that birds with teeth existed in this country also during Cretaceous times.

The American toothed-bird *Hesperornis* certainly resembles the recent Divers in several points of its structure, and these resemblances are doubtless fully appreciated by Prof. Marsh, although he thinks it more closely allied to the struthious than to any other type of bird (*vide* vol. vii. U. S. Geological Survey of the 40th Parallel, Odontornithes). Professor Newton has not failed to notice the resemblance between *Hesperornis* and *Colymbus* (Encyclo. Brit. 9th edit. vol. iii. p. 729, 1875). Professor Marsh thinks it probable that this great toothed-bird was descended from a struthious ancestor, and that it has left no descendants. That it has so descended seems probable; but if it has left no descendants, is it not remarkable that it should in many points resemble the recent *Colymbus?* The structure of the palate, the keelless sternum, aborted fore limb, and ostrich-like form of the scapula and coracoid, are doubtless important characters, showing alliance with the Struthionidæ; but may not some of the Carinatæ have arisen through such a form as *Hesperornis*? and if so, is it not possible that the recent birds, which show so much resemblance to this Cretaceous form, namely, the *Colymbidæ*, should have descended from this remarkable type?

DESCRIPTION OF PLATE III.

Colymbus septentrionalis from the "Mundesley River Bed."
All figures two-thirds natural size.

Fig. 1. Right humerus, outer surface.
,, 1*a*. ,, ,, seen from below.
,, 2. ,, radius and ulna, from the outer side. The proximal part of the ulna is somewhat broken.
,, 3. Right metacarpals, outer surface.
,, 3*a*. ,, ,, seen from the radial side.
,, 4. ,, first phalanx of second finger, outer surface.
,, 4*a*. ,, ,, ,, radial edge.
,, 5. ,, femur seen from above.
,, 5*a*. ,, ,, seen from inner side.
,, 6. Left tibio-tarsus, front view
,, 6*a*. ,, ,, view of outer side.
,, 7. Right tarso-metatarsus, front view.
,, 7*a*. ,, ,, view of inner surface.

II.—Notes on the Cheviot Andesites and Porphyrites.

By J. J. Harris Teall, M.A., F.G.S.

Literature.

Tate, George. The Cheviots, Proceedings of the Berwickshire Naturalists' Club for 1867, pp. 359–370.
Lebour, G. A. Outlines of the Geology of Northumberland, Newcastle-on-Tyne, 1878.
Clough, C. T. Notes on the Geology of the Cheviot Hills, Abstracts of the Proceedings of the Geological Society, Dec. 20th, 1882.
Geikie, James. The Cheviot Hills, "Good Words," 1876.
Winch. Geology of Northumberland and Durham. Trans. Geol. Soc. vol. iv.

Macroscopic Characters and Geological Age of the Cheviot Andesites and Porphyrites.

The Cheviot district is largely composed of those quartzless porphyritic rocks to which the term porphyrite has been applied both by English and Continental petrologists. The Cheviot porphyrites are characterized by a compact felsitic[1] ground-mass, through-

[1] The term "felsitic" is used with exclusive reference to the macroscopic characters of the ground-mass.

out which are scattered numerous crystals of felspar, mostly belonging to triclinic species. The ground-mass varies in colour; the two principal shades being dark purple and red. These porphyrites are evidently more or less altered rocks and sometimes the alteration has been carried so far as to make it almost, if not quite impossible to recognize their original nature by macroscopic examination. Amygdaloidal varieties are not uncommon, and in these agates are frequently found. In addition to the ordinary porphyrites, there occur masses of volcanic ash and breccia,[1] and also a remarkable rock which has been called pitchstone-porphyrite. This is dark almost black in colour, with a well-marked resinous lustre and a specific gravity lying between 2·53 and 2·62. It is porphyritic in texture; the large crystals consisting of a fresh glassy-looking triclinic felspar. Red veins usually traverse the rock in different directions. The boulders lying in the streams are covered with a thin light-coloured crust due to weathering, but at a distance of a quarter of an inch from the surface, or even less, the fresh unaltered rock is always found.

Mr. Tate mentions this rock as occurring near Cherrytrees, in Roxburghshire, and again in a conspicuous cliff near Yetholm. It has been used in the construction of the church at Yetholm. My attention was first directed to it by Mr. Clough's paper, and since that paper was read I have visited several of the localities mentioned by him. The rock may be seen in the Coquet at several points between Windy Haugh and Blindburn, and in the Usway between Battleshields Haugh and Fairhaugh. Large boulders occur in the bed of the Alwin above Clennel; a fact which proves the existence of the rock within the watershed of that river. About one mile up Allerhope Burn, a tributary of the Alwin, a rock of the same type, but having a dull semi-resinous lustre, occurs.

That the pitchstone porphyrites, or andesites as I should prefer to call them, belong to the same series as the ordinary porphyrites, is clearly shown in the sections in the Coquet and the Usway. The evidence, therefore, already on record as to the age of the latter will serve to fix that of the former. In "Good Words" for 1876, p. 85, Prof. Geikie states that at Hindhope the basement beds of the porphyrite series are a true volcanic ash or breccia, and that they rest unconformably on the Silurian greywackes. Mr. Clough describes a similar succession as existing between Philip and Makendon on the English side of the border. The rocks which directly overlie the porphyrites belong to the basement beds of the Carboniferous formation—the Tuedian series—and they are described both by Prof. Geikie[2] and Prof. Lebour[3] as consisting in places of conglomerates made up in part of pebbles of rolled Cheviot porphyrites. There can, therefore, be no doubt that we are here dealing with a group of igneous rocks of Post-Silurian and Pre-Carboniferous age.

We know that Central Scotland was the scene of intense volcanic

[1] These were recognized on the Scotch side by Prof. James Geikie, and on the English by Mr. Clough.

[2] Good Words, 1876, p. 265.

[3] Geology of Northumberland, p. 43.

activity during the deposition of the Lower Old Red Sandstone strata, when the porphyrites and tuffs of the Pentland, Ochil, and Sidlaw Hills[1] were formed, and it becomes therefore almost certain that the Cheviot volcanic rocks belong to this period of geological time.

It may be mentioned in passing that there occur about Kelso igneous rocks of Tuedian age, that is, of later date than those now under consideration. No doubt these belong to the period of volcanic activity, of which Prof. A. Geikie speaks as follows:[2]— "The most persistent zone of volcanic rocks in the whole of the Scottish Carboniferous series is that which succeeds the lower or red sandstone group of the Calciferous sandstones, composed of successive sheets of porphyrites and tuffs, it sweeps in long isolated ranges of hills from Arran and Bute on the west, to the mouth of the estuary of the Forth on the east, and from the Campsie Fells on the north to the heights of Ayrshire, and still further south in Berwickshire, Liddesdale, and the English border. These volcanic sheets sometimes reach a thickness of 1500 feet." I have one specimen of Kelso porphyrite, which was given to me by Mr. Clough. This rock will be described later on. It differs materially from any Cheviot rock known to me.

Microscopic Analysis of Cheviot Andesite (Pitchstone Porphyrite).

(1). The following remarks are based on the examination of sections prepared from specimens collected by myself in the Coquet, about a quarter of a mile above Windy Haugh, and near Carl Croft, two miles and a quarter further up the valley; in the Usway about Fairhaugh; in the Allerhope Burn, at a point about one mile from its junction with the Alwin; and from the Alwin boulders above referred to. Mr. House, of Newcastle, kindly supplied me with a specimen of the Yetholm rock. It will thus be seen that specimens have been collected from a tolerably extensive area. The first point to notice is the uniformity in the character of the rock. This uniformity is so great that it will be unnecessary, except in special cases, to refer to particular localities in giving a description of the rock. An examination of the sections at once proves that we are here dealing with a group of comparatively unaltered andesites. Messrs. Voight and Hochgesang, of Göttingen, have supplied me with a series of fifteen sections of the augite andesites of Tokaj (Hungary) and Santorin, and the resemblance between the Cheviot sections and this series is most striking. Indeed, one section of an Alwin boulder can scarcely be distinguished from a section of the 1866 lava from Aphroessa. At least, if the labels were removed, and the sections ground to the same uniform thickness, and remounted on similar slides, I doubt if I could refer them to their proper localities. Similar minerals occur in nearly the same relative proportions. They are similarly developed

[1] Prof. A. Geikie states that these volcanic rocks (porphyrites and tuffs) attain a maximum thickness of 6000 feet. Text-Book of Geology, 1882, page 707.

[2] Text-Book of Geology, page 739.

as to size and form, and there is in both sections the same well-marked fluidal structure. In the majority of cases it would not be difficult to separate the one series from the other, because fluidal structure is usually absent in the pitchstone porphyrites, and the felspars of the ground-mass are more fully developed.

The principal constituents of the rock are (*a*) large porphyritic felspars, (*b*) pyroxene, (*c*) felspars of the ground-mass, (*d*) irregular plates of a black opaque mineral (magnetite or ilmenite), (*e*) glassy base containing various devitrification products. Apatite and a hexagonal mineral, probably hematite, occur as accessory constituents.

Large Felspars.—These measure from 2 to 3 mm. across, and seem to be pretty equally developed in the directions of the different crystal axes, although lath-shaped forms occasionally occur which are decidedly longer than broad. The regularity of the outlines of these felspars is frequently interrupted by creeks and inlets of the ground-mass, while the more perfect forms often contain a large number of inclusions of the same material. In many cases the crystals are completely honey-combed by these ramifying inclusions, so that any attempt to obtain them for separate analysis would probably not be attended with very satisfactory results. A zonal arrangement of the larger inclusions is sometimes seen, but on the whole one is not struck with this feature. A band of small inclusions may frequently be seen close to the edge of well-defined crystals. Under crossed Nicols the striations characteristic of twinning on the albite type are usually seen, but the lamellæ frequently show a want of persistence and regularity. A second set of lamellæ is occasionally seen crossing the first at a high angle, and this, I presume, may be taken to indicate twinning on the pericline type.

Pyroxene.—This occurs in well-defined eight-sided sections, in elongated lath-shaped sections, and in irregular crystalline grains with more or less rounded angles. In very thin sections it is almost colourless; in thicker sections it exhibits under certain circumstances faint dichroism. Thus in sections which show more or less parallel cleavage cracks a greenish tint may be sometimes observed when the cracks are at right angles to the long diameter of the polarising Nicol, and a brownish tint when they are parallel to this diameter. Separate crystals or grains rarely measure more than 1 mm. in their largest diameter, except when they occur as narrow lath-shaped sections. The eight-sided sections are doubtless more or less at right angles to the principal axis. They show that the prismatic cleavages are fairly well developed, and that there is no marked pinakoidal cleavage. The pinakoidal faces are largely developed at the expense of the prismatic faces, and it is worthy of note that this feature is especially characteristic of the augites in augite-andesites.[1]

Sections more or less parallel to the principal axis show the usual parallel cleavage cracks and give extinctions referred to these cracks varying from 0′ to 44′. Twinning parallel to a pinakoidal face (doubtless the ortho-pinakoid) may frequently be recognized. These facts appear to establish the existence in the rock of a clino-

[1] Rosenbusch, Mikroskopische Physiographie der massigen Gesteine, p. 410.

rhombic pyroxene, viz. augite. Many of the lath-shaped sections are without well-marked longitudinal cleavage-cracks and a large number of them certainly extinguish with their edges parallel to the vibration plane of either the polariser or analyser. It is possible of course that the pyroxenic constituents of the rock may comprise more than one species of mineral. The pyroxene forms a very subordinate part of the whole mass. It is on the whole remarkably fresh, although occasionally it may be seen altered into a yellowish-brown substance. Inclusions are much less common in the augite than in the felspar, and a zonal banding is entirely wanting. When inclusions occur, they consist either of glass cavities with fixed bubbles,[1] or of colourless microlites. The pyroxene is distributed irregularly through the ground-mass of the rock, just as in the Santorin augite-andesites, several grains frequently occurring near together, and sometimes interfering with each other.

The constituents which remain to be described make up the ground-mass of the rock.

Felspars of the ground-mass.—These may appear in lath-shaped sections measuring as much as ·14 mm. by ·4 mm., or as extremely minute microlites. The latter sometimes occur in countless numbers and almost to the exclusion of the former; thus producing a ground-mass which may be described as a felted aggregation of microlites in a glassy base (mikrolithenfilz). This type of ground-mass occurs abundantly in the augite-andesites of Santorin. Two of my slides, one labelled Aphroessa 1866, and the other Palæa Cap., show it to perfection, and bear the most striking resemblance to some of the Cheviot andesites. Fluidal structure is admirably shown in both the Santorin and Cheviot rocks. It may be as well to mention here that the Santorin[2] andesites are described by Zirkel as having a pitchstone-like aspect.[3] In the majority of the Cheviot andesites examined by me the fluidal structure is absent, and the felspars of the ground-mass vary considerably in size. The sections of the felspars are short and lath-shaped, often with ragged or bifid terminations. They are without inclusions, and therefore differ markedly from the smaller porphyritic crystals. Under crossed Nicols they mostly present the characters of simple individuals or binary twins; but, as is now well known from the researches of M. Fouqué[4] on the Santorin lavas, we must not infer from this that they are sanidines. I have made attempts to determine both the large and small felspars by optical methods applied to the rock-sections; but the results are so unsatisfactory, that I prefer, at any rate for the present, to leave the question entirely open. No doubt the prevailing felspar is plagioclase, and it is of course highly probable that the felspars of

[1] I assume they are glass cavities, because I have not seen any spontaneous movement of the bubbles even in the smallest of them.

[2] Zirkel, F., Ueber die mikroskopische Zusammensetzung der diessjährigen Laven von Nea Kammeni, Neues Jahrbuch, 1876, p. 769. Also Mik. Besch. p. 390.

[3] The same author describes the augite-andesites of the 40th parallel of North America as having in most cases a resinous lustre. Microscopical Petrography of the 40th Parallel, Washington, 1876, p. 221.

[4] Santorin et ses Eruptions, 1879, Paris.

the ground-mass are more acid than those which occur as large crystals, and which certainly belong to an earlier stage in the process of rock consolidation.[1] In the Santorin lava of 1866, the porphyritic felspars consist of labrador, anorthite, sanidine and oligoclase, and the felspars of the ground-mass of albite and oligoclase, according to M. Fouqué.[2] Another constituent of the ground-mass is a well-crystallized mineral which occurs in extremely thin hexagonal plates of a deep brown colour. The largest of these plates measure only about ·03 mm. across, and therefore they may be easily overlooked when low powers only are used. It is doubtless either hematite or biotite, and on account of its great absorbing power in very thin plates, I am inclined to regard it as the former.

Colourless acicular microlites, brownish granules (globulites), and black opaque grains (magnetite), together with a base of true isotropic glass, sometimes brownish and sometimes colourless, make up the remaining portion of the ground-mass. I should have mentioned before that colourless prisms of apatite occur somewhat sparingly. The different constituents of the rock have consolidated in the following order: magnetite, pyroxene, porphyritic felspars, felspars of the ground-mass, base with devitrification products.

Secondary products.—The most striking of these are connected with the red veins, which frequently traverse the rock in different directions. The thin veins present, under the microscope, a deep red homogeneous tint. The thicker ones, however, are usually separated by a narrow transparent band of clear quartz or chalcedony. Scattered here and there throughout the clear substance are extremely minute particles of ferrite, and these are occasionally seen collected into more or less spherical masses, which remind one, in their mode of aggregation, of Vogelsang's cumulites.[3] Sharply-defined rays may be seen extending outwards from these spherical masses, although nothing like a radial structure can be observed in the masses themselves. Aggregations of the spherical masses may sometimes be seen shading off into the homogeneous red substance (jasper) which forms the margin of the vein. The red bands are separated from the clear quartz by a wavy line, which indicates that the interior surface of the jaspery portion of the vein is mammillated. The red colouring matter is not only collected in the vein itself, but may frequently be seen extending into the mass of the rocks for some little distance on either side.

In addition to the veins there occur, very sparingly in the andesites, though abundantly in the ordinary porphyrites, drusy cavities lined with a coating of chalcedony, and more or less filled with a clear green substance, sometimes appearing isotropic, and sometimes giving a feeble aggregate polarization.

Structural variations.—Only two important types of structure have been observed; in the one, the more common type, the porphyritic

[1] Rosenbusch, H., Ueber das Wesen der körnigen und porphyrische Structur bei Massengesteinen, Neues Jahrbuch, 1882, p. 13.

[2] Santorin et ses Eruptions, p. xi.

[3] Die Krystalliten, Bonn, 1875, page 139.

felspars form a large portion of the entire mass of the rock, and the felspars of the ground-mass vary in size from those giving lath-shaped sections (·4 mm. by ·14 mm.) to very small microlites, fluidal structure is absent; in the other and more interesting type the porphyritic felspars are not so abundant, the felspars of the ground-mass appear as innumerable minute microlites, and the whole section shows the most exquisite fluidal structure. It is this type which so closely resembles the Santorin lava of 1866. I have observed it only in some of the Alwin boulders.

General Relations of the Rock.

There exists, as is well known, between the basic and acidic igneous rocks, an extensively developed and widely distributed intermediate group. The trachy-dolerites of Abich,[1] and the andesites of Leopold von Buch,[2] belong to this group. Of these two terms the former has almost died out of petrological literature, while the latter has become definitively established, owing to the work of Groth, Zirkel, Rosenbusch, and others. An andesite, in the widest sense of the term, may be defined as a plagioclase-pyroxene (using the term pyroxene to include the entire group of the bisilicates) rock with a specific gravity of from 2·55 to 2·9, and a silica per-centage lying between 55 and 68. The entire group has been divided by Groth into hornblende-andesites and augite-andesites, and this division has now become perfectly well established. The group as a whole shades off through the hornblende-andesites into the trachytes, and through certain of the augite-andesites into the basalts.

The idea of hornblende-andesite has become fairly well fixed, but that of augite-andesite is still vague and fluctuating. The most precise definition of this, as of many other petrological terms, is contained in Prof. Rosenbusch's critical work on "The Microscopic Physiography of Massive Rocks";[3] a work for which all petrologists owe the author a deep debt of gratitude. One gathers from the description there given that the typical augite-andesites are *porphyritic* rocks, containing two generations of felspars, together with augite, magnetite, and a base which may be either glassy, micro-felsitic, crypto- or micro-crystalline. Quartz, hornblende, biotite, hematite, and ilmenite occur as accessory constituents in different varieties. The author, however, does not lay stress on the porphyritic character of the rock, and we find Dr. Hugo Bücking,[4] who claims to use the term augite-andesite in the sense adopted by Prof. Rosenbusch, applying it to a rock which occurs in the Rhön district, and which had previously always been regarded as a dolerite. Prof. Sandberger[5] objects, and I think with justice, to this extension of the term, and points out that the rocks in question are essentially similar to the typical dolerite of Meissner originally described by Hauy.

[1] Abich, A., Ueber die Natur und die Zusammenhang der vulkanischen Bildungen. Brunswick, 1841. [2] Humboldt's Kosmos.
[3] Mik. Phy. d. massigen Gesteine, p. 407.
[4] Mineralogische Mittheilungen, 1878, vol. i. p. 538.
[5] Min. Mitt. 1878, p. 280.

No doubt the confusion has arisen out of the proposal of Prof. Rosenbusch to exclude rocks which do not contain olivine, or which contain it only in very small quantity, from the basaltic group. At present I am of opinion that the best way out of the difficulty is to regard the Meissner rock as a typical dolerite, and to use the term very much in the sense in which it is used by Prof. Sandberger, that is, so as to include the same rocks, without, however, attaching that importance to the presence or absence of ilmenite as compared with magnetite which he does. At any rate, if we exclude such rocks as the Rhön dolerites from the augite-andesites, then we have remaining a group of porphyritic rocks with marked trachytic affinities, having silica per-centages ranging from 56 to 67, and a specific gravity of from 2·54 to 2·74. Our Cheviot andesite has a specific gravity of 2·57, and a silica per-centage of 63.

Chemical Analysis of the Cheviot Andesite.

My friend Mr. Thos. Waller has been kind enough to make a full analysis of a specimen of the Cheviot rock, and this is given in the following table side by side with the analyses of certain typical andesites. It corroborates the views recorded in this paper, and brings the Cheviot rock into close relation with the Santorin lava of 1866, the most important difference being the presence of a considerable amount of water in the base of the former.

	A.	B.	C.	D.	E.
Silica	63·0	63·05	58·76	66·62 to 67·35	62·76
Alumina	14·9	14·18	17·34	13·72 — 15·72	18·10
Ferrous Oxide Ferric Oxide	4·7	6·71	7·77	3·99 — 4·28 1·94 — 2·75	5·14
Lime	4·8	5·40	7·46	3·40 — 3·99	6·03
Magnesia	2·8	1·12	2·67	0·96 — 1·16	2·59
Soda	4·0	5·65	2·36	3·79 — 5·04	3·45
Potash	1·9	3·49	0·93	1·65 — 3·04	1·45
Loss	4·0	2·04	2·10	0·36 — 0·54	...
	100·1	101·64	99·39		99·42

A. Augite-andesite from the Cheviot district. Sp. gr. 2·54. Coquet, quarter mile above Windy Haugh. (Analysis by T. Waller.)

B. Augite-andesite from Tokajer Bahnhof, Hungary. Analysis by V. v. Hauer, given by C. Doelter, Mineralogische Mittheilungen for 1874, p. 210.

C. Porphyritic augite-andesite from Tuhrina, Hungary. C. Doelter, Min. Mitt. 1874, p. 205.

D. Santorin augite-andesites. Analyses by C. v. Hauer, quoted by Zirkel, Neues Jahrbuch, 1866, p. 769. The specific gravities of three Santorin rocks are given in the same paper as being 2·566, 2·544 and 2·507. (Specific gravity of Cheviot andesite, 2·53—2·62.)

E. Andesite from the volcano of Rincon de la Viega (Andes), Dr. Otto Proeless; Beiträge zur Kenntniss der Trachyte, Neues Jahrbuch, 1866, p. 652.

In the next communication I propose to describe a few of the normal porphyrites and to discuss their relations to the true andesites.

Note.—My friend Dr. Trechmann, of Hartlepool, has forwarded specimens of the rocks referred to in this paper to Prof. Rosenbusch, of Heidelberg, who is now working upon them. Hearing that Prof. Rosenbusch had not identified a rhombic pyroxene in the pitchstone porphyrite, I ventured to write to him asking for information on this point, and stating that I should be glad to add a note on the subject to the above paper, which was then in the hands of the Editor.

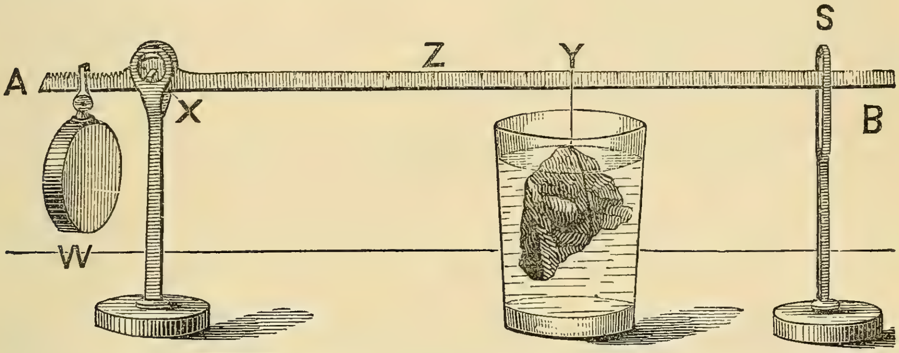
He has very kindly acceded to my request. After stating that there is undoubtedly a rhombic pyroxene, probably hypersthene, as well as augite, in the rock, and that his researches led him to the conclusion that the former is the predominating bisilicate constituent, he says :—"You may distinguish the two nearly related minerals by the following characters. The monoclinic augite is not in the least pleochroic; green in all sections. The ortho-rhombic pyroxene is strongly pleochroic in sections which are not too thin : the oscillations parallel to the vertical axis are green, those parallel to the horizontal axes are red and yellow respectively. The plane of the optic axes lies parallel to the green and red rays; that is to say, in the plane of perfect pinakoidal cleavage." Speaking of the affinities of this rock he says :—"If you should find that in general the monoclinic pyroxene is the dominating bisilicate, then the Cheviot porphyrite would be very closely related to the Permian palatinites of the Nape Valley; but if, as I must conclude from my observations, the ortho-rhombic pyroxene is the principal bisilicate constituent, then the rock would be the porphyritic equivalent of the ancient norites and directly equivalent to the recent hypersthene-andesites." We shall await with great interest the publication of Professor Rosenbusch's work on this remarkable rock. It seems clear that some of the pyroxene which I had taken for augite must be regarded as hypersthene or some allied mineral. M. Fouqué describes hypersthene as occurring in the Santorin rock, and on re-examining my Santorin slides, I am quite unable to distinguish between the pyroxenic constituents of these and of many of the Cheviot rocks. Sections across the prism show that corresponding faces are similarly developed, that the cleavages are similar, and that twinning parallel to a pinakoidal face also occurs in both rocks. Pleochroism is also present in both cases. If augite predominates, then the Cheviot rock will be an augite-andesite; if hypersthene, a hypersthene-andesite. A hypersthene-andesite from St. Egidi, in Steiermark, has been described by Niedzwiedzki (Min. Mitt. 1872, vol. iv. p. 253), and it is worthy of note that the bulk-analysis of the Cheviot-andesite agrees more closely with this than with the Santorin rock, especially as regards the presence of water in the base. Thus the St. Egidi rock contains: Silica 61·37, Alumina 15·76, Ferrous oxide 2·94, Ferric oxide 4·06, Lime 7·27, Magnesia 2·86, Soda 3·04, Potash 0·71, Water 2·64. Specific gravity 2·72.

III.—Walker's Specific Gravity Balance for Rocks and Minerals.

By Wm. N. Walker, F.G.S., Dundee.

THE determination, by means of the chemist's balance, of the specific gravity of rocks and minerals, now more than ever an important element in their classification, is an operation of some difficulty. Various instruments of different kinds have been devised to obtain the same results more easily and expeditiously, and as amongst these there is one I had constructed some time ago and of which I have lately had very favourable reports from practical workers, perhaps an account of it may interest some of the readers of the Geological Magazine.

The principle of this machine may be easily seen from the accompanying illustration.



A B is a lever resting on knife-edges at X and graduated from X to B in inches and tenths. W is a weight which can be moved out or in on A B to suit the size of the specimen weighed. S is an upright with a vertical slot to receive and steady the lever.

The piece of rock or mineral to be tested is suspended from the lever A B by a fine thread and weighed in air. The exact point of suspension is noted, suppose it to be Z, the distance from X is therefore XZ. The specimen is then immersed in water as shown in the sketch, care being taken to remove by means of a brush any air-bubbles that may adhere to it, and reweighed; suppose the point of suspension now to be Y, the distance from X is therefore XY.

Now since as follows from the properties of a lever, the weights in air and water are in inverse proportion to the distances of the respective points of suspension from X, and since the amount lost by immersion is exactly represented by the difference between the latter, it is evident that—

$$\frac{XY}{XY - XZ} = \text{the specific gravity of the specimen.}$$

An example may perhaps show this more clearly:—Suppose that in weighing in air, Z, the point of suspension, is 10 inches from X, and that, on reweighing in water, Y is 15 inches from X, then by the above formula:—

$$\frac{XY}{XY - XZ} = \frac{15}{15 - 10} = 3 = \text{the specific gravity of the specimen.}$$

It must be borne in mind that the weighings thus obtained, though sufficient data for determining the specific gravity of the specimen, are entirely relative. In the instance given above the 10 and 15 do not represent the actual, but merely the relative weights in water and in air. The determinations are of course only approximate, but are near enough for practical purposes.

The advantages claimed for this balance are :—

1. Simplicity, and speed in working.

2. There being no springs, it is not liable to get out of order, either with use or with changes of temperature.

3. By means of it, specimens of any size from half a pound in weight to a small chip can be tested.

4. Great portability, the whole being contained in a box measuring $20 \times 1\frac{1}{4} \times 2\frac{1}{2}$ inches.

I may mention that I have given the right of making these instruments to Mr. Lowden, Optician, Dundee, who can supply them at short notice. I understand his price is 25*s.* complete in a neat box.

Professor J. W. Judd, F.R.S., has kindly sent me the following note on the performance of my balance as used in the Geological Laboratory of the Normal School of Science and Royal School of Mines :—

Note on the Performance of Walker's Specific Gravity Balance. By Prof. J. W. Judd, F.R.S.

About four years ago Mr. Walker was good enough to send me an example of this balance, informing me at the same time of the circumstances which had led to its construction. While studying the volcanic rocks of the Western Isles of Scotland with the aid of my papers, Mr. Walker was impressed with the necessity which exists of some simple and portable apparatus, by the use of which an approximate determination of the specific gravity of rocks and minerals might be made. This led him to a series of endeavours to supply this want, and the instrument above described is the result of them.

I have had many determinations of specific gravity made by the aid of this instrument, and in 1880 felt so far satisfied with the results which it yielded, that I obtained four others of the same pattern for use in the Geological Laboratory of the Royal School of Mines. During the last two or three years many hundreds of determinations of specific gravity have been made by students in the laboratory, under the direction of the demonstrator, Mr. Grenville Cole, F.G.S.

The results of our experience of the use of this instrument, and of our comparison of it with other contrivances devised for the same purpose are, briefly, as follows :—

(1) Any one with ordinary care may, by the use of Walker's Balance, obtain for the specific gravity of a rock or mineral, a result which is absolutely reliable as far as the first place of decimals, and approximately true for the second.

(2) The time required for a determination is about the same as in

the case of Jolly's balance, the degree of accuracy obtainable being about the same in both cases.

(3) Walker's Balance is less cumbrous, lighter, and less likely to suffer injury in transport than any contrivance for the same purpose with which I am acquainted.

I may add in conclusion, that I have recommended Walker's Balance to many travelling geologists, and I find that by those who have employed it, it is universally well spoken of.

IV.—Canadian Pleistocene.

By J. W. Dawson, LL.D., F.R.S., etc., etc.

Reference is sometimes made, in the course of the active discussion of the Glacial age in the Geological Magazine, to the Pleistocene of Canada, a country which, perhaps, as much as any other, in its great extent from the Atlantic to the Pacific, and from latitude 45° to the Arctic Sea, affords opportunities for the study of the deposits of this period. It has occurred to me, in connexion with this, that it might be useful to your readers to present to them a short summary of Canadian facts, as I think I have established them in publications on this subject, which are, perhaps, better known in this country than in England.

In the St. Lawrence Valley, which may be regarded as a typical region, these deposits may be tabulated as follows, in ascending order : [1]—

(*a*) Peaty beds under Boulder-clay. (*b*) Lower stratified sands and gravels (Syrtensian deposits of Matthew).	These represent land surfaces and sea and coast areas immediately anterior to the Boulder-clay.
(*c*) Boulder-clay or Till; hard clay, or unstratified sand, with boulders, local and travelled, and stones often striated and polished.	The Lower St. Lawrence region holds a few marine shells of Arctic species. Farther inland is non-fossiliferous, but has usually the chemical characters of a marine deposit.
(*d*) Lower Leda clay; fine clay, often laminated, and with a few large travelled boulders, probably equivalent to Erie clay [2] of inland districts.	Holds *Leda* (*Portlandia*) *arctica*, and sometimes *Tellina groenlandica;* and seems to have been deposited in very cold and ice-laden water.
(*e*) Upper Leda clay, and probably Sangeen clay [2] of inland districts; clay and sandy clay, in the Lower St. Lawrence, with numerous marine shells.	Holds in Eastern Canada a marine fauna identical with that of the northern part of the Gulf of St. Lawrence at present; and locally affords remains of a boreal flora.
(*f*) Saxicava sand and gravel, often with numerous travelled boulders (Upper Boulder deposit), probably the same with Algoma sand, etc., of the West.	Shallow-water fauna of boreal character, more especially *Saxicava rugosa* and its varieties. Bones of Whales, etc.
(*g*) Post-Glacial deposits, river alluvia and gravels, Peaty deposits, Lake bottoms, etc.	Remains of *Mastodon* and *Elephas*, modern fresh-water shells.

The Lower Boulder-clay (*c*) is often a true and very hard Till, resting on intensely glaciated rock-surfaces, and filled with stones and boulders. Where very thick, it can be seen to have a rude stratification. Even when destitute of marine fossils, it shows its

[1] Supplement to Acadian Geology, 1878. Notes on Post-Pliocene of Canada, Canadian Naturalist, vol. vi. 1871. [2] Geology of Canada, 1863.

submarine accumulation by the unoxidized and unweathered condition of its materials. The striæ beneath it, and the direction of transport of its boulders, show a general movement from N.E. to S.W., or up the St. Lawrence Valley from the Atlantic. Connected with it, and apparently of the same age, are evidences of local glaciers denuding into the valley from the Lawrentian highlands. The Boulder-clay of the basins of the great lakes, and of the western plains, and of the Missouri Coteau and its northern extensions, seems to be of similar character. The basins of the lakes are parts of old Pliocene valleys dammed up with Pleistocene debris.[1] The Missouri Coteau and its extensions, probably the greatest moraine in the world, and the "terminal moraine" of the great continental glaciers of some American geologists, appears to be the deposit at the margin of a sea laden with vast fields of floating ice.[2]

The Lower Leda Clay (*d*) seems in all respects similar to the deposits now forming under the ice in Baffin's Bay and the Spitzbergen Sea. The Upper Leda Clay represents a considerable amelioration of climate, its fauna being so similar to that of the Gulf of St. Lawrence at present that I have dredged in a living state nearly all the species it contains, off the coasts on which it occurs. Land plants found in the beds holding these marine shells are of species still living on the north shore of the St. Lawrence, and show that there were in certain portions of this period considerable land surfaces clothed with vegetation. The Upper Leda Clay is probably contemporaneous with the so-called inter-glacial deposits holding plants and insects discovered by Hinde on the shores of Lake Ontario.[3] On the Ottawa it contains land plants of modern Canadian species, insects and feathers of birds, intermixed with skeletons of of Capelin and shells living in the Gulf of St. Lawrence.

The changes of level in the course of the deposition of the Leda Clays must have been very great; fossiliferous marine deposits of this age being found at a height of at least 600 feet, and sea-beaches at a much greater elevation, while at other times there must have been large land areas and even fresh-water lakes. Littoral gravels and sands of this period may also be undistinguishable, except by their greater elevation, from those of the Saxicava sand. I have recently described the bones of a large whale (*Megaptera longimana*) from gravel north of the outlet of Lake Ontario and 420 feet above the level of the sea, which is not improbably contemporaneous with the Leda Clay of lower levels, and much higher than deposits near Lake Ontario regarded as of lacustrine origin.[4] These changes of

[1] Newberry, Reports on Ohio; Hunt, Canadian Reports; Spencer, Ancient Outlet of Lake Erie, Ann. Phil. Society, 1881.

[2] Report on 49th Parallel, G. M. Dawson.

[3] Proceedings of Canadian Institute, 1877. Dr. Hinde in this paper incorrectly states that the Leda Clay belongs to the "close of the Glacial Period," and that boulder drift is not found above it. In truth, as Admiral Bayfield, Sir Charles Lyell, and the writer have shown, boulder-drift is still in progress in the Gulf and River St. Lawrence, though in a more limited area than in the Post-Pliocene period; but any considerable subsidence of the land might enable it to resume its former extension.

[4] Canadian Naturalist, vol. x. No. 7.

the relative levels of sea and land must be taken into account in explaining the distribution of marine clays and sands, boulder deposits, etc., which are often regarded with reference to the present levels of the country, or as contemporaneous deposits without regard to their elevation, a method certain to lead to inaccurate conclusions.

The Saxicava Sand (*f*) indicates shallow-water conditions with much driftage of boulders, and probably glaciers on the mountains. It constitutes in many districts a second boulder formation, and possibly implies a somewhat more severe or at least more extreme climate than that of the Upper Leda Clay. Terraces along the coast mark the successive stages of elevation of the land in and after this period. There is also evidence of a greater elevation of the land succeeding the time of the Saxicava Sand, and preceding the modern era.[1]

It is well known that very diverse theoretical views exist among geologists as to the origin of the deposits above referred to. The conclusions which have been forced upon the writer by detailed studies extending over the last forty years, are that in Canada the condition of most extreme glaciation was one of partial submergence, in which the valleys were occupied by a sea laden with heavy field ice continuing throughout the summer, while the hills remaining above water were occupied with glaciers, and that these conditions varied in their distribution with the varying levels of the land, giving rise to great local diversities, as well as to changes of climate. There seems to be within the limits of Canada no good evidence of a general covering of the land with a thick mantle of ice, though there must at certain periods have been very extensive glaciers on the Laurentian axis and in the mountainous regions of the west.[2] It does not, indeed, seem possible that, under any conceivable meteorological conditions, an area so extensive as that of Canada, if existing as a land surface, should receive, except on its oceanic margins, a sufficient amount of precipitation to produce a continental glacier.

Details on some of the above-mentioned formations will be found in my "Notes on the Post-Pliocene of Canada," and a large amount of recent information exists in the Reports of the Geological Surveys of Canada, and in papers published in the Canadian Naturalist and Geologist.

V.—Traces of a Great Post-Glacial Flood.

5. Evidence of the Marine Drift.

By Henry H. Howorth, F.S.A.

(*Concluded from page* 78.)

THESE difficulties are assuredly most embarrassing for those who conclude that the shell-beds point to the positions where they are found having once been the sea-bottom, and especially for those who argue that its submergence and re-emergence were the result of causes operating for thousands of years. We must remember

[1] Supplement to Acadian Geology, 3rd edition, pp. 14, et seq.

[2] G. M. Dawson, Reports on British Columbia, and Superficial Geology of British Columbia, Journal Geol. Society, 1878.

that if Sir Charles Lyell's calculations are of any value, they understate the problem, for many of the shells found in these beds are not littoral, but deep-water shells, and the land must not only have sunk to the level of the sea, but much below, to render it a fit habitat for them. We are to believe, then, that a whole continent, which was submerged for ages in this way, has nothing left to show the fact save these shreds left at different levels and always near the present coast-lines. In regard to the differing levels at which they occur, my acute friend, Mr. Darbishire, well says:—

"It is difficult to conceive of the deposit of a continuous bed of shingle, 600 feet deep, with precisely similar fossils in its highest and lowest layers, and of the removal of the whole of the formation, except a few patches of each layer lying within a space of 6 miles, It is more difficult to suppose that the cemetery beds (*i.e.* the beds at a lower level) can be a redistribution of such portions of Mr. Prestwich's gravel as the wave of a retreating sea carried away while the land was rising. It is scarcely more easy to believe that the cemetery beds and those of the higher land are merely portions of a deposit under similar conditions on a rising coast, the incline being not less than 600 feet in 6 miles" (Mems. Manc. Lit. and Phil. Soc., 3rd series, vol. iii. pp. 65 and 66).

Where, we may ask, if the current theory of submergence is to be accepted, are the continuous beaches that mark a rising coast, such as exist in Spitzbergen and elsewhere? Not a detached girdle like the 25-feet beach, but traces of sea-beaches up to 2000 feet above the sea-level? After I wrote this sentence I found that Mr. Jamieson, who will be everywhere accepted as a very learned and high authority upon the Glacial beds, had published similar remarks, but much more forcibly put, in a paper on the last stage of the Glacial period in North Britain, which I venture to quote. Speaking of the theory which postulates no disturbing influences, save subaerial ones, since the supposed great submergence, he says:—"In such a case I should expect to find level sheets of gravel, sand, and silt, containing some remains of marine fossils in a more or less perfect state; also, zones of beach pebbles mixed with some littoral shells, and deposits of a similar nature capping eminences that had been in shoal-water; and in particular I should look for traces of estuary mud along the curves of the wider valleys, where the tide and the river had formerly met. Now, in Scotland, so far as I am aware, we have absolutely no trace of any such estuary beds containing remains of animals peculiar to places of the sort, except at levels below 30 feet, and which belong, as I have elsewhere shown, to a more recent period, when glacial conditions had passed away, the shells indicating a climate rather warmer than at present. *How could the glacial sea have gradually retired, or, rather, how could the land have gradually emerged, without some tidal sediment being left here and there along the valleys where a pause in the change of level took place?* It is true some have thought they have discovered traces of ancient sea-margins in certain more or less horizontal banks and terraces, which, however, admit of a different explanation; but no one, so far as I remember, has been able to point out any estuary beds, containing estuary fossils, along the valleys at high levels. Why, also, should we not see some more distinct lines of old sea-cliffs and sea-caves at higher altitudes, and, likewise, some heavy masses of blown sand and shells like what we find on the coast at present? The beds of glacial marine clay and sand have been destroyed along the valleys to an extent inexplicable on the supposition that the sea gradually retired and nothing but ordinary subaerial action followed. In certain low districts, where this clay has nearly all disappeared, patches of it are left on eminences and places just where we might suppose it most likely to have escaped the action of glaciers [say, rather, of floods of water.—H. H. H.]; and at the mouth of some valleys (as, for example, that of the Dee, at Aberdeen) we find masses of it, which seem to be denuded remains of beds that some powerful agent has swept clean out of all the rest of the valley. And some of these beds appear to have been dislodged from their original position and thrust out seawards in a confused mass, as in the banks near the Aberdeen lighthouse and powder-magazine" (Journ. Geol. Soc., vol. xxx. pp. 318 and 319).

Let us now turn to the marine drifts in the valley of the Severn, which have given rise to the hypothesis of an arm of the sea having once occupied this area, to which the name of the Straits of Malvern has been given. Of the shells in these beds Mr. Maw says he could not find that any species are peculiar to particular parts of the deposit, but the fragments of shells are distributed throughout the whole mass of drift, including the clay and gravel beds. They are very fragmentary, only six or seven being perfect out of several hundreds. "Of that massive and strong shell, *Cyprina Islandica*," he says, "I have detected nothing but fragments scarcely an inch across and mostly much broken. The broken and water-worn condition of these remains would support the idea of their long transit from perhaps northern latitudes; but the evidence before us of the repeated tearing up and redeposition of the beds in which they occur would also account for their fragmentary state. . . . At the point where the drift beds rest against the old coast-line of Wenlock Shale I made a careful examination of the water-worn surface, with the object of ascertaining if some of the shells occurred *in situ*, but found nothing different from the usual state: all were broken and fragmentary" (Journ. Geol. Soc., vol. xx. p. 139). All this surely points most strongly to these beds having been completely moved and re-arranged. If it had been the case of a mere submergence of the area, the shells would have been found *in situ*, and widely distributed; and I have no doubt myself that the real explanation of the presence of the marine shells here is that they were brought hither by that mighty wave of waters whose presence we have tracked in so many quarters, and which swept them into their present quarters either from the Bristol Channel in the South or from the North—most probably from the South. The same result follows if we examine, not the shells, but the beds inclosing them, which do not have their constituents arranged the same throughout, but have, in the middle beds, unstratified clay, silt, and muddy gravel, while the upper and lower strata consist of clean sand and water-worn shingle, evenly stratified and without any trace of mud. The same conclusion seems to follow from the fragmentary and sporadic character of the patches of drift which seem to point to some powerful denuding agency, such as a current of water on a large scale since their deposition. "It is impossible," says Mr. Maw, "to compare the numerous outlying patches of drift, the various levels at which they occur, and the great individual thickness of some of the isolated patches, without being convinced of the large proportion that has been removed, compared with what remains" (*id.* p. 142).

Speaking of some of these drift beds, he says, "At the height of 60 or 70 feet above the river, and about 165 feet above the sea, these clean sand beds are replaced by a most heterogeneous mass of drift, in which stratification is almost absent: they are about 60 feet thick, and included within the top and bottom of the railway cuttings. So singularly various is their aspect, and so obvious in irregularity and variety of structure and materials, as to call forth the remark from one of the navvies that 'he had cut through plenty of hills in his time, but that he had never seen a hill with such a many kinds of muck in it as this.' The transition from the sand beds is well marked and sudden, and the beds immediately succeeding them consist of muddy subangular gravel, irregularly stratified, and containing beds of silt, drift coal and clay, irregularly disposed; and also, in common with nearly the whole mass of drift, rocks and stones of various sizes and from many formations, a list of which is given below. The middle of this heterogeneous stratum consists of a mass of very tough unstratified clay, containing fragments of Wenlock shale, waterworn and subangular boulders, pieces of flint, and patches of curiously contorted sand and silt, the structure of which is very similar to that of the strata at St. Acheul engraved at page 138 of 'The Antiquity of Man'; they seem to have been subjected to continual moving, washing, and changing, from constantly varying currents cutting fresh channels and redepositing the materials."

Whichever way we view these Severn Valley marine beds, we seem to be forced to the conclusion that they are not the remains of an old sea-bottom, but the result of some transient movement which transported them from elsewhere.

The present distribution of marine terraces points the same moral. If the land had been subject to secular movements of upheaval and subsidence on a large scale, they ought to be on a tolerably uniform level. As Mr. Jamieson says in a very recent number of this Magazine in reference to a very different theory, "The facts indicate a very unequal amount of submergence in places situated in the same latitude. The best-known high-lying marine beds of New England and Canada lie between lat. 44° and 52°, which corresponds to that of France and the South of England, just where evidence of submergence is conspicuous by its absence. Again, we find in

Scandinavia evidence of submergence to the extent of 600 or 700 feet, but in the same latitude along the eastern side of the Baltic and in Finland no evidence of a like submergence has been found. In the neighbourhood of Dublin, Lancashire and North Wales, sea shells are found in the superficial beds of sand and gravel to heights of 1200 and 1350 feet, but no evidence of submergence to anything like this extent has been detected on the eastern side of England or the neighbouring parts of Europe. In Canada the marine shell-beds reach up to 470 feet at Montreal, but, says Mr. Thomas Belt, 'going eastward from Montreal the elevation of the marine beds, marking the former submergence of the land, gradually decreases until in Nova Scotia it reaches zero.' Dana, in the 2nd edition of his 'Manual of Geology,' tells us that the altitude of the marine deposits on the southern shores of New England is 40 or 50 feet, at Lake Champlain (which is in the same lat. as Nova Scotia) they occur up to 393 feet. . . . . In Scandinavia the highest lying shell-beds are in the southern half of the peninsula, where they attain an altitude of 500 or 600 feet, but on going northward from Trondhjeim they seem to decrease in elevation, and in Finmark none have been discovered at nearly so great a height. At Hammerfest, according to M. Bravais, the highest of the old sea-beaches is only 92 feet. . . . Moreover, Bravais found that the old sea-beaches in Finmark are not horizontal, . . . his uppermost beach-line declines in level from 221 feet at its southern extremity in Altenfiord to 92 feet at its northern end at Hammerfest, thus lowering in level from south to north."—Geol. Mag. Sept. 1882, pp. 401, 402.

All this seems to me to be overwhelming evidence that none of the current theories either of ice-transport or prolonged submergence will support the facts. If not, where are we to turn? The sands with marine shells were undoubtedly left where they are by water. If we cannot bring the highlands of Western Europe below the sea-level without an injustice to our evidence, we must bring the water to the high ground in some other way. If the mountain did not go to Muhammed, Muhammed could, and in our view did, go to the mountain. We have accumulated a very great mass of evidence to show that further south the angular gravels, the loams and loess were distributed as we find them by a vast wave of waters which swept over the land and closed the Mammoth Period. Will not this explain our difficulty?

There is no more interesting and romantic place in the world for the student of recent geology than the famous inlet at Uddevalla in South Sweden, whose shell-beds have been so much used in their works by Lyell and others. I have visited these beds twice, and examined them with considerable care, on the last occasion with my friends Mr. Robert Darbishire, F.G.S., and Professor Marshall, and in the company of Mr. Dickson, who has done so much to work out their contents. It seems to me that the story furnished by these beds has hardly been sufficiently realized. I will just quote a description of them in the admirably graphic words of Linnæus, who first called attention to them, which have been translated into equally graphic English by Dr. Latham:—

"The shell hills (Skalbargen) are rightly reckoned amongst the greatest wonders of Bohuslaen; for they lay inland near a whole quarter of a mile, in some places, from the sea. These shell hills consist of periwinkles and bivalve shells (Snacke- och Muskle-skal), which are here assembled in such numbers that one wonders how so many living beings existed on the earth. We visited Capell Hill, which lay a quarter of a mile beyond the southern Uddevalla Gate; then we went to Sammered, which lay nearly a quarter of a mile from the town, north-east. In both places were these shell hills, especially and most markedly at Sammered. Here there were bare and hillocky ridges of grey stone, on the sides which face the town or the sea, where the bay was originally bent in. The earth was slightly convex on the summits of the above-named hill, and made a curve, where the black mould, which was seldom more than a foot and a half deep, thinned off; the shell-bed, which was two or three fathoms deep, underlaid it. Under this came in succession pure clay. No shells were seen above this stratum. Among the bare hill ridges they stretched, however, altogether from the hill downwards under the black mould, often to the breadth of several gunshots. The shells lay clean and unchanged, with no addition of soil, only strewn over with a little gravel, such as is thrown up on the beaches" (Linnæus, West Gotha Resa, pp. 197–8; Memoirs Geol. Survey, vol. i. p. 364).

This is a very faithful account of what is to be found here, and assuredly it is a very strange one. To find shells of the most fragile character, perfectly preserved, heaped up in this fashion many feet thick, with hardly any mixture of sand or shingle, quite heterogeneously, the species being mixed together in most admirable disorder, those from deep water being mixed with those which are purely littoral, shells which occur loosely in the sand being mixed up with abundant specimens of more than one species of barnacles which are attached to rocks, etc., and of mussels, etc., occurring gregariously in beds. This is assuredly a very puzzling assemblage. In the first place, it is absolutely clear that these shells could not and did not live where they are found. They could not have lived in heaps such as these are. Shells having such very diverse habitats could not have lived all together mixed up in this heterogeneous fashion, bivalves and univalves all huddled confusedly together in myriads. This is absolutely plain.

This has been noticed of the shell-beds elsewhere. Speaking of the Moel Tryfaen shells, Mr. Forbes says, "I have lately examined them carefully with a view to see whether they indicate an ancient coast-line and beach, or an ancient sea-bottom. But they cannot be regarded as indicating either, being a confused mixture of fragments of species from all depths, both littoral and such as invariably live at a depth of many fathoms—of such species as *Astarte elliptica*, *Mytilus edulis*, *Tellina solidula*, *Cardium edule*, *Venus gallina*, *Buccinum undatum*, *Mactra solida*, *Dentalium entalis*, *Cyprina islandica*, and *Turritella terebra*—inhabitants, some of muddy grounds, some of sandy, some of rocky. Deep- and shallow-water species, mingled, could at no time have lived together or have been thrown up on one shore" (*op. cit.* p. 384).

Mr. Mellard Reade makes similar remarks in regard to the Lancashire drift shells. Thus he says, "The association of the various species, distributed entirely without order through the clays, shows that they could not possibly have lived together on the same bottom, some being peculiar to sand, others to mud, some to rock, others to shingle, some requiring deep water and others shallow; so that the conclusion is irresistibly forced upon us that they must have been to a large extent transported" (Journ. Geol. Soc., vol. xxx. p. 32). The question then arises, What could have been the transporting cause? Forbes does not hesitate to say that this mixture "indicates the action of some disturbing influence—of having been accumulated far above the level of the then existing sea, *through the agency of an iceberg, as suggested by Mr. Darwin; or through the agency of a wave of translation, such as Sir Roderick Murchison has shown to play so important a part in producing the phenomena of the Scandinavian and Russian drifts; or, possibly, by the combined action of both causes.* That such propelling forces derived from afar," he says, "were powerful agents of disturbance at the period under consideration, is also rendered probable by the fact that the chief localities of stratified glacial beds, containing undisturbed testacea evidently *in situ*, as, for instance, great beds of *Pecten islandica, Panopœa arctica*, and even such delicate forms as *Nuculæ, Tellinæ*, and *Lucinæ*, in the position in which they lived, and with both valves connected, are to be found in the Clyde district (where this fact was noted by Mr. Smith), in localities sheltered to the North by mountain ridges, which were anciently islands in the glacial sea. These islands had saved many tracts of sea from the disturbing influence of icebergs [? icebergs, H.H.H.] *and great advancing waves*, the course of which, from the North, is indicated by the protected beds; for it is worthy of note that the glacial beds in the Northern districts of Scotland, which had no such protecting barriers to defend them—as, for instance, those at Wick—present the same disturbed and unstratified conditions and similar rolled and broken fossils with those so characteristic of the glacial beds around the Irish Sea" (*op. cit.* pp. 384-5). With this, save the introduction of ice, I most cordially agree. The introduction of ice as a co-ordinate factor with a translating wave of waters seems, as I have tried to show, to be very contrary to the evidence. The fact is, the more the problem is faced the more certain does it become that nothing but a wave of waters is competent to produce the effects we find. Such a wave moving up the rocky inlets on the Swedish and Norwegian coast would take up and carry along shells from various depths, the whole being sifted of gravel by their light weight, and carried clean and mixed as we find them at Uddevalla and elsewhere. Such a wave explains why the shells are only found on the coasts and not inland, and generally on coasts where the water would be throttled by land on either side, and be therefore forced to climb up to greater heights than elsewhere. It would leave these debris of the sea as its own high-water mark, a high-water mark which would be at different heights in different localities, according as it had room to spread or no. This removes the difficulty already referred to in the present distribution of marine terraces and raised beaches. Whichever way we view the question, we seem to come back to the conclusion formulated long ago by Hugh Strickland in regard to the Severn Valley beds. "The marine shells," he says, "which have been found in the gravel in Cheshire, Staffordshire, Shropshire, and Worcestershire, belong chiefly to existing species, and we must therefore assign a very recent epoch to the formation of these deposits. It appears also that the causes which transported the gravel were comparatively transient, for we can hardly suppose the sea to have occupied the central plain of England during a very long period without leaving some traces of Tertiary strata (Strickland wrote before the Quaternary deposits were separated from the Tertiary beds), especially in small valleys and basins, which might be sheltered from the action of the northern current" (Strickland, Mems. and Papers, p. 107).

I have now examined, I hope with fairness and candour, the evidence of the high-level marine drifts containing shells found at so many scattered points near the coasts of Western Europe. I cannot find them testifying anywhere to those gigantic vertical movements of the earth's crust over immense areas and within quite recent geological times, which are required by the theory of a long-continued submergence advocated by Sir Charles Lyell and his followers. Nor do I see in them effects which can with the smallest probability be assigned to the action of ice in any form. I find in them, on the contrary, a consistent testimony to the presence and action of the same diluvial movement of which such ample evidence has been accumulated from other sources, and which alone seems to me competent to explain them.

VI.—The Secret of the Highlands.

By Prof. Charles Lapworth, F.G.S.

Having gained a general comprehension of the probable physical and palæontological sequence among the Lower Palæozoic strata of the Southern Uplands of Scotland, as partly published in my memoirs upon the "*Moffat Series*,"[1] and the *Girvan Succession*,[2] I felt myself at liberty last summer to commence the study of those rocks of the North-west Highlands, which are supposed to be of corresponding age.

The area I fixed upon for examination was the coast region of Durness and Eriboll in North-west Sutherland. I selected that especial area for several reasons. It is the only Highland district where Lower Palæozoic fossils have been obtained in comparative abundance. It lies wholly upon that enigmatical zone of country where it has been asserted that we have a demonstrably ascending succession from the basal Hebridian gneiss through fossiliferous Palæozoic limestones into the metamorphic gneiss and micaceous schists and slates of the Central Highlands. It is the only area

[1] Quart. Journ. Geol. Soc., May, 1878. [2] *Ibid.*, November, 1882.

where the rocks of this remarkable zone come out in force upon the shore-line, and where, as a consequence, the stratigraphist might expect a more than ordinary abundance of serviceable rock-exposures. And, finally, as the keener disputants in the Highland controversy have already published their views as to the physical structure of this area, I should have the advantage of working alone, and drawing my own unfettered conclusions.

The final results of my investigations in the Durness-Eriboll region during August last seem to me to indicate most distinctly the probable truth of the theory which has long appeared to myself to be the only possible solution of the Highland difficulty. I believe that we have in the so-called metamorphic Silurian region of the Highlands of Scotland a portion of an old mountain system, formed of a complex of rock formations of very different geological ages. These have been crushed and crumpled together by excessive lateral pressure, locally inverted, profoundly dislocated, and partially metamorphosed. This mountain range, or plexus of ranges, which must have been originally of the general type of those of the Alps or Alleghanies, is of such vast geological antiquity, that all its superior portions have long since been removed by denudation, so that, as a general rule, only its interior and most complicated portions are preserved by us. In the area partly worked out by myself, the stratigraphical phenomena are identical in character with those developed by Rogers, Suess, Heim, and Brögger in extra-British mountain regions. They appear to me to account so naturally for the diverse views hitherto published by those who have personally studied the stratigraphy of the North-west Highlands, and to indicate so clearly the common ground of accord upon which all parties may eventually meet, that I am emboldened to give them in outline in this place, in anticipation of a more detailed paper upon the subject, which I hope to publish elsewhere. It is for those who are interested in this great geological problem to test for themselves the truth of these conclusions, by their consonance with their own discoveries, or to point out those difficulties which at present stand in the way of their provisional adoption.

I.—*Apparent structure of the Durness-Eriboll region.* (See Fig. 1.[1])

At first sight it would appear that the rocks of the Durness-Eriboll region are easily grouped, and that they are arranged with remarkable geological simplicity.

(*A.*) Lowest of all lies an enormous formation of massive gneisses with coarse folia of quartz, felspar, and hornblende (and more rarely mica). These gneisses are almost vertical, and have a steady N.W. and S.E. strike. They form the basal or fundamental gneiss of some authorities, the *Hebridian*, *Lewisian*, or *Laurentian* of others.

(*B.*) Upon the eroded edges of the Hebridian gneiss rest unconformably the basal beds of a second formation, the strata of which have a very gentle inclination, and strike, as a whole, to the north-

[1] The illustrative Figures will appear in the second part of this paper.

west and south-west, or at right angles to the direction of the underlying gneiss. This higher formation appears to be composed of two very distinct divisions, viz.:—

1. A *Lower* division of quartzites, flaggy beds, and limestones, often greatly hardened, but the calcareous beds of the division (Durness Limestone) afford *Maclurea, Murchisonia, Orthoceras*, and other recognizable Lower Palæozoic fossils. (This division may be termed the *Durness or Eriboll series.*)

2. This Durness-Eriboll series appears to be surmounted conformably by an *Upper division* of flaggy, quartzose, micaceous and chloritic schists, with thick zones of hornblendic and micaceous flaggy gneisses and bands of so-called igneous rock (dioritic or syenitic rock of some authors). This division forms the well-known *Upper Gneiss*, or *Sutherland Flaggy Schist* series.

As regards the superiority of the fossiliferous Durness-Eriboll series (B. 1) to the basal Hebridian or Hornblendic gneiss, there has never been any dispute. But the true relation of the Sutherland series or so-called Upper Gneiss (B. 2) to the fossil-bearing rocks is not yet settled, after years of the keenest controversy. This Sutherland series not only contains beds hardly more altered than those of the fossiliferous Durness-Eriboll series, but it includes also hornblendic and micaceous gneisses almost inseparable mineralogically from those of the basal Hebridian. It stretches too, in almost unbroken mass, eastward and southward from this region over the entire area of the Central Highlands, where it covers at least an area of 15,000 square miles,[1] and has not yet afforded a trace of a recognizable fossil. Many geologists, therefore, aware that the concession of the superiority of the Sutherland series to that of Durness, carried with it, almost of necessity, the admission of the Palæozoic age of *all* the schists and gneisses of the Central Highlands, have refused to pin their faith to the apparent stratigraphy, and have sought to explain it upon the hypotheses of hidden faults, or folds, or stupendous overthrows of the strata. Others, again, have boldly accepted the visible sequence as it stands, with all its awkward consequences. It is hardly necessary perhaps to point out that the latter view, being the most superficial and the most natural, is that which has hitherto been the most orthodox and the most popular.

II.—*Theories of the Physical Structure of the Durness-Eriboll Region:*—

At least four distinct theories have been already published in explanation of the Durness-Eriboll section.

1.—*Theory of Sir Roderick Murchison.*

According to Sir Roderick Murchison, the succession in this region is composed of two distinct rock systems, viz.[2]

(*A*) *Archæan or Laurentian*: composed of the basal Lewisian or Hebridian, hornblendic gneiss of Fashven and Ben Cannabin: a true crystalline gneiss with a steep dip and N.W. strike.

(*B*) *Palæozoic or Silurian*, consisting in ascending order of:—

[1] *Geikie*, Handbook of Geology, 1882, p. 584.
[2] Quart. Journ. Geol. Soc. August, 1859.

(*a*) A *Lower or fossiliferous* (*Durness*) *division*, composed of

1. *Lower Quartzite* and flaggy fucoid beds of Kyle of Durness, and west side of Loch Eriboll.
2. *Limestone of Durness*, with *Maclurea* (regarded as the equivalent of the non-fossiliferous limestone of Eriboll).
3. *Upper Quartzite* of east side of Loch Eriboll.

This lower division graduates upwards as a whole insensibly into the

(*b*) *Upper or Metamorphic division* of the Flaggy gneisses and schists of Fair Head and Ben Hope (*Sutherland series or Flaggy gneiss*).

2.—*Theory of Professor Nicol.*

Murchison's view of the superposition of the Sutherland gneisses and schists to the Durness series was strongly opposed by the late Professor Nicol, who held that the (*A*) *Archæan or Hebridian* of Fashven and Ben Cannabin was covered unconformably by the (*B*) *Palæozoic strata of Durness and Eriboll*, in which he recognized only three members—

1. The Lower Quartzite.
2. The Fucoid beds.
3. The Durness or Eriboll Limestone.

He held that the so-called *Upper Quartzite* of Murchison was merely the Lower Quartzite repeated by inversion, and that it was newer than the *Sutherland gneissic series.* The latter he held to be, upon the whole, an ancient metamorphic Pre-Cambrian gneiss brought up to the eastward of Loch Eriboll by a gigantic overthrow fault: running generally along a line of syenite or intrusive igneous rock, which occurred in occasional patches along the fault line from Whiten Head to Loch Maree.[1]

3.—*Theory of Professor Heddle.*

Founding mainly upon the fact that the Assynt-Eriboll, or easterly band of the Quartzite and Limestone series, is unfossiliferous, and that its most prominent bed to the south is dolomitic, while the Durness Limestone is fossiliferous, and its beds are not dolomitic, Professor Heddle agrees with Murchison in regarding the apparent ascending succession, from the basement quartzite of Ben Cannabin into the Sutherland schists, as the true one; the "igneous rocks" being interbedded, and not destroying the general continuity of the sequence. He differs from Murchison, however, in placing the whole in the Archæan, with the exception of the fossiliferous Durness Limestone, which he believes is merely an isolated fragment of an originally overlying Palæozoic formation dropped in by faults.[2]

4.—*Theory of Dr. Chas. Callaway.*

According to Dr. Callaway also, there are probably two distinct Archæan series in the region, (*a*) the massive Hebridian gneiss at

[1] Quart. Journ. Geol. Soc. 1856, p. 17, *et seq.*
[2] Heddle, Microscopical Magazine, 1881-82.

the base, overlain unconformably by (*b*) a second metamorphic series; composed, in ascending order, of the quartzite, the gneisses of Sango Bay, etc., etc., and the flaggy schists of Fair Head, Loch Hope, and Central Sutherland. He infers that the Palæozoic Durness Limestone was deposited upon the contorted gneiss, and owes its apparent infra-position to the latter merely to the effects of faults.[1]

III.—*Results in the Durness Area.*

In my study of the Durness area I ascertained that the following facts, among many others, are easily made out upon a careful mapping of the ground.

1. The Lower Quartzite rests at a gentle angle unconformably upon the almost vertical edges of the Lewisian or Hornblendic gneiss.

2. The highest bed of the Quartzite is a flaggy zone pierced by innumerable vertical annelide tubes. (*Pipe-rock* of Nicol.)

3. The Durness Limestone, though at first sight apparently homogeneous, of great thickness and of very gentle inclination, is actually made up of a few distinct lithological zones, repeated again and again in a series of faults or inverted folds. It is hardened and more or less crystalline throughout, but contains abundant relics of *Maclurea*, etc., upon one special horizon.

4. The Limestone is visibly *overlain* in excellent readable sections and at a very low angle by a series of wrinkled shales, micaceous flagstones and slaty schists, with intercalated zones of hornblendic gneissose schists; and even where transversely faulted against the limestone, this overlying series agrees precisely with the underlying limestone zones in dip, strike, and apparent amount of convolution.

As this physically overlying series is the *Upper Flaggy gneiss* series of Murchison, it would appear, at first sight, that his theory of the sequence, so far as the Durness area is concerned, is absolutely impregnable.

Such, at least, would be the unhesitating conclusion of any geologist whose field experience had been confined to the study of the gently inclined and slightly folded rocks of the Newer Palæozoic and more recent formations of Britain. But to those who, like myself, have been led again and again into error and difficulty by a too hasty reliance on *apparent* sequence among the excessively convoluted Lower Palæozoic rocks, it is needless to point out how utterly worthless is such evidence as this, in highly plicated and inverted strata, unless it be confirmed by other and more convincing testimony. And the folding, wrinkling, and inversion in the Durness area is excessive. The laminæ on almost every slab from the schistose and gneissose rocks exhibit the most extraordinary wrinkling and puckering; while the geographical distribution of the petrological zones of the Durness Limestone can only be satisfactorily interpreted upon the hypothesis that they are arranged in a number of flattened arches and troughs, whose very oblique axes all dip in one and the same general direction. Before discussing, however, the most natural methods of developing the true sequence of the beds in a complicated

[1] Quart. Journ. Geol. Soc., May, 1881.

area of this character, let us first examine the corresponding strata, as shown in the parallel valley of Loch Eriboll, where, if the visible phenomena are reliable, we again find an unmetamorphosed limestone and quartzite series, lying between the two generally metamorphic formations of the Hebridian gneiss and the Sutherland Series.

IV.—*Appearances in the Loch Eriboll Area.*

The long and narrow valley of Loch Eriboll lies a few miles to the eastward of the Strath of Durness, from which it is separated by the steep mountain ridge of Ben Spionna and Ben Cannabin. The northern and central parts of the valley are filled by the waters of the beautiful sea-fiord of Loch Eriboll, which is about ten miles in length, by two in breadth. The southern extremity of the valley is formed by the marshy flat of Strath Beag, which is shut in on all sides, except to the north, by the converging heights of Craig Erail and Conamheall.

The western wall of the valley of Loch Eriboll—the range of Ben Spionna and Ben Cannabin (2537 ft.)—is composed of the almost vertical Hebridian gneiss, overlain by sheets of the Lower Quartzite, which dip gently eastward and finally subside below the waters of the loch. Some islands in the loch itself, and the promontories along its eastern shore, are formed of thick-bedded limestones. These, like the underlying quartzites of Ben Spionna, dip generally at gentle angles to the eastward towards the mountain ridge of Ben Poll and Whiten Head, which forms the eastern wall of the valley, and constitutes the most westerly buttress of the great plateau of Central Sutherland. In the lower parts of this ridge the limestones appear to be generally surmounted by a second series of quartzites and flaggy beds (Upper Quartzite of Murchison and others). In its higher slopes this Upper Quartzite plunges in its turn below the flaggy schists, metamorphic gneisses and so-called igneous rocks, that make up the *Upper or Flaggy Gneiss* Series of Central Sutherland and the Highlands generally.

V.—*Sections West of Loch Eriboll.*

In my study of this area I ascertained that upon the western side of the Loch, the *Lower Quartzite* rests unconformably upon the Hebridian gneiss of Ben Cannabin.

I. a. The *basal* zone (*a*) of this lower quartzite is a well-marked breccia, or conglomerate, rarely more than a foot or two in thickness, filled with small quartz pebbles, angular fragments of vein quartz, and flakes of grey and greenish shales.

The main mass of the Quartzite itself is divisible into two primary zones, viz :—

I. b. A lower zone, of thick-bedded and occasionally flaggy quartzites usually weathering to a faint pink or buff colour. (Tinted Quartzite.)

I. c. A higher zone of massive quartzites, usually of a pure white. (White Quartzite.)

I. d. The highest zone, as in Durness, is composed of flaggy

Quartzites pierced by innumerable vertical worm-holes (*the Pipe rock*).

This last-named band is the highest bed exposed on the western side of the Loch, the superior beds having been removed by denudation.

VI.—*Sections East of Loch Eriboll.*

On the opposite side of the Loch, however, a magnificent section of the naturally succeeding strata is exposed in the cliffs of Hielem roadstead or Camas Bay. In this section, which occurs at the little headland of Ant-Sron, the strata are thrown into a long and broad arch, the beds dipping in opposite directions at a very gentle angle. They are laid bare in a continuous exposure nearly a quarter of a mile in length, in the cliffs and in the coast platform below, and every bed admits of easy study and admeasurement. Here we are presented with the following section, in ascending order :—

I. (*d*). *Lower or Eriboll Quartzite,* chiefly the highest zone (or *Pipe rock*), a series of flaggy quartzites, often iron-stained, and filled with hosts of vertical annelide tubes—30ft.

II. *Hielem or Fucoid Beds.*—50 to 60ft.

(*a*) Flaggy grey shales covered with Fucoids (branching worm castings)—*Fucoid zone.*

(*b*) Calcareous shales and flags (an impure dolomitic cement-stone)—*Fucoid Limestone.*

(*c*) Quartzose flags, with occasional Annelide holes, and a remarkable zone of dark blue shale at the summit—*Upper or Hielem flags.*

III. *The Salterella Grit or Quartzite*—10 to 15ft.

A conspicuous zone of Quartzite, often gritty with small pebbles of quartz, riddled with empty wormholes, and crowded with casts of *Salterella Macullochii.*

IV. The *Eriboll or Durness Limestone*—150 to 200ft.

(*a*) A thin zone of impure dolomitic limestone of a yellowish-buff colour, graduating upwards from the *Salterella Grit,* through a conspicuous transitional zone of calcareous grit, which weathers into a ragged scoriaceous rock of a most remarkable aspect (*Scoriaceous-bed*). This transitional band afforded me *Orthoceras, Linguloid* shells (?) and the usual *Salterella Macullochii.*[1]

(*b*) *Dark* (almost black) flaggy *Limestones* and calcareous shales (the latter cleaved) filled in patches with hosts of *Salterella Macullochii,* etc.

(*c*) *Grey,* white and mottled *Limestones* of great thickness, arranged in several well-marked zones, identical with those in the Limestone series of Durness. These are the highest beds discoverable at this locality.

[1] Between the base of the *Fucoid or Hielem beds* and the top of the *Scoriaceous bed* the rocks all weather to a yellowish-buff colour upon exposure to the weather, forming a striking contrast to the white quartzite below and the dark limestone above.

This cliff-section is merely the northern edge of a long and broad basin of Limestone which occupies the flat ground of Tor Leath and Eriboll House lying to the south of the promontory. To the westward of the basin its strata are truncated by the waters of the Loch. To the eastward, however, the outer edge of the basin is bent abruptly upwards, and the underlying strata again emerge in their natural order from below the limestone, between the latter and the *Sutherland gneiss* in the mountain slopes to the south-east of Ant-Sron. The beds are more or less looped and folded, and towards the summit of the ascent are vertical or even inverted. But by a careful study of the ground, which is comparatively bare, the stratigraphist is able to read off the descending succession in regular and unbroken order.

The dark limestones (VI. *b.*) here fringe the eastern edge of the basin. These pass downwards through the yellow band (IV. *a.*) into the *Salterella* grit (III.), which is often very conspicuous. Next emerge the yellow and buff-tinted flaggy beds, dolomites, and shales of the *Hielem* beds (II.), with their fucoids and worm-tracks. Rising out from below these to the east appears the *Pipe-rock* (I. *d.*) of the Lower Quartzite, charged with its hosts of rounded Annelide tubes. Next rises to day the massive *white Quartzite* (II. *c.*) so conspicuous at the opposite side of the Loch. Below follows the faintly-coloured and more flaggy quartzites of the underlying zone (II. *b.*), and lastly from beneath the whole, rises out the thin basal conglomerate itself, with its quartz-pebbles, and fragments of coloured shales.

This conglomerate rests at once upon the highly crystalline or so-called igneous rock of the Sutherland gneiss upon the platform above the ridge, where a narrow island of quartzite is surrounded by the crystalline "*igneous rock*," and is separated from it by the basal conglomerate, the visible phenomena affording very clear evidence of a distinct unconformity between the two series.

In this locality, therefore, we have not only a complete demonstration of the identity of the so-called Lower and Upper Quartzites, but proof that the Lower Quartzite (and of necessity the whole of the fossil-bearing series) is of newer age than the "igneous rock" of the Sutherland gneiss.

Hence, whether we agree with Murchison, Heddle, and Callaway, that this so-called igneous rock is an integral part of the Upper Gneiss, or whether, on the other hand, we accept Nicol's view that it is an intrusive rock of much more recent date, the final result is precisely the same. The unaltered fossil-bearing Durness-Eriboll series is demonstrably *newer* than the Sutherland gneiss. If, therefore, as commonly believed, the *Sutherland* or *Upper Gneissic Series* is merely part and parcel of a single rock-formation which extends over the Highlands generally, then the whole of the metamorphosed and altered rocks of the Highlands must be of "Pre-Silurian" age.

Here, then, we have a result which is diametrically opposed to that which we obtained in the Durness area. That is to say, *if we rely solely upon ordinary evidences of superposition*, we can apparently demonstrate in one area of the North-west Highlands that the altered Highland rocks *overlie* the fossil-bearing series, and in another that they *underlie* them. By an unconscious selection of favourable sections, either of these two mutually destructive views could be supported by what a partisan would naturally claim to be an overwhelming mass of evidence.

(*To be continued.*)

NOTICES OF MEMOIRS.

THE FLOOD OF THE CONNECTICUT RIVER VALLEY FROM THE MELTING OF THE QUATERNARY GLACIER. By JAMES D. DANA. (Amer. Journ. Science, vol. xxiii. 1882.)

THE title of this paper indicates its principal contents; the author pictures the general condition of the Connecticut and its tributaries during the progress of the flood, he treats of the origin of the channel-way of the river, of its terraces, and the bearing of the facts on the retreat of the glacier. According to the process described the terrace-plains were formed during the *rise* of the waters. The following conclusions may be read with interest:—

"At the time of maximum flood the ice was not lying along the center of the valley producing the river by its gradual melting, and retreating northward as the river elongated in that direction. The amount of water flowing off with a velocity of three or four or more miles an hour, making the great flood, was too vast to have been generated from a retreating body of ice in the valley. If, as Greenland facts authorize us to believe, sub-glacial rivers of large size and energy were a universal feature of the Glacial era, these streams must have entered on a career of real progress when melting began in earnest. As they enlarged, the icy tunnels they had hitherto occupied would have become widened, and the sub-glacial chambers have extended themselves in all directions, undermining the heavy glacier. And as rapidly as this removal from below went on, the deposition of the materials of the ground moraine—the stones, gravel, earth and clay—long before initiated—would have gone forward, covering with till the glacier-buried land. But subsequently, when the rising streams had volume enough to make the lower range of terraces, along the valleys, the roofs of the tunnels were probably, for the most part, gone. The ice still lay over the land, covering deeply the hills and mountains, but the wide channel-ways were open to the day. Evidence of this is afforded by the fact that these lower terraces, like the higher, are free, with rare exceptions, from deposits or droppings of till or of bowlders, such as would have come from an overhanging glacier. But outside of the terrace plains, up the hill-slopes, wherever the ice still remained in force, the till may have continued to fall, adding later to earlier till."

At the time of maximum flood the ice melted might have reached the amount of a cubic mile per day.

REVIEWS.

I.—Mémoires de la Société Paléontologique Suisse. Études sur la Faune des Couches du Gault de Cosne (Nièvre). Par P. de Loriol. 4to. pp. 115, 13 Plates.

The Museum of Geneva, amongst its many treasures, possesses a fine collection, formed by the late M. Ébray, from the above locality. This has supplied the material for the present work, and was obtained from two horizons. The lower fauna occurs in a thin bed of greensand situated in the "argiles micacées du gault," the upper one in the "graviers avec bois criblés de pholades," which are separated from the "craie chloritée" by a bed of blue clay with grains of silicate of iron.

The lower fauna is the most abundant, 89 species being enumerated, of which nearly half are described by the author as new. Cephalopods are extremely scarce; no Belemnites, but the rare presence of *Ammonites mammillaris* and *A. interruptus* seem to fix the geological horizon. There are 32 determinable species of Gasteropods (at least 10 more insufficiently diagnosed), whilst in actual numbers this is the predominant group. Such well-known forms as *Natica gaultina, Aporrhais Parkinsoni, Dimorphosoma calcarata,* and *Scalaria Dupiniana* occur in very small numbers, whilst *Avellana lacryma* is exceedingly numerous. On the other hand, a new *Natica* and a new *Trochus* are very abundant. Not the least remarkable feature is the recognition of such genera as *Trophon, Stenomphilus, Coralliophila,* and *Rapa,* and the absence of *Pleurotomaria* and *Solarium.*

The Lamellibranchiata are represented by 54 species, constituting the entire remainder of the fauna, in which even Brachiopoda have no part. A small *Corbula*, a small *Arca, Thetis major*, etc., are tolerably plentiful. Several specimens of *Inoceramus Salomoni* are quoted, but none of *I. concentricus* or *I. sulcatus.* The former of these three occurs in the *Mammillaris*-bed at Folkestone, whilst the first appearance of *I. sulcatus* at Folkestone is in the junction bed between the Upper and Lower Gault. This is a further confirmation of the position of the lower shell-bed at Cosne. The absence of *I. concentricus* may be regarded as one of the local peculiarities.

The collection from the upper shelly horizon of Cosne (graviers supérieurs des Brocs) contains only 20 species, 4 being Gasteropods and 2 Brachiopods. It is evident that more arenaceous conditions prevailed, and the old fauna returned to the locality in very small numbers. On the other hand, *Trigonia,* entirely absent in the lower fauna, puts in an appearance with three species. The Brachiopods, *Terebratella Menardi,* and *Rhynchonella sulcata,* are forms with a wide range in time, the latter in this country being very characteristic of a certain horizon in the Folkestone beds of the Lower Greensand.

The Swiss Palæontological Society have not stinted M. de Loriol as to illustrations. Nearly all the species, whether old or new, are figured, and in some cases about a score of figures are devoted to one species, *e.g. Trochus neverisensis.* The early plates are very good and clear, but some of the later ones, especially plate x., are not quite so satisfactory.

Palæontologists in this country may sometimes think that specific titles are conferred by continental authors where a less marked differentiation would meet the case. At page 112 M. de Loriol, whilst complimenting Mr. Hilton Price upon the value of his work, "The Gault," takes exception to his suggestion that many fossils, which are more or less identical, have different names in England and on the Continent. The author thereupon challenges the palæontologists of this country to make some use of their immense Gault collections, to prove or disprove these statements.

We suspect that the Gault is not the only formation where such is the case, but when the challenge is generally accepted, many preliminary arrangements will have to be made as to the meaning and value of terms, before anything like international palæontology can hope to be a success. W. H. H.

II.—Om de Palæozoiska Formationernas Operkelbärande Koraller, af G. Lindström. Med nio Taflor. Bihang till K. Svenska Vet. Akad. Handlingar, Band 7, No. 4, Stockholm, 1882.

On the Operculate Corals of the Palæozoic Formation. By G. Lindström. With 9 Plates. Appendix to the Transactions of the Royal Swedish Academy. 8vo. pp. 112.

In this memoir Prof. Lindström has brought together a complete description of all the known species of those peculiar fossil corals which are distinguished by the remarkable feature of having one or more movable valves or lids, attached to the margins of the calice, which probably served as a covering and defence of the soft parts of the animal. This abnormal feature gave rise in past times to much misconception respecting the characters of these fossils, and certain species were, till a comparatively late period, referred to the Brachiopoda, though, strange to relate, some of the earliest writers who noticed these forms—Born and Guettard for example—placed them in their true position amongst the corals.

All the operculate corals possess one or more plane outer surfaces; and that on which the coral rests on the sea-bottom during its earliest growth, and from which, in many instances, root-like processes are given out, is termed by Lindström the under-side (bottensidan). Within the calice this under-side carries the largest septum. The side opposite, whose inner wall has the septal fossula, is named the upper-side (uppsidan); the two other sides are right and left, according to their position to the left or right of the under-side. The so-termed costæ of the outer surface (not in the operculate corals merely, but in almost all the Palæozoic corals) differ fundamentally from the costæ of the Secondary, Tertiary, and recent corals, which are only continuations of the septal plates beyond the walls of the corallites, whereas in the Palæozoic forms, these vertical ridges actually occur in the interval between the two septa, and, as a distinction, should be termed rugæ. The rootlets are usually developed on the under-side of the coral, but in some cylindrical or conical forms they appear all round the exterior. Lindström finds that they originate, without exception, as small projecting spouts from the upper margin of the under-side of the coral. Their succeeding development varies exceedingly in different genera of corals; thus, in *Eridophyllum* they become hook-like extensions, in *Syringopora* they are connecting tubes between the corallites, in others again they are root-like appendages. It is probable that many so-called *Auloporæ* are merely the initial stages of *Syringopora*, in which the connecting tubes are adnate, and develope into fresh corallites. In *Diphyphyllum* the tube-extension proceeds from the summit margin of the coral, and is developed into a new polyp. In *Rhizophyllum attenuatum*, Lyon, the under-side is furnished with numerous root-like appendages, which grow into new corals. In *Rhizophyllum gotlandicum* and *elongatum* the interior wall of the under-side of the calice exhibits numerous apertures which connect with the interior of the root-like processes, and thus indicate that the fleshy part of the coral extended into them. The appendages may be considered as homologous to stolons, which, in some instances, develop into buds or germs of new forms, but in the majority of cases merely form tubes which serve to attach the coral to its underlying supports.

The septum in the *under*-side of the coral is the first developed, and it becomes also the largest in the corallum; it is styled by Lindström the *primary* septum. Next after this appears the opposite septum, in the wall of the upper side, whilst the septa of the right and left walls appear last in order. There are two kinds of dissepiments in these corals; one restricted to the loculi, or spaces between the septa, the other extends over several septa and loculi.

Lindström divides the Anthozoa operculata into two families; 1. Calceolidæ (or Heterotoechidæ), in which the septa in the interior of each opercular valve are unequal in size; the central septum being the largest; and 2. Aræopomatidæ (or Homotoechidæ), in which the septa of the operculum are equal in size.

In the family of the Calceolidæ are two divisions; (A) in which there is a single opercular valve, which includes the genera *Calceola, Rhizophyllum* and *Platyphyllum;* and (B) in which there are four valves or lids in the operculum, which comprises the single genus *Goniophyllum.*

In the family of the Aræopomatidæ are included (1) *Aræopoma,* a new genus with an operculum of four triangular valves; (2) *Rhytidophyllum,* a new genus with a single valved operculum, which covers a calceola-like coral; and (3) An indetermined genus with a single semi-elliptical operculum, with wide, closely-arranged septa on its interior surface.

The well-known *Calceola sandalina*, Lamarck, the only representative of the genus, first noticed as a coral by Brückmann, in 1849, but by succeeding authors as late as 1861, referred either to the Brachiopoda or Lamellibranchiata, is the most familiar example of the group of the operculate corals. A detailed description of the species was given by Kunth in 1869, who seems, however, according to Lindström, to have been in error respecting the number of the septa in the coral. This species is characteristic of the Devonian, and has a wide distribution, having been found in the Eifel District (where it is exceedingly abundant), also in the Harz-mountains; near Chimay in Belgium; in Devonshire; Asturias in Spain, and in the Altai district.

There are six species of *Rhizophyllum*, Lind.; four of which, viz. *R. gotlandicum*, F. Roemer, sp., *R. Gervillei*, Bayle, sp., *R. tennesseense*, F. Roemer, sp., and *R. australe*, R. Etheridge, jun., are simple forms, whilst the other two species, *R. elongatum*, Lind., and *R. attenuatum*, Lyon, are compound forms; the former species increasing by calicinal budding, and the latter by stolons from the angles of the under-side of the calice. With the exception of *R. Gervillei* from the Lower Devonian of Néhou in France, the other species of the genus occur only in the Silurian of Gothland, New South Wales, the United States and China.

The genus *Platyphyllum*, Lind., is distinguished from *Rhizophyllum* by its strongly-developed septa; the operculum was probably single. Only one species, *P. sinense*, Lind., is known from the Silurian of China.

The genus *Goniophyllum*, Edw. and Haime, with its peculiar pyramidal form, has an opercular apparatus of four valves, two of which, viz. those of the under and upper sides of the calice, are trapezoidal in form, and constitute one pair, whilst the valves of the right and left sides are triangular, and constitute the other pair. The valve of the under-side is the largest, and probably the oldest of the four, and is the only one which is completely homologous with the operculum of *Calceola* and *Rhizophyllum*. Occasionally some of the opercular valves fall off, and are replaced by new valves. There are two species of the genus, *G. pyramidale*, Hisinger, from the Silurian of Gotland, the West of Ireland, and England; and *G. Fletcheri*, Ed. and H., from Dudley and Malvern.

Lindström has made a careful investigation of the development of the septa in *G. pyramidale*, and has examined young specimens with a calicinal aperture of only 5 mm. in length by 4 mm. in breadth. The following are the results of his observations: (1) That in the young individuals septa are absent. (2) That the septum of the under-side is first developed, and may therefore be properly styled the primary septum. (3) That the median septa of the right and left sides are next formed. (4) That the median septum of the upper side appears last. (5) The *lateral* septa of the under-side are already developed before the *median* septa of the other sides appear. Thus the generally received opinion of four primary septa in rugose corals is not tenable, just as little as that four prominent septa are present in this group, when, as a general rule, they only occur in *Goniophyllum* and *Stauria*.

The genus *Aræopoma*, Lind., is represented by the single species *A. prismaticum*, Lind., from the Silurian of Gotland. In general appearance this species resembles a *Cystiphyllum*, but it is slightly sub-angular, and has an apparatus of four triangular valves with rounded corners.

The genus *Rhytidophyllum,* with the single species *R. pusillum,* Lind., is a very minute form with a single semi-elliptical operculum. It is also from Gotland.

In connexion with these distinctly marked operculate corals, Lindström describes two long-known species, *Pholidophyllum tubulatum,* Schlotheim sp., and *Syringophyllum organum,* Linn., which possess on the outer surface of the corallum, peculiar exothecal structures, which, in a certain sense, are homologous with the opercula of the genera above mentioned. In the widely distributed *P. tubulatum,* the walls were covered with vertical rows of regularly disposed, minute, overlapping calcareous scales or plates, oval or pear-shaped in outline, minutely striated on the outer surface, and with a small process on the inner surface as if in connexion with a muscular attachment. The plates are in paired rows, each pair covering over the slight vertical furrow between two rugæ or costæ. Judging from thin sections, one side of each scale seems to have been slightly imbedded in the wall of the coral, but the attachment must have been slight, for examples in which these scales are preserved *in situ* are very rare.

In the other form, *Syringophyllum organum,* the exothecal scales are minute, convex, shield-shaped bodies, not more than ·9 mm. in length and ·8 mm. in breadth, which appear to have thickly covered the surface of the collar-like extensions which surround the corallites and form the horizontal floors uniting them together. They are now without regular arrangement, though it is probable that this is owing to subsequent disturbance. Lindström compares them with the small convex lamellæ of the peritheca in the existing genus *Galaxea.*

By some authors the concentric films or membranes which extend over the upper surfaces of some species of *Favosites,* such as *F. turbinatus,* Bill., for example, have been regarded as of an operculate character, but in reality they have nothing in common with true opercula, and are merely of epithecal origin.

In conclusion, Lindström points out that in nearly all the details of their organization the operculate corals approach so closely to other Cyathophylloid or Rugose corals, that they must be regarded as belonging to the same group with them, notwithstanding the peculiarity of their possessing opercula. The question remains as to the true zoological position of the whole group of the Rugosa, and Prof. Lindström shows that in the main features of their organization, the corals of this order resemble to a great extent the corals of Mesozoic, Tertiary, and recent periods. No great dependence can be placed on a comparison of the characters of the tabulæ or the vesicular laminæ of the interior of the coral, as similar structures are present in the hard skeletons of other vertebrate divisions. The general similarity of outer form is well known, and even the peculiar four-sided *Goniophyllum pyramidale* finds its parallel in the six-sided *Flabellum Roissyanum,* Ed. and H. As regards the presence of stolons, there are several species of Mesozoic and recent corals possessing these structures, and the same may be said of the vertical rugæ. The septa in the Rugosa consist of a thin central lamella, which is inclosed, on both sides, by a later formed sclerenchyma, the same as in recent corals. The spines, tubercles, and other outgrowths on the sides of the septa, which project into the loculi, are the same in the Palæozoic and recent forms, and the tabulæ and vesiculæ of the interior are similar both in the Rugosa and Aporosa.

Great weight has been laid on the supposed fact that the Aporosa have six primary septa and the Rugosa only four. But observations on very minute forms of several genera of Rugose corals show that in the earliest stages of growth there is either but a single septum, or that several are present, for example a specimen of *Palæoclycus porpita* only 1·3 mm. in width possessed 20 septa. Even in so strongly a four-sided coral as *Goniophyllum* we have seen that at first there is but a single septum. Perhaps *Stauria* is the only genus in which the septa are four-fold at the commencement and continue so throughout its growth. Lindström denies the accuracy of Kunth's [1] figure of the four primary septa in *Omphyma turbinata.* Even the septal fossula, which indicates so plainly a bilateral symmetry in the Palæozoic Rugosa, can be paralleled in existing corals. Again, the existing genera *Primnoa* and *Paramuricea* possess an opercular apparatus of eight valves. And lastly, the existing Aporosa also increase by calicinal budding in the same manner as many of the Palæozoic Rugosa.

A table is appended showing the distribution in space and time of the operculate corals. Thirteen species, belonging to seven genera, are at present known. None have been found below the Silurian (= Upper Silurian, Lind.), but in this division eleven species of six genera appear; the lowest division of the Devonian has but a single species, whilst in the Middle Devonian the group is finally represented by a single species. The group thus appears to reach a maximum development in that division of the Silurian which corresponds nearest to the English Wenlock.

We have only to add that in the nine plates accompanying this important monograph, the corals themselves and all their structural details are fully illustrated. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 10, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Lower Eocene Section between Reculvers and Herne Bay, and some Modifications in the Classification of the Lower London Tertiaries." By J. S. Gardner, Esq., F.G.S.

The author noticed Prof. Prestwich's classification of the Lower London Tertiaries, and the introduction by the Survey of the term "Oldhaven Beds" for some of his basement beds of the London Clay. He next discussed the conditions under which the Lower Tertiaries were produced, and showed that throughout the Eocenes there are

[1] Wachsthumsgesetz der Zoantharia rugosa, taf. 18, fig. 3.

indications of the close proximity of land and of the access of fresh water. Two types of faunas are to be recognized, namely, those of the Calcaire Grossier and the London Clay, the latter indicating more temperate climatal conditions. The former is represented in England by the Bracklesham series. The areas of these two faunas were separated by land forming an isthmus, as each formation is bounded by a shore-line and separated from its neighbours by freshwater formations; but this isthmus probably shifted its position to the north and south without ever being broken through. A vast Eocene river existed, draining a great continent stretching westward; the indications of this river in Hampshire and Dorsetshire would show it to have been 17 or 18 miles wide.

The Lower Tertiaries have been divided by Prof. Prestwich and the Survey into the marine Thanet Beds, the fluviatile, estuarine and marine Woolwich and Reading Beds, and the Marine Oldhaven Beds. The mode of occurrence of these was described by the author, with especial reference to the section between Herne Bay and the Reculvers, from his investigation of which he was led to the following conclusions:—The Thanet Sands were probably deposited by a rough sea outside the estuary of the great Eocene river, but within its influence. The area became silted up, rose above the surface, and became covered with shingle and sand. The Thanet Beds closed with a period of elevation, during which the Reading Beds were formed, and this was followed by a subsidence during the Woolwich period, which finally ushered in the Oldhaven and London-Clay deposits. The formation of the Oldhaven Beds may be compared with that of the modern beach at Shellness; and during the period of depression the beaches would advance steadily over the flat area of Sheppey, and the earlier formed ones would sink and become covered up by the silt of the great Eocene river. These beaches, forming vast aggregations of sand and shingle between the Thanet Beds and the London Clay, form integral portions of one or other formation, and cannot be recognized as forming a separate formation at all equivalent to the other divisions of the Eocene.

2. "On Mr. Dunn's Notes on the Diamond-fields of South Africa, 1880." By Francis Oats, Esq., F.G.S.

The author referred to the hypothesis put forward in 1880 by Mr. Dunn (Quart. Journ. Geol. Soc. vol. xxxvii. p. 609), that the carbon for the production of the South African diamonds was furnished by the black carbonaceous shales found throughout the district, and the conclusion drawn by him therefrom that therefore diamonds would not be found below the level of these shales. The author stated that the shales, so far as he knows, do not occur below 270 feet, whilst the ground is successfully worked for diamonds at a depth of 350 feet. He maintained that the carbonaceous shales have nothing to do with the origin of the diamonds, and stated that the "craters" containing the diamantiferous rock, at an earlier date erupted quite different material, and he instanced the occurrence in the Kimberley mine of a mass of "dolerite" between the diamantiferous ground and the surrounding shales.

II.—January 24, 1883.—J. Gwyn Jeffreys, LL.D., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On *Streptelasma Rœmeri*, sp. nov., from the Wenlock Shale." By Prof. P. Martin Duncan, F.R.S., V.P.G.S.

A great number of simple corals were found amongst the washings of Wenlock Shale prepared by Mr. George Maw, F.G.S., and most of them belong to a genus new to England, but which has been observed by Messrs. Nicholson and Etheridge at Girvan. The species now described is allied to the Scottish form, but differs in having a fossula in the calice, a smaller septal number, and fewer dissepiments and tabulæ. The author described the new species from sections and perfect corals, showing the great variability of the septal, and the persistence of the calicular arrangement, and explained the remarkable method of growth by increase at certain points of the calice only. He enlarged upon the variability of the same coral during growth, and noticed the bisymmetry of this coral. The relation of the double pinnation of the costæ to the septa was noticed, and also the relation of a constant vertical pair of costæ to the fossula. Agreeing with Messrs. Nicholson and Etheridge upon all material points regarding the diagnosis of *Streptelasma*, the author maintained that there is a true theca with costæ and not a simple epitheca. With those authors he placed the genus in the Zaphrentidæ. The morphological data indicate that transverse sections of Rugose corals are apt to mislead when taken alone as furnishing specific characters.

2. "On *Cyathophyllum Fletcheri*, Edw. and H., sp." By Prof. P. Martin Duncan, F.R.S., V.P.G.S.

This was a short communication explanatory of the finding of this coral in the Wenlock Shale with *Streptelasma Rœmeri*. The author referred to his essay in the 'Philosophical Transactions,' 1867, in which he showed that the group of *Palæocycli*, Edw. and H., belonged to the genus *Cyathophyllum*—to the Rugosa and not to the Fungidæ. Milaschewitsch having associated the name of Kunth with that of the author in proving the non-Fungoid character of the group, it was explained that Kunth wrote in 1869, and that he had nothing whatever to do with the original work. The author alluded to his late researches into the nature of synapticula, read before the Linnean Society, and explained the probable cause of the error of the distinguished French zoophytologists in their differentiation of *Palæocyclus porpita*.

3. "On the Fossil Madreporaria of the Great Oolite of the Counties of Gloucester and Oxford." By Robert F. Tomes, Esq., F.G.S.

This paper is in continuation of the papers which the author has already published in the 'Quarterly Journal of the Geological Society.' The author called attention to the fact that there has been sometimes in the study of corals a confusion made between growth by fissiparity and by gemmation. If the former process result from the gradual conjunction of two opposite septa, so as to form a new divisional wall in the calyx, there is no risk of any such confusion; but if the separation has been by the formation of a constriction in the central part of an elongated calyx, this may be, and has been, confused with growth by gemmation.

A large number of the forms here described by the author are in the collection of Mr. T. S. Slatter, F.G.S., and were collected near

Fairford, Gloncestershire. They occur in a white marly clay, occurring between the Forest Marble and the Cornbrash. A detailed section was given, and the particulars of some other coralliferous beds. These, the author showed, are not all upon the same horizon, though there is a considerable relation between their coral faunas. The author gave a description of twenty genera and thirty-four species. Of these the following genera are new to the British Oolites: *Bathycœnia*, a new group of the family Astræidæ (*Eusmilinæ*), containing two species; *Favia*, *Astrocœnia*, *Enallohelia*, and *Trycycloseris* are for the first time recorded as occurring in the British Oolites; and *Confusastræa* and *Oroseris*, recorded by the author from the Inferior Oolite, are now added to the coral-fauna of the Great Oolite. The latter part of the paper consisted of an elaborate description of the genera and species.

III.—February 7, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Metamorphic and Overlying Rocks in parts of Ross and Inverness shires." By Henry Hicks, M.D., F.G.S. With Petrological Notes by Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

In this paper the author described numerous sections which have been examined by him in three separate visits made to the north-west Highlands. In some previous papers, sections in the neighbourhood of Loch Maree had been chiefly referred to. Those now described are to the south and south-east of that area, and occur in the neighbourhoods of Achmashellach, Strathcarron, Lock Carron, Loch Kishorn, Attadale, Strome Ferry, Loch Alsh, and in the more central areas about Loch Shiel and Loch Eil to the Caledonian Canal.

In these examinations the author paid special attention to the stratigraphical evidence, to see whether there were any indications which could in any way be relied upon to prove the theory propounded by Sir R. Murchison that in these areas fossiliferous Lower Silurian rocks dip under thousands of feet of the highly crystalline schists which form the mountains in the more central areas. On careful examination he found that in consequence of frequent dislocations in the strata, the newer rocks were frequently made to appear to dip under the highly crystalline series to the east, though in reality the appearance in each case was easily seen to be due to accidental causes. Evidences of dislocation along this line were most marked; and the same rocks, in consequence, were seldom found brought together. He recognized in these eastern areas at least two great groups of crystalline schists metamorphosed throughout in all the districts examined, even when regularly bedded and not disturbed or contorted; and they have representatives in the western areas, among the Hebridean series, which cannot in any way be differentiated from them. These he called locally by the names, in descending order, of Ben-Fyn and Loch-Shiel series. The former consist, in their upper part, of silvery mica-schists and gneisses, with white felspar and quartz; in their lower part, of hornblendic rocks, with bands of pink felspar and quartz, and of chloritic and epidotic rocks and schists. The Loch-Shiel series consists chiefly of massive granitoid gneisses and hornblendic and black mica-schists. Thirty-three microscopical sections of the crystalline schists and the overlying rocks are described by Prof. Bonney, and he recognizes amongst them three well-marked types. In No. 1 he includes the Torridon sandstone, the quartzites and the supposed overlying flaggy beds on the east side of Glen Laggan. These are partially metamorphosed, only distinct fragments are always easily recognizable in them in abundance. In No. 2, the Ben-Fyn type, the rocks are crystalline throughout, being typical gneisses and mica-schists. In No. 3, the Loch-Shiel series, he recognizes highly typical granitic gneisses of the Lower Hebridean type. Dr. Hicks failed to find in these areas at any point the actual passage from group 1 to group 2; neither did the same rocks belonging to group 1 meet usually the same rocks belonging to group 2. The evidence everywhere showed clearly that the contacts between these two groups were either produced by faults or by overlapping. Group 3, placed by Murchison as the highest beds in a synclinal trough, supported by the fossiliferous rocks, the author regarded as composed of the oldest rocks in a broken anticlinal. They are the most highly crystalline rocks in these areas; and the beds of group 2 are thrown off on either side in broken folds. These, again, support the rocks belonging to group 1. The author therefore feels perfectly satisfied that the crystalline schists belonging to groups 2 and 3, which compose the mountains in the central areas, do not repose conformably upon the Lower Silurian rocks of the north-west areas with fossils, and that these highly crystalline rocks cannot therefore be the metamorphosed equivalents of the comparatively unaltered, yet highly disturbed and crumpled, richly fossiliferous Silurian strata of the southern Highlands, but are, like other truly crystalline schists examined by him in the British Isles, evidently of Pre-Cambrian age.

In an Appendix by Prof. T. G. Bonney, F.R.S., Sec.G.S., on the Lithological Characters of a Series of Scotch Rocks collected by Dr. Hicks, the author stated that he observed in the above series, as he had done in other Scotch rocks lately examined by him, three rather well-marked types:—one, where, though there is a certain amount of metamorphism among the finer constituents forming the matrix, all the larger grains, quartz, felspar, and perhaps mica, are of clastic origin; a second, while preserving a bedded structure and never likely to be mistaken for an igneous rock, being indubitably of clastic origin, retains no certain trace of original fragments; while the third, the typical "old gneiss" of the Hebridean region, seldom exhibits well-marked foliation. It is sometimes difficult to distinguish between the first and second of these; but this the author believed to be generally due to the extraordinary amount of pressure which some of these Scotch rocks have undergone, which makes it very hard to determine precisely what structures are original. Even the coarse gneiss is sometimes locally crushed into a schistose rock of comparatively modern aspect. The least altered of the above series the author considered to be the true "newer-gneiss" series of the Highlands, but both of the others to be much older than the Torridon Sandstone.

2. "On the Lower Carboniferous Rocks in the Forest of Dean, as represented in typical sections at Drybrook." By E. Wethered, Esq., F.G.S., F.C.S. With an Appendix by Dr. Thos. Wright, F.R.S., F.G.S.

The author described a series of beds overlying the normal Old Red Sandstone and underlying the normal Lower Limestone Shales in the above district. They differ from the ordinary Old Red Sandstone in two particulars:—(1) No fossils characteristic of this series have as yet been discovered in them. (2) The materials of which the Old Red of the neighbourhood is formed are well water-worn, while those composing the beds referred to are not so; they also contain calcareous material, and the author considered them to correspond, in time, with the Calciferous series of Scotland for the following reasons in addition to their stratigraphical position:—(1) with those of Berwickshire in the rapid succession and variation in the colour of beds; (2) the presence of certain Polyzoa and of *Rhynchonella pleurodon* in a limestone which succeeds them. The author also described a section in the Millstone Grit at the Morse railway-cutting. Here the Millstone Grit dips at about 40°; resting on it is a rose-coloured sandstone passing up into a pebble-bed dipping at 19°. The pebbles are vein-quartz and a quartzite like that of the Lickey. The Old Red Sandstone, Calciferous Sandstone, and Millstone Grit appeared to him to have derived their materials from a common source, viz. ancient granitic rocks.

An Appendix by Dr. T. Wright described the organisms in specimens of the above-named limestone of Drybrook. Polyzoa are abundant, individuals being numerous, but species few. *Rhabdomeson gracile* and *Fenestella tuberculata* are abundant in one specimen, the other containing in addition *Ceriopora similis*. Fragments of a Crinoid, referred to *Poteriocrinus crassus*, also abound. There are a few crushed shells of *Rhynchonella pleurodon*, and spines, possibly of a *Productus*. The organisms of a slab from the Bristol district were also described. This contains *R. gracile*, with one or two other Polyzoa, and numerous Crinoid fragments.

CORRESPONDENCE.

THE HIGHLAND PROBLEM.

Sir,—Geologists are aware, from two short papers which I have communicated to the Geological Society, that I have been engaged for some years in the investigation of the relations between the Durness and Assynt Limestones and the great Eastern Gneiss. The difficulties surrounding the inquiry are so great that for the first two years I did not feel justified in announcing a definite conclusion on the main question. Two months of hard work last summer enabled me to fill in many important gaps in my evidence, and I am now in a position to make a definite announcement. My most important conclusions are the following:—

1. The Eastern Gneiss has been brought over the Quartzo-dolomitic group by earth-movements subsequent to the deposition of the latter, and is of Archæan age.

2. The Quartzo-dolomitic series is frequently, at its junction with the Eastern Gneiss, folded back upon itself.

3. The "Upper Quartzite" of Murchison is the "Lower" Quartzite repeated by either faulting or folding, and the "Upper Lime-

stone" is either the Dolomite repeated by faulting or a part of the Eastern Gneiss.

4. The "igneous rock" of authors ("Logan Rock" of Professor Heddle) is usually the Hebridean Gneiss brought over the Quartzo-dolomitic group by enormous overthrows.

I hope to submit to the Geological Society, in the course of the spring, detailed and, I think, very decisive proof of the results at which I have arrived. C. Callaway.

Wellington, Salop.

THE HIGHEST POINT IN NORFOLK.

Sir,—What is the locality and the height of the highest point in Norfolk? Quoting Mr. Penning[1] in my paper "On the Chalk Masses in the Cromer Drift,"[2] I, incautiously perhaps, stated its height at 650 feet, the locality being in the chalk escarpment of West Norfolk. Mr. Searles Wood says he does not think the "Cromer lighthouse hill (248 feet) is exceeded by any point in Norfolk to the extent of more than a few feet."[3] Mr. Whitaker, in his late clever presidential address to the Norwich Geological Society, says after some very complimentary allusions to my paper, "I may notice the repetition therein of a strange error, the endowment of the Norfolk Chalk with a highest point of 650 feet."[4]

With a view of settling these discordant opinions, for it is to be borne in mind the "endowment" was not the result of my "munificence," being simply a quotation from the work of one of Mr. Whitaker's fellow-labourers, I applied to the Director-General of the Ordnance Survey, who kindly informs me they "are unable to give certain information as to the highest point in Norfolk," but states that the highest point *levelled to* is 6725 links North-east of Aylmerton Church, and 331·4 feet above O. D. The "point," therefore, remains still an unsettled and knotty one.[5]

This is a question of fact on which it is desirable to be correctly informed, but for aught it has to do with my theory of the transport of the Chalk Boulders, might have been omitted. The lesser heights are all that are required for my ice rafts. which could not have "stranded on a submarine bank" if launched into 600 feet of water. T. Mellard Reade.

OBITUARY.

E. B. TAWNEY, M.A., F.G.S.

Died December 30, 1882; Aged 42.

We have recently lost by the death of Edward Bernard Tawney one of our very best all-round geologists. From physical weakness and a retiring disposition he did not throw himself much to the front, and so few knew what work was being done by that

[1] Q. J. G. S. xxxii. 191. [2] *Ibid.* xxxviii. 233. [3] *Ibid.* xxxviii. 684.

[4] Proc. of the Norwich Geol. Soc. 1882, p. 209.

[5] The English Encyclopædia (1855), article Norfolk, says, "The highest ground in the county is probably on the North-west side, where the chalk downs appear."

indomitable spirit. His influence was only beginning to be widely felt, but in a paper here, or a controversy there, he showed his power, and how he had made himself acquainted with all that had been done by others in the subject of which he wrote and spoke. That he had no small share of the ability and originality of his talented family he gave abundant proofs in early life. His father—a clergyman who had distinguished himself at his school and college of which he became a Fellow—died when Edward Tawney was still young, and he therefore lived much with relations, some of whom were men of science. His uncle, Dr. Bernard, who was his guardian, encouraged him much in his work, giving him now a book, now a microscope, and so his attention was turned to Natural Science, the Reports of the Royal School of Mines tell with what success. He became an Associate, gaining diplomas in Mining and Geology. But he went through the course of study in several other branches, and highly distinguished himself in all. He won a Royal Scholarship, also the Duke of Cornwall's Scholarship. He was awarded the Edward Forbes medal for proficiency in Natural History, and in Mining he gained the Delabeche medal.

He then enjoyed some years of leisure, in which he carried on original research, travelling at home and abroad, and contributing many valuable papers to various scientific publications. In the Journ. of Geol. Soc. for 1866 we find a paper on the Western Limit of the Rhætic Beds in South Wales, and on the position of the Sutton Stone. In this we observe the same careful working out of the sections bed by bed, and the same painstaking determination of the exact species found in each zone, that always characterized his work. He had a marvellous faculty of seeing and of sticking to the point in any discussion in which he took part. All he thought of was whether the evidence was conclusive or not; whether a fact was proved or unproved. The individuality of the speakers he lost sight of, and mentioned them by name when he had to refer to their views only as a man would move about the wooden chessmen with which he was playing. He could be severe when unfair reasoning or the *argumentum ad hominem* was brought in by those who differed from him in opinion, while he felt that he was only bringing in hard facts, bearing directly upon the subject-matter before them, and hurting only those who felt that they were being proved to be wrong—and were endeavouring to gain a temporary advantage but avoiding the real point at issue, or by trying to throw ridicule on their opponents.

In 1870 he contributed a paper on the occurrence of *Terebratula diphya* in the Alps of the Canton de Vaud, referring the rock from which he procured it to the Jurassic. This paper gave rise to an interesting communication from Mr. Davidson on the range and affinities of that and some allied forms. In the same year he published, in the Transactions of the Devonshire Association for the Advancement of Science, Literature and Art, a paper "On the Occurrence of Fossils at Smuggler's Cove, Torquay," in which he speculates upon the correlation of the North and South types of some of the Devonian Rocks, and in 1872 he wrote a short note "On the Occurrence of *Zoophycus scoparius* (Thioll.)," a plume-shaped alga "in the Inferior Oolite of Dundry." In the same year he accepted a post in the Bristol Museum, and by the time the British Association visited Bristol in 1875, he had got the Museum into a very different state from that in which he had found it. The specimens were arranged and a large proportion named. All this time he was carrying on his researches in the rocks of that most varied district, and the results of his original work and of his extensive reading were embodied in a succession of papers communicated to the Bristol Naturalists' Society. He contributed to the excellent guide which was published under the sanction of the local executive committee of the British Association, the Introduction to the Chapter on the Physical Geography and Geology of the district, as well as the articles on the Coal-measures and New Red Period, and that on the Inferior Oolite.

In the Proceedings of the Bristol Naturalists' Society also we find, under the head of "Museum Notes," a paper on the Dundry Gasteropoda, read in 1873, in which he describes and figures at least nineteen new species.

In the same year he offered to the same Society a review of the Coal Question, a subject of exceptional interest in that district, and then being much discussed. Also a paper "On the Use of the Divining Rod in the Neighbourhood of Bristol," in which he gives, in conjunction with a friend, the results of some experiments they had persuaded a *diviner* to make before them.

In the course of his work in the Bristol Museum he found that the Lias fossils of various zones had all got mixed up together, and, in order to rectify the errors arising from this confusion, he set to work to examine the district and collect the fossils of each horizon, and as the result of his examination, he read before the Bristol Naturalists' Society, in 1874, a valuable paper "On the Lias in the Neighbourhood of Radstock." In the same year he communicated to that Society some "Notes on Trias Dykes."

There had long been much difference of opinion about the age of the Cannington Park Limestone. The views of previous writers were founded almost entirely upon lithological and stratigraphical evidence. Tawney, however, was at last able to collect a sufficient number of fossils from the limestone to consider that the question was settled, and in 1875 he read before the same Society his paper "On the Age of the Cannington Park Limestone and its Relation to the Coal-measures South of the Mendips." He referred the rock to the Mountain Limestone, thus making it probable that if any coal-bearing strata should be found above the Cannington Park Limestone further south, it would be of the Welsh or Coal-measure type, rather than of the less valuable Devon or Culm-measure type.

In 1875 he read a paper on Professor Renevier's Geological Nomenclature and Table of Sedimentary Rocks, and gave a comparative table of English equivalents. He thus showed that he was watching the progress of geology all over the world, and preparing himself for work in a more important sphere, where, however, it was cut off all too soon.

In 1878 he read a short note on the supposed Inferior Oolite at Branch Huish, Radstock, in which he showed, by lists of fossils collected by himself, that the upper beds of the section had been erroneously referred to the Inferior Oolite. About the same time he described "an excavation at the Bristol Waterworks Pumping Station, Clifton," through *Infra Lias*, *Rhœtic*, and *Keuper*.

He next took part in the inquiry into the nature and origin of the Archæan Rocks, and examined the St. Davids sections in company with Dr. Hicks and another friend. His views on the classification of this group he published in a paper "On the Older Rocks of St. Davids," read in February, 1878, before the same Society, to which, as we have seen, he had already communicated so much good original work. While he was hammering along the South Wales coast he accepted the offer of a post at Cambridge, and from that dates a new era in his life and work. He now, as Assistant to the Woodwardian Professor, had charge of one of the largest collections in the kingdom, and soon made himself master of all the contents of each part of the Museum in turn. This work was just beginning to bear fruit in a series of papers under the head of Woodwardian Laboratory Notes, in this Magazine, of which only a few had appeared.

In these he published the result of the microscopic examination of the rocks collected by Professor Sedgwick, and others which he had procured himself in his rambles in Wales over Sedgwick's ground, when verifying his localities and sections; but he was cut off in the commencement of his work, and with him swept away those stores of knowledge, that keen intellect and that matured judgment from which we might have hoped so much. He has, however, left his mark in the Museum where Salter and M'Coy did some of their best work. But he also gave much of his time to teaching, and from this too we may hope the world will reap some benefit hereafter. His unusually varied acquirements enabled him to conduct classes in Palæontology and Petrology, as well as in Stratigraphical and Dynamical Geology.

There are, perhaps, few sections so likely to attract amateurs and, as such, the early observers in Geology as those exposed along the cliffs of the Isle of Wight. The succession of different formations and different groups of organic remains is so obvious that no one can help attempting a classification. Any new work must therefore go into great detail and involve the most careful determination of species and varieties and a wide knowledge of homologous sections, for the general grouping was settled long ago. However, an able paper was read before the Geological Society, in which a new reading of some parts of the Headon Hill Section was proposed, and upon this was founded a revised classification and nomenclature of the whole. It required the most intimate acquaintance with Tertiary fossils to take part in this question.

Tawney took the matter up, and with Mr. Keeping, who went over most of the work with him and had been for years familiar with the sections, laid before the Geological Society a masterly review of the whole question, maintaining the general correctness of the classification of Edward Forbes and the Survey.

He also read a résumé of his views on this subject before the Cambridge Philosophical Society.

The controversy was carried on with much force and vigour; some said it was occasionally too personal, but most thought that they would not have learned so much on a somewhat involved question if there had been a less clear statement of the points referred to, and a less clear quotation of the views commented on. The scientific world was much the wiser for the discussion, which had the effect of eliciting most valuable information. That question may be considered to have been set at rest, but he was engaged upon some details required for the fuller working out of the correlation of the series at the time of his death. However, the work was far advanced, and it is hoped that it will be shortly published.

He was a good linguist, and read with ease scientific papers in French, Italian, and German. This, with his wide range of knowledge and his strong critical faculty, made him a valuable contributor to the Geological Record, of which he was sub-editor. It also gave him great facility of correspondence and conversation with foreign geologists, whether in carrying on his own studies or in connexion with the International Geological Congress of the British Committee, of which he was general secretary.

His worth was soon recognized at the University, and on Dec. 4, 1879, an honorary M.A. degree was conferred upon him—the public orator referring in flattering terms to his educational and scientific successes, and alluding to the distinguished career of some of his relatives. He was at the same time made a member of Trinity College, allowed to put himself in commons and granted the ordinary privileges of a Fellow of the College. He commonly dined in hall till lately, when he complained much of the climate, and did not go out at night. In December he went to Mentone, accompanied by the Professor of Mineralogy, and put himself under a foreign medical man. At first it was hoped that the warmth and fresh air, which he was now able to get out and enjoy, were doing him good; but in a few days he complained of great weakness, and on Dec. 30, before he had been out a week, he passed quietly away in sleep.

He was followed by the Secretary of the Geological Society of France, of which he was an esteemed member, and by the Professors of Mineralogy and of Geology at Cambridge, to the tomb in the rocky cemetery that overhangs the town and looks out on the Mediterranean beyond; among the rocks that only a few days before he had been hammering for fossils.

To the scientific world, and especially to the University whose interests he had identified with his own, his loss can hardly be repaired.

Those who knew him well saw beyond that keen critical mind the warm heart ever prompting him to do unostentatiously acts of consideration and kindness. T. McKenny Hughes.

Fig. I ×8.

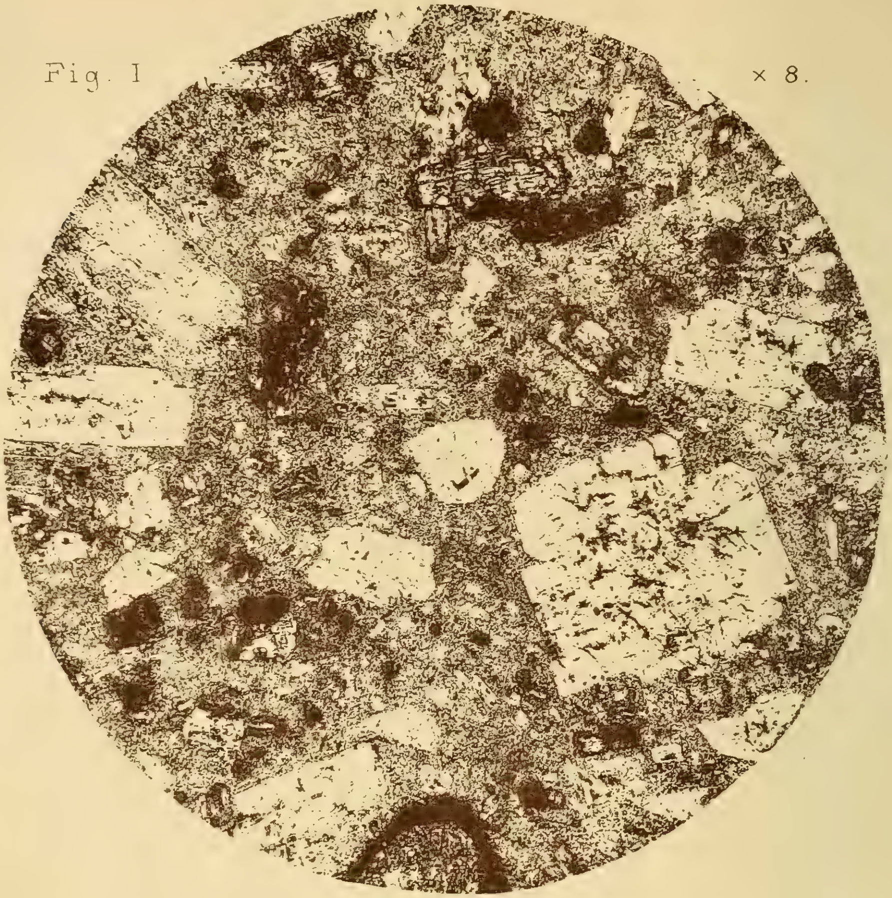


Fig. II. × 16

J.J.H.Teall Photo. West Newman & Co. imp

Cheviot Andesites.

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ORIGINAL ARTICLES.

I.—Notes on the Cheviot Andesites and Porphyrites.

By J. J. Harris Teall, M.A., F.G.S.

[PLATE IV.]

(*Continued from p.* 108.)

BEFORE proceeding to describe the more common porphyrites, I wish to return to the subject of the true andesites, referred to in my last paper, and their relation to Tertiary and recent rocks of a similar chemical and mineralogical composition. On referring to the note appended to that paper, it will be seen that my description of the pyroxenic constituents of these rocks was very imperfect, not to say inaccurate. The number of elongated sections which extinguished parallel with the vibration-planes of the crossed Nicols attracted my attention when first I examined the rock, but seeing that the same feature occurred in the so-called augite-andesites of Hungary and Santorin, and seeing further that as regards cleavage and crystalline form the pyroxenic constituents of the Cheviot rock resembled those of the augite-andesites above mentioned, I came to the conclusion that the prevailing pyroxene in both cases was the same, and also that it was augite. In the former conclusion I still think I was right, but in the latter I was unquestionably wrong.

A flood of light, as far as I am concerned, has been thrown on this question by an article in the February number of the American Journal of Science, by Mr. Whitman Cross, to which my attention was called by Prof. Judd. The article is an abstract of a paper to be published as a Bulletin by the U. S. Geological Survey, and is entitled "On Hypersthene-Andesite." It commences as follows: "In the course of the investigation of some apparently normal augite-andesites of the most typical variety, occurring at the Buffalo Peaks in South Park, Colorado, the writer found that a large part of the pyroxenic constituent possessed the crystalline form and chemical constitution of hypersthene rather than of augite. The comparative study of similar andesites from this country and from well-known European localities has forced him to the conclusion that in very many, if not in all of them, augite is decidedly subordinate to a rhombic pyroxene, which is presumably hypersthene." After giving a description of the general macroscopic and microscopic characters of the Buffalo Peaks rock which would answer very well for the Cheviot andesite, he states: "When the pyroxene crystals and grains . . . are examined in polarized light, it is clear that a large portion of them do not belong to the monoclinic augite. If, in the first place, all those individuals of which the vertical axis seems to lie in, or nearly in, the plane of the section, be examined, it is seen that much more than half of them are distinctly dichroic, and that all of these extinguish light parallel to the vertical axis. The others are not visibly dichroic, and extinction takes place at a very decided angle, usually approaching 40° from the vertical axis. If, on the other hand, those crystals which are apparently cut at right angles to the principal axis (judging from cleavage and outline), are tested, more than half of them are found to extinguish light when the diagonals of the prism, as indicated by the best developed cleavage-planes, coincide with the principal sections of the crossed Nicols."

The author describes the pleochroism of the mineral, and remarks that it does not seem to differ from that often described for the "augite" of the andesites. The mineral in question was isolated by the method of M. Fouqué, and three separate analyses of different specimens were made. These agree very well with each other, and the following may be taken as representing its composition :—SiO_2 51·157 Al_2O_3, 2·154, FeO, 18·360, MnO, 0·363, CaO, 3·812, MgO, 24·251, Total, 100·097. In conclusion, the author states that he does not claim all the augite-andesites as hypersthene-bearing rocks, but only those with which he is acquainted.

So far as my own observation has gone, I can confirm the opinions of Mr. Whitman Cross, and it will perhaps be as well if I describe the rhombic pyroxene as it is now known to me, and indicate the localities of the rocks in which I have observed it. Sections more or less parallel with the principal axis are usually long, and sometimes very long in proportion to their width. The ends of such a section are sometimes bounded by two definite crystalline faces, which meet at an obtuse angle. Irregular transverse cracks are usually present, and these evidently exercise an important influence on the alteration of the mineral. Longitudinal cleavage-lines may sometimes be observed, but as a rule they are not conspicuous. The dichroism of these sections is well marked in sufficiently thick preparations, and the colours vary from green to yellowish or reddish-brown; green when the axis lies parallel with the vibration-plane of the polarizer (short axis of the Nicol), yellowish or reddish-brown when the axis lies at right angles to the vibration-plane. Cross-sections of the prism show that the pinakoidal faces are largely developed at the expense of the faces of the prism. The prismatic cleavages are strongly marked, though somewhat irregular. The two sets of lines in the cross-section meet at an angle of about 90°. The dichroism in these sections is less marked than in the longitudinal sections; the colours being yellowish and reddish-brown. The pyroxene in the Cheviot and other andesites of a similar character occasionally shows twinning parallel with a pinakoidal face, as pointed out in my previous paper. I suspect, however, that this only occurs in the monoclinic [1] mineral, though I am not able to speak positively on this point.

[1] Mr. Whitman Cross expresses doubt as to the monoclinic character of the pyroxene associated with hypersthene in the American rocks. I have not examined a sufficient number of sections of the corresponding mineral in the Cheviot rocks to speak positively on this point, but I have seen nothing to suggest a doubt as to its being a true augite. I therefore speak of it as monoclinic in this paper.

Putting the above facts together, we may say that the rhombic pyroxene, when fully developed, occurs as columnar, doubly terminated crystals, which are made up mainly of the pinakoidal, and only to a slight extent of the prismatic faces. It is markedly pleochroic, the three axial tints being green, yellow, and reddish-brown. The prismatic cleavages are strongly marked. Prof. Rosenbusch speaks of a perfect pinakoidal cleavage, but this I have not been able to make out in my sections.

I will now enumerate the rocks in which I have observed this mineral, and it must be remembered that in each case there is a striking general resemblance to the Cheviot type. In short, there is not the slightest doubt that, unless we are prepared to make geological age, *per se*, a point of classificatory value in petrology,[1] the same name must be applied to each and all of the rocks about to be referred to, with the exception of the one from Dorf Hladomer.

The anorthit-trachyte of Szabó[2] from Lörinczi, West-Mátra and South Servia, contains this mineral in abundance, and this rock also resembles the prevalent Cheviot type in the most striking manner in other respects. A hand-specimen from Lörinczi in the British Museum may be described as a compact rock with semi-resinous lustre and conchoidal fracture.

It also occurs as the characteristic bisilicate in specimens of andesite from Kohlbach, Bagonya near Schemnitz, Dorf Nevolut near Kremnitz, and Dubnik near Eperies. An andesite-lava from a point near the summit of Ararat contains it along with a twinned monoclinic and non-dichroic pyroxene, and a similar association occurs in the rock which forms the summit of Stromboli. The above statements are based on the examination of specimens kindly shown to me by Prof. Judd, to whom I am also indebted for the loan of Prof. Szabó's communications.

As already stated, all the Cheviot andesites contain the mineral in a comparatively unaltered condition, while many of the porphyrites contain it in an altered form. It occurs also in the so-called augite-andesites from Tokaj, Hungary, and in those from Santorin, including the lava of 1866.

A rock from Dorf Hladomer, Hungary, which in other respects resembles the hypersthene-bearing andesites, contains as the pre-

[1] I do not wish to be understood as holding the view that there is no difference between igneous rocks of different geological epochs. I do hold, however, that a petrologist should be able to name a rock without reference to its geological age, just as a palæontologist should be able to name a well-preserved fossil without reference to its age. If geological age, *per se*, is to be accepted as a point of classificatory value in petrology, then there are, as every field geologist knows, many intrusive rocks that we can never name, for we can never determine their geological age. Such, for instance, are the rocks forming many of the dykes in the North of England.

[2] Trachyte eingetheilt nach den natürlichen System. Exposition Universelle, Vienne, 1873.

Classification macrographique des trachytes par J. Szabó.

Sur la classification et la chronologie des roches éruptives tertiaire de la Hongrie, Paris, 1880. Extrait du compte rendu sténographique du Congrès international de Geologie tenu à Paris du 29 au 31 août et du 2 au 4 Sept. 1878.

dominating bisilicate, if we may judge from a single microscopic section, a twinned monoclinic and slightly pleochroic pyroxene. This rock looks then as if it might be a true augite-andesite.

It thus appears that many of the rocks hitherto known as augite-andesites ought rather to be called hypersthene-andesites, and the question arises what rock are we to regard as typical augite-andesite? In connexion with this, I should like to point out, as indeed is well known, that there are undoubtedly non-olivine bearing plagioclase-augite rocks of a porphyritic character, with a silica per-centage varying from 55 to 59, and a specific gravity of from 2·7 to 2·8; such, for instance, as the rock forming the Cleveland dyke, which is, be it remembered, certainly Post-Jurassic, and almost certainly Miocene. These can scarcely be called basalts, and it becomes a question therefore whether the term augite-andesite may not with propriety be applied to them. If so, we should then have as the generic term *pyroxene-andesite,* and as specific terms, *hornblende-andesite, hypersthene-andesite*, and *augite-andesite.* In a short time I hope to publish a detailed description of the rock of the Cleveland dyke, and it can then be decided whether such a rock has any claim to the now somewhat discredited term augite-andesite.

Microscopic Analysis of the Cheviot Porphyrites.

These rocks are for the most part only altered andesites, and it becomes a question, therefore, whether the term porphyrite should be applied to them at all. There is no doubt that in this country we have included under the general term porphyrite rocks of extremely diverse character; and a considerable difficulty therefore arises when we attempt to give the term a precise petrological signification. Considerable work will have to be done on the porphyrites before it becomes advisable to remodel the terminology; meanwhile, it is important to note that a large number of the Cheviot porphyrites are merely altered andesites, and therefore quite different from the felspar-magnetite rocks, which are described as porphyrites by Prof. Geikie in his paper on the Carboniferous Volcanic Rocks of the Firth of Forth.[1]

For the purpose of description the Cheviot porphyrites not belonging to the type described in my previous paper, in which the distinguishing macroscopic feature is a resinous lustre, may be divided into two groups according to the presence or absence of mica, and it is worthy of note that Szabó divides the Hungarian trachytes, under which term he includes the andesites, in a similar way. Whether the mica porphyrites of the Cheviots occur as true lavas, I am not able to state definitely; but they certainly occur as dykes, and in this respect, as well as in others, they are related to the mica-bearing quartz porphyries or porphyrites which occur in the same district. To these latter rocks, however, I do not propose to refer in the present paper. The porphyrites without mica are by far the most

[1] Trans. Royal Soc. Edin., vol. xxix. part 1.

abundant, and they undoubtedly occur as lavas in association with tuffs of a similar andesitic character. The vesicular and scoriaceous portions of the original flows are now amygdaloidal, owing to the deposition of chalcedony, jasper, and quartz, together with certain green minerals in the original cavities. A cursory examination of the thin sections of the porphyrites shows at once that they are closely related to the andesites; that some of them in fact are andesites, whilst others are merely altered andesites. The altered forms very largely predominate, and the question arises, why is it that certain andesites have been preserved from alteration, whereas others have been so profoundly modified as to have lost almost all traces of their original character? No doubt the original rocks varied in character as do the Tertiary andesites of Hungary; some were vitreous, others semi-vitreous, and others compact and crystalline. It is these latter types which appear to have suffered most during the lapse of time; the former, in which the constituents were imbedded in a highly acid glassy base, having retained their original characters to a surprising extent. As the rocks now to be described vary in character much more than those referred to in the previous paper, I propose to select a few of the more characteristic specimens and describe them individually.

Thompson's Walls, near Yetholm.—My attention was called to this rock by Prof. Lebour, who kindly gave me a specimen. I have since visited the locality. The rock is exposed in an old quarry on the hill-slope behind the houses at Thompson's Walls, and a similar but more altered rock occurs at Goldsmouth Hill, about two miles S.S.W. of Thomson's Walls. Macroscopically it consists of a dark purple or black compact matrix, throughout which porphyritic felspars of triclinic species are abundantly scattered. The pyroxenic constituent cannot be easily recognized with a hand lens. The specific gravity of the rock is 2·67. The microscopic appearance of a thin section is represented in the Plate, Figure 1. The rock from which the section was prepared is very fresh, and thoroughly entitled to the term andesite. I will now give a description of that portion of the section which is represented in the Figure. Nearly in the centre of the field of view is a somewhat rounded grain of felspar, evidently a fragment of one of the larger porphyritic felspars. Many other similar grains may be recognized in the section. To the south-east of this grain, supposing the figure to represent a map, is a section of a felspar crystal with definite crystalline boundaries; inclusions of the ground-mass are abundant and their characters are well represented in the Plate. Under crossed Nicols the section is seen to be striated, so to speak, from E.N.E. to W.S.W.; but the striations are somewhat ill-defined, owing to the fact that the section is cut very oblique to the twinning plane.

On the west side, and with its longer edge parallel with a diameter of the figure, is an elongated rectangular section taken out of the zone of the macrodiagonal axis. In this case the twin striation is sharply defined. If we use the letters *a* and *b* to indicate the two sets of lamellæ, then the character of the twinning may be described as follows. The right-hand portion of the section is divided into three tolerably equal bands. The lower third consists of very broad bands of the *a* set, with two or three narrow bands of the *b* set; the middle third consists of broad bands of the *b* set, traversed by extremely narrow bands of the *a* set; the upper third is divided into two halves, the lower half consisting of broad bands of the *a* set, divided by fine lines of the *b* set, and the upper half having this condition of things reversed. The bands here referred to are not continuous along the whole length of the section. So far as my very limited observation has gone, I have found this type of twinning characteristic of felspars, which give the extinction angles of labradorite in cleavage flakes parallel with the basal plane.

Immediately to the north of the felspar section just described there occurs another containing inclusions of the ground-mass arranged in a zonal manner round the edge of the crystal section; and to the south there occurs a felspar reduced to the condition of a skeleton by the number of inclusions which it contains. In this case the bulk of the foreign matter must be greater than that of the felspar substance, and yet the felspar has impressed its character on the compound mass. One is reminded of the masses of Fontainebleau sandstone, on which calcite has impressed its characteristic crystalline form. This portion of the Plate should be examined through a lens.

Rather more than half-way between the central felspar grain first referred to and the top of the Plate there occurs a somewhat elongated rectangular section lying with its longer axis inclined a little north of east and south of west. It shows a fibrous structure. This is a longitudinal section of a somewhat altered crystal of the rhombic pyroxene. The fibrous structure is due to the fact that the altered and unaltered portions lie side by side in bands which run, roughly speaking, parallel with the longer edge of the section. The altered portions give aggregate polarization which may be best seen when the unaltered portions are dark. The black patch below, and slightly to the right of the section just described, is a more highly altered crystal of the same mineral. Another similar section may be seen a little above the largest porphyritic felspar. At the bottom of the figure and intersected by the margin is a fragment of an altered pyroxene, surrounded by a dark ring due to the segregation of iron oxides. Magnetite occurs, mostly as opaque grains, and may be recognized in the Plate. The ground-mass of the slide is composed of small felspars together with numerous specks and grains of opacite (? magnetite) and ferrite (? hematite) imbedded in a tolerably clear crypto-crystalline base. I doubt whether any true isotropic glass occurs in this rock. Apatite occurs in comparative abundance.

Roadside, half a mile above Shillmoor Farm, Coquet.—At the point in question the road makes a slight turn to the right, and on the north side there occurs an exposure of dark purple porphyrite. The ground-mass is compact, and throughout it are scattered crystals of plagioclase and ill-defined greenish patches resulting from the alteration of pyroxene. Sp. Gr. 2·56. The following is an analysis of this rock by Mr. Waller, of Birmingham:—

Silica	64·2
Alumina	16·0
Iron oxide[1]	4·3
Lime	1·7
Magnesia	2·5
Soda	2·9
Potash	5·9
Loss	3·3
	100·8

On comparing this analysis with the one given in the last paper, it will be seen that the lime is replaced by alkalies, and that the proportion of soda to potash is reversed. Notwithstanding this, the porphyritic felspars appear to be entirely plagioclase.

Microscopically the rock is a very interesting one. The large felspars are fresh and of the usual character, so that a special description of them is unnecessary. The pyroxene is in the condition of a green slightly dichroic mineral, sometimes showing definite optical characters and at others passing into the condition of serpentine. A fibrous structure may sometimes be observed in it. Alteration appears to have proceeded along the cracks, as in the case of olivine, and sometimes iron oxides have been formed along these cracks. These characters connect this mineral with bastite, the well-known alteration product of enstatite. Magnetite occurs as large crystals and grains and also as minute grains abundantly scattered throughout the ground-mass together with ferrite. Apatite prisms are not uncommon. The iron oxides also have segregated in places in a patchy manner. The ground-mass itself is mainly composed of minute felspar microlites intimately interwoven with each other (mikrolithenfilz), and I do not think, though on this point it is difficult to be positive, that any portion of it remains persistently dark between crossed Nicols.

Coquet, one mile below Windy Haugh.—A dark purplish-grey compact ground-mass containing porphyritic felspars and a few elongated amygdaloids all lying with their longer axes parallel to one another. The form of these amygdaloids is probably due to the flow of the semi-fluid magma in which the original vesicles were produced. The amygdules consist of quartz and calcite. Specific gravity of the rock, 2·63. Under the microscope the ground-mass is resolved into a felted aggregate of extremely minute and somewhat ill-defined felspar microlites and specks of opacite (? magnetite). It is difficult to say whether any true isotropic substance remains. The porphyritic felspars contain the usual inclusions and exhibit the characteristic twin striation. There is no pyroxene at present existing in the single section of this rock which I have examined, but there are numerous patches of calcite and quartz, and some of the outlines of these patches suggest the form of pyroxene. Pseudomorphs after pyroxene of this kind are not however seen in other specimens of the Cheviot rock which I have examined.

Coquet, quarter of a mile above Windy Haugh.—This rock is exposed only a short distance from the glassy andesites described in the previous paper. It consists of a dull compact ground-mass,

[1] Estimated as Fe_2O_3.

containing altered felspars and a dark greenish mineral derived from the pyroxene.

Under the microscope it is at once seen to be most closely allied to the pitchstone-porphyrite which occurs in the immediate neighbourhood. It is a rock of essentially the same composition and structure; the same constituents may be recognized down even to the minute reddish-brown mineral which occurs in thin hexagonal plates (? hematite) in the ground-mass. There was doubtless some slight physical difference in the condition of the ultimate base of this rock which led to its being more easily attacked by the ordinary agents of weathering than its glassy relative; such a difference, however, may have been produced by slight differences in the conditions under which the rock consolidated, so that after all this porphyrite and the andesite with a glassy base may have originally been portions of one and the same molten mass. As there is such a marked macroscopic difference in the two kinds of rock I did not suspect their close relationship in the field, and consequently did not look closely for evidence as to their connexion with each other.

In the thin section the felspars are seen to have been slightly attacked and in the usual way; iron oxides are scattered pretty abundantly throughout the rock, and some of these appear to be of secondary origin. The most interesting mineral, however, is the one which exhibits the characteristic form of the rhombic pyroxene. It is now green in all sections, but still pleochroic in various shades of green. Cross-sections have lost their prismatic cleavages, and so also have the longitudinal sections; these latter, however, sometimes contain numerous rigidly parallel interpositions of perfectly straight hair-like rods, which were probably present in the original mineral. When examined under a high power, the substance is seen to be not perfectly homogeneous, and longitudinal sections show a somewhat indistinct parallel fibrous structure. At times very minute fibres may be seen to proceed from a central axis, exactly like the barbs of a feather. Under crossed Nicols the mineral approximates in character to an orthorhombic crystal, but owing to the want of uniformity above referred to, the sections do not give perfectly definite extinctions. We have here, doubtless, a mineral closely allied to bastite, and like bastite[1] occasionally passing, by almost imperceptible gradations, into serpentine.

EXPLANATION OF PLATE IV.

Figure I. is described in the text.

Figure II. represents a thin section of the prevailing type of Cheviot andesite, described in the last number of the GEOLOGICAL MAGAZINE. The two kinds of felspar are well shown; the earlier and larger crystals with inclusions, and the later and smaller ones for the most part without inclusions. A longitudinal section of the rhombic pyroxene occurs immediately above the large porphyritic felspar. The microscopic ground-mass is not well represented in the Figure; it consists of black opaque grains (? magnetite), a minute hexagonal mineral occurring in thin plates (? hematite), and a considerable amount of nearly colourless isotropic glass.

[1] Levy and Fouqué, Min. Micro. p. 383.

(*To be continued.*)

ERRATA IN PREVIOUS PAPER.—Page 103, line 47, for 0′ to 44′ read 0° to 44°; page 108, line 4, omit the word *not*; page 108, line 23, for *Nape* read *Nahe*.

II.—A Contribution to the Tertiary Flora of Australia.[1]

By Prof. Dr. Constantin Baron von Ettingshausen,
Of the University of Graz, Austria.

THE series of fossil plants from the Tertiary strata of New South Wales and Tasmania, to which these remarks relate, were sent to Mr. R. Etheridge, jun., at the British Museum, for examination partly by Prof. Liversidge, of Sydney University, and by Mr. C. S. Wilkinson, F.G.S., Government Geologist for New South Wales, whilst the remainder already formed a portion of the National Collection.

I was invited to study and describe these fossil plants during my recent visit to London, where Dr. Henry Woodward, the Keeper of the Geological Department, kindly placed at my disposal for examination all the Australian Tertiary plants preserved in the British Museum, whereby my work has been completed. I also had access to the necessary materials for comparing the fossil with the recent plants in the Botanical Department of the British Museum through the kindness of Mr. W. Carruthers, F.R.S.; and to the magnificent Botanical Museum at Kew Gardens under the care of Sir Joseph Hooker, K.C.S.I., C.B., etc.

Although I did not underrate the difficulties of the task I had undertaken, I have been enabled successfully to investigate the fossil plants of the nearly unknown Tertiary flora of Australia, and to introduce into palæo-botanical science the following general results. In the first place, however, I have to acknowledge my thanks for the valuable help the above-mentioned gentlemen have afforded me.

The literature of the Tertiary flora of Australia is not extensive. Hitherto we have been acquainted with only a small number of species, mostly fruits and seeds, described and figured by Baron Ferdinand von Mueller in the Reports of the Mining Surveyors and Registrars of Victoria for 1871, 1873–78, and in the Annual Reports of the Department of Mines of New South Wales for 1876 and 1878. A few species were also described by Prof. M'Coy in Dec. IV. Geol. Survey, Victoria, 1876, and mentioned in R. B. Smyth's Progress Report, 1874.

The species I have described come from the following localities:—

1.—*Dalton, near Gunning*, New South Wales.

The series of fossil plants from this locality have been collected by Mr. C. S. Wilkinson, who sent them to Mr. Etheridge at the British Museum. They belong to 27 species, 21 genera, and 17 families. The species I have under examination are all new; of the genera only two (*Ficonium* and *Pomaderrites*) are new, whilst the others occur both in the Tertiary formation of Europe (19), North America and North Asia (13), Java (4), Sumatra (3), and Borneo (3). Only six of the genera are contained in the living flora of Australia, and of these only two belong to the numerous genera which characterize this flora.

[1] Being the substance of a paper read before the Imperial Academy of Sciences in Vienna.

Of the species the more remarkable are: *Pteris Humei*, nearly allied to *P. tremula*, R. Brown, of the living flora of Australia; *Betula Daltoniana* allied to *B. prisca* of the European, and *B. Vogdesii* of the American Tertiary; *Alnus Muelleri*, like *A. gracilis* of the same, and *A. Americana* of the American Tertiary strata; *Quercus Hookeri* allied to *Q. laurifolia* of the Tertiary flora of Java; *Quercus calophylla*, nearly allied to the living *Q. Philippinensis*; *Quercus Darwinii* allied to *Q. bidens* of the Tertiary flora of Sumatra; *Fagus Wilkinsoni* connects *F. prisca* of the Cretaceous flora with *F. Feroniæ* of the Tertiary; *Castanopsis Benthami* nearly allied to *C. mephitidioides* of the Eocene flora of Borneo; *Cinnamomum Leichardtii*, allied to *C. spectabile* of the European and *C. Missipiense* of the American Tertiary flora; *Laurus Australiensis*, allied to *L. Swoszowiciana* of the first and to *L. socialis* of the latter flora; *Knightia Daltoniana* related to *Knightia Nimrodis* of the European Eocene flora; *Apocynophyllum Etheridgei*, allied to *A. Reinwardtianum* of the Tertiary of Java; *Tabernæmontana primigenia*, allied to the Tertiary *T. bohemica; Magnolia Brownii*, like the European Tertiary *M. Dianæ*, and the *M. tenuifolia* of the American Cretaceous flora.

There are further, species of *Artocarpidium*, *Bombax*, *Pittosporum*, *Celastrophyllum*, *Eucalyptus*, *Dalbergia*, *Cassia*, and *Leguminosites*, which are allied mostly to species of the Eocene flora. The fossil flora of Dalton belongs, I do not doubt, to the Tertiary formation. As the number of the characteristic Australian forms is so small, and therefore the flora of Dalton so unlike that now living in Australia, I think there must be a greater part of the Tertiary period between both. Besides this, several species are closely allied to European and American Eocene plants, and some species even to Cretaceous. I therefore regard the deposit at Dalton, from which the fossil plants come, as Eocene.

2. *Wallerawang*, New South Wales.

Of the Plant-remains which there occur in Tertiary strata I could ascertain only one new species—*Microrhagion Liversidgei* (so named in honour of Prof. A. Liversidge, who sent the specimen to Mr. Etheridge); it belongs to the Monocotyledons. The exact age of these beds cannot be determined accurately.

3. *The Tertiary Travertin in the neighbourhood of Hobart Town, Tasmania.*

This Travertin has been ably investigated and written on by Mr. R. M. Johnston.[1] I have examined in the British Museum a series of

[1] 1. Johnston (R. M.)—Regarding the Composition and Extent of certain Tertiary Beds in and around Launceston. Proc. R. Soc. Tas. for 1873, pp. 34—48.
2. ——— The Launceston Tertiary Basin; Second Paper. *Ibid.* for 1874, pp. 29 and 53—62.
3. ——— Note on the Discovery of *Spondylostrobus Smythii* (v. Mueller) and other Fossil Fruits in the Deep Lead Drift at Brandy Creek Gold Field. *Ibid.* for 1879, pp. 29—41.
4. ——— Notes on the Relations of the Yellow Limestone (Travertin), of Geilston Bay, with other Fluviatile and Lacustrine Deposits in Tasmania and Australia, together with Descriptions of the two New Fossil Helices. *Ibid.* for 1879, pp. 81—90.

fossil plants from Risdon, Geilston Quarry, and Shoebridge's Lime Kiln, etc., near Hobart Town. The first is one of the best localities for the Travertin containing the leaves. In the British Museum there is also preserved a series of fossil plant-remains which are labelled "Erebus and Terror," and were collected during the exploring voyage of those vessels to the Antarctic Seas, by Dr. C. McCormick, who was attached as Surgeon and Naturalist to the "Erebus." The fossil plants I examined came from the Tertiary Travertin which is so extensively developed in the neighbourhood of Hobart Town. Finally I have also examined the figures in R. M. Johnston's Paper No. 5, with the view of enlarging the knowledge of this interesting fossil flora. It contains till now 35 species, which are distributed into 21 genera and 17 families. Of the species I have to mention:—*Araucaria Johnstoni*, v. Muell., *Myrica Eyrei*, closely allied to *M. salicina* of the European Miocene; *Betula Derwentensis* corresponding to the Miocene *B. Brongniartii; Alnus Muelleri*, nearly allied to the Miocene *A. gracilis*; *Quercus Tasmanii* like the *Q. Palæococcus* of the fossil flora of Radoboj; *Fagus Risdoniana*, nearly allied to *F. Deucalionis; Salix Cormickii* closely allied to *S. varians; Cinnamomum Woodwardii*, allied to the Miocene *C. Scheuchzeri; Lomatia præ-longifolia*, allied to *L. borealis* of the European, and to *L. Torreyi* of the American Tertiary flora; as well as to the living Australian *L. longifolia; Dryandroides Johnstoni*, referring to living species of *Banksia* and *Dryandra; Coprosma præ-cuspidifolia*, the ancestral species of the living *C. cuspidifolia*, of Australia; *Echitonium obscurum* allied to *E. macrospermum* of the European Miocene Flora; *Elæocarpus Bassii* nearly allied to the Miocene *E. Albrechti; Sapindus Tasmanicus* allied to *S. falcifolius* of the European Miocene; *Cassia Flindersii* allied to *C. ambigua* of the same strata. Besides these species of *Apocynophyllum, Cordia, Premna, Sapotacites,* and *Ceratopetalum* occur. This flora contains more characteristic genera referable to the living Australian flora than that of Dalton, in New South Wales, especially such genera as *Lomatia, Dryandroides, Coprosma, Ceratopetalum,* but with a great number of genera occurring in the Tertiary flora of Europe, North America, and North Asia. The species are mostly allied to Miocene, and therefore the leaf-beds of the Tertiary Travertin belong, I believe, to the Miocene formation.

The result of my report is as follows. I find that the Tertiary flora of Australia is far more nearly allied to the Tertiary floras of the other Continents than to the living flora of Australia. It seems, therefore, that the numerous forms which characterize the latter have been developed out of Pliocene or Post-Tertiary forms of plants till now unknown to us. The recent flora of Australia contains also genera which characterize other floras, but not the Australian. It was till now enigmatical how they came to form part of this recent

5. ——— Notes showing that the Estuary of the Derwent was occupied by a Fresh-Water Lake during the Tertiary Period. *Ibid.* 1881, pp. 1—21.

[A full list of Mr. Johnston's Papers on Tasmanian Geology and Palæontology will be found in the *Catalogue of Works*, etc., on Australian Geology, etc., by Messrs. Etheridge, Jun., and Jack.]

flora, as the species are endemic and have not wandered; for instance, the species of the European and North-American genus *Fagus*, of the Asiatic genera *Tabernæmontana* and *Elæocarpus*, etc.

As some of them now have been discovered in the Australian Tertiary, for instance the above-named, there is no doubt they passed over into the living flora from the Tertiary. The proofs of this may be easily introduced into palæo-botanical science by means of future discoveries and investigations. For, in every case the more species of Tertiary plants we are enabled to examine, and especially if taken from large and well-preserved series, the more readily shall we be enabled to show the origin of our living floras.

Enumeration of species from the Tertiary strata of Australia.[1]

CRYPTOGAMÆ.

Filices.

Pteris Humei, Ett.

PHANEROGAMÆ.

Gymnospermæ.

Sphondylostrobus Smythii, F. v. M.
Araucaria Johnstonii, F. v. M.

MONOCOTYLEDONES.

Microrhagion Liversidgei, Ett.

DICOTYLEDONES.

Apetalæ.

Myricaceæ.

Myrica Eyrei, Ett.

Betulaceæ.

Betula Daltoniana, Ett.
,, *Derwentensis*, Ett.
Alnus Muelleri, Ett.

Cupuliferæ.

Quercus Hookeri, Ett.
,, *præ-philippinensis*, Ett.
,, *drymesoides*, Ett.
,, *Darwinii*, Ett.
,, *Tasmanii*, Ett.
Fagus Wilkinsoni, Ett.
,, *Risdoniana*, Ett.
Castanopsis Benthami, Ett.

Salicineæ.

Salix Cormickii, Ett.

Moreæ.

Ficonium Solandri, Ett.

Artocarpeæ.

Artocarpidium Stuartii, Ett.

Laurineæ.

Cinnamomum polymorphoides, M'Coy.
,, *Leichardtii*, Ett.
,, *Woodwardii*, Ett.
,, *Hobartianum*, Ett.
Laurus Australiensis, Ett.
,, sp. adhuc indet., Smyth.
,, *Werribeensis*, M'Coy.
Daphnogene, sp. adhuc indet., Smyth.

Proteaceæ.

Lomatia præ-longifolia, Ett.
Knightia Daltoniana, Ett.
Banksia, sp. adhuc indet., Red.
Conchocaryon Smithii, F. v. M.
Celyphina Maccoyi, F. v. M.
Conchotheca (?) *rotundata*, F. v. M.
,, *turgida*, F. v. M.
Dryandroides Johnstonii, Ett.

Gamopetalæ.

Rubiaceæ.

Coprosma præ-cuspidifolia, Ett.

Apocynaceæ.

Apocynophyllum Etheridgei, Ett.
,, *alstonioides*, Ett.
,, *microphyllum*, Ett.
Tabernæmontana primigenia, Ett.
Echitonium obscurum, Ett.

Borragineæ.

Cordia Tasmanica, Ett.

Verbenaceæ.

Premna Drummondii, Ett.
Trematocaryon Maclellani, F. v. M.

Sapotaceæ.

Sapotacites oligoneuris, Ett.
,, *achrasioides*, Ett.

Dialypetalæ.

Saxifragaceæ.

Ceratopetalum Woodii, Ett.
,, *præ-arbutifolium*, Ett.

Menispermaceæ.

Rhytidocaryon Wilkinsoni, F. v. M.

Magnoliaceæ.

Magnolia Brownii, Ett.
,, *Torresii*, Ett.

Cappárideæ (?).

Liversidgea oxyspora, F. v. M.
Dieune pluriovulata, F. v. M.
Ochtodocaryon Wilkinsoni, F. v. M.
Plesiocapparis leptocelyphis, F. v. M.
,, *prisca*, F. v. M.

Sterculiaceæ.

Bombax Sturtii, Ett.
,, *Mitchellii*, Ett.

[1] For an enumeration of the species known, previous to the researches of Baron Ettingshausen, see the *Catalogue of Australian Fossils*, by R. Etheridge, jun.

Tiliaceæ.
Elæocarpus Bassii, Ett.
Olacineæ (?).
Eisothecaryon semipetalum, F. v. M.
Sapindaceæ.
Sapindus Tasmanicus, Ett.
Pentacoila Gulgonensis, F. v. M.
Penteune brachyclinis, F. v. M.
,, *Clarkei*, F. v. M.
,, *trachyclinis*, F. v. M.
,, *Allporti*, F. v. M.
Phymatocaryon angulare, F. v. M.
,, *bivalve*, F. v. M.
,, *Mackayi*, F. v. M.
Tricoclocaryon Barnardi, F. v. M.
Pittosporeæ.
Pittosporum priscum, Ett.
Celastrineæ.
Celastrophyllum Cunninghami, Ett.
Rhamneæ.
Pomaderrites Banksii, Ett.
Calcycifloræ.
Acrocoila anadonta, F. v. M.
Myrtaceæ.
Eucalyptus Delftii, Ett.
,, *obliqua*, l'Herit.
Eucalyptus Pluti, M'Coy.
Papilionaceæ.
Dalbergia Diemenii, Ett.
Cæsalpinieæ.
Cassia Cookii, Ett.
,, *Flindersii*, Ett.
Leguminosites Kennedyi, Ett.

Plantæ incertæ sedis.

Odontocaryon Macgregorii, F. v. M.
Platycoila Sullivani, F. v. M.
Pleiacron elachocarpum, F. v. M.
Rhytidotheca Linchii, F. v. M.
,, *pleioclinis*, F. v. M.
Wilkinsonia bilaminata, F. v. M.
Xylocaryon Lockii, F. v. M.
Carpolithes Gaertnerioides, Ett.
,, *Risdonianus*, Ett.
Phyllites populiformis, Ett.
,, *ficiformis*, Ett.
,, *juglandiformis*, Ett.
,, *ligustroides*, Ett.
,, *pyriformis*, Ett.
,, *Phaseolites*, Ett.
,, *sophoræformis*, Ett.
,, *mimosæformis*, Ett.

III.—On the Outcrop of the Brockenhurst Bed near Lyndhurst.

By the late E. B. Tawney, M.A., F.G.S.[1]

Brockenhurst fossils were found as long ago as 1858 by Mr. Keeping on Cutwalk Hill, Lyndhurst. He had been lately excavating in the railway cutting near Brockenhurst, at the time that the line was being converted to a double one,[2] and he was anxious to prove the presence of this bed, which just then was attracting much attention at Lyndhurst.

Accordingly he made a few little pits near the spot where he had picked up the characteristic fossils. He obtained only a few well-preserved specimens, the bed not seeming rich at this spot. He succeeded, however, in proving that the Brockenhurst bed lay immediately on the freshwater Lower Headon Marls. It is these freshwater marls which used to be so much used for marling the land, and the whole country is riddled with pits where these or similar shelly freshwater marls occur.

It is necessary then to pay attention in making excavations, so as not to touch soil which has been moved before.

Mr. Keeping's pits were well selected as to position, and it was due to no fault of his that he did not find a rich fauna. He never, however, published an account of his researches, so I make no apology for recounting them here.

The next mention of Brockenhurst fossils is in Mr. Wise's work on the New Forest. He mentions the digging of a well on Emery

[1] The MS. of this paper in the author's own hand-writing has just (March 2nd) been transmitted to me by Mr. Henry Keeping of the Woodwardian Museum, Cambridge.—Edit. Geol. Mag.

[2] The L. & S. W. R. single line was made in 1847.

Down or Silver Street, about a quarter of a mile from Mr. Keeping's locality, in which abundance of Brockenhurst forms were found. These mostly came into the possession of the Rev. J. Compton, of Lyndhurst, who showed them to Prof. von Kœnen, and has lately given me much information concerning them.

It appears that the well-sinker did not keep accurate records of the depth at which the various beds occurred, so that the measurements in Mr. Wise's books are not strictly to be depended on.

We are told by those who now daily use the well that it is 82 ft. deep, which is 10 ft. more than might be inferred from the book in question. The said section gives 7 ft. of *Voluta geminata* zone, and at a further depth of 19 ft. the Brockenhurst fossils cease. Where-ever we have seen this bed, it is a thin bed, and separated from the *V. geminata* zone by beds poor in or devoid of fossils. It is not likely then that the whole of the nineteen feet contained Brockenhurst fossils, as is implied in Mr. Wise's section.

The date of the digging of this well seems to have been about 1863.

Since the original Brockenhurst locality is closed to investigation, from the fact that the rich bed there lies below the metals of the railway, I have attempted in the last week to open the equivalent layer at Cutwalk Hill.

In this I have been helped both by Mr. H. Keeping and the Rev. J. Compton. To the co-operation of the latter I am specially indebted, both for his constant advice, and also for permission to dig on land belonging to Minstead Manor, in immediate proximity to the Silver Street well.

The Brockenhurst bed being sandy, and lying on impervious clay, it is advisable not to work at its immediate outcrop, but to begin above and dig down to it, so as to cut it as far as possible from the actual outcrop, where it is sure to be weathered, and the fossils probably have vanished. Of course one is limited by considerations of depth, and dependent on the contour of the ground. In the field below the well we struck the Brockenhurst at a depth of 4 ft. It is here a sand bed as at Brockenhurst; it lies immediately on fresh-water Lower Headon Marls (which again lie on the Upper Bagshot Sands, as proved in the well), while it is succeeded above by unfossiliferous brown and green clays, which become gradually sandier below as the fossil bed is approached. We were unsuccessful in finding good fossils. A few of the characteristic oyster, *Ostrea ventilabrum*, were found, also *Cytherea Solandri* var., but most of the fossils had perished, and white calcareous spots or concretions alone represented them. Mr. Keeping informs me that it was precisely the same at the outcrop of this bed in the Brockenhurst railway cutting.

We were therefore evidently too near the outcrop for obtaining well-preserved fossils. It was, however, impossible to approach nearer by reason of the gardens of the cottages, which extend to about 50 yards from the well. This is the more to be regretted, because the fossils obtained in sinking the well were especially well preserved. They were greyer in colour, less weathered, and altogether much harder than those obtained in the railway cutting.

The position of the bed is however the same here as at Brockenhurst, as shown by the succession of the beds noted above.

We next moved to the west side of Cutwalk Hill, and excavated a little in the *V. geminata* zone sufficiently to prove the position of this bed, and collect some of its fossils.

Callianassa Batei, Woodw.
Cancellaria muricata, S. Wood.
Rimella rimosa, Brand.
Voluta geminata, Sow.
Pleurotoma pyrgota, Ed.
,, *transversaria*, Lam.
,, *Headonensis*, Edw.
,, *denticula*, Bast.
Natica labellata, Lam.
Bulla Lamarckii, Desh.
Pisania labiata, Sow.
Cerithium pseudocinctum, D'Orb.
Cytherea incrassata, Sow.
,, *suborbicularis*, Edw., MS.
Trigonocœlia deltoidea, Lam.
Cyrena obtusa, Forbes.
Psammobia æstuarina, Edw. MS.

Using this as a datum-line, we began to excavate a pit which should have found the Brockenhurst bed about 14 feet below the last zone. We dug through 7 feet of unproductive greenish-brown clays, which became sandier below, and then found the Brockenhurst sandy bed as we expected. It was lying on an uneven eroded surface of the freshwater Lower Headon Marls, but was thin and poor in fossils.

We obtained *Voluta suturalis*, *V. spinosa*, *Ostrea ventilabrum*, *Cytherea Solandri* var., *C. incrassata*, *Corbula cuspidata*.

Among these are some of the most characteristic forms of the Brockenhurst bed, but it was found useless to expect a rich fauna from here, as the fossils were mostly represented by calcareous remnants, as at the outcrop of the equivalent bed at Brockenhurst. Though fully 7 feet deep, the pit was therefore abandoned.

The freshwater Lower Headon Marl at this point of the hill has been much worked, as may be inferred from remains of old pits. Of fossils we noticed in it *Lepidosteus* scales and layers of *Potamomya*. It is a shelly bluish clay.

The Rev. J. Compton informs us that the 200 feet contour-line passes close to where we excavated, while the top of the hill just exceeds the 300 feet contour-line. We have therefore, about a hundred feet of beds from the Brockenhurst bed to the top of the hill.

Examination of the hill-top showed us other old pits; these we found to have been marl pits. The clay worked there is a stiff green marly clay with very shelly layers. We found *Melania muricata* in abundance. Mr. Keeping considers it as Osborne beds, and in this we agree. We have therefore a perfect insight into the structure of the hill.

At the base all round the hill are the Upper Bagshot Sands; they may be seen in the ditch near the Swan, on the south side; better in the sand-pit west of the Forest View Inn, while these sands are the water-bearing stratum of the Emery Down well.

Above come the Lower Headon Shelly Clays, formerly much used for marling, and said to be 15 feet thick in the well shaft. Next is the marine Brockenhurst bed, quite thin here and only one foot at Brockenhurst; above are clays unproductive of fossils for about a dozen feet, then the *V. geminata* clays, while the remainder of the marine Middle Headon, the freshwater Upper Headon and Osborne Series occupy the above-mentioned interval to the top of the hill.

Before leaving the hill, we made another set of excavations some few hundred yards to the east of the last. First the *geminata* bed was proved, and then a pit of 7 feet deep was sunk on the Brockenhurst bed. The result was the same as the preceding, the same fossils and succession of beds, but the same poverty of fauna and weathered state of the shells.

There is therefore, I fear, little hope of obtaining good Brockenhurst fossils in this outlier.

As we have had to mention the *V. geminata* zone which comes next above the *V. suturalis* zone or Brockenhurst bed, I may perhaps be permitted to add a word about the succession at the Roydon brick-pit near Brockenhurst, where the *geminata* zone is best seen.

In another place we have mentioned that the freshwater Lower Headon occurs at the floor of the pit. We have now to add that the Upper Headon, also freshwater, occurs at the top, above the Middle Headon beds. Mr. H. Keeping discovered this last year. Last August we together re-examined the pit, and found at least 7 feet of freshwater Upper Headon clays and sand. At the base are sandy clays exceedingly rich in *Potamomya plana* occurring in bands. There are other layers rich in *Cyrena*, and near the top is a band of clay iron ore full of *Potamomya*, much as at Headon Hill and Colwell Bay. We found a *Cerithium*, apparently *C. trizonatum*, a shell which has occurred only in the Upper Headon of Colwell Bay.

This is supplementary to our former description of the section.

IV.—"Bergstürze," or "Landslips."

By the Rev. A. Irving, B.A., B.Sc., F.G.S.,
of Wellington College.

As recent events in Switzerland have called the attention of the world to these startling phenomena, perhaps a short summary of what is known of them may be of some service to the readers of the Geological Magazine. In the text-books in use in this country they generally receive little more consideration than the comparatively small scale, on which 'landslips' occur in England, would seem to claim for them; and these for the most part occur on the sea-coast. Examples familiar to most of us are such as those of the Isle of Wight, where the Upper Cretaceous strata are known from time to time to slide over the Gault, which is locally known as the "blue slipper," and that between Seaton and Lyme Regis. On the west coast of South America, in Ecuador, they have been known to occur on a much more gigantic scale in recent years.[1] The tertiary strata of the district of more than 400 feet in thickness consist of sandstones interbedded with clays, and dip towards the coast. The erosive action of the sea eating away the base of the cliffs, and the clays getting softened by water, an enormous portion of the upper

[1] Vide Wolf, *Zeitsch. d. Deut. geol. Gesellsch.* 1872, quoted by Credner.

strata descended into the sea during the years 1870 and 1871. The landslip of Naina Tal is also fresh in the recollection of most of us. It is however in connexion with the Alps that I propose here to treat of phenomena of this class. The worn-down stumps of ancient mountain-systems which these islands furnish give us only a faint idea of the importance of Bergstürze in relation to the physiography of the Alps, which are of comparatively recent elevation. In our own language we have scarcely even a vocabulary which conveys accurately the meaning of such words as 'Bergsturz,' or indicates adequately such modifications of the phenomenon as are expressed by the words 'Schuttrutschung,' 'Schuttsturz,' 'Felsschlipf,' 'Felssturz.' For a clearer idea of these I am greatly indebted to the interesting and masterly memoir on them recently compiled by Prof. Heim of Zürich.[1] From this I extract a few instances, which will suffice perhaps to show the important part which Bergstürze have played both in historic and pre-historic times, in forming some of the minor features of Alpine valleys. They occur most frequently among the stratified deposits of the Alps; and one of the most interesting facts about them is the part which they have played in connexion with valley-lakes.[2] As Herr Heim points out, they are but extraordinary instances of that general process of degradation which is going on in every mountain-range, through the action of well-known sub-atmospheric agencies, a process which is going on "day and night, year in year out."

Four principal types of Bergstürze are recognized by H. Heim.

1. *Schuttrutschungen.*—In such cases vast accumulations of débris ('Schutt') on the mountain-slope, whether as talus or moraines, getting water-logged, descend into the valley. The water increases the weight of the mass and at the same time diminishes both the internal friction of the constituent parts of the mass and its friction against the mountain-side. In some instances, as in that of the village of Herdern in Thurgau, the downward movement has been arrested in its earlier stages, and much valuable property thereby saved: the mass being tapped and its surface drained, sufficient friction has been produced to prevent further descent. One of the most remarkable instances of this class is perhaps the movement which is now going on at the village of Fetan in Unter Engadin. Houses are tilted or parted asunder, and the solid rock on which the tower of the church stands is found to be but a great mass of granite which is slowly moving with the looser materials in which it lies imbedded. The slow preliminary movement which precedes the final catastrophe, goes on in some cases for years, and is accompanied by much friction of the parts against one another, so that the contained fragments are often found to be polished ('spiegelglatt') and striated in the direction of their descent. This is worth some consideration from its simulation of some of the effects of glaciation. Minor instances of such earth-movements cited by Herr Heim are

[1] "Ueber Bergstürze."

[2] Cf. paper on "The Origin of Valley-lakes," by the author, Quart. Journ. Geol. Soc. vol. xxxix. part 1.

those of Hottingerberg in 1878 (resulting from an unusually wet spring and early summer); between 30 and 40 (on a small scale) between Utznach and Weesen in the year 1846; Böttstein in Canton Aargau in 1876; one on the Zürichberg above Oberstrass in 1770; one above Weggis on the slopes of the Rigi in 1795 (lasting 14 days); also a larger one which in 1797 buried 37 houses with many gardens and other property of the village of Brienz, and befouled the waters of the lake for several months.

2. *Schuttstürze.*—It sometimes happens, especially in cases where strata of various composition dip into the mountain, that minor lateral valleys are formed on the high alp; and in these a quantity of débris is sometimes accumulated. As the strata which inclose such an accumulation of débris get further worn away by weathering, a passage is opened for the rubbly mass to find its way down into the valley below; and this it usually does, when, as the result of a more than usually wet season, or of the descent upon it and subsequent thawing of avalanches, it gets saturated with water. One of the most remarkable examples of these Schuttstürze happened in 1868 in the spring of the year, at Bilten in Canton Glarus. Above the village rises the Hirzliberg, composed of the conglomerates commonly known to Swiss geologists as 'Nagelfluh,' sandstones and marls. Upon the brow of this mountain a minor valley 300 mètres long, 50 broad, and 15 to 20 deep, was formed and filled with the loose detritus produced by the weathering of the rocks above it. The valley lies about 450 mètres above the village of Bilten. An avalanche descended upon it during the previous winter, and in melting saturated the loose mass. As the result of this the mass descended in a 'dirty thundering waterfall' of mud and stones through an opening in the front ridge of the mountain, continuing for some 48 hours. The dimensions of the mass which descended were estimated at 180,000 cubic mètres.

Another instance occurred on a smaller scale at Oberarth on the side of the Rossberg in 1874; and in the summer of 1881 an enormous mass descended in a similar way in the Eisak Thal, by which the channel of that rapid river was temporarily blocked up. This was the result of a sudden and heavy rainfall; and when I saw it about a fortnight later, the houses of the lower part of Sterzing were still standing in the water, which had flooded that part of the valley owing to the obstruction mentioned.

In the two varieties of Bergstürze which follow, a portion of the actual strata of the mountain, and not a mere accumulation of loose materials on the mountain-slope, makes its descent into the valley below.

3. *Felsschlipfe.*—The typical 'Felsschlipf' results from the loosening of the upper strata, where the general dip is towards the valley, the antecedent conditions being prepared for it by the erosion of the sides of the valley. The lower part of the mountain is often worn in this way into a slope much steeper than the dip-slope of the strata in the mountain above. The occurrence of soft clayey strata between the more massive beds is of course favourable to the pro-

duction of the phenomenon. The most gigantic instance of this kind on record is perhaps that of Goldau, which occurred in the year 1806. This enormous landslip has been so often described that details need not be given here. The mass which descended has been estimated at 15,000,000 cubic mètres. By it 457 human lives were lost, and 14 more people were dug out alive; while 111 dwelling-houses, 2 churches, and 220 hay huts and stables were buried beneath it.

Other instances on a smaller scale were those of Röthen in the Goldau district in 1395, and Rorschach in 1857.

4. *Felsstürze.*—These are much more frequent than Felsschlipfe. They can be counted by hundreds in the Alps alone both in historic and pre-historic times, the majority of them occurring in the more uninhabited parts of the mountains. Huge masses of rock break loose from the mountain-side and roll or fly down into the valley below. They usually separate from the mountain by irregular cross clefts. In these cases the action of water (except in widening the fissures by expansion during the process of freezing) is of much less significance than in the three types previously described. Very often the descending mass shoots forward over the edge of a precipice, so that an eye-witness can see through beneath the mass during its descent, as happened in the Bergsturz at Elm in 1881. Other instances, more or less remarkable, cited by H. Heim, may be worth mentioning here.

1486. Destruction of Zarera in the Poschiavo Valley, in which 300 lives are said to have been lost.

1512. Monte Crenone above Biasca, in which 600 lives were lost and 400 houses destroyed. The river Blegno was dammed up by it and formed a lake, which remained for three years, when the barrier was broken through and the whole valley down to Lake Maggiore devastated by floods.

1618. Destruction of Plurs in Bergell, the most destructive Bergsturz within historic times. The number of lives lost has been variously given at from 980 to 2500. The village was, and still remains, completely buried, and the river Maïra was temporarily dammed.

1714 and 1749. Diablerets. The river Licerne was obstructed, and in this way the present Lake of Derborence was formed: 120 huts, 18 human beings, and 130 head of cattle were overwhelmed.

The formation of Lake l'Alleghe from a similar cause in the last century is well known.

"We find," says H. Heim, "no Alpine valley without such heaps of mountain débris, and traditions having reference to them. A still older series belongs to a time extending far back beyond the range even of tradition." He particularly describes that of Flims in the Vorder-Rhein Thal, which is 600 mètres high. On its back are found moraines and huge blocks transported from the interior of the mountains, proving the date of the Bergsturz to be anterior to the Glacial Epoch; and at the present time above Ilanz there are still to be seen traces of the ancient lake which was formed by the waters of the Rhein as they were ponded back by the Felssturz of Flims.

In addition to what has been said, mention might be made of instances (which are pretty numerous) in which the Bergsturz can hardly be referred definitely to either of the four types above described, but combines rather the characters of more than one of them.

Near the Fern Pass in Tirol I observed last summer a whole series of such heaps of débris. They are overgrown with pine-woods, and one of them is surmounted by the ruins of an ancient fortress. They occur in the form of conical hills in the *middle* of the charmingly beautiful valley which leads from the Fern Pass down to Nassereit. Several of the most lovely little lakes I ever saw lie between these hills, giving to the valley, as one looks down upon it from above, an aspect of surpassing beauty. One or more of these lakes has no visible outlet. It is as clear as possible that the hills are not moraines, for, where they have been opened for road-materials in places, the uniformly ragged and angular form of the blocks contained in them is different from what we see in a moraine heap; and the only explanation of them which appears possible is that they are the work of pre-historic Bergstürze which have shot over the precipices from the steep mountain-slopes above.

Opposite the town of Hallstadt another great 'fall' from the Sarstein is recorded in the tumbled and confused and broken condition of the rocks which there abut upon the lake. I think too that a further examination of the northern end of the Königsee would show that this lake is maintained at its present level by rock-material which has fallen *en masse* from the mountain, and that in this way the existence of the islets at that end of the lake would be accounted for.

Scant justice seems to be done to these important phenomena by English geologists, if we may judge from the brief references to them to be found in our latest text-books, such as those of Professors Geikie and Green; and this brief sketch will have answered its purpose if it serves to direct attention to the writings of continental geologists, in which the subject is discussed more fully.

V.—The Lincoln Lias.

By W. D. Carr, Esq.

The Lias in the vicinity of Lincoln is well exposed in the several brick-pits that lie at the foot of the "cliff" or in the steep slope beneath the escarpment of the Northampton Sand and Lincolnshire Oolite which go to form the cliff; the exposures however show us nothing below the *Ammonites capricornus* zone of the Lower Lias, the limestones and lower beds of this division lying several miles away to the west. The whole of the series, Upper, Middle, and Lower, is almost purely argillaceous, the usual sandy beds of the Middle and Lower Lias being entirely absent or only very feebly represented. The following is a description of the beds. Zone of:—

Upper Lias.	*Ammonites bifrons.*	Light blue paper shales: few fossils.
	A. communis.	*Nucula Hammeri Beds.* Blue Clay with septaria: many fossils in bands.
	A. serpentinus.	*a.* Blue clay with large septaria, gritty bands locally passing into limestone: Belemnites very abundant.
		b. Blue pyritous clay with strong limestone bands weathering yellow.
Middle Lias.	*A. magaritatus.*	Slightly sandy shales with bands of ferruginous nodules: few fossils.
Lower Lias.	*A. capricornus.*	Thickly bedded hard blue shales with *Ostrea* bands (2) and small septaria.

Just outside the city on the north cliff we find in the brick-pit belonging to Swan Brothers about 60 feet of the Upper Lias with the ironstone series of the Northampton Sand cropping out above it. Commencing at the top, and working downwards, we find beneath the ironstone about 31 feet of lightish blue shale, which splits up on the weathered surface into very thin laminæ. These beds contains few fossils, chiefly *Ammonites bifrons* in a fragmentary condition, and a few Belemnites. They terminate downwards in a thin band of septaria, below which come in the *Communis Beds.* On the top of the latter, and underlying the nodule band, is a bed of gritty dark coloured shale about 18 in. thick, made up largely of shelly debris, and containing *Nucula Hammeri* very abundantly. This bed is especially interesting as being the chief repository of the very rare *Trigonia pulchella* (rare at least in England, though known from 3 or 4 localities on the Continent), which in fact occurs only in this band and a few feet below it. Underlying this gritty band of shale we have clay 4 ft., and beneath that another gritty band 9 in. thick, similar to the first, and containing the same fossils. Again, below this comes clay 2ft. 6in., which terminates the *Communis Beds,* and brings us to the zone of *Ammonites serpentinus.* At the top of the *Serpentinus* beds we have a strong band of septaria, underlying which and filling the spaces between the nodules occurs another dark gritty shale, locally indurated into limestones very similar in appearance to those that occur in the *Communis* beds, but containing different fossils, minute species of *Dentalium, Chemnitzia,* and *Actæonina* occurring in hundreds, while fine examples of *Belemnites subtenuis* 5 or 6 inches long are abundant; very large examples of *Ammonites serpentinus,* and *A. heterophyllus* also occur, and a large Nautilus. *Nucula Hammeri* occurs very sparingly, and *Amberlya, Delphinula* and *Astarte* not at all. We have again blue shale for 12 inches below this, and then another band of gritty shale 4 inches thick, which contains the same fossils as the band 1 foot above it. Blue shale again follows for 8 inches, when we encounter a strong double band of septaria 2 ft. in thickness, and below it 8 ft. of blue shale to bottom of pit. The whole of the beds in this pit are conformable and have a dip of about 4° E. 30° N.

Owing to surface metamorphism the upper 3 or 4 ft. of shale is altered to a tenacious yellow clay, which contains in its lower part fossils changed to a bright yellow; crystals of selenite are found where the yellow clay merges into the blue, and the clay there has a rotten appearance. Included also in the yellow bed are septarian nodules presenting a very curious wrinkled appearance, being exactly like gigantic kidneys; these when traced into the blue beds quite lose this character and appear as depressed spherical masses having a hard polished surface often covered with small shells.

This kidney-like appearance is due to the partial and unequal decomposition of the mass. The veins of calcite which traverse the septarium in all directions are harder than the indurated clay that goes to form the bulk of the nodule, and stand out in relief. When decomposition is more pronounced, the veins of calcite stand well out from the nodule, and present much the appearance, only on a larger scale, of one of the Palæozoic chain corals.

Crossing the valley that the river Witham has cut through the Oolitic escarpment, we find on the south cliff a series of three sections in different brick-pits which expose nearly the whole of the Lias down to the top of the *Capricornus* zone. The upper pit, belonging to Mr. Best, is in Upper Lias, and the same beds containing the same fossils are traceable in the upper part as in the pit belonging to Messrs. Swan. Continuing the section here about the same horizon at which we left off on the north cliff, we find about 20 feet of blue clay, containing occasional Belemnites and crushed shells, and below it a calcareous gritty band of shale, containing many Belemnites and a few other fossils. Leaving this pit, and entering the second, we again take up the section, and find one foot below this last gritty band two thick beds of argillaceous limestone separated by five feet of clay. The upper limestone is less sandy than the lower, and rather ferruginous, and the lower shows occasional traces of concretionary action. On weathering they readily split up into very thin laminæ, and pieces are readily detached a couple of feet across having an uniform thickness of not more than one-sixth of an inch. These limestones form the base of the Upper Lias, which is here about 90 feet thick, and no doubt represent the first and insect limestones of other districts, though the only fossils found in them are *Inoceramus dubius* and *Ammonites*; small fragments of the shells of *Inocerami* are found scattered between the laminæ, and might occasionally be mistaken for fish scales or fragments of the elytra of beetles. The fossils of the Upper Lias are tolerably numerous and well preserved (with the exception of the *Ammonites*, which are seldom perfect), and are interesting as including several new forms; there is also a remarkable absence of common Upper Lias species, *Nucula Hammeri*, for instance, taking the place of *Leda ovum*, the latter common shell being absent. Below is a full list of fossils:—

Sauria—
Ichthyosaurus sp.
Plesiosaurus sp.

Pisces—
Hybodus sp.

Mollusca = Cephalopoda—

Ammonites bifrons.
A. crassus and var.
A. communis.
A. falcifer.
A. heterophyllus.
A. serpentinus.
Belemnites clavatus.
B. subtenuis.
B. vulgaris.
B. (2 or 3 other sp.).
Nautilus (large sp.).

Gasteropoda—

Actæonina sp.
Amberlya sp.
Cerithium costulatum.
Cerithium sp.
Chemnitzia sp.
Delphinula sp.
Dentalium sp.
(?) *Fusus* sp.
Littorina sp.
Pleurotomaria anglica.
P. sp.

Conchifera—

Arca sp.
Astarte Voltzii.
Avicula sp.
Crenatula ventricosa.
Cucullæa sp.
Inoceramus dubius.
Lima duplicata.
Lucina sp. (large).
Lucina sp. (small).
Macrodon sp.
Nucula Hammeri.
Opis sp.
Ostrea sp.
Pholadomya sp.
Pleuromya unioides (?).
Trigonia pulchella.

Brachiopoda—
Discina sp.
Rhynchonella sp.

Articulata = Annelida—
Serpula.

Annuloida = Echinodermata—
Pentacrinus.

Plantæ—
Wood.

The first exposure of Middle Lias is seen in the middle pit on the south cliff underlying the Upper Lias Limestones, and consists of about 10 feet of blue clay with few fossils to bottom of pit. We cannot take up in this division a continuous section as we did in the Upper Lias, about 20 feet of the middle beds being doubtfully seen; about 10 feet of the lower beds are exposed in the lowest of the three pits here, belonging to Messrs. Kirk and Parry, but obscured somewhat by rainwash and therefore not easy to examine. The bottom beds in this pit belong to the top of the *Capricornus* zone, but the pit is now out of use and half full of water, so they cannot be seen. A much better working section occurs a mile further south in the pit of the Bracebridge Brick Company. The lowest 20 feet of Middle Lias is seen at the top, and consists of clays divided by 3 bands of ferruginous nodules, a few phosphatic (?) concretions are found attached to some of the nodules in places giving them rather a conglomeratic appearance; the fossils are few and badly preserved and seem to belong more to the *Margaritatus* than the *Spinatus* zone. There is a small pit in Middle Lias below that of Messrs. Swan on the north cliff which probably links together the upper and lower beds that are seen in Mr. Best's second pit and that of the Bracebridge Brick Co. respectively; it consists of clays with ironstone nodules and irregular bands of soft ferruginous clayey sandstone, with occasional casts of shells, which, however, do not help us much in determining its exact horizon.

The Marlstone (rock-bed) appears to be entirely absent, for although about 20 feet of Middle Lias is not exposed positively, the slope between the upper 10 feet and the lowest beds which are seen above each other on the south cliff is quite uniform, and proves there is no hard bed of any importance between, or it would have caused a recognizable feature. This disappearance of the Marlstone is the more remarkable as it is known at Leadenham about 10 miles to the south, though rather rapidly thinning out, and it occurs also at some distance north of Lincoln.

The lower beds of this division of the Lias are not quite so purely argillaceous as the rest of the series; a few Brachiopods are found resting on the surface of the nodules and pressed between some of the more sandy clays. The full thickness of the Middle Lias is about fifty feet. Below is a list of fossils :—

SAURIA—
Ichthyosaurus, sp.

MOLLUSCA = CEPHALOPODA—
Ammonites capricornus (rare).
A. margaritatus.
A. spinatus.
Belemnites, 1 or 2 sp.

GASTEROPODA—
Trochus imbricatus.

CONCHIFERA—
Avicula cygnipes.
Cardium multicostatum.
Hippopodium ponderosum.

CONCHIFERA—*continued.*
Pecten æquivalvis.
Pleuromya unioides.

BRACHIOPODA—
Lingula sp.
Rhynchonella calcicostata.
Waldheimia sarthacensis.

ARTICULATA = CRUSTACEA—
Glyphea.

ANNULOIDA = ECHINODERMATA—
Pentacrinus.

PLANTÆ—
(Wood).

The only exposures of Lower Lias seen near Lincoln belong quite to the top of the series, and are entirely in the zone of *Ammonites capricornus.* These beds are well seen in the pit last mentioned underlying the Middle Lias, and consist of bright-blue shale with bands of nodules; these beds are difficult to distinguish from the Upper Lias, the nodules being also very similar. These latter, however, are unfossiliferous with the exception of an occasional *A. capricornus* or Belemnite sticking to the outside; the fossils are chiefly found in the *Ostrea* bands, or resting on the nodules, but not attached to them. *Trochus imbricatus* and *Modiola scalprum* are found throughout. About 30 feet of these beds are seen in the pit of the Bracebridge Brick Co., and about twelve additional feet in a pit a mile and a half further south, near Waddington Station; these latter are evidently lower in the series. Here the characteristic Ammonite is very abundant, and occasionally reaches a large size, with very strong ribs; other fossils are not very abundant excepting Oysters and Belemnites. Two well-known Lower Lias genera are altogether missing, namely, *Gryphœa* and *Cardinia*, bands of the normal form of Oyster take the place (at this horizon) of the usual *Gryphœa* bands.

Fossils from the zone of *Ammonites capricornus* :—

SAURIA—
Ichthyosaurus, sp.
Plesiosaurus, sp.

MOLLUSCA = CEPHALOPODA—
Ammonites capricornus (common)
A. defossus.
A. Henleyi.

MOLLUSCA—*continued.*
A. spinatus (rare).
Belemnites clavatus.
B. (One or two other species.)

GASTEROPODA—
Dentalium, sp.
Trochus imbricatus.

Conchifera—
Avicula inæquivalvis.
Cardium multicostatum.
Cardium truncatum.
Cucullæa, sp.
Gervillia lævis ?
Goniomya V-scripta.
Inoceramus, sp.
Leda longicaudata.
Lima pectinoides.
Modiola Hillana.

Conchifera—*continued.*
Modiola scalprum.
Ostrea, sp.
Pecten æquivalvis.
Pecten liasinus.
Pholadomya Hausmanni.
Pleuromya unioides.
Spondylus spinosus.

Plantæ—
(Wood).

VI.—The Glacial Phenomena of North America, as studied in Long Island, New York, U.S.

By John Brysen, Esq.

Having resided for some years past on Long Island, the terminal moraine of the Great American continental glacier, and having given considerable attention to the drift phenomena, I am convinced that no oscillation of the continent has taken place subsequent to the Glacial period ; and that the river kames, with their assorted gravel, etc., can be accounted for, without resorting to any such doubtful interpretations. I am aware that the presence of shells in the Boulder-clay argues in its favour; but that shells become mixed with the drift while the glacier is in motion is evident from what Prof. Geikie saw in Scandinavia. I will now try in a brief way to give your readers the result of my observations; and, though the sketch may be somewhat crude and imperfect, it may serve to throw a little light on this difficult problem.

Let us imagine a great ice-sheet some 10,000 feet in thickness, covering the eastern half of the North American continent. It begins to move from the region of Lake Superior, and, after a lapse perhaps of some 25,000 years, its terminal moraine ends in the sea, and stretches along the whole length of the Atlantic border from Jersey to Nova Scotia. It must have been much higher than now; and as the ice began to melt, vast streams of muddy sediment washed down in front of it, forming what is now known as the 'south side' of Long Island. Behind the moraine the waters of the melting glacier were dammed up, and were trying to cut their way through the rocky *débris* in front of them. Previous to the Glacial age the waters of the Hudson, Connecticut, and other rivers, must have flowed directly into the sea, and as this barrier was piled up in front of them, new channels had to be formed, the existence of which is still visible in the low marsh-lands throughout the interior of the island. Underneath the glacier wild and turbid streams fought their way to the sea, almost, and at some places altogether, penetrating the main ridge, or what is now known as the backbone of the island. The Sound, or East River, did not yet exist, and the waters flowed *around* not through Hurlgate as at present. Vast basins at Maspeth and Hunter's Point received the waters from above, and, in fact, all the bays and numerous streams were connected from Flushing to Gorvanus. Most of what is now the City of Brooklyn was under water; and to the same cause is due the broken character of the north side of the island. Above Great Neck at Hempstead, the waters broke through the main ridge, carrying away the debris in front of them for several miles, forming the gravelly plains, as at Garden City, and making a gap clear through to the ocean. To this fact is due the barrenness of the soil, for had it not been for this, Hempstead plains would have been as fertile as those of Kings. The evidence of this is very clear, as the stones around Hempstead are all smooth and water-worn, and differ in this respect only from those of the drift, as the pebbles are formed from the same material brought from the north, coarse conglomerate predominating, pieces of which the writer found on the very summit of Harbor Hill, at Roslyn, not carried there by the drift, but washed up by the current, showing that the water at the close of the Glacial age must have stood as high as our highest hills, Roslyn being the highest point on Long Island. This seems almost incredible ; but when we remember that the glacier was from ten to fifteen thousand feet in thickness, it does not seem impossible. It was *under* the glacier that these mighty torrents prevailed.

Sand hills, intercalated with gravel, attest their force. River terraces were formed as the waters gradually subsided, and as the ice finally melted, a stratum of Boulder-clay was deposited on the top; this is evident from the fact that the stratum of clay grows thinner as we near the margin of these icy streams. The currents being strong and high until the close of the Ice age would naturally sweep away most of the debris that fell into them. Evidence of this is seen in the smooth rounded boulders found at the mouth of these ancient rivers, some of which, dug out of the channel at Gorvanus, are of the most beautiful description ; the different kinds of granite and sandstone being polished as if by machinery. The larger boulders which the currents were unable to carry away may be seen lying at the bottom of the now dried-up streams; for when the present channel of the East River was formed, these interior rivers were all drained, leaving only a swamp to mark their site, and the city of churches was well named "Brucklin" by the Dutch settlers of the west end of the island. In these facts it seems we have an explanation of all the phenomena so puzzling to scientists.

Here on Long Island is the key to the long perplexing problem. It is written so plainly that, as Prof. Agassiz says, one must shut his eyes if he fails to see it.

Shells, if found at all, are at the bottom of the drift, the former bed of the ocean, yet Long Island is spoken of as of marine origin, and the wood found in the *débris* must, according to Dawson, have been brought from some island in the sea, as if no trees grew on the continent prior to the Glacial age. Terraces are made into sea-beaches where no sea existed, as the parallel roads of Glen Roy, and the seventeen parallel ridges south of Richmond, Mass., are laid down by icebergs, according to Sir Charles Lyell. How strange it is that some scientists will resort to far-fetched and doubtful conclusions when plain evidence is within their reach, and in order to account for a few broken shells, a whole continent had to be sunk and re-elevated, a thing that is entirely out of the question, as there is not the least evidence as far as we can see to support it. Lake Champlain and the Gulf of St. Lawrence at one time formed an arm of the sea, which may account for the marine fossils found in the drift of that region. Shells could be washed up on the top of high gravel beds, as at Airdrie, where the writer of this article was born, as easily as the pieces of conglomerate found on Harber (Harbour?) Hill, and other acclivities of like nature on Long Island. It may seem like presumption for one like myself, who is by no means a scientist, to advance views in conflict with such learned authorities; but I am confident that when the whole drift phenomena is better understood, these theories will be found to be in the main correct.

NOTICES OF MEMOIRS.

I.—Short Notices of Memoirs.

1. "*RIVERS*" is the title of a paper by Mr. T. Mellard Reade (reprinted from the Transactions of the Liverpool Geological Association, 1882): he treats of the subject practically and poetically. He thinks "there is no doubt that every river basin must have had its fluctuations of rainfall within certain limits; but there is no reason to suppose that on the whole there was more or less rain in previous periods than now; at all events the onus of proof lies on those who assert that there was." He deals with the mechanical and chemical denudation of rivers and with their age, remarking also upon the great thickness of the delta-deposits of the Ganges, Mississippi, etc.

2. A useful paper "*On the Classification of Lake Basins*" has been prepared by Mr. William M. Davis (Proc. Boston Soc. of Nat. Hist. vol. xxi. Jan. 1882). He gives notes on the literature of the subject, and describes various lakes, under the headings, *A.* Construction or Orographic Basins, *B.* Destruction or Erosion Basins, and *C.* Obstruction, Barrier or Enclosure Basins. He observes that "The theory of the glacial origin of lakes was first proposed by Hind in 1855, but did not attain prominence until advocated in a more general way by Ramsay in 1859, and especially in 1862."

3. Mr. W. M. Davis has also contributed some notes on "*The Little Mountains East of the Catskills*" (Appalachia, vol. iii. No. 1), which are made up of Devonian and Silurian Beds, showing interesting synclinal, anticlinal and monoclinal structures.

4. A paper "*On the Löss and associated deposits of Des Moines,*" Iowa, has been communicated by Messrs. W. J. McGee and R. E. Call (Amer. Journ. Science, vol. xxiv. Sept. 1882). Lists of land and freshwater shells from the deposit are given, as well as figures of some of the species—the authors observing that "In similar deposits to that now under consideration in Belgium many of the same genera and some few of the same species are found. This is

really an important fact as establishing the former wide geographical distribution of forms now confined almost solely to one or the other of the two continents." In the district under consideration, it appears that the löss is confined to elevated plateaux, its upper portion is broken up, contorted and commingled with glacial drift, and the whole is overlain by unmodified glacial drift. The authors consider that the löss was deposited in an ice-bound basin, the coldness of the waters and the low temperature of the air, being attested by the depauperate shells found imbedded in it. The observations of the authors indicate the unipartite character of the drift-sheet above the löss, and lead them to disbelieve in the hypothesis of a ground-moraine and a superficial moraine being formed by each glacier; finally, from the disappearance of the blue colouration downward in certain sections of drift clay, they conclude that this colour is not normal but is changed to brown or yellow by oxidation from above.

5. Mr. W. J. Harrison, in a paper "*On the Quartzite Pebbles contained in the Drift, and in the Triassic Strata of England; and on their Derivation from an Ancient Land Barrier in Central England*" (Proc. Birmingham Phil. Soc. vol. iii. p. 157, 1882), has treated of a subject of great interest to English geologists. Describing first the lithology, he passes on to enumerate the fossils obtained in the pebbles, which belong to Lower and Upper Silurian and Devonian species; and it is remarkable that the *Orthis Budleighensis* is the most abundant fossil in the quartzite pebbles at Birmingham, and also at Budleigh Salterton. Mr. Harrison says: "It seems perfectly clear that the quartzite pebbles, which occur so abundantly in the Drift of the Midland Counties, were derived from the Pebble-bed or Conglomerate which forms the middle member of the Bunter Sandstone, or Lower Trias." The author discusses the origin of this conglomerate, and points out its formation from the Palæozoic axis of the Midlands. An appendix giving a list of papers on the subject, and another by Mr. J. J. H. Teall on the microscopic structure of certain specimens of Quartzite, complete this very carefully prepared paper.

6. "*On the Geological Effects of a Varying Rotation of the Earth*" (American Naturalist, Jan. 1883) is the title of a paper by Prof. J. E. Todd. The forces tending to accelerate rotation are, the contraction of the earth, and the transfer of matter (in the form of ice, sediment, etc.) from lower to higher latitudes. The retarding influences are, the friction of the tides, the transfer of matter from higher to lower latitudes, elevation of the earth's crust in lower latitudes, and distortion of the earth's body by the attraction of the sun and moon. The author enters into a brief theoretical view of the action of these forces. He then proceeds to compare the theory with recorded facts relating (1) to changes during the present epoch, (2) to changes in the early Quaternary period, and (3) to changes in earlier ages. In conclusion he indicates certain important lines of investigation in connexion with the subject.

7. Dr. Charles Barrois has described the Raised Beaches on the west coast of Finistère ("*Sur les plages soulevées de la côte occidentale du Finistère*," Ann. Soc. Géol. du Nord, vol. ix. 1882). In connexion

with this subject, Mr. Ussher's paper on the Recent Geology of Cornwall (Geol. Mag. 1879) may be studied with advantage. Dr. Barrois points out indications of glacial phenomena in Finistère, which he attributes to transport by floating ice.

8. An article "*On the Fauna of the Lower Carboniferous Limestones of Spergen Hill, Ind., with a revision of the descriptions of its Fossils hitherto published, and illustrations of the species from the original type series*" (Bulletin of the American Museum of Nat. Hist. vol. i. No. 3), by Mr. R. P. Whitfield, furnishes us with descriptions of Foraminifera, Echinodermata, Brachiopoda, Lamellibranchiata, Gasteropoda, Heteropoda, Pteropoda, Cephalopoda, Annelida, and Ostracoda.

9. Mr. G. H. Kinahan, in a paper entitled "*Palæozoic Rocks of Galway and elsewhere in Ireland, said to be Laurentians*" (Scientific Proc. Roy. Dublin Soc. vol. iii.), discusses the evidence on which this classification has been based. He considers that the claim to the title of Laurentians for rocks in counties Donegal, Tyrone, and Mayo, has not been satisfactorily proven; on the contrary, the facts already put forward elsewhere, in favour of their being of Cambrian age, remain unanswered. In county Wexford, he points to the occurrence of *Oldhamia* as proving the Cambrian age of certain rocks, similar in character to others asserted to be older. Again, in West Galway, Mr. Kinahan points out that there is no conclusive evidence for identifying rocks of Laurentian age, observing that years ago Dr. Haughton classed the granitic rocks of Donegal and Galway together, and Dr. Hull also refers them to the same period of time. Mr. Kinahan remarks "that the Laurentianists pin their faith too much on lithological characters; while they nearly altogether neglect petrological or stratigraphical evidence; and it would appear to me that if they go on as they have began, we shall have, before long, every metamorphic region, no matter what the age of its strata, dotted over with their Laurentian rocks." H. B. W.

II.—Geology of Cromer.

1. The Geology of the Country around Cromer. By Clement Reid, F.G.S. (with Notes by H. B. Woodward, F.G.S.). Memoirs of the Geological Survey, England and Wales. (London: 1882.)
2. Section of the Norfolk Cliffs, from Happisburgh, through Bacton, Mundesley, Trimingham, Sidestrand, Overstrand, Cromer, Runton, Beeston, and Sherringham, to Weybourn. By Clement Reid. 1882.
3. Explanation of (the above) Horizontal Section, Sheet 127. By Clement Reid.

The country described in the Memoir and Section above noted, is that embraced by Quarter-sheets 68 N.E. and S.E. and a part of 68 N.W. of the Geological Survey Map. The chief interest of the district lies in the coast-section, which includes the finest exhibition of Glacial Drift in the country, and shows these beds in connexion with the so-called "Forest Bed" of Pre-Glacial or Pliocene Age: the inland sections (described by Mr. Reid and Mr. Woodward) furnishing, for the most part, details of a very local and far from interesting nature.

Some of the newly ascertained facts concerning the Pliocene and Glacial beds of Norfolk have been communicated by Mr. Reid to the GEOLOGICAL MAGAZINE (see Decade II. Vol. IV. pp. 300–305; Vol. VII. pp. 55–66, 238, 239, 548, 549), while earlier papers by Mr. John Gunn, Messrs. Wood and Harmer, the Rev. O. Fisher, and others, treating of the same subjects, have also appeared in former volumes of this MAGAZINE.

Excellent diagrams of the cliffs were published by Samuel Woodward in 1833, and by Mr. S. V. Wood in 1865; but these of course were exaggerated in outline, and on a much smaller scale than the very carefully drawn Section by Mr. Reid, to which we now call attention. Being on a true scale, the character of the contortions in the Contorted Drift may be well studied. This section is described in detail in the Memoir, and more briefly in the Explanation above mentioned: why this latter should be published in addition to the Memoir it is hard to say.

The chief feature in Mr. Reid's Memoir is the detailed account of the Pliocene beds shown in the cliffs: the notes are far more systematic than any previously attempted, while the organic remains obtained by Mr. Reid and Mr. A. C. Savin, of Cromer, have added very largely to our knowledge of the fauna and flora of the beds. Occasional woodcuts and a coloured plate give details which are not shown in the large sheet of sections. One very interesting chapter is devoted to the Climate, Physical Geography, and Natural History of the Newer Pliocene Period, and here Mr. Reid remarks that the most important feature in the scenery was the "Forest Bed" river, which in all probability was the same as the Rhine—for not only do the rocks found in the Pre-Glacial gravels support the view, but in the "Forest Bed" there is a distinctly southern land fauna contemporaneous with an equally marked arctic marine fauna.

The Glacial beds and their method of formation are treated of at some length, the author further explaining his views on the origin of the Contorted Drift, and its huge transported masses of chalk.

Nor are the Alluvial deposits neglected, but their description occupies little space; the phenomena of Denudation are noticed in one chapter, and the concluding one is devoted to Economic Geology, the Soil, Road-metal, Lime, Brick-earth, Peat, etc., Mineral Waters, and Water Supply.

REVIEWS.

I.—THE VERTEBRATA OF THE FOREST BED SERIES OF NORFOLK AND SUFFOLK. By E. T. NEWTON, F.G.S., etc. [Memoirs of the Geological Survey of England and Wales. (London. 8vo. pp. 143, 19 Plates. Price 7*s.* 6*d.*).]

THE fossils of the celebrated "Forest Bed" of Cromer are of very great interest to Geologists and Zoologists, for they belong to the group of animals and plants which inhabited this country in times immediately antecedent to the long period of cold known as the Glacial Epoch or Great Ice Age—a period separating the Recent from the Pliocene fauna and flora. The early labours of R. C. Taylor, followed closely by those of S. Woodward, and carried on with the utmost vigour and enthusiasm by John Gunn, and for a short time by the late Rev. S. W. King, have made us acquainted with the prominent characters of the "Forest Bed," and the larger mammalia entombed in it. But it has been left to the Geological Survey to collect the smaller fossil forms, and to work out the detailed structure of the beds, far more completely than has hitherto been done, notwithstanding the labours of Messrs. Wood and Harmer, Prof. Prestwich, the Rev. O. Fisher, and others. As our readers are already aware, a number of new forms have thus been added to the list of the Vertebrata from the Forest Bed, while the list of those forms previously recorded, has been revised and corrected in many important particulars by Mr. E. T. Newton, the author of the present elaborate work.

As a summary of Mr. Newton's work has so recently appeared in the pages of the Geological Magazine (Decade II. Vol. VII. pp. 152-155, 424-427, 447-452; Vol. VIII. pp. 256-259, 315-317; Vol. IX. pp. 7-9, 51-54, 112-114), it will be unnecessary here to go over the same ground: and we need simply call attention to the publication, and to the way in which the subject is illustrated. An introduction is devoted to the history of the subject: and therein the labours of Falconer and Boyd Dawkins are duly mentioned, while on the part of the Geological Survey the labours of Mr. J. H. Blake, on the district near Yarmouth and Lowestoft, and of Mr. Clement Reid on that of Cromer, have furnished many of the smaller fossils now made known. Nor should mention be omitted of a very zealous worker resident at Cromer, Mr. Alfred C. Savin, who has contributed many new and interesting forms, particularly the *Caprovis Savinii*, the same genus as the Sardinian Sheep. The recent works of Dr. Leith Adams on the Fossil Elephants have rendered it unnecessary to figure this genus; nor have any of the *Cervidæ* received illustration, for, as Mr. Newton remarks, to do this satisfactorily much space would have been required, and Mr. Gunn has already had many of them drawn for the new edition of his "Geology of Norfolk."

It is interesting to note that the Mammoth is now recorded by Mr. Newton from the "Forest Bed," from specimens obtained *in sitû* by Mr. Savin. Although they differ from the typical *Elephas primigenius*, and are almost deserving of specific distinction, yet the author finds it satisfactory to regard them, as does Mr. Leith Adams, as a "Forest Bed" representative of the Mammoth, especially as this accords with the opinion long held by Prof. Boyd Dawkins.

At the end of Mr. Newton's work is a table showing the Distribution in Time of the Vertebrata of the "Forest Bed Series," and he remarks that about 79 different forms have been shown to occur in the beds, exclusive of the unnamed *Cervidæ*, and of these 38 are new to the "Forest Bed," and three are new species described for the first time. Mr. Newton's cautious remarks on the distribution in time of the species are particularly valuable, and they will be read with much interest in connexion with Mr. Clement Reid's observations on the same subject in his Memoir on the Geology of the Country around Cromer (which we are promised shortly). Therein the Invertebrata are enumerated, and can be taken into consideration along with their more highly developed associates, in studying the changes of climate, the distribution of life, and the alterations of land and water during this interesting period. H. B. W.

II.—Palæontologische Abhandlungen herausgegeben von Dames und Kayser. Erster Band, Heft 1. C. Struckmann. "Neue Beiträge zur Kenntniss des Oberen Jura und der Wealden bildungen der Umgegend von Hannover. Mit 5 Tafeln."

Herr Struckmann, who is already well known to the readers of the Geol. Mag., opens a new Palæontographica, which has lately been issued in Berlin, with a supplementary contribution to the palæontology of the Upper Jurassics of the neighbourhood of Hanover. On the appearance, in 1878, of "Der Obere Jura der Umgegend von Hannover," this author was able to list 404 species as then known to occur in the beds from the "Heersumer Schichten" (Upper Oxfordian, or *perarmatus*-zone) to the "Purbeck-mergel and Serpulit" inclusive. The species listed in his works on the Wealden beds are far less numerous, but include several plants.

The present work is devoted to filling up the gaps left in previous publications. In four years Herr Struckmann has added 70 species to the previous tables, and of these 16 are described as being new. Both new and old are very well figured in the five quarto plates. Deducting three species claimed for the Purbeck Wealden, there remain 67 species not previously noted in the beds which range from the "Heersumer Schichten" to the Upper Portland (Eimbeckhaüser Plattenkalke), and besides this the range of some of the fossils noted previously has been extended. Herr Struckmann has evidently hit upon a good locality lately in the Lower Coralline Oolite, where several additional Corals and Polyzoa have been found. English geologists can hardly fail to be surprised that *Ostrea deltoidea*, Sow., should now be noted for the first time, and that too in the Lower Coralline Oolite. An entire quarto plate is devoted to a pair of valves of this expensive oyster, an admirable likeness no doubt.

After the Lower Coralline Oolite the *Pteroceras*-beds of the Middle Kimmeridge come in for the most important accessions. The Lower Portland is for the first time credited with *Cardium dissimile*, Sow., *Ammonites gigas*, Zieten, and *Am. giganteus*, Sow., whilst the Upper Portland is enriched by very considerable additions, most of which, however, had already been noted in the underlying subdivisions, and are not therefore entitled to appear in the table, page 35. Amongst the species now recognized in beds referred to the Upper Portland are *Mytilus autissiodorensis*, Cott., *Corbula autissiodorensis*, Cott., *Modiola æquiplicata*, von Strombeck, *Trigonia variegata*, Cred. (variety, if not a synonym of *T. gibbosa*, Sow.), *Corbicella Pellati*, Lor., *Pleuromya tellina*, Ag., together with such univalves as *Melania attenuata*, Sow., *Paludina Rœmeri*, Dkr., and *Valvata helicoides*, Forbes, evidently pointing to a higher horizon. It is clear from the lists both of this and the previous work that the Hanoverian Upper Portland has but little in common with the more regular marine Portlands of England.

Geologists and palæontologists alike are indebted to Herr Struckmann for the care and fidelity with which he has worked out the stratigraphical position of the numerous fossils so well figured and described. He is in fact doing for his own district what De Loriol and Pellat achieved for the Boulonnais, and the valuable information thus obtained cannot fail to be of great assistance to Jurassic geologists in this country. W. H. H.

III.—Die Vergletscherung der deutschen Alpen, ihre Ursachen, periodische Wiederkehr, und ihr Einfluss auf die Bodengestaltung. Gekrönte Preisschrift von Dr. Albrecht Penck, Privatdocent an der Universität München. Mit 16 Holzschnitten, 2 Karten, und 2 Tafeln. 8vo. pp. 483. (Leipzig: Barth, 1882. London: Trübner & Co.)

The Glaciation of the German Alps; its Causes, Periodical Return, and its Influence on the Configuration of the Surface. Prize Essay by Dr. Albrecht Penck, of the University of Munich. With 16 Woodcuts, 2 Maps, and 2 Tables.

To this treatise the Philosophical Faculty of the University of Munich awarded the prize for the best competitive essay on the subject of "A thorough Description of the Diluvial Glacial Formations and Phenomena in the Region of the South Bavarian High Plateau, and also in the Bavarian Alps." The author is already well known to all students of Glacial Geology from his investigations in the Glacial strata of North Germany and Scandinavia, and this present work contains not only a complete description of all the effects of ice action which now remain in the portion of the German Alps above mentioned, but also a comparison of the phenomena there displayed with those of North Germany and Scandinavia, and a consideration of the still-contested questions of the recurrence of glacial periods, and the erosive power of glaciers.

The subject is treated under three different sections—(I.) The Last Glaciation of Upper Bavaria and North Tyrol; (II.) The Older Glaciations of the same districts; and (III.) The Formation of the Upper Bavarian Lakes.

In the first division, which comprises 16 chapters, the author begins with an orographical sketch of the glaciated districts of South Bavaria and the Tyrol, and remarks that this Eastern division of the Alps is characterized by numerous well-defined longitudinal valleys, which run between the central chain composed of crystalline schists, and the northern chain of calcareous rocks. Only in three places east of the Rhine is this northern calcareous chain broken through; by the valleys of the Inn, Salzach, and the Enns. The valley of the Inn forms a deep trough about 150 kilomètres in length, between the central chain, from which it receives numerous affluents, and the North Alps; and it finally bursts through the northern calcareous chain at Kufstein. None of the valleys between the Rhine and the Inn which run northwards from the Alps, extend through the northern chain of calcareous rocks, and thus never reach the districts of the crystalline schists; but at the heads of most of these valleys there are deep gaps or notches opening into the Inn Valley, about 1000 mètres below the average height of the crests of the range, and from 500 to 800 m. above the bottom of the Inn Valley. Through these notches run most of the passes which lead from the valleys of Upper Bavaria into the Inn Valley. The mighty glaciers of the glacial period which descended the Inn Valley overflowed through these notches, and thus found their way along the valleys running northwards into the Bavarian high-level plateau.

The Boulder-clay of the Upper Bavarian plateau partly corresponds in character with the ground moraines of the present day, and with the Boulder-clay of northern countries. It consists of layers of mud and stones, from 60 to 70 m. in thickness, which the author states must have been carried forward under and through the motion of the ice, and not by being frozen into its substance. This clay contains, mingled together, portions of every kind of rock traversed by the glacier, and thus indicates the path which the glacier must have followed. On the Bavarian plateau it is filled with erratics from the crystalline schists of the central Alpine chain, together with fragments of Triassic, Jurassic, and Cretaceous strata from the northern chain, and portions of Tertiary Flysch and Molasse from the districts at the foot of the northern chain. On the sides of the Inn Valley erratics have been transported to heights of 1830 m. S. L. or 1170 m. above the present level of the valley, and at Kufstein, where the Inn cuts through the northern chain, the erratics reach to 1400 m. S. L. or 850 m. above the level of the valley. It is therefore probable that the old glacier at Innsbruck attained a thickness of 900 to 1000 m., and therefore sufficiently high to overflow many of the passes leading from the Inn, northwards, into the valleys of Bavaria.

One of the most important gaps on the north side of the Inn Valley is that of the Fern pass. It is between 2 and 3 km. in width, bounded by high walls of rock on both sides, and its highest point is 1250 m. S. L. and 600 m. below the line of erratics. This gap leads into the Loisach Valley, and thus leaves open a clear course for the old glaciers to have poured a stream of ice northwards. But, curiously enough, though the characteristic erratics of the Inn have been carried over neighbouring passes, 350 m. higher than the Fern pass, none are to be found in this pass, and the probable explanation is that the Fern pass did not exist at the time of the great glaciation, but that it has been formed since then by the solution of beds of gypsum and the caving in of the overlying Dolomites. Lower down the Inn is the Seefelder pass, 1200 m. S. L. and 600 m. above the Inn. The pass was one of the main channels through which the masses of ice from the heart of the Alps streamed northwards, carrying the crystalline rocks across the Inn Valley, and leaving them strewn over the sides of the pass to a height of 5000 feet. This icy stream extended down the valleys of the Ammer, Loisach, Kochelsee and Isar, and reached to the Bavarian plateau. It filled up the valleys in the passes to a height of 1580 m., and only the highest peaks and crests of the northern limestone-range projected above its surface. Still lower down the Inn is the pass of the Achensee, only 400 m. above the Inn Valley. Though this lake has no rocky walls between it and the Inn, and is but a distance of 4 km. from it, yet it has its outlet to the north. The erratics in this pass show that a small branch of the Inn glacier must have flowed through it to connect with the Isar glacier. The most important glacier stream, however, which reached into the North Alpine plateau, is that which flowed down the Inn Valley itself. Still further westwards of the Inn, the valleys of the Iller and the Lech were also filled with enormous glaciers.

As the individual glaciers debouched from the mountain passes in which they had been confined, they widened out on the plateau to the north, and joined together so as to form a sea of ice, which can be traced along the base of the Alps from Lyons to the Inn. The Swiss glaciers were dammed in by the Jura; but the glaciers which poured over the Bavarian high-level plateau had no barrier to hinder their progress northwards, and their former limits can be clearly traced by the ground moraines which they have left. This boundary in the Swabian-Bavarian plateau follows a wavy line with four very distinct northerly prolongations: the most westerly encircles the Rhine Valley, the next eastwards is north of the Lech, the third is north of the exit of the Loisach Valley, through which the main portion of the Isar glacier streamed out of the mountains, and the fourth and most easterly extension reaches its maximum north of the exit of the Inn. The author observes that the development of glaciers on the north slopes of the Alps decreases from west to east, notwithstanding the fact that the district supplying the glaciers is more extended and also higher in the east than at the west, and the same law prevailed in the glacial period as at the present time. This result is probably owing to different temperatures and variations of the snow-fall in different divisions of the Alps.

That portion of the Bavarian plateau over which the ancient glaciers extended is distinguished by its covering of morainic material, but the chief part of the morainic deposits is situated in the peripheral margin of the district, and form the terminal moraines which in Upper Bavaria appear as elongated chains of hills from 20 to 30 mètres in height, whose longitudinal axes run parallel to the outermost margins of the glaciers, and mark their former borders. The composition of some of these terminal moraines is almost identical with the clay and scratched stones of a typical ground moraine, whilst others are composed almost exclusively of bedded clays and sands, which dip at an angle of 10° to 20° away from the direction of the glacier. In places these stratified materials are heaped and crumpled together. Penck states that these terminal moraines could only have been produced by relatively stationary glaciers, as a continually advancing glacier would override the terminal wall, and a retreating glacier would not form one. The stratified moraines he considers as due to the action of the water streaming from the end of the glacier on the ground and terminal moraines. By the constant action of the glaciers in pushing outwards morainic materials, the margins of the districts over which they extended would gradually become higher than their central portions, and thus these terminal moraines inclose central depressions, which, when the outer wall is not broken through, frequently appear as lake basins. This central area shows distinctive features of the eroding action of the glacier, whilst the outer marginal area affords convincing proofs of its power of heaping up the materials which have been transported in a forward direction under its bed. The district of the old Isar glacier furnishes a well-marked instance of this fact, for whilst its northernmost border moraines are more than 600 m. above the sea, the levels of the Ammer See and of the Wurm See, inclosed by these moraines, are only 440 m. and 460 m. S. L. respectively.

Another important feature of the glacial deposits in the Upper Bavarian plateau is the presence of widely extended beds of rolled gravel which *underlie* the morainic materials. These are exhibited more particularly at Murnau, on the borders of the Staffel See, in the Loisach Valley, and in the wide plain of which Munich is the centre. These gravels are named "Lower Glacial" (untere glacial Schotter). The materials of these gravels must originally have been transported by glaciers, for they contain fragments of crystalline rocks, and none of the valleys in which they occur reach into the crystalline range of the Alps. The dam which separates the Achen See from the Inn Valley is formed of this Lower Glacial gravel, mingled with sand and clay beds.

In many places, too, similar beds of rolled gravel with sand and clay *overlie* the ground moraine, and appear to have been formed by the water from the melting ice during the recession of the glacier.

In a chapter treating of the Alpine inland ice the author shows that in the Glacial Period the Alps were, as also at present, great centres from which glaciers streamed on all sides. At present in the Eastern Alps the permanent snow-line is 2800 m. S. L., and the lower boundary of glacier extension 1750 m. S. L.; but the old glaciers descended as low as 550 m. S. L., and it is therefore probable that the permanent snow-line at the time of the greatest extension of the glaciers in this district may have sunk to 1600 m. S. L. The enormous accumulations of ice reached nearly to the tops of the mountains, and thus there could not have been any great amount of morainic material on the surface of the glacier. The old moraines were undoubtedly produced by the erosive action of the glacier in the higher regions. The force of glacial erosion is shown by observation on the amount of fine sediment in streams issuing from glaciers to be more than double as great as that of merely running water. The moraines at the terminal ends of the glaciers do not by any means indicate the total amount of their erosive action, for the enormous beds of sand, gravel, and clay, extending far beyond the bounds of the morainic districts, are merely the results of the streams issuing from the glaciers upon the material which the glacier itself has transported, and thus should be considered as the products of glacial erosion.

In the second division of the book, the author discusses the question of the recurrence of different periods of glaciation in Upper Bavaria and the Tyrol, and from observations on the relations of different morainic deposits, he concludes that there is evidence for at least three distinct glaciations during the Glacial period. Thus, for example, near Innsbruck, on the left slope of the Inn Valley, there are well-marked beds of red and white breccia, with traces of plant-remains, which have caused them to be referred to Miocene age. But Penck discovered that this breccia is overlaid by the morainic materials of the last glaciation, whilst the breccia itself overlies a distinct ground moraine with crystalline erratic materials, showing a glaciation of the valley previous to the formation of the breccia by mountain streams. These facts cannot be explained by the mere oscillations of one and the same glacier, for the plants preserved in the breccia at 1000 m. S. L. clearly indicate that the ice must have retired from this level for these heights to have been covered with vegetation.

Another fact discovered by the author is the presence of thin beds of coal inclosed in conglomerates 30 to 40 m. in thickness on the slopes of the valley of the Iller near Sonthofen, at an elevation of 940 m. above the sea. This coal-bearing conglomerate is both overlaid by moraines and rests upon moraines. The course of events indicated by these deposits is thus stated by Penck:—

1. The valley is filled with glaciers, which near Sonthofen descend to a level of 900 m. S.L. Temperature low.

2. The glaciers have retreated. Masses of gravel up to 60 m. in thickness are formed. Elevation of temperature.

3. Vegetation spreads over the surfaces of gravel, and accumulates sufficiently to form beds of coal reaching to over 3 m. in thickness, indicating an extended period of time. These coal-beds are covered by gravel.

4. The Iller Valley is excavated to a depth of 210 to 220 m. Temperature continuing higher.

5. For the second time the glacier covers the district. The temperature falls.

Penck also refers at length to the older conglomerates, or "diluviale Nagelfluh," so extensively developed near Munich and in the country between the Iller and the Lech, northwards to the Danube. These deposits of water-worn gravels show by their contents that only ice transport could have brought many of the fragments into the districts where they have been rolled and arranged by water, and now the upper surfaces of these consolidated gravels show the striations of the last glaciation, and are covered by its moraines.

The third division of the work, on the formation of the Upper Bavarian Lakes, commences with a chapter on the changes which have taken place in the configuration of the surface of South Bavaria and North Tyrol in the Glacial Period. The author estimates that the Swabian-Bavarian plateau must have experienced a decided elevation of its surface by the enormous amount of transported material which has been spread over it by the old glaciers. Thus between the Iller and the Inn over a district 150 km. in length from south to north, and 60 km. in width, Penck estimates that these transported materials form a surface layer of 60 mètres in thickness. To furnish this amount, the northern chain of the Alps must have suffered an enormous erosion, equivalent to 36 m. in thickness over their entire area. Large, however, as is the amount of material which the glaciers have abstracted from the Alps and spread over the plains in front of them, it would by no means be sufficient to fill up the Alpine valleys could it be replaced, and there appears to be clear evidence that the entire excavation of the Alpine valleys has not been due to glaciers, but is the result of ordinary meteorological influences in Pre-Glacial times. The erosion which took place during the Glacial Period must have taken place beneath the ice, since the entire region would have been covered by permanent snow, and therefore protected against destructive sub-aërial influence.

The Bavarian plateau to the north of the Alps, like most other glaciated districts, is characterized by numerous lakes, both large and small. These lakes as a rule are not abundant in the valleys among the mountains, but are most numerous in the plains immediately in front of the exits of the valleys. Well-known examples are the Schliersee, Tegernsee, Kochelsee, and Walchensee, which occur in the tracks of large valleys which penetrate the northern or calcareous chain of the Alps; and the widely extended bogs of Rosenheim, Murnau, and Füssen, are undoubtedly filled-up lakes, which from the outlets of the Inn, Loisach and Isar valleys extended far northwards into the plateau. Further to the northwards are the Ammer See and the Wurm See, and beyond these in the same direction is a zone filled with an astonishing number of small depressions. The evidence brought forward shows very clearly that the *larger* lakes have been produced by the erosion of the glaciers at their exit from the mountains. They have been mostly excavated out of the conglomerates (Nagelfluh), and occasionally also out of the soft tertiary strata which underlie the conglomerates, and the material excavated has been carried onwards and upwards by the glacier and heaped up to form the walls of the terminal moraines already mentioned. The *smaller* lakes to the north of the larger are mostly contained in hollows produced by the unequal deposition of morainic material. It is a noteworthy fact that at the outlet of each Alpine valley in this area there is either a lake or a filled-up lake-basin. These latter are more frequently present in front of the more important valleys, owing to the great quantity of material which the streams in these valleys are ceaselessly bringing down, whilst in front of the smaller valleys the lakes still remain. The character and position of these Bavarian lakes can only be explained by the theory of glacial erosion and transportation of material.

In Chapter 28, Penck considers the objections brought against the glacial formation of the great Alpine Lakes, and amongst others, those of Prof. Bonney against the glacial origin of the lakes of the Salzkammergut. With respect to two of these lakes, the Königsee and the Zellersee, Penck agrees with Prof. Bonney that no one would attribute their origin to glacial influence, the former, indeed, had been already recognized as produced by a sinking of the surface due probably to the solution and removal of beds of gypsum, and the latter results from a dammed-up valley. But with regard to other lakes in that district, which, according to Prof. Bonney, are situated in closed-up valleys into which glaciers could not penetrate, Penck declares on the evidence of striated surfaces and erratics that these valleys have been filled with ice, which entered them by overflowing the low passes which separated them from the adjoining valleys.

But notwithstanding the author's strong convictions of the erosive power of glaciers, he states that the formation of valleys must be ascribed to water-action, and that ice has only effected a relatively inconsiderable widening of these valleys, as well as local depressions in them.

The concluding chapter contains an able discussion of the causes of the Glacial Epoch.

At the end of the book is a table showing the manner in which the Alpine glacial formations have been divided by the most important authors who have studied them. Another table exhibits the succession of the Alpine Quaternary deposits in South Germany, Switzerland, and Upper Italy. There is also a Map of the glaciated districts of South Bavaria, and another, exhibiting on a small scale the present and former glaciated areas of the earth, besides a profile drawn to scale of the northern calcareous chain of the Alps, and smaller profiles of the Iller Valley, and of quarries near Innsbruck.

To all those who are interested in the study of glacial geology we can recommend this treatise as the most important contribution on the subject which has appeared of late years. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting.—February 16th, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1882. The Council expressed their regret that, owing probably to the same causes as last year, they could announce no material advance in the prosperity of the Society, although its financial position was well maintained, the balance at the close of 1882 showing an increase over that of the previous year, notwithstanding a large expenditure upon the Quarterly Journal. The total number of Fellows was diminished by one, but there was an increase of nine in the number of contributing Fellows. The Council stated that Mr. Ormerod had furnished a second Supplement to his Classified Index to the publications of the Society, bringing that work down to the end of 1882. The Council's Report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In presenting the Wollaston Gold Medal to Mr. W. T. Blanford, F.R.S., F.G.S., the President addressed him as follows:—Mr. Blanford,—The Council has awarded you its highest distinction, the Wollaston Medal, in recognition of your services to geology in Abyssinia, in Persia, and on the Geological Survey of the Indian Empire. They are so well and so generally known that it is not necessary for me to enlarge upon them here. Your writings, which treat of a not inconsiderable portion of the Eastern Hemisphere, comprise, in addition to geology, much information respecting zoology and the climates of the countries in which you served. Stamped with thoroughness and comprehensiveness, they constitute important additions to our knowledge of those regions. In conferring upon you this distinction, the Council of the Geological Society desires to mark its sense of their great value.

Mr. Blanford, in reply, said:—Mr. President,—I find it difficult to express adequately my sense of the honour that the Geological Society has conferred upon me by the award of the Wollaston Medal, an honour enhanced by the flattering expressions which you, Sir, as President of the Society, have added to the gift. I believe that my own geological labours do not entitle me to this distinction, and that, for this award, I am indebted fully as much to the work of my colleagues on the Geological Survey of India as to my own, and in receiving the Medal I appear as their representative, and that I owe that fortunate position at least as much to a series of accidents as to my own merits, partly to my having been selected for work of wider interest, though not of greater importance, than that executed by my comrades, and partly to my having resisted for a longer period than some others the injurious effects of a tropical climate. My own career in India is at an end; but the twenty-seven years that have elapsed since I first landed in that country have witnessed the gradual accumulation of observations sufficient not merely to throw much light upon the geological structure and history of India itself, but occasionally to reflect a few rays on obscure spots in the geology of other regions. That the results of our labours have been considered worthy of so honourable an award by the Geological Society will, I am sure, prove most gratifying to my colleagues who are still engaged in working out the geology of India; whilst to myself the Medal is an unexpected recompense for many years of laborious exploration.

The President then handed the balance of the proceeds of the Wollaston Donation Fund to Prof. J. W. Judd, F.R.S., Sec. G.S., for transmission to Prof. John Milne, F.G.S., of Tokio, Japan, and addressed him as follows:—Prof. Judd,—The Council, in bestowing upon Mr. Milne the balance of the proceeds of the Wollaston Fund, wishes to mark its appreciation of the importance of his investigations into the phenomena of earthquakes, to which he has devoted so much time and attention during his residence in Japan. In handing to you this cheque for transmission to him, I would ask you to convey to him the hopes of the Council that this award may assist him in continuing those inquiries in Seismology which he has proved himself so well able to undertake.

Professor Judd, in reply, said:—Mr. President, I feel sure that the pleasure with which my friend Prof. Milne will hear in his distant home of this award of the Council of this Society will be enhanced when he learns the kind and appreciative terms in which you have spoken of his work. When Mr. Milne left England last year, it was with the intention of visiting the several Italian observatories in which investigations on those minute earth-tremours which are now attracting so much attention from geologists are carried on. In Japan Prof. Milne hopes to have ample opportunities for applying these new modes of investigation; and I have no doubt that the award from the Wollaston Fund which has been made to him this day will be of material assistance to him in carrying on these important observations.

In handing the Murchison Medal to Mr. Warington W. Smyth, M.A., F.R.S., F.G.S., for transmission to Prof. Heinrich Robert Göppert, F.M.G.S., of Breslau, the President said:—Mr. Warington Smyth, The Council of the Geological Society has awarded one of its high distinctions, the Murchison Medal and a part of the proceeds of the Murchison Fund, to Prof. H. R. Göppert, of Breslau, one of our Foreign Members, in recognition of his labours in fossil botany. The very large number of papers, 245, recorded in the Scientific List of the Royal Society under Prof. Göppert's name, testifies to the zeal and success with which he has cultivated this branch of biology during half a century. In asking you to transmit to him this Medal, I would desire you to express to him the high estimation in which this Society holds his work.

Mr. Warington Smyth, in reply, said: I have been requested by Prof. Göppert to convey to the Society his hearty thanks for the honour done him by the award of the Medal founded by his lamented friend and correspondent Sir R. Murchison. The announcement came at an opportune time, as serving in some degree to raise his spirits when suffering from a domestic bereavement. It happens also to have been coincident with the completion of the great work on his favourite subject of amber and its organic remains, first brought before this Society by our Medallist in 1845. And when I remind our younger Fellows that Göppert commenced writing on scientific subjects as far back as 1828, and that the number of his works and papers amounts in the Royal Society's Catalogue to 245, they will be apt to wonder that he was not years ago selected as the recipient of the highest honour the Society could bestow. Regretting deeply the circumstances which prevent Dr. Göppert from being present on this occasion, I have great pleasure in receiving for him a mark of honour so well deserved by the veteran geologist, whose name stands in so prominent a position in the special branch of palæophytology.

The President then handed to Prof. Morris, M.A., F.G.S., for transmission to Mr. John Young, F.G.S., the balance of the proceeds of the Murchison Donation Fund, and said:—Professor Morris,—The Council of the Geological Society, in awarding to Mr. John Young, of the Hunterian Museum, Glasgow, the balance of the proceeds of the Murchison Donation Fund, wishes to mark its appreciation of the value of his long-continued researches on the fossil polyzoa, especially those of the western part of Scotland, and of his investigations into the structure of the shells of the Carboniferous Brachiopoda. In his absence, I have much pleasure in placing the amount in your hands for transmission to him.

Professor Morris, in reply, said: Mr. President, I have much pleasure in receiving the balance of the Murchison Fund for Mr. J. Young, who regrets his inability to attend, and has sent me the following letter to read to the Society:—

"Hunterian Museum, University of Glasgow, Feb. 7th, 1883: Will you kindly convey to the President and Council of the Geological Society the gratification I feel at the honour they have conferred upon me by associating my name with those of the former recipients of the Murchison Geological Fund, and at the same time express my regret that circumstances prevent my being present at the Meeting of the Society to receive the award in person from the hands of the President.

"I appreciate the honour all the more as having been altogether unexpected by me. It has been my greatest pleasure during my life to employ my leisure time as an humble investigator of the Carboniferous strata and fossils of the West of Scotland; but I never imagined that my work would have merited the distinction which the Council of the Society have bestowed upon it.

"My work among the Scottish Carboniferous fossils has led me to collect and study carefully under the microscope, not only the Microzoa but also the shell-structure of many of the larger organisms found in the strata, and that I have been fortunate in discovering some new forms, and also in finding some new points of structure in others already known and described, I attribute chiefly to the methods of research which I employed, and to the fact that the organisms found in our strata are often better preserved than is usual elsewhere.

"It has been for me sufficient reward to have been able to assist, in however small a degree, several eminent palæontologists in their researches among some of the fossil groups, such as the Brachiopoda, Foraminifera, and Entomostraca, by sending them specimens from our western Scottish coalfield, many of which have been figured and described. But the honour which the Society has now conferred upon me will, I trust, encourage me to further research among the Scottish Carboniferous fossils, in which, especially among the Polyzoa and their allies, much still remains to be discovered. By so doing, I hope to fulfil in some measure the object which the illustrious geologist had in view when he instituted this fund.—John Young."

I may state in conclusion, that in addition to the assistance rendered to other palæontologists, to which Mr. Young so modestly alludes, he has within the period of the last twenty years published nearly 50 papers, the results of his researches during that time.

The President next presented the Lyell Medal to Dr. W. B. Carpenter, C.B., F.R.S., F.G.S., and addressed him in the following words:—Dr. Carpenter.—The Council of the Geological Society has awarded to you the Lyell Medal with (in compliance with the terms of the bequest) a portion of the proceeds of the Lyell Fund, in recognition of the great value of your investigations into the minute structure of invertebrate fossils and deep-sea researches. Your contributions "On the Structure and Affinities of the Eozoon Canadense," "On the Microscopic Structure of Nummulina, Orbitolites, and Orbitoides," published in our Journal, your numerous papers on the intimate structure of shells, communicated to the Royal Society, and others published in the "Annals and Magazine of Natural History," your long-continued work on Foraminifera, your communications on Oceanic Circulation and on Abyssal Life-forms, all testify to a life-long devotion to branches of natural knowledge bearing on that department of science, the cultivation of which is the *raison-d'être* of this Society. I count it a pleasure, Dr. Carpenter, that it has devolved upon me to hand you this Medal.

Dr. Carpenter, in reply, said:—Mr. President,—It is with no ordinary gratification that I receive from your hands the Medal of which the Council of the Geological Society has been pleased to think me deserving. For as the work of my life has been done almost entirely in the domain of biology, it has but incidentally brought me within the wide area covered by geological science. Although familiar from very early years with its great fundamental ideas, and a deeply interested observer of its progress, I have never ventured to call myself a geologist. And it is, therefore, a distinction which I highly value, to be the recipient of so distinguished a token of appreciation on the part of those who are best qualified to judge of the importance of my work in its relation to geology. This distinction is yet more gratifying to me from its having been founded by one whom I have held in the highest honour from my boyhood, when (as I well remember) I heard Charles Lyell spoken of as a young man who was advancing in the Geological Society doctrines of a most heretical kind, but was defending them so ably as to hold his own against the most weighty opponents. The study of his "Principles" was not only the delight of my youth, but a most valuable part of my scientific training; and the privilege of subsequent intercourse with him through nearly forty years was one which I ever highly esteemed; for whilst it brought me under the immediate influence of his philosophic spirit, it also afforded me the continual stimulus of his kindly encouragement. I would recall a little incident which is doubly illustrative. When, in 1855, I made my monograph of the genus *Orbitolites* the basis of a disquisition on the general subject of the variability of species (a doctrine early impressed on me by Dr. Prichard), I sent him a copy of the memoir (published in the Philosophical Transactions), with a sort of apology for having tried to make so much out of what might be thought so small and trivial a subject; he replied with a most kindly approval of the object and manner of my work, adding, "any single point is really the universe,"—a remark whose pregnancy left an impression on my mind that time has only deepened. I cannot but esteem it a piece of singular good fortune that my association with my friend Prof. Wyville Thomson in the "Lightning" Expedition of 1868, which was fitted out for the biological exploration of deeper sea-bottoms than had been then examined by the dredge, should have brought me into contact with a physical problem of the greatest interest, that of deep-sea temperature; and that the subsequent Expeditions of which the elucidation of that problem was a leading object have not only succeeded completely in all that it was hoped that they might accomplish, but have also brought back new and valuable data for the solution of one of the most fundamental questions of modern geology,—the antiquity of the great existing distinctions between continental and oceanic areas. In conclusion, I would assure the Geological Society that their generous recognition of my past labours will serve as an additional inducement to me to devote what may yet remain to me of time and ability to the completion of several researches, already far advanced, which will, I trust, be found to have no unimportant bearing on the future of geological science.

In presenting one moiety of the balance of the Lyell Donation Fund to Mr. P. Herbert Carpenter, the President addressed him as follows:—Mr. P. Herbert Carpenter,—The Council of the Geological Society, in awarding to you a portion of the balance of the proceeds of the Lyell Donation Fund, desires to express its sense of the great value of your researches into the structure and relationship of several families of fossil Echinodermata. Your papers "On some little-known Jurassic Crinoids," "On the Cretaceous Comatulæ," "On the Crinoids from the Upper Chalk," and that read last session, "On Hybocrinus, Baerocrinus, and

Hybocystites," are models of clearness and an excellent earnest of future work. The Council hopes that this award may aid you in continuing those lines of research in which you have already achieved signal success.

Mr. Carpenter, in reply, said:—Mr. President,—It was with very great gratification that I heard from my valued friend and former teacher, Prof. Bonney, of the honour done me by the Council of the Geological Society in awarding me a portion of the Lyell Fund; and I am greatly indebted to you, Sir, for the kind way in which you have referred to my palæontological work. It has been done as a kind of recreation from the duties of a busy schoolmaster's life, and from the highly interesting but lengthy business of preparing the Reports on the "Challenger" Crinoids. But I have always found that the few days which I have devoted to fossils during my holidays have sent me back to schoolwork and to recent Crinoids with renewed vigour, and often with fresh ideas. I have the strongest conviction (and many mistakes would be avoided were it a universal one) that the only way to understand fossils properly is to gain a thorough knowledge of the morphology of their living representatives. These, on the other hand, seem to me incompletely known if no account is taken of the life-forms which have preceded them. I have thus been led to carry on the two lines of work simultaneously; and I am happy to think that, in the opinion of those best qualified to judge, I have been able to throw some light upon the study of the fossil Pelmatozoa. In two respects I have been more than usually fortunate. My artist friends thoroughly understand their work, and the Council of the Society have always treated me with the utmost liberality in the very important matter of illustrations. For this and for many other acts of individual kindness on the part of the Fellows, I gladly take this opportunity of expressing my warmest thanks to the Society.

The President then handed the second moiety of the balance of the Lyell Donation Fund to Prof. Seeley, F.R.S., F.G.S., for transmission to M. E. Rigaux, of Boulogne, and said:—Professor Seeley,—In conferring upon M. Rigaux a portion of the balance of the proceeds of the Lyell Donation Fund, the Council of the Geological Society desires to signify its estimation of the value it places on his researches in the Jurassic formations of the Boulonnais and their contained fossils. In asking you to transmit to him this cheque, I would desire you to convey to him with it our hopes that he may continue those lines of inquiry in prosecuting which he has attained so great success.

Professor Seeley, in reply, said:—Mr. President,—I feel that M. Rigaux deserves recognition for excellent stratigraphical work on the Primary and Secondary rocks of the country round Boulogne, and for careful descriptions of their fossils. But he is one of those modest men whose published writings represent but a small fraction of his knowledge, and who is far readier to deposit his collections in the public museum, and to impart knowledge to scientific friends, than to print his work. There can be but few geologists of our time who have visited the Boulogne country without being under obligations to M. Rigaux; and although, in a letter received from him, he speaks of this honour as being undeserved and unexpected, it is one for which he offers you his sincere thanks, and which will stimulate him to carry on those researches which have secured our esteem.

The President finally presented the Bigsby Gold Medal to Dr. Henry Hicks, F.G.S., and addressed him in the following words:—Dr. Hicks,—The Council, in conferring on you the Bigsby Medal as a mark of their appreciation of your labours amongst the oldest fossiliferous and the Archæan rocks of Great Britain and Ireland, feels, in your community of interests, a peculiar fitness in associating you with the memory of the founder of this distinction. Your numerous communications, beginning with one "On the genus *Anopolenus*," written in 1865, and culminating in that which you read at our last meeting, show to what good purpose you have employed the *horæ subsecivæ* of a busy professional life in prosecuting those researches which have had a distinct effect on geological thought. In handing to you this Medal, I would express the wish that you will continue to prosecute the line of inquiry to which you have so long and so successfully devoted your leisure hours.

Dr. Hicks, in reply, said: Mr. President, I feel exceedingly grateful to the Council of the Geological Society for the great honour they have done me in selecting me to receive the Bigsby Medal, for I cannot fail to recognize in this award a recognition, by those whose opinion I most value, that work which has long been to me a means of recreation and of much intellectual enjoyment has also yielded something towards the advancement of that science to which I am so deeply attached. I must also express my gratitude to you, Sir, for the kind manner in which you have referred to my labours. It is just 20 years since I commenced my search for fossils among the old rocks at St. David's, and the enthusiasm with which every new find was welcomed by the late eminent palæontologist, Mr. Salter, to whom they were first sent, was in itself a sufficient stimulus for any exertions required. I had the honour also from time to time to conduct many eminent geologists over the ground explored, and received from them much encouragement. Among these, however, no one was more anxious to show enthusiastic sympathy than the amiable Dr. Bigsby, the founder of this Medal, who visited St. David's in the summer of 1866. His interest in the sections was extreme, due doubtless in part to the fact that a few years before he had communicated a paper to this Society on the relation between the Cambrian and Huronian rocks, and that here at St. David's I was able to show him some proof in support of the view which he maintained, that the Huronian rocks were older than any which could be classed as Cambrian in America. It is therefore, Sir, peculiarly pleasing to me that I should now be thought worthy of the great honour of receiving the Bigsby Medal; and I can only hope that I may be able, in the words of the founder, to do further work, and to continue with renewed vigour those researches which have brought me this honour, and what I value almost equally, namely, the friendship of so many eminent Fellows of the Geological Society.

The President then read his Anniversary Address, in which he passed in review the work done by the Geological Society during the past year, and discussed at considerable length a question arising out of this review, namely, the structural characters presented by the sternal framework and the limbs of Enaliosaurians, and the classificational value which they possess. He also referred to the discoveries which have been lately made in America of numerous remains of Pterosaurians. often of gigantic size; adverted to the proceedings of the International Geological Congress, held in 1881, at Bologna, and noticed, as one gratifying result of the latter, the establishment of an Italian Geological Society.

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year: *President*: J. W. Hulke, Esq., F.R.S. *Vice-Presidents:* Prof. P. M. Duncan, M.B., F.R.S.; R. Etheridge, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. J. Prestwich, M.A., F.R.S. *Secretaries:* Prof. T. G. Bonney, M.A., F.R.S.; Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A., F.L.S.; *Council:* H. Bauerman, Esq.; W. T. Blanford, Esq., F.R.S.; Prof. T. G. Bonney, M.A., F.R.S.; W. Carruthers, Esq., F.R.S.; Prof. P. M. Duncan, M.B., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; A. Geikie, LL.D., F.R.S.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D.; Prof. T. M'Kenny Hughes, M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; S. R. Pattison, Esq.; J. A. Phillips, Esq., F.R.S.; Prof. J. Prestwich, M.A., F.R.S.; F. W. Rudler, Esq.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; W. Topley, Esq.; Prof. T. Wiltshire, M.A., F.L.S.

II.—Ordinary Meeting.—February 21, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Relation of the so-called 'Northampton Sand' of North Oxfordshire to the Clypeus-Grit." By Edwin A. Walford, F.G.S.

The objects of the paper were said to be twofold:—in the first place to show the existence of some hitherto unrecognized beds of the Inferior Oolite in North Oxfordshire, and then to endeavour to define their position by comparison with one of the uppermost of the Cotteswold subdivisions, the Clypeus-grit. The area under discussion was said to be for the most part embraced in Quarter-sheet 45 N.W. of the Geological Survey, in the N.E. corner of which is situate the town of Banbury, whilst to the extreme S.W. lies Chipping Norton. The author first called attention to some remnants of a series of Oolitic Limstones at Coombe Hill, near Deddington, which he considered to be the equivalent of the Oolitic Marl. He then pointed out near Burton-on-the-Water the intervention of some sandy limestones and carbonaceous clays between the Clypeus-grit and the Fuller's Earth; he thought they might possibly represent beds found above the Clypeus-grit near Chipping Norton. The beds marked in the map $5'$ g $7'$, hitherto termed Northampton Sand, he said were well shown in the new railway-cutting at Hook Norton, and were capable of being split into several divisions, the two thin base-beds containing *Ammonites læviusculus* and corals; the next higher (series C) yielding a large fauna, amongst which were *Rhynchonella spinosa, Trigonia signata,* and a doubtful fragment of *Ammonites Parkinsoni.* These, with a higher series of sandy, marly, and siliceous limestones, designated D and E, were proved to extend over the high lands to the S.W. It was shown that at one end of a ridge called Otley Hill the beds C rested on the Upper Lias, whilst on the S.W. flanks of the ridge the Clypeus-grit was to be seen also resting upon the Upper Lias. A road section near Over Norton, he said, showed beds similar in lithological character to C and D of Hook Norton, resting upon the Clypeus-grit and evidencing a fauna of a somewhat similar character. The author thought that the almost unfossiliferous series E, which had been called the Chipping-Norton Limestone, might probably be found to be the equivalent in time of part of the Fuller's Earth, or of some of those beds of the Inferior Bathonian of the Côte-d'Or described by M. Jules Martin.

2. "Results of Observations in 1882 on the Positions of Boulders relatively to the Underlying and Surrounding Ground, in North Wales and North-west Yorkshire; with Remarks on the Evidence they furnish of the Recency of the Close of the Glacial Period." By D. Mackintosh, Esq., F.G.S.

The author began by showing how boulders may be regarded as natural time-measurers by their protecting the rock-surface underneath from the action of rain, which, around the boulders, denudes the surface, especially on the leeward and windward sides, where hollows resulting from pluvio-torrential action may generally be seen. He then described and explained the origin of the different forms of *supports* under boulders which graduate from flat surfaces to *pedestals* of various forms, which he divided into *appropriated* (or preexisting), and those *acquired* through the boulders protecting the underlying rock from denudation. The author then described the positions of boulders on the high and uninhabited Eglwyseg limestone plateau near Llangollen, where it is certain they had never been disturbed by man. There he found that the average vertical extent of denudation by pluvial action around the boulders, since their arrival, was not more than six inches. After endeavouring to account for the fractured and crushed condition of the rocks under these boulders by precipitation from floating ice, he gave an account of his discoveries on the high limestone plateau north-east of Clapham (Yorkshire), where there is a "ghastly array" of many hundreds of large Silurian grit and slate boulders, nearly black in colour. From many facts and considerations the author endeavoured to show that most of the pedestals of these boulders must have existed *before* the arrival of the boulders, while the pedestals *acquired* through the boulders protecting the underlying rock from denudation, were generally imperfectly formed. On the Clapham plateau he found that the *average* vertical extent of denudation around the boulders with acquired pedestals was not more than on the Eglwyseg plateau, or about six inches. In the case of boulders which are not well adapted to concentrate rain-water, the extent of lowering of the surrounding rock-surface was often inappreciable; and this accounted for the continuous extension of flat limestone rock-surfaces under some of the boulders. The author then described what he had found to be *preglacial* as well as postglacial rain-grooves on limestone rock-surfaces, near Minera and on Halkin mountain (North Wales), where he found the average depth of those of the grooves which were probably postglacial to be about six inches. In conclusion the author entered into a consideration of the time which has elapsed since the close of the glacial period, and stated the main results of his observations as follows:—

1. That the average *vertical extent* of the denudation of limestone rocks around boulders has not been more than six inches.

2. That the average *rate* of the denudation has not been less than one inch in a thousand years.

3. That a period of not more than six thousand years has elapsed since the boulders were left in their present positions by land-ice, floating ice, or both.

3. "Notes on the Corals and Bryozoans of the Wenlock Shales (Mr. Maw's Washings)." By G. R. Vine, Esq. Communicated by Prof. P. Martin Duncan, M.B., F.R.S., V.P.G.S.

The author briefly discussed the views of different writers upon the systematic position of the genera *Chætetes*, *Monticulipora* and their allies, and also of the forms referred to the Polyzoa, and gave a list of 39 species and varieties of Corals and Polyzoa obtained by him from Mr. Maw's washings of deposits belonging to the Wenlock series in Shropshire. These forms were referred by him to the genera *Dekayia*, *Monticulipora*, *Callopora*, *Heliolites*, *Thecia*, *Favosites*, *Syringopora*, *Halysites*, *Cœnites*, *Cyathophyllum*, *Lindstrœmia*, *Cladopora*, *Leioclema*, *Ceriopora*, and *Ceramopora*. New species are *Leioclema granatum* and *pulchellum*.

CORRESPONDENCE.

MR. HOWORTH ON IRISH GLACIAL DRIFTS.

Sir,—Some errors have crept into Mr. Howorth's reference to the Irish Glacial Drifts, in your February Number. Bovevagh (not Boreragh) in Co. Derry, where the fossiliferous glacial deposits in the North of Ireland attain their greatest altitude, is 450, not 1150 feet above the sea-level, and this particular bed does not yield either *Nucula oblonga* (*Leda pernula*) or *Cyprina*, as stated on authority of Mr. W. A. Bell (Geol. Mag. Vol. X.). Portlock only mentions

Turritella terebra, and *Astarte multicostata?* as found at Bovevagh. The former is the characteristic shell at that place, and the only one at all plentiful. Some time since, I had the opportunity in company with two other geologists of examining the river-bank near the old church at Bovevagh, and we found a number of specimens of *Turritella*, but not in such abundance as we had been led to expect. The only other fossil we could find was one valve of *Venus gallina.*

The inaccuracies cited would no doubt have been avoided by relying more on the work of Portlock, and subsequent writers having a personal knowledge of the country and its geology, and less on that of a gentleman, who, however qualified in other respects, has not, I fear, had the advantage of personally examining the beds concerning which he wrote, and who has consequently not been in all cases as accurate as could be desired when treating of the drift of the North of Ireland. Mr. Howorth's argument is scarcely affected by the above corrections, but the slightest error should be avoided in such discussions. William Swanston, F.G.S.

Belfast, *5th March*, 1883.

HÆMATITE IN THE PERMIAN BRECCIAS.

Sir,—Can any of your readers inform me of any locality or localities where Hæmatite occurs *in situ* in the neighbourhood of the Longmynd or of other parts in the West of England or in Wales, whence these Breccias of Central England are considered to have been derived? Also, are the Hæmatites fossiliferous, and have they been commented upon or in any way referred to by geologists? If so, in what publications do they appear? W. S. Gresley.

Overseal, Ashby-de-la-Zouch.

RECENCY OF THE CLOSE OF THE GLACIAL PERIOD.

Sir,—As very little attention has been devoted to this subject in England, you would oblige by inserting extracts from a letter I received from the late Mr. Belt[1] a few years ago. "I am heartily with you about the comparative recentness of the Glacial Period. My earliest lessons in glaciation were in the north of England, where the freshness of the ice-tracks are most remarkable. All the arguments for putting it back are founded on theories which may be, and I think are, incorrect. . . . I shewed some time ago that the argument that had been founded on the cutting out of the gorge below the falls of Niagara, was a weak one, as only three miles, and that in the softer rocks, had been excavated since glacial times. Some of the American geologists, including Professor Hall, have visited Niagara since, and convinced themselves that my explanation is the right one."

Dr. J. W. Dawson, in his review of Wallace's "Continental and Island Life,"[2] remarks that "in Canada the character of the river-courses cut through the Glacial beds, and their very unformed and

[1] See an account of Mr. Belt's theory of the Glacial Period, with accompanying remarks, in the Presidential Address to the Geologists' Association (1874), by Henry Woodward, F.R.S., F.G.S.

[2] Princetown Review for July, 1881.

imperfect excavations, would lead to the belief that only a few thousand years have elapsed since the glacial beds were laid down. The same conclusion can be drawn from the good preservation of the glaciated surfaces, and of the shells and bones on the terraces. Similar evidence is afforded by the rate of recession of coasts and waterfalls, and by the condition of eskers and lake ridges. If we adopt the shorter estimates afforded by these facts, it will follow that the submergences and emergences of land in the Glacial Age were more rapid than has hitherto been supposed, and that this would react on our estimate of time by giving facilities for more rapid denudation and deposition. Such results would render it less remarkable that no new species of animals seem to have been introduced since the Glacial Age." D. Mackintosh.

ON SILURIAN PLANTS FROM CENTRAL WALES.

Sir,—In the January Number of this Magazine is a communication from Dr. Nathorst on the Silurian "Plants" of Central Wales, in which he disputes the conclusion expressed in my paper on the "Fossils from Central Wales,"[1] as to the nature of the plant-like structures there described. In his opinion the *Buthotrephis major*, *B. minor*, *Palæochorda tardifurcata*, and *Nematolites Edwardsii*, are no plants at all, but merely the "trails and burrows of Annelids" such as he has lately obtained from worms placed on a surface of mud and plaster.

It is difficult to understand how such a conclusion could be arrived at from my description; for taking first the species of *Nematolites*, these are described as "solid bodies of pale chocolate colour," perfectly separate from the dark shales in which they occur, and from which they can be readily removed with a penknife. Such a structure can be no mere impression nor the filling up of a trail of worms or crustaceans, and I can think of nothing more probable than the suggestion in my paper that it is a Coralline Alga. In the second species, *N. dendroidea*, the lateral branching is tree-like, diminishing in size in a way impossible for a worm track. Also the *Buthotrephis major* are no filled up tracks and trails. They are thin surface structures, or impressions on the shales and slates, very regular in their form and branching, and the main stem is straight and regular, about two or three inches long and in no case resembles or passes into an ordinary worm track. Also they do not generally occur in association with the worm markings which are so abundant in the grits. Many of these latter are, I have no doubt, tracks similar to those obtained by Dr. Nathorst, and to others which I have observed in the Cambridge slough-ponds at the coprolite diggings, but the *Nematolites* and *Buthotrephis* are quite distinct from these, and I can only refer them to the vegetable kingdom.

Lastly, referring to my new species *Myrianites Lapworthii*, I have no hesitation in maintaining that name, to designate a group of well-defined markings agreeing perfectly with each other, and very distinct from their nearest allies. Walter Keeping.

[1] Geol. Mag. November, 1882, p. 485.

Fig 1. Apparent Sequence in the Durness-Eriboll Region generally

Fig. 2. Coast N.E of Village of Durness.

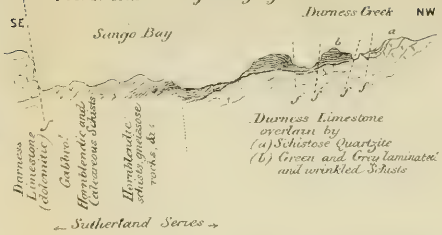


Fig 3. Near Loch Ceallu-Dail

Fig. 5. Generalized Section. Slopes south-east of Ant Sron. (Loch Eriboll)

Fig. 6. Undulated or Orthoclinic Strata (with major and minor Amphiplexal folds.)

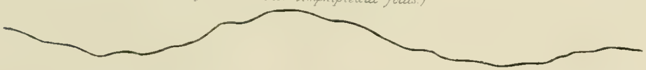


Fig. 7. Theoretical arrangement of folds in a Symmetrical Mountain Range

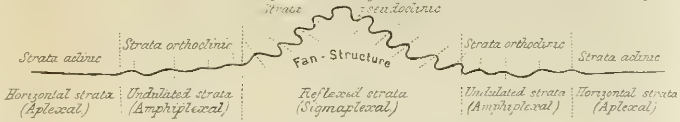


Fig. 8 Theoretical arrangement of folds in a Symmetrical Mountain Complex

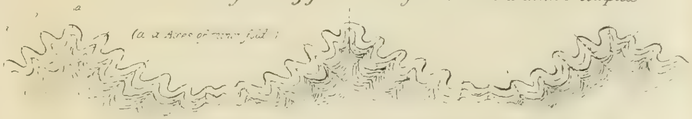


Fig 9 Theoretical arrangement of strata in a Denuded Mountain Complex

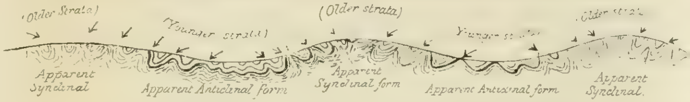
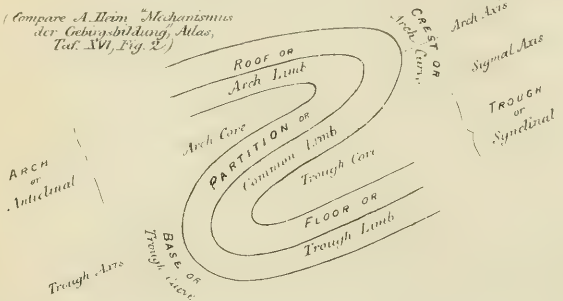


Fig. 10. Terminology of a Sigmaflexure or Reflexed Fold



THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. X.

No. V.—MAY, 1883.

ORIGINAL ARTICLES.

I.—The Secret of the Highlands.

By Prof. Charles Lapworth, F.G.S.

(*Continued from p.* 128.)

(PLATE V.)

VII.—*Difficulties in the Local Stratigraphy of the Oldest Geological Formations of Britain.*

In those parts of Britain upon which all geologists are agreed with respect to the natural order of their ascending series of rock-formations, the stratigraphy is of a comparatively simple character. The beds are either gently inclined, or but slightly convoluted. The rules by which the original sequence of the strata is worked out have been settled by common consent. The nature and effects of those physical accidents which have affected the rocks subsequent to their deposition have long since been almost exhaustively worked out. The rules and conclusions thus developed are now-a-days part and parcel of the working material of every field-geologist worthy of the name.

These undisputed British rocks are, generally speaking, of Neozoic and Upper Palæozoic age. They afford an abundance of fossils; and, taught by the generally acknowledged truth of the maxim of William Smith, the stratigraphist, in those rare cases where continuous sections fail him, calls in the aid of organic remains, upon which he relies with almost as much assurance as upon the clearest visible physical proof.

But in proportion as we descend in the order of the British geological formations, the stratigraphical complexities increase; and, unfortunately, the means of unravelling these complexities begin to disappear in almost equal proportion. The strata grow more monotonous in their physical characters, and their fossils decrease most markedly both in abundance and variety. When finally we reach the Lower Palæozoic rocks, we find that in certain special regions (notably those of South Scotland, the Lake District, parts of Ireland, and Western Wales) their strata are intensely folded, crumpled, and often inverted. In these regions the stratigraphist, who has been trained among the newer and less complicated formations, becomes bewildered and deceived. He follows of habit and necessity the rules he found so serviceable in the less disturbed regions. He groups his strata in grand physical masses, and he settles the probable inter-relationships of these major groups by their *visible* order of superposition. The more extended has been his experience in British Neozoic geology, the more irresistible in his eyes is this visible physical evidence. When, however, his survey is completed, he frequently discovers that his successive "formations," distinct as they appear lithologically, present a wonderful identity in organic remains through thousands of feet of vertical extent, when the fossils are regarded *en masse;* but show the most vital difference in their minor horizons, only a few yards apart, when the species are considered in detail. Such astounding palæontological phenomena he would scorn to acknowledge as probable or even possible in the Neozoic rocks. But the physical evidences at his command in these ancient convoluted strata appear unquestionable. There can, therefore, he imagines, be but one possible solution of the enigma. These palæontological difficulties are probably due in some mysterious way to the effects of migration, and may be safely ignored altogether. The outsider is left to draw for himself the implied conclusion: the dogma of "strata identified by superposition *and organic remains*" is of paramount consequence in the gently inclined, unbroken and varied recent formations; but in crumpled, dislocated and monotonous Lower Palæozoic strata such fossils as are discoverable are of no special stratigraphical value; the apparent superposition of the several recognizable rock-groups is the sole and sufficient clue to the original order of the beds.

This highly unsatisfactory method of eluding the difficulty I have long resisted to the best of my ability. In all those cases which I have myself been able to investigate, the asserted discrepancies between the physical and palæontological sequences have entirely disappeared wherever the strata admit of being worked out *zone by zone.* The difficulties of this task, however, are so great, and the natural tendency to rely upon *apparent* superposition so irresistible, that I feel assured that in some of its minor points my earlier work needs revision in the light of more recent discoveries. But the detailed palæontological sequence developed by the method of zones by myself several years ago among the convoluted Moffat rocks of South Scotland has been subsequently confirmed, as I shall show elsewhere, to an extent, and with a minuteness, which, even in my most sanguine moments, I hardly dared to anticipate.

In labouring to discover the original order of succession in such of the Lower Palæozoic rocks as are excessively convoluted, I find that the ordinary broad rules of British stratigraphy, as laid down in our text-books, are inadequate to the task. But they are not *superseded*, they are merely *supplemented* by a few additional principles applicable more especially to mountain regions. Even these additional principles are not new. Buried in the note-book of the mountain geologist, or in little studied foreign scientific publications, they have not yet made their way into our authoritative text-books.

I intended to publish some of my own conclusions upon the subject in the second part of my paper upon the "Girvan Succession," and to demonstrate their utility by showing how their application reduces to naturalness and symmetry the awkward-looking preliminary sketch-map of the region, as there developed almost wholly by the presently accepted rules of British stratigraphy. But the light thrown upon some of the more obscure points in my study of the Durness-Eriboll district is so clear and vivid, that they fall most naturally into this place. Many of the points discussed in the following paragraphs (Pars. ix. and x.) will be found in the truly magnificent work of Professor Heim[1] upon the convoluted rocks of the Alps. For those not hitherto published, I hold myself responsible. The latter therefore are the only points open to the objection of being original or heterodox, and the attempt here made to summarize a few of the more essential principles of mountain stratigraphy, and to apply them to the investigation of the Highland region, may be, perhaps, received as a first essay in one of the most difficult and obscure departments of British geology.

But, before these principles can be introduced into this discussion, it will be necessary to demonstrate the inadequacy of the ordinary methods of stratigraphy as applied to the rocks of the N.W. Highlands; for, like the Upper Palæozoic and Neozoic strata, these rocks are often very gently inclined, dipping at angles varying from 60° to 30°, and sometimes as low as 10° or even 5°.

VIII.—*Application of the ordinary rules of British Lowland Stratigraphy to the study of the Durness-Eriboll Formations.*

The chief rules of British stratigraphy as applied to gently inclined rock-formations, which bear upon our present subject, may be thus shortly defined.

(*a*) Two successive series of gently inclined strata agreeing essentially in dip, strike, and apparent amount of convolution, are *conformable* to each other, and of these two conformable series, the physically overlying series is necessarily the *younger*.

(*b*) When the basal bed of a conformable series of strata rests immediately upon the surface of an underlying and discordant series, and contains included fragments of that underlying series, the two series are *unconformable* to each other, and the underlying series is necessarily the *older*.

(*c*) Faults or dislocations in gently inclined formations are normally *right lined*, and the plane of fracture normally hades or inclines in that direction in which the rocks have been *depressed*.

These are almost the only fundamental stratigraphical rules which have hitherto been employed in common by all parties in the study of the N. W. Highland succession. By the aid of the diagrams upon Plate V. and the descriptions given in the earlier paragraphs of the present paper,[2] the reader may easily gather for himself the results

[1] Mechanismus der Gebirgsbildung, A. Heim, Zurich, 1878.

[2] I have to apologize for the following errata in the previous part of this memoir:
- p. 122, line 1, for north-west, read north-east.
- p. 123, par. 3, line 10, for placing the whole in the Archæan, read regards the Silurian age of the Sutherland gneiss as open to doubt.
- p. 123, bottom line, for Microscopical Magazine, read Mineralogical Magazine, 1879, p. 137; 1881, p. 322; 1882, No. 22, p. 5.
- p. 126, line 7, for Hielem, read Heilim.
- p. 127, line 13, for VI. *b.* read IV. *b.*
- ,, line 20, for II. *c.* read I. *c.*
- ,, line 23, for II. *b.* read I. *b.*

of their application to the investigation of the geology of the Durness-Eriboll region.

(1.) When they are applied in the usual manner to the section of the region as a whole (see Fig. 1, Plate V.), they appear to demonstrate that the unaltered Durness-Eriboll series is *older* than the generally metamorphic Sutherland series, and that it is strictly *conformable* to the latter; the Durness-Eriboll Limestone forming the central member of the unaltered series, and graduating upwards through the Upper Quartzite and a massive group of "igneous rocks" into the typical altered rocks of the Sutherland series.

(2.) When they are applied to the most important sections in the Durness area [2] (see Figs. 2 and 3), they apparently demonstrate that there is no intervening igneous group lying between the conformable Durness and Sutherland series, but merely a thin seam of flaggy quartzite, which is only locally present.

(3.) When they are applied to the most easily interpreted section in the Loch Eriboll district, they apparently demonstrate that the unaltered Durness-Eriboll series, of which the Durness-Eriboll Limestone is the highest member, is *younger* than the generally metamorphic Sutherland series, overlying the latter with marked *unconformability* (see Fig. 5).

In brief, if these rules are to be our sole guides, it follows that

[2] As it has been suggested that the fossiliferous limestone of Durness is distinct from the generally non-fossiliferous limestone of Eriboll, from the fact that the two have "an absolute difference of composition" (Dr. Heddle, Mineralogical Magazine, 1881, p. 316); the limestone of the Eriboll-Kishorn line being throughout its whole range in the county "a very typical dolomite," while the Durness rock is a "fairly pure limestone;" I beg to submit the following analyses of four specimens of the Durness rock, collected by myself at the four localities named in the appended list. They may be looked upon as affording a fair idea of the chemical composition of the Durness beds, as they are traversed from west to east upon the ground. The specimens were analysed for me in the Chemical Laboratory of the Mason College, under the kindly personal superintendence of my colleague Dr. W. A. Tilden, F.R.S. From these analyses it would appear that while some of the zones of the Durness Limestone contain but a small proportion of magnesian carbonate, and may be defined as "fairly pure limestone," yet many of the beds, like those of Eriboll and Assynt band, are unquestionably dolomitic. The composition of the rock occurring in that special Durness zone, which, according to my own view, is repeated again and again in the Eriboll-Assynt area, is given in the last of these analyses, and this is clearly that of "a very typical dolomite."

Analyses of Specimens of Durness Limestone.

	a. (292)	*b.* (281)	*c.* (363)	*d.* (335)
Ca Co_3.	96·27	65·60	52·94	54·12
Mg Co_3.	1·40	26·20	43·71	45·90
Insoluble	2·01	6·85	2·43	trace
Fe.	?	?	?	?
	99·68	98·65	99·08	100·02

(*a.*) Specimen 292, from Eiland-Dhu, on Kyle of Durness.
(*b.*) Specimen 281, from hills near Loch Borralann.
(*c.*) Specimen 363, from near fossil-bed Balnakiel.
(*d.*) Specimen 335, from cliffs between Sango-bay and Smoo Cave.

the fossiliferous Durness-Eriboll series is composed both of two members and of three members, and the well-known Durness Limestone forms both the central and the highest of these. This strangely constituted fossiliferous series is both older and younger than the Sutherland gneiss, for it underlies the latter conformably, and it overlies it unconformably.

In all three cases the physical appearances are incontestable and admit of no dispute. It is needless to point out to the youngest tyro in geological field-work that we have here a complete stratigraphical dead-lock. It is impossible to reconcile these conflicting results as they stand. If no stratigraphical principles additional to those enunciated above are to be permitted in this discussion, the N.W. Highland controversy, which has already lasted for one generation, may well last for another, to divide and embitter geological investigators, and bar the way to those higher and more important geological problems that await solution.

Now in this Durness-Eriboll region the physical geologist, pure and simple, is in his own element. There are, practically, no fossils to complicate matters: the successive recognizable formations are totally distinct in petrological character, and the evidences of superposition are complete and unequivocal. And yet with all these advantages the accepted methods of British Lowland stratigraphy utterly break down. They land us in a set of conclusions so unnatural and absurd, that it would be ridiculous to suppose that any scientific man could entertain them for a moment.

Here, then, I reach from the purely physical side, precisely the same point I attained several years ago largely from the palæontological side: viz. the ordinary broad rules of British stratigraphy enumerated above, as applied to gently inclined strata, do not of themselves afford irrefragable evidence of sequence among the greatly convoluted older rocks *when the latter are regarded as grouped in broad masses*, and conclusions founded solely upon the testimony they afford under these circumstances are practically valueless.

In this desperate extremity, it may be suspected that our physical geologists will be tempted to look a little more closely into the matter, and see if a more detailed study of these rocks in the light of the discoveries made of late years in mountain regions will aid us in clearing up the difficulty.

In the following sections I have shortly summarized some of those more important points in the stratigraphy of convoluted rocks which bear upon the present question. For the sake of simplicity of treatment, I have merely investigated here that simplest hypothetical case in which the mountain strata are comparatively homogeneous, have been subjected to opposing pressures acting along parallel lines, and have consequently been looped up into symmetrical folds of infinite length. In order to avoid prejudicing my case, I have, where possible, selected my illustrations from standard authorities, especially from the classical work of Professor Heim.

IX.—*Essential Principles of Mountain Structure.*

(*a.*) *General Principles.*

1. All sedimentary strata were originally deposited in an approximately horizontal position, and they owe their present inclination, undulation, or contortion to the effects of lateral compression, or tangential thrust and counter-thrust of the exterior parts of the earth's crust, and the results of this lateral pressure in distorting the strata are most typically displayed in *mountain regions.*

2. Where the local force of compression is comparatively slight or ineffective, the originally horizontal strata are bent into a series of gentle undulations (normal flexures or amphiplexes) composed of alternate arches and troughs (anticlinal and synclinal folds), whose axes are normally vertical, and whose beds dip in opposite directions (*orthoclinic* or *amphiclinic* strata). These folds are of two kinds—major and minor, each major fold being generally made up of a series of minor undulations (Fig. 6, Plate V.).

3. Where the lateral pressure is of excessive intensity, the anticlinal and synclinal waves become crushed more closely together into a series of much narrower folds, and the entire rock-mass loses greatly in horizontal extension, but gains proportionately in height, giving origin to what is known as a *mountain range*, the major fold forming the crest, and the harmonic minor folds constituting the flanks of the range (Fig. 7).

4. At the foot of a mountain range the inward thrust and the outward counter-thrust are approximately equal in amount, and opposite in direction, and the resulting folds are normal and regular (normal or amphiplexal folds). But as we proceed towards the centre of the range, while the thrust inward remains approximately the same, the counter-thrust outward is aided by the effects of the gravity of the mass above, and these two unequal forces are applied to the stratum obliquely with respect to each other. As a natural consequence, the axes of the rock-folds no longer remain vertical, but *slope obliquely outwards*—*i.e.* in that special direction in which the folding and ascending strata encountered the least resistance to their extension (Fig. 7).

5. In a simple and equal-sided *mountain-range* these phenomena being correspondingly developed upon the two opposite sides of the range, give origin to the well-known *fan-structure* (Fig. 7), seen in greatly denuded mountain forms, the younger beds upon the flanks of the range being reflexed and inverted in position, apparently dipping inwards in both directions below the older strata of the ridge above.

6. In a typical complicated *mountain-system* of vast antiquity (which may be regarded theoretically as a series of simple mountain ranges pressed more closely together), this special fan-like structure must be again and again repeated (Fig. 8), and after denudation has taken its full effect, its *newer* strata will of necessity be found in the apparent anticlinals, and its *older* strata in the apparent synclinal forms (Fig. 9).

7. Thus in the gently undulating rocks of the Lowland regions the visible dips of the strata are reliable indices of the original relations of the sediments (*Orthoclinic strata*); but in intensely folded mountain regions the dips have been generally inverted, and give false ideas of the original sequence of the beds (*Pseudoclinic strata*).

(*b*.) *Special Principles.*

8. In *Orthoclinic* or slightly folded rocks, each fold or undulation (*ampliplex* or normal fold) is composed of two members, an arch or anticlinal, and a trough or synclinal. In both of these the axis is vertical, and the strata dip in opposite directions (*Orthoplexal* or amphiclinic strata) (Fig. 7).

9. Where the compression increases in amount of force and obliquity of direction, as in the flanks of mountain chains, the amphiplex, or normal fold, becomes gradually transformed into an oblique sigmoidal or S-shaped fold (*sigma-flexure, sigmaplex* or *overfold*), both axes of which are inverted (Fig. 10), and its beds all dip in one and the same general direction (*Plagioplexal* or isoclinic strata).

10. Each *sigmaplex* or sigmoidal fold is also composed of two members, an inverted *arch* or anticlinal, and an inverted *trough* or synclinal, having an intermediary wall or *partition* which is common to both. Its various parts may be conveniently distinguished as follows (compare Heim, Mechanismus der Gebirgsbildung, taf. xvi. Fig. 2):—

Terminology of a sigmaplex or sigmoidal fold (*Overfold of Brögger*) (Fig. 10).

A. The arch or anticline.
  A.[1] *Core* of the arch; *A.*[2] *Crest* of the arch; *A.*[3] *Roof*, or outer limb of the arch.
B. The Partition, or common limb.
C. The Trough or syncline.
  C.[1] *Core* of the trough; *C.*[2] *Base* of the trough; *C.*[3] *Floor*, or outer limb of the trough.

x, Sigmal or Plexal axis; *y*, Anticlinal or Arch axis; *z*, Synclinal or Trough axis.

(*To be continued.*)

II.—Second Note on the Pebbles in the Bunter Beds of Staffordshire.

By Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

IN my brief paper published in this Magazine for 1880 (Decade II. Vol. VII. p. 404), I mentioned that pebbles of felstone were not uncommon in the Bunter conglomerate on the northern part of Cannock Chase. Since that time, as opportunity has occurred, I have been making a more special study of these pebbles, and think it may be worth while publishing a description of some of the commoner varieties, as a contribution to the lithology of this interesting deposit and a help to the determination of the question of the origin of its material. I believe that I have observed most of the varieties, which commonly occur in the district, but do not pretend (for circumstances have not allowed of this) to have made anything like a complete collection. Many of my specimens have been derived from the broken materials spread upon some roads newly made over the portion of the Chase in the vicinity of Rugeley, but several of them were obtained in a large pit in the Bunter itself, by the side of the railway on the road to Hednesford, and I was able by a careful search in it to identify most of the varieties that I had collected elsewhere. I cannot say that erratics are absolutely unknown in this district, but they are extremely rare, and there is practically no danger of making a mistake as to the source of the pebbles. These pebbles of felstone (to use an inclusive term) appear to be by no means rare. I think one could hardly search a couple of square yards of a newly "metalled" road without picking up a fragment. Now and then specimens are found with a dark ground-mass, and occasionally one which seems to be an indurated felspathic breccia; but in the majority there is a certain common character, though there are many varietal differences. These have a compact ground-mass, varying from a pale brick-red (the commonest) to some tint of pinkish-grey. In this are scattered crystals of felspar, sometimes as much as 0·4 inch in longer diameter (generally paler in colour than the matrix), grains of quartz, and occasional specks of greenish or dark-coloured minerals. They are in short a group of porphyritic quartz-felsites—the quartz-porphyries of many authors. Not seldom a trace of fluidal structure can be detected in the matrix, and occasionally this is very conspicuous. Vesicles also may now and then be noticed. The rock appears usually in very fair preservation, but the exterior of the pebbles is generally a little paler than the interior. I have examined microscopically ten varieties, but as it would be rather wearisome to the reader to describe each specimen in detail, I will endeavour to give the general results of my investigation. Three of the specimens exhibit a more or less distinct spherulitic structure; in the remainder the ground-mass is either minutely micro-crystalline or crypto-crystalline, consisting obviously of quartz and a felspathic mineral, more or less decomposed and ferrite-stained. In one specimen these are associated with microliths of a greenish, rather fibrous mineral, which in part is tourmaline, but in part is a nearly colourless mica. In two others tourmaline is a constituent of the ground-mass; in these it seems to have replaced a magnesia-iron mica, probably biotite, and in one possibly a hornblende.

The quartz grains are usually rather abundant, and are variable in form, even in the same specimen. Sometimes one or more crystalline angles are well exhibited, sometimes (and this may be in the same grain) the margin is rounded or pierced with inlets of the ground-mass, inclosures of which are also common. Cavities are always present; in some more abundantly than others, in one or two slides they appear to be empty, in others they contain fluid with bubbles. The relative size of these varies considerably, perhaps most commonly they occupy about $\frac{1}{8}$th of the cavity, but the difference is sometimes considerable even in the same grain—in one such case the ratio of the bubbles to the cavity is from 1 : 10 to 1 : 5. I also observed that in some slides the bubbles were steady, while in others they vibrated briskly, though I could not discover any difference in the circumstances to account for this. Microlithic inclosures of ferrite, opacite, and perhaps brown glass are noticed.

The felspar crystals are commonly much decomposed and ferrite-stained, in some cases more or less replaced by microliths. In one specimen the whole crystal is a felted mass of a colourless flaky mineral, which is very probably a hydrous mica; in another the replacing mineral more nearly resembles my section of a typical pinite.

Tourmaline is conspicuously present in three of the specimens. It occurs both in scattered tufts of an acicular pale indigo-blue tourmaline, and in larger crystals of brown tourmaline. The former are most abundant in the slide where this mineral is a conspicuous constituent of the ground-mass, and some of the larger of these are surrounded by clear quartz, as I have already described.[1] In one the tourmaline is much clouded with opacite. In one or two specimens brown mica and possibly hornblende may be detected.

Two specimens contain a ferruginous mineral which often decomposes and falls out, leaving small cavities. As this usually grinds away, I have not been able to ascertain to what to refer the original mineral; it appears now to be ferrite associated sometimes with granules of quartz, and with a felted mineral like a mica.

These rocks then, as plagioclase felspar does not appear to be a common constituent, may be properly designated as quartz-felsite (quartz-porphyry).

Of the three specimens which exhibit a more or less spherulitic structure, one has a crypto-crystalline ground-mass consisting of rounded aggregates of crystallites composed of quartz and (probably) a decomposed ferrite-stained felspar, which are intercrystallized in irregularly radiate bunches. The crystallites are slightly wavy, so that the spherules resemble tufts of diverging roots rather than, as is very commonly the case, of diverging rays. Spherules have frequently a sharply distinguished outer zone, in which the ferrite staining is markedly darker. In the interstices microcrystalline quartz and felspars (decomposed) may be seen; there are a few small irregular quartzes with numerous very minute cavities—empty, so far as I can observe.

Another specimen has a crypto-crystalline ground-mass with the spherulite-structure less distinctly marked. This one is more distinctly micro-porphyritic. The quartzes, generally rounded externally with many inlets and inclosures of the ground-mass, are bordered with a zone above ·01 in. wide exhibiting an imperfect radial structure. They contain minute empty cavities, and glass or 'stone' inclosures. In this specimen all the felspars exhibit the twinning of plagioclase. The extinction angle between successive laminæ is a large one, as much sometimes as 31°, when the plane in the case of the smaller extinction angle makes an angle of 13°, with a vibration plane of the polarizing apparatus. These also contain numerous crystals of a

[1] In *Luxullianite*, Mineralogical Magazine, vol. i. p. 215.

filmy greenish mineral associated with granules of hematite. The former proves to be an aggregate of a doubly refracting mineral, which is probably a hydrous magnesia-iron silicate, akin to serpentine; the whole being, I have no doubt, a secondary product after a magnesia-iron mica.

The third specimen exhibits macroscopically a very marked fluidal structure, the ground-mass being crypto-crystalline, with some approach to a spherulitic arrangement, among which are patches of interstitial quartz, and of a pinite-like mineral which may replace a felspar. This and the first one have no doubt once been very typical rhyolites.

Two rather different rocks remain to be noticed—one a pale pinkish microgranular specimen with numerous dark spots, sometimes nearly a quarter of an inch in diameter, with irregular edges, looking somewhat as if a greenish ink had been dropped on the stone and allowed to dry. Microscopically examined, the rock has a minutely micro-crystalline, almost crypto-crystalline ground-mass, of quartz, and of felspar more or less decomposed, intermingled with specks of (probably) tourmaline. The larger dark spots are seen to consist of aggregate granules and crystallites of tourmaline, generally olive-brown, but occasionally indigo-blue, associated in the case of the larger patches with small crystals of quartz. Many of the larger among these are so irregular in form that it is a matter of conjecture what was the original mineral, but among the smaller are many single crystals, which exactly recall the outline of a crystal of biotite cut transversely to the basal plane. I have therefore no doubt that the tourmaline in the main has replaced magnesia-mica. The external boundary of the elongated crystals just described is irregular, like that of a mica plate sketched by a tremulous hand. This I explain by the fact that tourmaline can be formed from felspar as well as from mica, and so the new mineral would occasionally encroach upon the ground-mass. We accordingly have here a tourmalinized mica-felsite; for the mica is not abundant enough to allow us to call it a minette.

The last specimen has a very dark ground-mass, in which are scattered pale pinkish crystals of felspar, of elongated outline, some of which are nearly an inch in diameter; these are seen to be speckled with a blackish mineral. The ground-mass is minutely micro-crystalline, consisting of irregularly crystallized very decomposed felspar (the chief constituent) with quartz and tourmaline. In this are scattered tourmaline, both in tufts and apparently replacing mica: grains of quartz of various sizes up to about 0·1 inch (as described above), and crystals of felspar. The largest felspar crystal lies in the slide; it is much decomposed, and incloses aggregates which seem to be a mixture of tourmaline and opacite, and so have probably replaced some other mineral. It is a twin apparently of the Carlsbad type, and appears to be orthoclase; if this, as is very possible, be the dominant mineral, it must have had the tabular habit of sanidine. The rock then may once have been a rather micaceous and markedly porphyritic quartz-felsite.

From what locality or localities then have these pebbles been derived? A few present some slight resemblances to the rhyolitic rocks of the Wrekin district, and to the rather similar rock recently discovered near Nuneaton; but I have no hesitation in asserting that we cannot refer them to that source. Again, I may with equal confidence exclude the felstones in the Ordovician rocks of North Wales. To these, so far as I know them, they bear no resemblance. They are more like the felstones which occur beneath the well-known Cambrian conglomerate in the Bangor-Carnarvon district, but still I cannot refer them to these. They certainly are not from any rock now visible at Charnwood, neither are they from the lava-flows of the Lake District, though one or two of the specimens remind us a little of certain intrusive felstones there. Further, in these districts tourmaline is all but unknown. The only case that has fallen under my own experience—and it is a rather large one—is in the intrusive felsite of Mynydd Mawr. But they recall very strongly to my memory the felstones so abundant in the Southern Uplands, and in parts of the Highlands of Scotland, which I have examined, both in the Museum at Edinburgh, through the courtesy of Dr. Traquair, and in a few localities in the field.

I have also submitted a selection from my specimens to Dr. Geikie, Director-General of the Geological Survey, who informs me that as a whole they have a remarkably close correspondence with the Scotch rocks with which he is so familiar; some agreeing best with the felstones of the Southern Uplands, others rather resembling those occurring as intrusive masses in the Western Highlands. Two specimens in which a fluidal structure was well developed especially reminded him of pebbles which abound in a great mass of conglomerate of Old Red Sandstone age at Uam Vam; and he showed me a specimen therefrom which was as nearly as possible identical with one of my own. The dark porphyritic rock he did not remember to have seen; but as regards the rest, he entirely concurred in my view that they were probably of Scotch origin.

Since the date of my last paper, one by Mr. J. W. Harrison has been printed in the Proceedings of the Birmingham Philosophical Society (vol. iii. p. 157), in which he combats the view which I had put forward as to the derivation of many of the Bunter pebbles from Scotland, and prefers to refer them to an axis of ancient rock now buried (except in one or two localities) beneath newer deposits in Central England.

The following paragraph is a statement of his arguments (p. 176): "Professor Bonney refers many of the Bunter pebbles to the Torridon Sandstone of the West Coast of Scotland on the ground of their agreement in microscopical structure. In reply to this I would urge that the test can hardly be considered decisive in any case, but that (*a*) one quartzite very much resembles another; and (*b*) that there may be a quartzite further south of the same age and structure. The distance also is a formidable objection: the pebbles in the Scotch 'Old Red' are very little larger than those in the English 'New Red,' although after travelling 300 miles, hurried along and knocked together by a current running at the rate of at least three miles an hour (the least speed necessary to move pebbles of this size), one would think they would have been reduced to sand. Moreover, on Prof. Hull's theory, the pebble bed should surely increase in thickness and in the relative size of the pebbles as we follow it either to the north-east or north-west. But on the contrary the pebbles become fewer and ultimately disappear, as the Bunter is followed towards North Notts on the one hand, or towards Liverpool on the other; while in the Carlisle district Mr. T. V. Holmes has lately shown that the Keuper beds are the only Triassic strata present. The lines of false bedding of the Bunter beds point almost invariably to currents sweeping from the west or north-west."

He also holds that the Bunter beds were formed in an inland sea, but refers them to the action of littoral currents, rather than to more distinctly fluviatile action, as I have suggested.

As regards the first paragraph, Mr. Harrison (no doubt unconsciously) entirely misrepresents my argument. I did not refer the bulk of the pebbles to the Torridon Sandstone of Scotland, but to the *Quartzites* which overlie it; these two very distinct rocks, he obviously (in the passage which I have quoted) supposes to be identical. My argument was, (*a*) that the most abundant quartzite in the Bunter was exactly like that of the N.W. Highlands, and to my eyes differed from that of the Lickey or of Hartshill; (*b*) that though "one quartzite may be very like another quartzite," [1] yet this identification was strengthened by finding with these quartzite pebbles others of a sort very like the Torridon Sandstone; the latter rock being of a most marked character, and very different from any other that I know in Britain. Thus Mr. Harrison must locate in his Utopian central ridge (which I infer from his words must be West or North-West of Staffordshire, where it will be rather in the way of the drift of the materials) not only a quartzite like that of the N.W. Highlands, but also a grit with the characteristics of the Torridon, and felsites like those of Scotland, differing from all I know in the English Midlands or Wales. I may also ask to what source he refers the quartzite pebbles of Arran (for instance) which are indistinguishable from those [2] of the Bunter beds of Staffordshire, and lie in a red sandstone, just like Bunter sandstone, mingled with schists and a variety of Scotch rocks.

Mr. Harrison's objection of the distance, which ought to have "knocked the Scotch pebbles to sand," I meet with a simple negative. Pebbles, less hard than the quartzite, can travel quite as far as this.[3]

[1] I must admit that Mr. Teall in his valuable note to Mr. Harrison's paper shows that the Lickey quartzite presents in some of its microscopic peculiarities a very close resemblance to that of N.W. Scotland and of the Bunter. This, while it deprives me of one point in my argument, does not of course establish an identity between the Bunter pebbles and the Lickey quartzites, but only shows that both have derived their materials from a common source (no doubt Hebridean rocks). In some respects, however, his specimens (which he kindly allowed me to see), do not seem to bear out Mr. Harrison's conclusions.

[2] Be it remembered that I have admitted the presence of more than one quartzite here. I speak of the highly altered compact-looking quartzites, which I maintain I can distinguish from the others in almost every case.

[3] The greater European rivers during some periods in their history must have transported gravel quite as far as this. See, for instance, Lyell's Antiq. of Man, chap. xvi.

His objection of the absence of the pebbles towards Liverpool and North Notts is doubtless of some weight; but in the former place, vein-quartz pebbles (abundant in Staffordshire) occur with some of quartzite about Liverpool, and I have seen both in Nottinghamshire. Hence I think a more natural explanation—seeing that at any rate in the former district the total thickness of the Bunter increases—is that the main drift of the coarser materials happens not to be exposed. The absence of Bunter beds from the Carlisle district proves nothing. Keuper overlaps Bunter in many places.

I should also be glad to learn, as a matter of physical geology, how currents "running at the rate of at least three miles an hour" could be set up along the coasts of an inland sea. I suggested that our Bunter beds were rather of the nature of a "Weald," because it seemed to me probable that they were not marine in the ordinary sense of the word. In some of the valleys and lake deltas of the large European rivers we find beds presenting a general resemblance to them, and in the Lower Carboniferous beds of Arran (admitted to be fresh-water) deposits almost indistinguishable. The resemblance also to the Old Red Sandstone conglomerates of Scotland is very considerable. They may of course be lake deltas, but in that case they must have been near enough to the influent river to allow the velocity of its current to be maintained. The Keuper, however, with its finer sediments, salt and gypsum, is just the deposit we might expect in a true inland sea.

I may add that the occasional presence, in the Bunter beds, of schists and granitoid rocks, generally too rotten for examination, and of a third group of much altered rocks, fine black quartzites, extremely indurated grits, lydites (?), and rocks of the "halleflinta" type, of which I have not yet completed the examination, all point to a distant source for the Bunter pebbles.[1]

Where in the Midland counties can we, in a geological epoch so late as the Trias, locate with reasonable probability ridges which would be of sufficient magnitude to supply the enormous mass of material which the Bunter beds require for their pebbles alone? I cannot but think that the proximity of these quartzite ridges to his home, and the fascination of a discovery, has deprived Mr. Harrison of his power of mental perspective, or he would have seen the improbability of his theory. Some geologists of no mean reputation have even doubted whether the ridges of the Lickey and of Hartshill were not wholly buried in Triassic times. It is, at any rate, obvious that the masses exposed cannot have been large, and that they must have been mere insular outcrops in the area of deposition, be that in sea, lake, or river delta.

[1] Since the date of my last paper I have found two specimens of the compact quartzite with annelid tubes, one of the usual "fossiliferous" quartzite with *Lingula Rouaulti*, and two pebbles moderately rounded, of May Hill Sandstone. The last two are not quartzite, but one of the ordinary fine brown grits.

III.—The Fauna and Flora of the European Loess, being a Reply to Professor Dr. Nehring.

By Henry H. Howorth, F.S.A.

It is not every controversialist who has the good fortune to persuade two such distinguished warriors as Baron Richthofen and Dr. Nehring to buckle on their armour and do battle with him; and if there were room for vanity in the shifting panorama of Science, I might at least claim to have stated my case with sufficient point and clearness to make it necessary for more than one elaborate reply. There is no room for vanity however. It matters not who wins, so far as I am concerned, if we only get our difficult problem more sifted and get closer to the truth. If there be no room for vanity, there is less for irony; and I am not surprised that Dr. Nehring should feel hurt if he thinks I have openly or covertly had the indecency to sneer at himself or his work. In referring to Cuvier, it was not to minimize what Dr. Nehring has done, but to do justice to an old philosopher, whose memory I reverence, and whose claims had been overlooked by Baron Richthofen. It was he, I must emphatically repeat, if it needs repetition before such an audience as that reached by the Geological Magazine, who first proved the fauna of the European Loess and its correlated deposits in its broad features to be identical with that found under the Siberian tundras. Cuvier was followed by a great crowd of diligent and close students of this subject, especially in France and America, without naming England.

It would be impertinent in me to praise what I value so highly as Dr. Nehring's researches among the Rodents and other associated animals he has so diligently studied in Central Germany, but he must not expect (in these latitudes at all events) that we can so magnify these researches as to forget the vast work done elsewhere, when the subject was virtually neglected and overlooked in Germany. The best of us can only turn over two or three leaves of the big book, and it is sheer delusion to suppose that we can appropriate it all or even a whole chapter. Dr. Nehring has well thumbed more than one leaf, and has earned the gratitude of us all. May he live for ever! Enough of the personal issue. Let us now turn to one of greater importance.

Dr. Nehring complains that I have not quoted his work. One good reason is that, valuable in every way as it is, it does not immediately illustrate the subject I am about, namely, the *distribution* of the Post-Glacial surface deposits and its causes. The only person who has reason to quarrel with a large portion of Dr. Nehring's paper, notwithstanding its apparently polemical aim against myself, is Baron Richthofen; for in so far as his theory is affected by zoological evidence, it seems to me to furnish a complete, if not disastrous refutation of it. Balak, the king of Moab, was not more dubiously supported in effect by the son of Beor than my most distinguished correspondent Baron Richthofen has been by Dr. Nehring. First let me quote one or two details, and then turn to the main issue.

Dr. Nehring protests that he never confounded the Arctic Tundras with the sub-Arctic grassy herbed Steppes of South-western Siberia, adding, that he "knows very well that they (*i.e.* the former) display both a different fauna and different climatic conditions as compared with the southern grassy Steppes." I never said Dr. Nehring had so confused them; but I certainly understood Baron Richthofen to treat them as the same for the purposes of his argument.

Again, Baron Richthofen says in his answer to me: "There is but one great class of agencies which can be called in aid for explaining the covering of hundreds of thousands of square miles, in little interrupted continuity, and almost irrespective of altitude, with a perfectly homogeneous soil. It is those which are founded in the energy of the motions of the atmospheric ocean which bathes alike plains and hill-tops" (Geol. Mag. Dec. II. Vol. IX. p. 297). Contrast this passage with the following by Dr. Nehring: "That all deposits of Loess have been caused by sub-aerial means, I do not venture to maintain." This is surely but scanty support. Dr. Nehring then goes on to say, "At any rate, the wind has played an important part in the formation of the Loess-like deposits of Westeregeln, Thiede, and many other places in Central Europe." It would have been grateful to us if Dr. Nehring had enlarged this dogmatic statement by some evidence. How does he explain by the action of the wind the calcareous elements in Loess, its capillary structure, its homogeneous character over wide areas, the absence from it of minute laminæ such as occur in wind-drifted dunes, the presence in it of skeletons undecayed, etc., etc.? Whence does he derive the dust, and how does he make such accumulations of dust compatible with the growth of the herby grasses that characterize the Steppes he defends? These are the questions I in common with others have asked, and I must not be remitted for an answer to oracular dicta reminding us of "the Syllabus." Dr. Nehring says it is not out of the regions of possibility "to postulate for Central Germany the climatic conditions of Western Siberia and Eastern Europe." Putting aside the fact, which I altogether dispute, that Dr. Richthofen's arguments would apply to plains covered with long grasses like the Russian Steppes, instead of being deductions from the stony and bare plateau of what he well calls the Salt Steppes of Mongolia, I would join issue with Dr. Nehring even on his smaller postulate. The Loess occurs not only in Central Germany, but over a large part of France and in Spain. Is he prepared to argue that this peninsular area with its peninsular climate, having the West and South-west humid winds from the Atlantic continually passing over it, can, under any possible conditions, have had a climate like that of an inland continental district, like that of the Asiatic Steppes? If so, let us by all means have the evidence.

Perhaps he bases his view on the previous paragraph in which he contends that at that time Germany was more distant from the Atlantic than now, and that Europe extended itself further west and south-west. This again (if Dr. Nehring means a substantial extension westward) I must dispute, unless he have some evidence inaccessible to us. No doubt in earlier geological periods, in the Middle Tertiary age for instance, it is possible that such an extension existed; but that it did so when the Mammoth lived here, and when the beds on the same horizon with the Loess were being deposited, is it seems to me entirely contrary to the evidence. The presence of *Marine* shells mixed with the Mammoth remains in the diluvium of the lower Somme—their presence at Selsea—their presence again on the Yorkshire coast in conjunction with the Mammoth—point to the sea at this period not having been far away from the present coast-lines. It is quite true that the evidence is tolerably complete that England was then united to the Continent; but this was by an isthmus, and it is certainly going deep down into the abysses of conjecture when, in the face of these facts, we place the western coasts of Europe during the Mammoth period at the present hundred-fathom line, as Baron Richthofen does, or indefinitely "further west and north-west," as Dr. Nehring does.

Let me quote another sentence from Dr. Nehring's paper. He says, "The Mammoth is, as Professor Boyd Dawkins has already pointed out, Pre-Glacial, Glacial, and Post-Glacial; his remains occur not only in the Loess, but in the most varied deposits of Europe, as in the Forest-bed, in Glacial gravel layers, in clay and loam, in Tuff deposits." Dr. Nehring is surely not aware of the very thin ice upon which he is skating in this passage. Whether the Mammoth is found in the Forest-bed or not is assuredly one of the most disputed points in English geology. The evidence seems to point most certainly to its not occurring in the Forest-bed *in situ* at all, and that I believe to be the matured opinion of those geologists who have the best right to decide such a point. In regard to the Mammoth being Pre-Glacial, I altogether dispute it according to our present lights. The evidence is of the most fragile and unsatisfactory kind, so fragile that it is not surprising my gifted friend Professor Dawkins, who is quoted by Dr. Nehring, has published more than one opinion on the subject. As to the Mammoth being Inter-Glacial I shall have a good deal to say, if my friend Dr. Woodward will permit me to continue the series of papers I have been writing in the GEOLOGICAL MAGAZINE. At present, I can only say that I believe the Mammoth and the *Rhinoceros tichorhinus* to have been, at all events in Europe, so far as we at present know, entirely Post-Glacial, and I maintain that they are the characteristic quadrupeds of the Post-Glacial Ante-Neolithic deposits. When Dr. Nehring in the above passage speaks of clay and loam and tuff, and he might have added brick-earth and valley gravels, as if they were entirely different deposits, he is only of course speaking of their texture. He does not dispute, I take it, the view which is so universally adopted, that, whether in the form of brick-earth, so-called diluvium or Loess, all these beds are on the same horizon, mark the same great epoch, and are to be largely explained by the operation of the same causes. They mark geographical areas and local circumstances, but their differences in no wise mark successive epochs or periods. If he considers they do so, it would be most valuable to have the evidence produced.

Having dealt with the various subsidiary points raised by Dr. Nehring, I must now face his main argument, which occupies the larger portion of his paper. Here I have this difficulty, that the issue is not altogether a straight one. I admit his facts very largely, although I quarrel with his inferences; but I contend that, far from supporting Baron Richthofen, these facts make his theory virtually untenable. Dr. Nehring would seem to argue as if I held or had ever maintained the preposterous view that because the Mammoth and the Rhinoceros cannot browse upon short grasses, but need the herbage of trees and long grasses or reeds for their food, and these need a correspondingly damp climate, and that inasmuch as remains of Mammoths and Rhinoceroses are found from the Pyrenees to Behring's Straits, therefore, that there must have been unbroken continuous forests over the whole of this area. Such a view could hardly be seriously maintained by any one living within our seas. For example, we have in Ireland an area apparently well suited *à priori* to the Mammoth, and yet from which remains of the Mammoth are virtually absent, its bones having occurred there very sporadically. While the Mammoth is virtually absent from Ireland, the Megaceros had its focus of distribution there. Such facts, which are patent to us all here, make it clear that during the Mammoth epoch Ireland was an area where the conditions were unfavourable to the Mammoth, and exceedingly favourable to the great Deer. Perhaps its forests were too dense for the Mammoth, or perhaps they were composed of trees unsuited to its food. But Ireland is a mere type at our own doors of what is well known elsewhere; and to show I am not merely coining arguments for the nonce, I must be allowed to quote two short paragraphs from one of the earlier papers of this series:—"It was long ago observed that the borders of the Baltic are much less fertile in Mammoth remains than those of the North Sea, and they do not in fact seem to have occurred in some large districts bordering upon it. At all events they are not named by Eichwald as occurring in Livonia, nor are they named from Ingria or Lithuania" (Geol. Mag. Dec. II. Vol. VIII. p. 204). Scotland and Scandinavia present similar areas, while of Germany, I expressly said, "South Germany, with its mountainous contour was not well adapted to the habits of the great pachyderms, and, like the mountainous district of Siberia, is not so fruitful in Mammoth remains as the more level country" (*id.* p. 201). I might have even said, considering their scarcity there, that the more southern and hilly zone in Siberia virtually produces no Mammoth remains. Such facts at once strike the observer, and impress him with the very important conclusion which geologists do not always remember, that just as at present we have geographical areas in close contact marked by different botanical and zoological facies, so it must always have been. These botanical and zoological provinces are no doubt largely controlled by climatic considerations. It is very elementary to say that such climatic provinces may be represented by a cold zone in upland districts, and a warm one in lowland districts. Now, although the general assemblage of animals found with the Mammoth from

Central Europe to Eastern Siberia prove that the climate over this wide area must once have been much more uniform than it is now, we can also gather from a comparison of many facts that its mean was probably lower than it is at present. This seems to point to the land having been generally at a higher level; and as it is probable that the great beds of till lying between Dunkirk and the Nore, famous for the number of Mammoth remains found there, were dry land during the Mammoth epoch, we have some evidence that the land was, *pro tanto*, in fact at a higher level than now.

The general elevation of the land would give the European uplands a more decidedly Northern climate than they now have, with corresponding surroundings of fauna and flora. The low-lying valleys would not be affected quite so much. This seems to be a reasonable view of what was the fact. What then would be the result? Assuredly that in the higher ground of Devonshire, of the Ardennes, and of Central Germany, we should have upland tracts marked by mountain-loving animals and plants, and in the valleys have a fauna and flora corresponding to their position; and as the areas were small, there would be often a passage to and fro. This is what we should expect to find. This is what we actually do find. We have a zone marked by low-lying lands stretching from the Pyrenees to Behring's Straits, marked in Post-Glacial times by abundant remains of the Mammoth and certain other of his companions which we know loved the shelter of forests and lived on the leaves and shoots of trees, etc.; and we have another zone, including such places as Fisherton and the Mendips on the borders of the Devonshire Hills, certain deposits in Auvergne, certain others in Belgium, larger ones in Central Germany, and larger ones again in the Altai, as we know from the contents of the caverns there, all marking a zone where a more mountainous condition of things both in regard to climate and life prevailed. It has been the especial honour and privilege of Dr. Nehring to work out this upland fauna, as it presents itself in Central Germany, with a completeness, a critical skill and knowledge which are simply beyond all praise. I do not quite agree with him in describing the particular fauna he has explored so well as a "Steppe fauna:" it is rather a hill or upland fauna; the particular grassy and herby steppes he refers to reproducing because of their climate the surroundings of upland pastures. Thus the characteristic habitat of *Alactaga jaculus* is the southern slopes of, and the grassy plains on either side of the Urals. It is replaced by other species on the more sterile steppes of the Kirghiz Kazaks and Central Asia. The *Spermophiles* are rather inhabitants of hilly rocky districts than of Steppes. This is also the case with the *Arctomys*. In regard to the pikas or tail-less hares (*Lagomys*), this is even more characteristically so, their only present habitat in the United States being in the Rocky Mountains. The *Arvicolæ* are ubiquitous. Of the pouched rats, one of the two species quoted by Dr. Nehring, viz. *Cricetus frumentarius*, is still found all over the European area as far west as the Rhine, and is therefore no guide. The porcupines are also hill and fell animals. The particular species referred to by Dr. Nehring, *Hystrix hirsutirostris*, is surely not found in the Siberian Steppes at all, or only just on their borders. It is characteristic of a more southern zone, extending from Syria to India, at least so I gather from Mr. Murray's careful work (Distribution of Animals, pp. 248 and 351).

Let us see then where we have arrived. I do not deny that during the deposition of the Loess and its associated deposits there were two zones of life all over "the Mammoth area," an upland zone and a lowland zone. Nor do I deny that the Mammoth is less frequently found in the former, as in fact it is natural it should be; but this upland zone is after all a local disintegrated one compared with its neighbour. Even in the upland tract of Central Germany, as Dr. Nehring does not deny, the remains of the Mammoth are of frequent occurrence, but he surely somewhat minimizes its occurrence even there. I will quote a condensed passage from that admirable storehouse of well-digested facts, Mr. Geikie's "Prehistoric Europe." He says, "The Mammoth, Woolly Rhinoceros, Reindeer, Horse, Ox, etc., have been recorded from the Loess of many other parts of Central Europe (*i.e.* other than Thiede and Westeregeln). Prinzinger and Czjzek mention Mammoth, Woolly Rhinoceros and *Cervus dama gigantea*, as occurring in the Loess of Upper and Lower Austria; Zeuschner has observed a similar fauna (Mammoth, Rhinoceros, and *Bos priscus*) in some of the valleys of the North Carpathians; according to Dr. Roemer, Mammoth, Woolly Rhinoceros, *Bison priscus* and *Urus* occur in the Loess of Silesia, and Hauer and Stache state that the two pachyderms appear in association with the Reindeer and the Horse in the Loess of Transylvania. The same species, along with Ox, characterizes, according to Dr. Littel, the Loess and Lehm of Bavaria" (*op. cit.* p. 150).

It will be seen, therefore, that even in this upland zone in Central Europe the Mammoth was a by no means uncommon animal. Much more frequent are his remains in the great alluvial valleys of the Danube and the Rhine, and the lesser ones of the Thames, Seine and Somme, and the broad flats of Russia and Siberia, while with species of Deer, the Urus and the Bison, it also characterizes the Loess of China. This being so, I claim to have been strictly right in describing the Mammoth, the Rhinoceros, and the accompanying wood animals as the characteristic quadrupeds of the Loess.

From a remark at the end of Dr. Nehring's paper, I am not quite sure whether he considers his Steppe-fauna of Central Europe contemporaneous with the Valley-fauna characterized by the Mammoth, the Bison and the Red Deer. That it was so contemporaneous we have surely ample evidence. At Fisherton Mr. Blackmore found in the same deposit of Brick-earth remains of more than 50 specimems of *Spermophilus* (in 13 cases the skeletons being perfect and lying curved in the position of hibernation), two species of Lemming and an *Arvicola*; and with these he found *inter alia* remains of the Mammoth and *Rhinoceros tichorhinus*, *Bos primigenius* and *Bison priscus*, *Cervus elaphus*, *Cervus tarandus* of two varieties, and *Ovibos moschatus*, together with at least three varieties of *Equus*, and remains of a fourth doubtful variety, assigned by the explorer to the Ass. The remains of Horses we are assured by Dr. Blackmore were especially abundant (Flint Chips, pp. 12—30). Here then we have a complete mixture of the two series of animals all found together and proving they were contemporaneous. The remains of Horses are habitually found mixed with those of the Mammoth, the Bison, and the different species of Deer, all forest animals. The *Lagomys* occurred at Kent's Hole with all the forest animals above cited, as did the Lemming at Brixham, and so we might go on. I would name one more instance only as a typical one, namely, the case of the Franconian deposits reported upon by Dr. Sandberger. The following is his list (Prehistoric Europe, p. 62) :—

Not yet sufficiently determined, 8 species.	*Arvicola ratticeps.*	*Ursus spelæus.*
Cervus tarandus.	*Arvicola gregalis.*	*Bos primigenius.*
Gulo luscus.	*Spermophilus altaicus.*	*Bison priscus.*
Myodes obensis.	*Alactaga jaculus.*	*Elephas primigenius.*
,, *torquatus.*	*Arctomys (? bobac).*	*Rhinoceros tichorhinus.*
	Hyæna spelæa.	

This is surely plain enough. It may, and does happen, that in certain special localities we have sometimes a deposit containing animals belonging to one or other of the classes only, but this would naturally occur occasionally and locally. At all events, it seems most clear that both classes of animal, the upland and lowland class, were perfectly contemporaneous. Dr. Nehring will not dispute that the Mammoth could not browse on upland pastures denuded of wood or thick shrubs. He will not deny that with the Rhinoceros, the Elk, the Red Deer, the Reindeer, and the Bison, the Mammoth presupposes the presence of a forest vegetation. This vegetation of shady trees and long grass or reeds must have grown very luxuriantly in the great European valleys when the vast herds of pachyderms found pasturage there. He will not deny that at Cannstadt in the Loess of Germany, and at La Celle in France, we have in the tuffs, and at Bruhl and Mamers we have in the travertines, ample remains of these very forests, which have been minutely examined and reported upon by Saporta and others. Since I wrote my early papers, Mr. Geikie has published his work on Prehistoric Europe, and as I find myself completely in agreement with him on this point, I will quote his condensed result of these examinations, rather than repeat those I have already printed. Speaking of the plants at La Celle, he says, "This very remarkable assemblage of plants tells a tale which there is no possibility of misreading. Here we have the clearest evidence of a genial, *humid*, and equable climate having formerly characterized Northern France" (*op. cit.* p. 51). Again, "If the winters in Northern France were formerly mild and genial, the summers were certainly more *humid*, and probably not so hot. This is proved by the presence of several plants in the tufa of La Celle which cannot endure a hot arid climate, but abound in the shady woods of Northern France and Germany" (*id.* p. 52). In regard to the flora of the tufas at Cannstadt, Saporta maintains "that it indicates a climate more equable and *humid* than at present" (*id.* p. 54).

Surely these facts are absolutely at issue with the theory of Baron Richthofen, with the dry parching winds and dust storms which he invokes to explain the Loess, and I do not understand how Dr. Nehring can avoid admitting it.

If we turn from this lowland zone to the upland zone, we shall surely have the same answer to give.

Dr. Nehring postulates for his Steppe region, which I call the upland region, that it was marked by an expanse of grass pastures and prairies such as are found in that nomadic paradise, the valleys around the Altai Mountains, and in the famous Nogai Steppes, where the largest cattle and the finest sheep in the world are raised on the most succulent grasses, and he urges that these llanos or grass pastures were the homes of herds of Horses, and wild Asses, of Marmots, pouched Rats, and tail-less Hares, of Jerboas, and Porcupines, and were invaded at times by Mammoths and other beasts from a differently constituted area. I see nothing to object to whatever in this. It seems fairly to describe the kind of country to be found on the southern slopes of the Ural Mountains and the inner valleys of the Altai. But let me ask, in all seriousness, how are these grassy pastures compatible with Dr. Richthofen's theory at all? Whence, let me ask, are we to derive the calcareous dust? How is luxuriant grass to grow where dust is accumulating in the fashion he describes? The grass protects the subsoil from denudation by winds completely. How, therefore, can we derive the dust from its surface? Again, if dust were to bury whole carcases of Mammoths and other great quadrupeds so that their bones should not decay or become weathered, or their bodies dispersed and carried off by beasts of prey, or otherwise, the dust must have accumulated in great quantities, whence did it come in this way? and if it came, how did the herbage grow, and the animals live?

I cannot help expressing my astonishment that Dr. Nehring should have burdened his ingenious and convincing arguments in favour of a steppe or plateau fauna in Central Europe with a theory which necessitates the importation there, not of the grass prairies of the Nogai Steppes, but rather of the bare Salt Steppes of Mongolia, with their occasional tufts of hard wiry grass and occasional bushes of the still more hard and wiry Steppe-shrub, the *Lasiagratis splendens*. Even with these Salt Steppes, as we argued before, the problem seems quite insoluble if we adopt Baron Richthofen's theory, *à fortiori* in the case of llanos and prairies of luxuriant grass.

One more issue. Dr. Nehring disputes my reading of the evidence of the Mollusca found in the Loess, and quotes against me Dr. Martens. Here again I must claim that my view has the support of the facts. He refers to Dr. Todd as if he were an exceptional American witness. He is quite the reverse. I have just received from two American friends, Professors McGee and Elsworth Call, both experienced authorities on the Loess and its contents, an elaborate paper discussing the Molluscs they have found in the Loess of Iowa, and their view is entirely at issue with Dr. Nehring's. They contend that these shells require such humid conditions that they will have it the Loess is a lacustrine deposit, and Mr. Elsworth Call tells me that the American authorities upon the Loess, including himself, Dana, Packard, Powell, Hayden, McGee, Russell, Dutton, White, etc., all maintain the same view. I cannot concur in this lacustrine theory, at least as applied to Europe and China, but I do hold strenuously with them that a large portion of the shells found in the Rhine Loess necessitate a humid condition of things. No doubt some of the Molluscs point to upland districts and to drier conditions, but these are quite a minority. M. Daubrée, who reported on 200,000 specimens from the Rhine Loess, says, "Nearly all still live in cold damp climates, and some in the Alps as high as the limits of snow." Heer says of the shells from the Upper Rhine Valley, all the species except *Helix ruderata, H. sericea, H. glabella, H. arbustorum, H. subalpina,* which belong to mountain districts, and *Helix strigella,* with a wide umbilicus, which is locally limited, are either forest-snails from the region of leafy trees, or species which prefer shady moist places, inhabitants of many localities are wanting. M. Tournouër, a first-rate authority, speaking of the similar Molluscs from the Seine Valley, says, "They must have lived in the recesses of moist woods attached to leaves, to tender herbaceous plants, and to rocks where waters fell. . . . . . They bespeak a diffusion of European species more uniform than prevails now, with a damp and more uniform climate than now prevails." But we need not surely enlarge on this part of the subject. Any one who will take the trouble to sift out the proportion of *Succineas* found in the Rhine Loess, and who is aware of the life conditions of this most common Mollusc, will assuredly never assign as its *habitat* in the Mammoth period dry Steppes continually blown over by fierce winds. I do not dispute that the upland tracts which we know existed in Germany in Post-Glacial times, and were characterized by their own fauna, were also the home of a certain number of *Helices*, etc., which frequent mountain slopes. This is perfectly certain, but it does not in any way affect the problem as I stated it, nor does it mean the importation into Europe of the parched conditions that prevail in Mongolia, where the ground is practically bare, and where Pumpelly could say that in travelling from Kalgan to Urga, a distance of 420 miles, he only saw two trees.

I have now done. I have frankly faced every argument produced by Dr. Nehring. I do not profess to contest the brilliant series of facts he has so carefully collected, but I do claim to have shown that these facts and the inferences they necessitate are completely fatal to Baron Richthofen's theory. In conclusion, I would add that even if they had not been so, they surely affect one element and factor in the problem, as he states it only, namely, the biological element, and the various objections, geological and otherwise, adduced by myself and others, remain unanswered. I hope some effort at all events will be made to meet them, for we are all engaged in hammering iron, and the only product of our labours which is likely to live is that which has been well hammered on every side. I hope also that Dr. Nehring will find nothing in tone or substance in this paper which he can construe into a slight, either to himself or to Baron Richthofen. It is not my aim nor yet my custom to throw stones, and if it were I should choose some objects for the purpose whom I rate very much less highly than I do my very distinguished opponents.

IV.—On Some New Railway Sections and other Rock Exposures in the District of Cave, Yorkshire.

By Walter Keeping, M.A., F.G.S., and C. S. Middlemiss, B.A.

THE country between Market Weighton and the Humber is characterized geologically by the reappearance of the Oolites along an outcrop of ten or a dozen miles, after having disappeared under the Cretaceous beds further north at Acklam Brow, near Malton.

The physiography of the area clearly indicates its structure.

Travelling in an easterly direction, the long low level of the plain of York gives way as the Jurassic beds are approached to a series of escarpments rising one behind the other, the most marked being the first and last, which are respectively the Lower Lias and Chalk. Between them, a distance of about two miles is occupied by three undulations of less importance representing the hard beds of the Middle Lias, Millepore Rock, and Upper Kelloway Rock. On the map the beds all run roughly N.N.W. and S.S.E., and three faults are marked by MM. Tate and Blake, as cutting at right angles across the strike in the direction of the valleys which penetrate the Chalk by the villages Drewton, Newbald, and Sancton.

It is through part of this region that the Hull and Barnsley Railway, now in process of construction, has recently laid bare some fine sections; and it is the object of this paper to describe them, with more particular reference to the Kelloway Rock, which, as here developed, has hitherto received no more than a passing notice by geologists.

The railway runs in an east and west direction directly across the strike of the strata and immediately south of the fault running up the Drewton Valley. This line of section does not end westerly in the usual cliff-like escarpment of the Lower Lias; for denudation, prompted perhaps by the fault, has taken away the Lower Lias at this point, and the circumstance has been turned to advantage by the engineers of the line.

The first of the railway cuttings to the west overlooking the Plain of York commences half-way between the villages North Cave and Everthorpe. It is about 18 ft. high at its highest point and 1551 ft.[1] long. It exhibits, first, two thick beds of chalk gravel with flint lying lodged on the west side of the escarpment. The pebbles are loosely cemented together and covered in the case of the lower bed

[1] These and similar measurements were kindly afforded us by Mr. C. J. Corrie, one of the engineers.

with a lichen-like growth of oxide of manganese. The gravels are almost free from sandy admixture, and only here and there occur foreign (non-local) pebbles and blocks, viz. grits and sandstones, together with Oolitic limestone.

The heart of the cutting showed when fresh (it is now covered with soil and overgrown) the following rocks in ascending order.

Middle Lias Clay.—Of this 10 or 15 ft. are visible at this particular place. It is a dark slaty-blue clay of the ordinary type, and from the fossil remains (*Ammonites* (*Ægoceras*) *capricornus* and a *Pecten*) may belong to the *Capricornus* zone.

This is quickly succeeded by 3 ft. of soft, rubbly, red sandstone, and then by a strong zone of dark brown, flaggy, micaceous sandstone about 5 ft. thick. This last has a good deal of earthy admixture, and here and there a calcareous development along the bedding and joint planes, which appears to have been segregated out and re-deposited. It probably represents the *Spinatus* zone of the Middle Lias, and stands out as a prominent ridge on each side of the cutting.

Fossils are very scarce, but *Waldheimia resupinata* and a number of *Rhynchonella tetrahædra* were obtained.

Dip about 5° due E.

The Lower Lias was found in a bridge foundation 45 chains west of the cutting. It was a stiff blue clay with beds of limestone, containing *Gryphea incurva.*

The Upper Lias we did not actually see in the cutting, but a blue clay has been proved in digging in the low ground to the east, which probably represents it.

The rail now runs for 2508 ft. on an embankment, and then comes the next cutting in the Lower Oolites. The lowermost beds, however, are not seen here, but can be examined in one or two small exposures further south in this district. Hence, it is probable that they are also hidden along with the uppermost Lias beds in the depression just alluded to.

The cutting now entered is 12 ft. in the highest part and 792 ft. long. The rock is uniform in character, being a characteristic well-bedded Oolite quite like the Millepore Oolite of the Howardian Hills. Oolitic grains form the mass of the rock. Fossils are not abundant, but the following species have been found: *Trigonia conjungens*, Lyc., *Lima pectiniformis*, Schl., *Hyboclypus* and *Cricopora straminea*, Phill. Some of the beds are blue-hearted, others have a pale purple tinge, and near Brough the rock is so compact that it was formerly worked for ornamental purposes and was called Brough marble.

The dip of the beds is almost uniformly about 3° E., though there are indications of a slight roll near the middle of the cutting.

The "Millepore" (*Cricopora straminea*) can be found with readiness on slightly weathered surfaces.

Between this and the next cutting a short distance of level ground (990 ft.) intervenes, but short as it is it has been sufficient to deny a view of the upper beds of the Lower Oolites.

We now reach a magnificent section in the Kelloway Rock 36 ft. high and 1584 ft. in length. The slopes have now been covered with soil and are grass-grown, but the hard upper bed still stands out well, and following the slope of the hill dips down to the east end of the cutting at an angle of about 5° or 6°.

Commencing at the westernmost end, there is a thickness of about 25 ft. of pale yellow sands, slightly cohesive, coming under the hard bed just mentioned. They have some well-marked characteristics which continue fairly constant over the whole of the district. The level ground just crossed obscures the more clayey beds below these sands, but they are exposed in a quarry at Newbald further north.

The sands in the cutting commence as an almost perfectly pure white sand-rock, only slightly cohesive, but sharply jointed along the bedding and at right angles to it. Pale silvery mica plates divide the rock along the bedding planes. The whole, when the cutting was new, had a most beautiful appearance, being only interrupted here and there by thin irony bands with sometimes carbonized plant-remains. No fossils have been obtained, and the sands look barren.

These sands are only a few feet thick here (5 ?), and merge upwards into a less pure slightly yellowish sand-rock of the same general composition, but without the mica plates, and also without the fine jointing. They are about 20 ft. thick. In the lower part a double band of decomposed plant-remains and broken *Belemnites,* deeply stained with iron, occurs, and in the upper part numerous lines and irregular patches of iron staining. But besides this, the upper 10 ft. of these sands are characterized by two broken lines of large compact concretions of an ovoid shape, and in size varying from 1 to 4 ft. along their largest diameter. They occur along lines of scanty fossils, chiefly *Myacites* and *Belemnites,* and are composed mainly of siliceous particles bound together by a small per-centage of lime. The lime which is present in them seems to have been derived from the fossils in the strata above, of which chiefly nothing but casts remain. Where the fossils are absent, the concretions do not appear.

Generally speaking, these 20 feet of pale-yellow sands are barren of organic remains, the few that do occur being chiefly casts, massed together in the concretions and in the Belemnite beds below.

Above these beds what may be called the Upper Kelloway rock has a markedly different appearance. It is from 8 to 10 feet thick, of a dark reddish-yellow colour, and crowded with lines of *Gryphea bilobata,* Sby. The rock still only merits the name of sand-rock, though its highly ferruginous character gives it greater stability, so that it stands out as a prominent wall of rock in the cutting. Here and there little nests of *Rhynchonella sociale* have become compacted together, and helped to harden it sufficient to make it ring under the hammer.

Corresponding with its marked lithological character the number of fossils has so increased as to crowd the rock, and this increase has not taken place gradually, but becomes apparent immediately the lower sands are passed.

List of Drewton Kelloway Rock Fossils.

Belemnites Owenii, Pratt.
Ammonites modiolaris, Lind.
,, *Duncani*, Sby.
,, *Kœnigi*, Sby.
,, *Gowerianus*, Sby.
,, *Mariæ*, D'Orb.
Turbo sulcostomus, Phill.
,, sp.
Cerithium Culleni, Leck.
,, sp.
Alaria bispinosa, Phill.
Pleurotomaria.
Gryphea bilobata, Sby.
Pecten demissus, Phill.
,, *lens*, Sby.
,, *fibrosus*, Sby. (?)
,, large ribbed species.
Avicula Braamburiensis, Phill.
,, *inæquivalvis*, Sby.
Perna rugosa, Goldf.
Pinna mitis, Phill.
Modiola (cylindrical species).
Modiola pulchra, Phill.
Trigonia Rupellensis, D'Orb.
Cucullæa, sp.
,, *corallina*, Damon.
Arca.
Cardium Crawfordii, Leck.
,, *cognatum*, Phill.
Isocardia.
Cyprina (2 or 3 species).
Astarte (small ribbed species).
,, *ungulata*, Lyc. (?)
Unicardium depressum, Phill. (?)
Corbicella (*ovalis*, Phill. ?)
Pholadomya ovulum, F. and M. (?)
,, *Heraultii*, Ag.
Gressleya peregrina, Phill.
Goniomya v-*scripta*, Sby.
Anatina undulata, Sby.
Myacites decurtatus, Phill.
,, sp., and other doubtful bivalves.
Rhynchonella socialis, Phill.
Terebratula ornithocephala, Sby.

Lying along the surface of the upper rock bed, the eastern half of the cutting shows a thin dark homogeneous clay about 15 ft. thick, the representative of the Oxford clay. Since, however, this clay where seen, is completely covered by surface deposits which lie with the dip, its original thickness may have been considerably more; and it doubtless extends under the level ground to the east. Fossils in this clay are scarce, but we obtained *Belemnites Owenii*, *B. abbreviatus*, and *Gryphea dilatata*, sufficient to identify the horizon of the rock. A *Plesiosaurus* paddle-bone was also found, and fossil wood was not infrequent.

The surface-beds exposed in this cutting are very thick on the east side of the ridge. Fragments of a stiff Boulder-clay occur at the summit, and two beds, a coarse chalk gravel above and a fine yellow sand below, occupy the east end of the cutting and sink with it to the level of the next embankment.

The embankment hides the junction between the Oxford and Kimmeridge Clays, the next exposure, after an interval of 1188 ft., being a dark, almost black clay slightly shaley, underlying the Red Chalk. After dipping away out of sight, it reappears in the cutting further east by a slight bend in an upward direction. It is probably the Kimmeridge Clay, but characteristic fossils were not obtained.

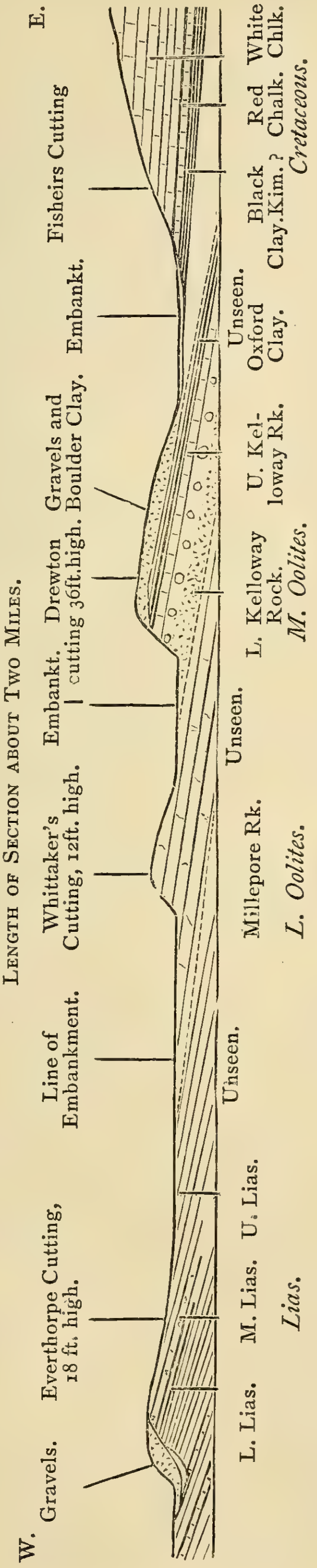
The Red Chalk is for the most part rubbly, hard and nodular, the lumps being often veined with a grey-green marking.

The following section was well exposed:

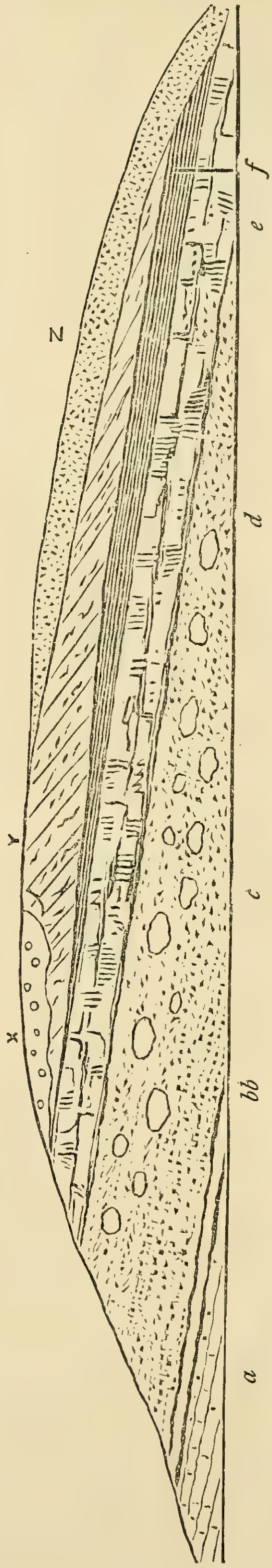
	feet	inches
Nodular Red Chalk	1	6
Pale Nodular Chalk	1	3
Clayey Red Chalk	0	6
Gray Nodular Chalk	1	0
Red Chalk	0	3
Yellow-green Clay	0	9
Unctuous Red Clay	1	6
	6	9

HULL AND BARNSLEY RAILWAY CUTTINGS NEAR CAVE, EAST YORKSHIRE.

LENGTH OF SECTION ABOUT TWO MILES.



KELLOWAY ROCK.—DREWTON CUTTING. LENGTH 1584 ft. HEIGHT. 36 ft.



a. Sharply pointed micaceous white sands. 5 ft.
bb. Belemnite-beds.
c. Pale yellow sands, slightly cohesive. 10 ft.
d. ditto with concretions and irony bands. 10 ft.
e. Upper dark red rock, very fossiliferous. 8 ft.
f. Oxford Clay. 8 ft.

x. Boulder Clay.
y. Fine sand
z. Coarse Chalk gravel.

Fossils are not abundant, but *Terebratula semiglobosa,* and portions of *Inoceramus* occur, and *Belemnites minimus* is common, especially in the nodular beds.

Above this comes the Grey and Lower White Chalk of the usual characters, but about 30 ft. above the true Red Chalk there is a pink band of about a foot thick resembling those at Speeton and Louth, Lincolnshire. A few irregular pale-coloured flints occur in the Lower Chalk, and the joint surfaces are in many places blackened by a deposit of manganese. Thin bands of Fullers Earth occur in the Lower Chalk. A remarkable set of beds of an argillaceous and carbonaceous character occurs in the White Chalk 25 ft. above the Pink Chalk above mentioned. The total thickness is about 3 ft., consisting of three divisions, the lowest being a pale yellow laminated and jointed marl (1 ft.), the upper zone a similar rock usually greenish or brown in colour (1ft. 3in.), and the central band a dark carbonaceous shale or black coaly shale with fragments of plants.

We now propose briefly to notice one or two other exposures of the Kelloway Rock seen between Market Weighton and the Humber.

The first and only exposure along the escarpment south of the railway cutting is a sand pit by the road-side at South Cave. It is about 10 ft. high and embraces the uppermost 10 ft. of the unfossiliferous sands, crowned with a thin portion of the upper hard fossiliferous bed. The sands are, if anything, slightly more irony than in the cutting, and though indications of concretionary action are present, no nodules occur. These sands were formerly supposed to be Lower Greensand, from their great similarity to those of that age in Lincolnshire.

South of this point the Kelloway Rock is not found, and the well-marked ridge comes to an end with a slight trend to the south-east, indicating that here with a change of strike the beds are completely overlapped by the Cretaceous series.

In an opposite direction, north of the railway cutting, and across the valley in which Drewton lies, the position of the Kelloway Rock is shown by a well-marked ridge, and there is a slight exposure of the pale sands with concretions in a field some few yards below the house called "Kettlethorpe" on the Ordnance Map.

Beyond Kettlethorpe the line of outcrop follows the road to Market Weighton for about two miles, and then runs easterly, forming a V-shaped curve, owing to the wide valley in which Newbald lies having been excavated across the strike. The return curve shows a quarry in the Kelloway Rock under the hill-side north of the town.

The base of this quarry is of interest, inasmuch as it exposes lower beds than we have hitherto met with. At the top is about 5 ft. of the usual red-brown rock full of the usual fossils; below that 20 ft. of the pale sands with incipient concretions, and a few well-formed ones in the upper part, but without the singularly pure development below of the micaceous well-jointed sand rock. Beneath these about 5 or 6 ft. of the rock becomes gradually more clayey, and an iron staining again sets in, giving the rock a pale-brown colour. Here too the rock becomes fossiliferous, though few of the fossils are well preserved.

From the position of this quarry with respect to others close by in the Millepore Rock, it seems probable that these argillaceous beds represent the base of the Kelloway Rock. Moreover, the presence of clayey beds below is in conformity with the Cayton Bay series, where a gradual passage is described by Mr. Hudleston down into the *Avicula echinata* shales.

North of Newbald the outcrop is easily traced for a good way on the east side of the road, and on the road dipping down into Sancton Valley it makes another V-shaped curve, and returns as the road rises again. Close to the church is an exposure about 25 ft. high. It is altogether in the lower beds. At the base is a slightly clayey development ($4\frac{1}{2}$ ft. thick), but without fossils. This passes upwards into a magnificent section of about 20 ft. of the white barren sand-rock. Here, however, it is poorer than elsewhere, and has the pale glistening mica plates almost throughout. Hence the rock is more finely split up than in the other localities. Near the top, however, is a faint indication of incipient concretionary action, and the jointing there is not so perfect. Very thin layers of irony material and indistinct plant-remains are seen at intervals. The uppermost part of the section is ploughed into by an irregularly lodged mass of boulders and churned-up chalk, clay, and sand. No foreign rocks were obtained amongst the boulders. All were either portions of the Kelloway Rock (*e.g.* displaced concretions and masses of the upper hard rock), or Millepore Oolite with a considerable amount of Red and White Chalk powdered up.

Dip about 5° E.S.E.

Beyond this point the outcrops of the Red Chalk and the Millepore Rock approach one another more and more, leaving less room for the Kelloway Rock, until in a field near the bend in the road about a mile and a quarter from Market Weighton, the last evidence was obtained by a newly sunk well, the turnings out of which showed the presence of the Lower Sands.

Across the valley running east from Market Weighton the Kelloway Rock is hidden from view, and the whole of the Oolites are overlain completely by the Chalk.

From this brief description it will appear that, taken as a whole, the Kelloway Rock of this district resembles very closely, lithologically and palæontologically, the same rock in North Yorkshire. The rocks are essentially similar, and in both districts there are two fossiliferous beds separated by an unfossiliferous portion, and it is in the upper bed that the Cephalopoda and larger Lamellibranchs first make their appearance.

V.—Some Suggestions on the Cromer Forest Bed.

By T. Mellard Reade, F.G.S.

Like many other geologists at the present time, I have been engaged in reading Mr. Clement Reid's Memoir on the Geology of the Country around Cromer—reading it, I may say, with mingled feelings of pleasure and pain;—pleasure, at the amount of interesting and valuable matter which he has assiduously unearthed; and dissatisfaction at his attempts to destroy one of the cherished convictions of childhood—faith in the Cromer Forest Bed! Mr. Reid evidently does not believe in the Cromer Forest Bed; but then what would a Manual of Geology be without it? This either he or his superior officers have felt, and the name "Forest Bed" has therefore been retained for a bed which, according to his own confession, "least deserves the name."[1] This course, though illogical, is no doubt a concession to popular geological prejudice.

But my object in writing is to try and point out some consolatory considerations which have perhaps been lost sight of by the author of this careful memoir, by which those who are inclined that way may still preserve some shreds of faith in the observations of the older geologists.

The term "Forest Bed" is now given to an estuarine series of varying and often considerable thickness, viz. from 21 feet to 1 foot,[2] with in some places a "Lower Fresh-water Bed" underlying and in others an "Upper Fresh-water Bed" overlying it, and capped in places with a "*Leda-myalis* Bed," which again is covered between Mundesley and Runton with an "Arctic Fresh-water Bed," the whole having superimposed upon them the Cromer Till and Contorted Drift; the basement rock being either the Weybourn Crag or the Chalk, according to the locality of the section.

The reason Mr. Reid urges against the name which he has been forced to retain, is the evidence he considers he has gathered, that the stools of trees found in the deposit have not grown on the spot, but have drifted down some large river and been stranded in the form of snags. A somewhat similar explanation was volunteered to account for the Post-Glacial sub-marine Forest Bed on either side of the estuary of the Mersey; and I have been struck by the remarkable similarity of the arguments made use of in both cases. It is not my intention to prejudge one case by what happened in the other, but I may say that, after many examinations of these Post-Glacial Forest Beds, there remain not more than two individuals who have failed to be convinced that the trees have grown on the spot where the stools stand.[3]

From the time of W. Arderon in 1746 to the present "the roots and trunks of trees" have been noticed by many observers at low water on the coast near Hasborough; and the Memoir fairly states all the historical information relating to the subject, so it is unnecessary for me to detail it here. That the stools in their appearance and arrangement were similar to those of the Post-Glacial Forest Beds—that is, they were numerous, erect, and in the same horizon—is pretty evident, or such good observers as R. C. Taylor, the Rev. Mr. Gunn, and others would scarcely have thought they were in the position of growth. But Mr. Reid states he has pulled up upwards of a hundred stools at different localities,[4] and found that "the roots do not end in small fibres, but are broken off,

[1] Page 22. [2] See sections, pages 29 and 41.
[3] Q. J. G. S. vol. xxxiv. p. 447. [4] Page 23.

generally from one to three feet from the stem, and the ends are either rounded or frayed out." He mentions one stool, however, in which the roots extended 9 feet in one direction and 11 feet in the other, or over a circle of 20 feet in diameter; this, however, was not considered satisfactory, nor was the case of interlacing roots figured in p. 24.

Of course it is not possible for me, nor is it my object to call in question the accuracy of the information given, but I may observe that it is very difficult to dig up and thoroughly observe in such cases all the complicated ramifications of roots and rootlets, and that *one* example of a tree *in situ* would upset all the negative arguments relied upon in the memoir.

But there are some general considerations open to all who choose to read the published information on the subject even in the memoir itself, to enable them to form their own opinions. Leaving out of account for the present some of the special cases of prostrate stools, and stools and drift wood at different horizons in the estuarine series or "Forest Bed," we may ask what river at the present day brings down the stools of trees with the trunks cut off or broken off at a certain average level, floats them down, roots and all (even though frayed), and plants them erect upon a shore so as to deceive geologists into the belief that they had grown there? If the trees grew on the banks of a large river as suggested by Mr. Reid and were undermined by it and floated away, I venture to think they would have come down trunk and broken roots complete—if I may be permitted the Hibernianism—and have been invariably deposited prostrate. I have considerable doubts if a stool alone with roots and earth attached would float, more probably it would be rolled along the bottom. But it would be a nice calculation of probabilities, assuming properly prepared stools existed on the river banks, to find out what proportion would be stranded erect. The idea is altogether too far-fetched to commend itself to the average mind.

Perhaps, however, the following circumstance will help to explain some of the difficulties. Although the stools of the Post-Glacial trees are undoubtedly where they have grown, when found embedded in peat, in some cases they have been washed out of the peat bed, by its destruction in stormy weather, and pushed along the shore erect on the platform of roots and re-embedded in sand and silt. It is, however, curious, how few are treated in this way;—the majority get washed out to sea and lost. I can, however, conceive conditions in which the removal and replanting may have occurred with greater frequency.

It is noticeable in the examples of sections given in the memoir that the stools are often found along with a bed of clay-pebbles and pholas-bored peat, such pebbles or boulders also arise from the destruction of the Post-Glacial beds underlying the peat and forest bed on this coast, and pieces of pholas-bored peat are also met with.[1] If the "Forest Bed" were formed in this way, it must now be in the immediate vicinity of the place where it grew, and must have

[1] Geol. Mag. 1878, p. 571—"Clay Boulders."

arisen from the destruction of an underlying bed. But I am not prepared to admit that *none* of the stools are *in situ;* for it has not been proved. Considering the rottenness, and the very spongy nature of the rootlets even in the Post-Glacial Forest-Bed trees, I am not surprised that, in this much older bed, the author of the memoir has so often failed to detect the "smaller fibres" he has so assiduously looked for, but would not 20 feet in diameter of roots satisfy most men?

One more observation before I conclude. A map is given, p. 57, showing "the Rhine Estuary during the formation of the Cromer 'Forest Bed.'" The materials on which this is based are of the slightest, which criticism is perhaps applicable to the generality of such maps. Considering that the Forest Bed is at about the same level as the present mouth of the Rhine, and that they are in a direct line about 120 miles apart, that the basin of the German Ocean intervenes, that the rivers on the east coast, including Norfolk, are even in their Post-Glacial beds much below the sea-level, that the bed of the Rhine is far below its modern delta, that the solid chalk is seen now on the Norfolk shore and immediately underlies the Forest Bed in places, and in others is not far off, and the author does not assume "any tilting or disturbance in beds of so recent a date unless such can be clearly proved." Considering all these difficulties, it would surely have been well—if they occurred to the author—to have discussed them. But I suppose the bringing of the Rhine to Norfolk is the necessary outcome of the author's view of the mode in which the trees have been deposited. Such unfortunately, on very little provocation, are the liberties taken with physical geography.

VI.—On "Overlap" and its Related Phenomena.

By J. G. Goodchild, Esq.;
of H.M. Geological Survey.

It must be sufficiently obvious to the readers of the Geological Magazine that any modification of the original meaning of a descriptive term that may serve the purpose of enabling us to convey a specific idea with less chance of ambiguity is a distinct gain to both author and reader. This is especially the case when other specific terms are forthcoming to fill the vacancies in descriptive terminology caused by the restriction in meaning of the term in question, and when it is possible at the same time to supply a suitable generic term sufficiently comprehensive in its meaning to embrace the common characteristics of the whole.

Every now and then local exigencies in the treatment of some special subject require a writer to employ a term in a signification somewhat more limited than it had been customary to give to it before. If the applicability of the term in its modified sense to similar cases of a less general and specific character are perceptible to other workers in the same field of research, it would seem much more advantageous to give the specialized form recognition by employing it, as occasion arises, than to lose the opportunity of making a useful addition to our stock of descriptive terms by allowing it to revert to its original meaning. This principle is generally admitted to be a good one; nevertheless, in practice it is by no means always observed. Numerous as are the terms already at our disposal, the advance of knowledge is constantly reminding us of the necessity of multiplying rather than of lessening the number of terms of specific signification as occasion requires us to limit the meaning of related terms already in use.

As an instance of a word whose employment commonly gives rise to ambiguity may be mentioned the word Overlap. For example, when a writer has occasion to make the statement that a certain stratum "overlaps" another, it is often impossible, without a reference to the context, to discover whether the case referred to is that of a higher member of a continuous series of deposits coming into natural contact with a lower, as a consequence of the local attenuation of a third stratum elsewhere known to occur between them; or whether it refers to a case of true unconformity, where there is no necessary sequential relation between the bed that "overlaps" and the rock it may happen to lie upon. The two cases are, of course, essentially different. It is true that in the first case mentioned the contact of the upper stratum with the lower can be shown to be due to a kind of break in the succession, inasmuch as sufficient time must have elapsed for the accumulation of the stratum that is elsewere known to intervene. But the group as a whole may have been deposited from beginning to end with no more important interruptions than are incident to the accumulation of any sedimentary deposits of the ordinary kind. The case is simply one of wedge-bedding of greater horizontal extent than usual.

Or the kind of overlap referred to may be a case of essentially the same nature as the last, manifested under a form slightly different; as, for example, where the higher bed referred to extends beyond the lower as a consequence of the deposition of horizontal strata upon a surface that is itself inclined. A wall built up the slope of a hill supplies a familiar illustration of a case of this kind. If the masonry is laid horizontally, then course after course, from the lowest upwards, extends in succession beyond the others, with the result that a particular line of masonry may at one spot form the very top of the wall, and yet be, at the end next the hill, in actual contact with the foundation.

This last case may be regarded as a typical example of what several authors have meant by the word overlap. But as, in nature, the several strata are usually found to thin away where their edges approach the bank, instead of ending off against it abruptly as the masonry does, it is perhaps hardly advisable to advocate the introduction of any distinction between the terms employed to denote the approximation of two beds as a consequence of the lenticular deposition of a third, and the unequal extension of strata deposited upon an irregular surface.

As well-known illustrations of typical overlap I would refer to the Coal-measure outliers on the borders of Wales, which extend, in places, beyond all the Lower Carboniferous strata, so as to lie directly upon the older rocks. Another illustration is supplied by the mountain limestone between the south-eastern border of Westmorland and the district of Craven, which, as it is traced from the neighbourhood of Sedbergh, where the lower members of the formation are very fully developed, can be shown to overlap what is practically the whole of the vast thickness of the Upper Old Red, as well as some of its own lower strata, and to come down into direct natural contact with the Pre-Carboniferous rocks as we advance in the direction of the Craven Faults. To convey a correct idea of this kind of relation of one member of a series to another, it would probably be found difficult to employ any more expressive, and, at the same time, more suitable term than that of Overlap.

But it is not always convenient, or possible, to take as the starting-point in a description that part of the district where the downward development of the formation under notice attains its fullest known dimensions. In such a case it might be advantageous to add to our descriptive terminology by employing some other word correlative in its meaning with overlap. I would here suggest as a term likely to be of service for such a purpose the corresponding term *Underlap*. The examples above given may be again cited in illustration of its use. I should say that as the Coal-measure strata referred to on the borders of Wales are followed in the direction where deeper-water conditions prevailed in the Carboniferous Period, we find first the stratigraphical equivalents of the Millstone Grit, and then of the Lower Carboniferous subformations successively *underlapping* the strata that, nearer the centre of the Principality, lie directly upon the rock of the various Pre-Carboniferous series. Or, to take a case in the North of England, still more to the point for the present purpose, I should say that the Roman Fell beds of the Pennine Escarpment right and left of Milburn, as they trend on the one hand towards Gamasby, and on the other towards Brough, are gradually underlapped by the Upper Old Red, in just the same way as the Welsh Coal-measures are underlapped by the Lower Carboniferous.

Overlap, and its correlative Underlap, as it is here suggested to employ them, thus denote the stratigraphical relations of one part of a formation to another where the original extent of the lower part occupied a smaller area than that of the next higher members of the same series.

If it should, on consideration, hereafter be deemed advisable to re-adjust the signification of the term Overlap to the extent here suggested, a vacancy in our terminology will be created, and another term of parallel meaning will have to be provided to denote the corresponding phenomena in the case of true unconformability.

It is by no means an uncommon case to find two groups of associated strata presenting examples of both overlap and unconformity in one and the same section. On the large scale the Coal-measures of the Welsh Border both overlap the Lower Carboniferous strata, and extend transgressively across the edges of the rocks older in the geological series. The New Red of Leicestershire behaves in precisely the same way, so does that of Kirkby Stephen, in Westmorland; or, again, the Mountain Limestone between Sedbergh and the Craven Faults, as already referred to. It is not often that any such striking examples as the last mentioned can be cited, especially where the rocks under description appertain to the higher horizons of the Neozoic division. But among the Palæozoic rocks the perfect distinctness of the two phenomena hitherto included under the one term Overlap is constantly forced upon the attention of the field-geologist. For example, the quartz-conglomerates of the Roman Fell Series in the Pennine area, overlap the perfectly-distinct conglomerates of the Upper Old Red; while the Carboniferous rocks as a whole (assuming that the Upper Old Red really forms a conformable subformation of the Carboniferous series) are known to extend, within a short distance, across the denuded edges of strata ranging from the Skiddaw Slate up to the Coniston Grit at Gamasby. In other words, while one of the minor subdivisions can be shown to overlap another subdivision of the same series to the extent of a few hundred feet or so, that series as a whole is transgressive across the edges of the older rocks to an extent that may be stated in miles. In such a case the necessity of employing separate terms to enable us clearly to convey the distinction observable in the field between the one kind of "overlap" and the other will at once be recognized.

The question arises, what term is there that is not already appropriated and whose suitability to the purpose in view would be likely to be generally admitted?

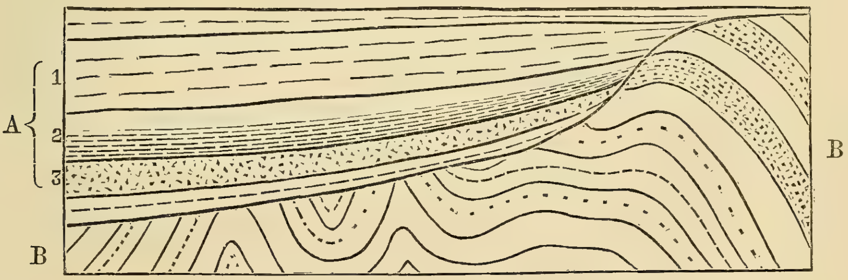


Diagram to illustrate the distinction in meaning between the terms Overlap and Overstep, and their respective correlatives Underlap and Understep. In the figure, beds 1 and 2 of series A successively overlap bed 3, while the series A, as a whole, oversteps the various subdivisions of the older group B.

Conversely, 3 underlaps 2, as this itself underlaps 1; and the several members composing the series B understep the formation that lies unconformably across their edges.

In oral descriptions I have found it convenient, in explaining these points upon the ground to my colleagues and others, to speak of this stratigraphical relation of unconformable beds to the various rocks immediately beneath as *Overstepping*. For example, I should say that the Roman Fell Beds in the neighbourhood of Melmerby overlap the Upper Old Red, while the Carboniferous formation—whose basement beds are formed by the Upper Old Red and the Roman

Fell Beds collectively—*oversteps* the older rocks there from the Skiddaw Slate up to the Coniston Grit. In like manner, describing the Pre-Carboniferous rocks themselves—whose dips and strikes, be it remembered, bear no necessary relation to those of the beds that lie unconformably upon their upturned edges—I have used the correlative term *Understep*, and have spoken of the older rocks forming an ascending, or a descending series in this or that direction as the case may be, *understepping* the beds that lie unconformably above.

The convenience of having some such addition to our descriptive terminology will, I feel sure, be fully recognized by others who, like myself, have had various instances of similar phenomena before their eyes for many years. Whether the terms here suggested be ultimately adopted or not, is a matter of indifference, provided that, as soon as the desirability of increasing our stock of words in this direction is once admitted, the terms proposed, whatever they may be, are such as shall enable us clearly to distinguish between the essentially-different ideas that have been confounded under the one term Overlap.

REVIEWS.

I.—Contributions to the Physical History of the British Isles. With a Dissertation on the Origin of Western Europe, and of the Atlantic Ocean. By Professor Edward Hull, M.A., LL.D., F.R.S. pp. xvi. 143. (London: Stanford, 1882.)

In his efforts to picture the physical geography of past epochs, the geologist finds three principal features to restore: (1) those of land and water, (2) those of life, and (3) those of climate. In the present work the author has attempted to delineate the outlines of land and water during the principal geological periods, over the area now occupied by the British Islands. This is naturally one of the most attractive of geological subjects, leading us away from the details, to contemplate the grand series of changes our area has undergone: and, so far as we are aware, in no country has it ever before received such full, careful, and, we may add, sumptuous treatment. Among the earliest and best attempts to sketch the history of past periods were those of De la Beche in 1834 (Researches in Theoretical Geology), while his disciples R. A. C. Godwin-Austen and A. C. Ramsay have devoted their lives in great measure to the questions affecting the physical geography of the past. To the former of these two geologists Prof. Hull pays a graceful tribute in his preface, observing that his elaborate essay on the Possible Extension of the Coal-Measures beneath the South-Eastern Part of England, will ever be considered a masterpiece of geological induction. Other geologists have dealt with particular periods, as Prof. Prestwich has with the Eocene strata, Dr. Hicks with the Palæozoic strata (Geol. Mag. 1876), and so on.

The only general attempt to show by map the successive changes in the British Area we call to mind, was that of the late J. C. Ward, in a Dream on Skiddaw, reprinted in his Elementary Geology (1872). Of ideal pictures of different scenes in the past, we have had many both at home and abroad, and especially of the Coal-measure period and of the "Age of Reptiles." Professor Hull's restorations, though of course more or less ideal, refer not to the landscape: they are maps, and as such are essentially based upon fact, and form a most useful index to our present knowledge of the subject. As he rightly observes, such a series of illustrations could hardly have been carried out without the aid of the numerous deep borings, which, especially of late years, have furnished so much useful information; nor, need we add, without the combined labours of many geologists for a number of years. Of these labours those of Prof. Hull himself have done material and conspicuous service, not merely by the field-work carried on in England, Scotland, and Ireland on behalf of the Geological Survey, but in several important memoirs dealing more or less particularly with the configuration of the land in past times.

The author introduces his present subject as the Palæo-physiography of the British Isles, and makes some useful remarks on the general principles to be observed in attempting restorations of old sea-margins. Thus the method of formation and deposition of strata are pointed out, as illustrated by recent researches; and we may mention, by the way, that an excellent summary of deep-sea investigation was given by Mr. W. H. Hudleston in his first Address to the Geologists' Association (1881). Therein we learn, from Mr. Murray's observations, that "Even the finer materials derived from the wear of the coast, or brought to sea by rivers, are deposited almost entirely within two hundred miles of land." The importance of this fact is pointed out by Professor Hull, although he states that in some cases the distance is much greater, as, for instance, in that of the Amazon, the muddy water from which discolours the ocean at the surface for several hundred miles, and by the time the mud subsides, it must reach to much greater distances. Thus (as he observes) the fact that sediment will tend to increase in thickness in the direction of its source, furnishes us with a valuable guide for the determination of the directions towards which we are to look, for the lands which yielded materials for the strata during any special geological period. The evidence furnished by coarse and fine sedimentary materials, and by limestones, is duly pointed out, and in a manner that will be understood by those not versed in the technical language of geologists. The author is careful to point out that neither life, nor the deposition of strata, in one place or another, has been completely interrupted for a moment, and that hence our great divisions, though convenient, are necessarily based on local interruptions or changes.

A chapter on the "permanency of continents and oceans" leads us to consider the view maintained by some naturalists, and lately expressed by Dr. A. Geikie, that "The present continental ridges have probably always existed in some form, and as a corollary we may infer that the present deep ocean basins likewise date from the remotest geological antiquity." This view at first seems to run counter to that stated by Lyell (Principles, Edit. xii. vol. i. p. 260) that "It is not too much to say that every spot which is now dry land has been sea at some former period, and every part of the space now covered by the deepest ocean has been land." But Prof. Hull brings forward good reasons for believing that the North Atlantic Ocean, properly so called, did not exist until after the close of the Carboniferous period.

The main object of his work is to show by means of coloured maps (of which there are no less than twenty-seven), the relative position of land and sea as they appeared at certain well-recognized epochs. In the case of each epoch represented, there are two maps, one displaying by different tints the area over which the formation is exposed and concealed, and the other the respective areas of land and water at the time when the formation was laid down.

The first map deals with the Laurentian period, or with the Archæan or Pre-Cambrian rocks, the only vestiges of which the author recognizes in the North of Scotland and Ireland. He thinks that a "primæval Atlantis" was probably the parent land for the strata of this age on either side of the Atlantic. Thence we pass to the Cambrian period (in which Murchison's grouping is taken), and behold the whole of England and Wales under water, with an Archæan ridge stretching from the North-west of Ireland through the Highlands of Scotland.

In Lower Silurian times all the British Islands, with perhaps the exception of a portion of the Hebrides, are under water: land stands out to the west. Then we come to the Upper Silurian and Devono-Silurian periods, taken together, and we have on the maps representations of the extent of these strata, and of the various areas of deposition. Here we see the Lakes Orcadie, Caledonia, the Welsh Lake, etc., so named by Dr. A. Geikie, in which the "Lower Old Red Sandstone" was formed. The Lower and Middle Devonian periods are also represented on another map. Then we come to the "Old Red Sandstone and Lower Carboniferous periods" grouped together for convenience, although the author regards the [Upper] Old Red Sandstone as a member of the Upper Devonian series, rather than of the Carboniferous.

In dealing with the Lower Carboniferous rocks, the author points out that from the distribution of limestones and shales and the alternations of these beds, it is evident that over the central region of the British Islands, the sea waters of this period were clear, and almost free from sediment; on the other hand, both to the north and south of the central region, they were laden with impurities. From this he infers that the lands from which this sediment was derived must necessarily have lain in these directions, namely, to the north-west and south-west of the British Isles. Thus even then the Atlantic Ocean, as such, had no existence. At this time, and during the succeeding Upper Carboniferous (Coal-bearing) epoch, there was, however, a barrier of the older rocks stretching from North Wales through Charnwood Forest to the east of England. Of course it is problematical how far eastwards this barrier did extend, and whether it ran due east or north-east, or very little further east than the Charnwood area: but as it appears on the map it looks uncomfortable for those who advocate the possibility of Coal-measures occurring at a workable depth under the surface in Norfolk. The succeeding maps illustrate the physical geography of the Permian, Triassic, Jurassic, Cretaceous, Lower and Middle Tertiary, and Glacial Epochs. The Pliocene beds seem altogether neglected, but the omission is unimportant. We are informed by the author that in the Triassic map there is an error in the position of the New Red Sandstone boundary in Cheshire. It ought to be taken further westwards; and we may add that it should also have been taken across the southern part of Glamorganshire. The exposure of Lias might also have been represented on fig. 1, plate x., in the same part of South Wales. These, however, are but trivial corrections which do not affect the main outlines of land and water as delineated on the maps. Space forbids our entering into further particulars concerning them, but we have probably said enough to convince our readers of the very great interest and importance of the work. Each map, with the accompanying explanatory remarks, furnishes a most instructive lesson, and we feel grateful to Prof. Hull for having devoted such pains to the description and illustration of his subject, as the production of such results must have involved a great amount of study and thought. All geologists will likewise feel indebted to the Royal Dublin Society, for having originally undertaken the burden of expense in the preparation of the numerous coloured plates.

II.—Department of Mines, Sydney.

1. Mineral Products of New South Wales. By Harrie Wood, Esq.
2. Notes on the Geology of New South Wales. By G. S. Wilkinson, F.G.S., etc.
3. Description of the Minerals of New South Wales. By A. Liversidge, F.R.S., etc.
4. Catalogue of the Reports, Works, Maps of the Geology, Palæontology, etc., of the Australian Continent and Tasmania. By Robert Etheridge, jun., and R. L. Jack, F.G.S., etc. (Sydney, 1882.)

The Report of Mr. H. Wood on the Mineral products of New South Wales is a valuable document, as showing the important progress that the mining industries of the colony has made within the last ten years (to 1881), when compared with the value of the production of each of the four preceding decades; in the last decade the value of production amounted to £23,441,890, during which time it is interesting to notice that tin, silver, lead, iron, bismuth, and asbestos have been added to the mineral products, which previously comprised only coal, gold, antimony, and copper. A detailed description is given respecting the discovery, character and occurrence of the minerals found, and their economic bearings as affecting the interest of the Colony.

Mr. Wilkinson, in his Report, gives in a very clear and concise manner an account of the physical and geological features of New South Wales. After noticing the orographical features, the author describes the geological structure of the colony, in which most of the principal life periods of the Earth's history are represented; and if we were to include the Eocene and Lower Silurian of Victoria, and the great development of Mesozoic rocks of New Zealand, the geological series would be almost complete. The oldest rocks hitherto determined are the Upper Silurian, unless the altered sandstones and slates in the Murrambridgee district belong to the Lower Silurian; the latter group however in Victoria are estimated to be not less than 35,000 ft. thick.

The Upper Silurian occur in many places throughout the Colony, but chiefly on the western watershed of the Great Dividing Range. They consist of conglomerates, sandstones, slates, and limestones, in some places highly contorted and cleaved and considerably metamorphosed, near Bathurst, and even altered into gneissoid granite as at Adelong. Some beds are rich in corals, crinoids, mollusca, and trilobites, specially near Yass, the limestone of this and other localities being chiefly composed of corals and crinoids. Mr. Wilkinson enumerates about 70 species from these beds.

The Devonian consist of sandstones, conglomerates and limestones, the lower beds of which are related by their fossils to the Silurian, and the upper to the Carboniferous. Near Rydal these beds are not less than 10,000 feet thick. The fossils have been examined by Prof. De Koninck, and comprise about eighty species.

The Carboniferous strata are about 10,000 feet thick, the lower beds contain many plants and a marine fauna, but no workable coal-seams are known. Gold-bearing quartz reefs however traverse this series and are worked in the Copeland gold-field. The Upper Carboniferous series include the Lower Coal-measures of N. S. Wales, they comprise marine strata with interstratified plant-beds and workable coal seams, one being, as at Greta, 26 feet thick. The *Glossopteris* and *Phyllotheca* occur with an undoubted marine Carboniferous fauna, while in India Dr. Feistmantel regards the *Glossopteris* beds as of Triassic age. More than 200 species of plants and invertebrata have been obtained from this series. The Upper Coal-measures are provisionally classed as Permian, they contain abundant plant-remains, *Glossopteris*, etc., but no marine shells. Nearly all the coal-seams of the Newcastle Coal-field occur in this upper series. About 25 fossil plants and one heterocercal fish have been noticed.

The lithological characters and fossil contents of the Mesozoic group are successively given, including the Hawkesbury and Wianamatta series of Triassic? age, the Clarence river beds (Jurassic), and strata in the north-western portion of the Colony which are provisionally referred to the Lower Cretaceous.

Mr. Wilkinson describes somewhat fully the Cainozoic or Tertiary strata; they are of the highest economical importance in yielding the chief supply of gold and tin production of N. S. Wales, and are also replete with scientific interest, "for not only in them may be traced the development of the principal physical features which form our beautiful landscape scenery, but they also reveal much information regarding the early history of the ancient forms of life now characteristic of this portion of the globe."

The last two pages are devoted to the igneous and metamorphic rocks, the former of which occupy about one-eighth of the whole area of the Colony, or not less than 39,500 square miles; while under metamorphic rocks some interesting points are discussed as to alteration and gradual passage of the sedimentary into the igneous rocks. Altogether those interested in Australian geology will be indebted to Mr. Wilkinson for this careful and useful *resumé* of the geology of N. S. Wales, accompanied as it is by an excellent geological sketch-map compiled by the author from the original map of the late Rev. W. B. Clarke.

The report on the minerals of N. S. Wales by Prof. A. Liversidge is the second edition of a paper published in the Trans. Roy. Soc. N. S. Wales for 1874. Since that time every opportunity has been taken advantage of, to correct and add to it; special attention has been paid to the chemical composition of the minerals, and a useful list of localities is appended.

The Catalogue of the Reports and Works on the the Geology, Palæontology, etc., of the Australian continent by Messrs. R. Etheridge, junr. and R. L. Jack, has been already noticed in the GEOLOGICAL MAGAZINE (1883, Vol. X. p. 44). J. M.

III.—GEOLOGY. Part I. PHYSICAL GEOLOGY. By A. H. GREEN, M.A., F.G.S., Professor of Geology in the Yorkshire College, Leeds. Third Edition. (London: Rivingtons, 1882.)

IN the GEOLOGICAL MAGAZINE, for January, 1877, the first edition of this excellent manual was brought before the notice of our readers; we have now much pleasure in calling attention to the third edition. The author has abbreviated the title of his work, changed his publisher, increased the number of pages from 552 to 728, and the number of woodcuts from 143 to 236. The change of title is right—the book is admirably adapted for advanced students and teachers, but is by no means likely to attract "general readers." The first 186 pages of the work are devoted (with the exception of a short historical sketch) to Mineralogy and Crystallography, rock-forming minerals and rocks, and it is only when we come to "denuding agents and how they work" (page 187) that the matter would be at all interesting to an elementary student or general reader; and he might read on happily through the next chapter, which tells him what becomes of the waste produced and carried off by denudation, and describes the method of formation of bedded rocks, and some structures impressed on them after their formation. Chapter v. (pp. 304-338) contains a lithological description of the "Confusedly-crystalline rocks," and is necessarily dry, though a capital introduction to Petrology. In this way, with alternations of pleasant and easy reading on volcanos and volcanic action, and subterranean disturbances, with more or less detailed accounts of rocks and rock-structure, we reach chapter xii., which deals with Mineral Deposits and Metallic Ores.

One of the most interesting portions of the book (chapter xiii.) explains how the present surface of the ground has been produced by sea and subaerial agents. In speaking of the origin of certain lakes, Prof. Green says, "The arguments in favour of the glacial origin of many rock-basins are very forcible, even though we may not yet have hit on the exact nature of the mechanism by which ice has been able to scoop out these hollows; but while we admit this, we must not lose sight of the possibility of some rock-basins, specially some very large ones, having been formed by subterranean movements in the manner already described." Chapter xiv. on the original fluidity and present condition of the interior of the earth—the cause of upheaval and contortion—the origin of the heat required for volcanic energy and metamorphism—with remarks on speculative geology; and chapter xv.

on changes of climate, and how they have been brought about, conclude the work, and furnish us with a very careful and impartial statement of our present knowledge on these debateable subjects.

Full references are given to memoirs that treat in detail of the subjects sketched and discussed, and we are glad to notice that the labours of our American geological brethren are duly appreciated. The illustrations are very clear and in many cases pictorial. The work was most highly spoken of in the former notice: it is now brought up to date, and we can only express our hope that it will find its way into the library of every working geologist.

Geology of Asturias and Galicia.

(First Notice.)

IV.—Recherches sur les terrains anciens des Asturies et de la Galice. Par Dr. Charles Barrois. Extrait des Mémoires de la Soc. Géol. du Nord. Tome 2, 1882.

THIS great work, which occupies 630 quarto pages of letter-press, and is accompanied by 20 plates, details the observations and researches of the author, commenced in 1877, and communicated in parts to the "Société Géologique du Nord" during the years 1880 and 1881. The district to which he has devoted so much labour is situated on the north-west coast of Spain, and had been proved to be of great interest by previous observers who had made known some of the treasures of its "Primordial fauna" and of its Devonian rocks. In an Historical Introduction we are presented by Dr. Barrois with a sketch of these earlier writings and a list of the Memoirs, the first of which dates as far back as 1644, and among the authors of which we note the names of Schulz, Paillette, De Verneuil, Collomb, and Casiano de Prado.

The first part of the work is devoted to Lithology, commencing with a description of the sedimentary rocks, comprising clay-slates, quartzites, limestones, mimophyres (a kind of porphyroid), granites, quartz-porphyries, diorites, diabases, etc. These are illustrated by three plates of microscopic sections.

The second part is devoted to Palæontology, commencing with an account of the fossils of the Cambrian and Silurian rocks. Some new species are added, the author appending the initials C. B. to avoid the confusion that might arise with the name of Barrande. New species of Trilobites, Bilobites (Algæ ?), and of several forms allied to *Scolithes*, and one new species of *Lingulella* are described and figured.

The fauna of the Devonian and Carboniferous rocks is next taken into consideration. Several new species of Corals are described, and some are exquisitely reproduced by a process of "Phototypie." The Foraminifera, Sponges, Crinoidea, Polyzoa, Echinodermata, Brachiopoda, Lamellibranchiata, Gasteropoda, Cephalopoda, Pteropoda, Ostracoda, Annelida, Trilobites, and one Ichthyodorulite are described, and many, including the new species, are figured.

The third part of the work is devoted to Stratigraphy—to the composition and succession of the strata.

The Primitive rocks comprise a lower division of mica-schists, and an upper division of chloritic talcose and other schists, with subordinate beds of quartzite, serpentine, etc.

The Cambrian rocks consist of slates and "*phyllades*" with beds of quartzite and limestone, having a thickness of about 3000 mètres, and they are intercalated in the Cantabrian mountains, between the Primitive crystalline schists and the Silurian rocks (*grès à Scolithes*). The system contains the Primordial fauna of M. Barrande, in its upper part, but the author has not been able to recognize any important line of division between this and the much thicker lower azoic portion of the system. Together they appear to represent the Harlech, Llanberis, Longmynd, and Menevian groups, and the Lingula Flags and Tremadoc Slates.

The Silurian rocks, which attain a thickness of from 700 to 1000 mètres, are grouped into Lower, Middle and Upper Silurian, and include the second and third faunas of Barrande. The beds are said to rest conformably upon the Cambrian rocks, and to be overlain conformably by the Lower Devonian strata.

The Devonian strata, consisting of limestones, slates, and red sandstone, reach a thickness of about 1000 mètres. They are a conformable series, and are divided into eight zones distinguished by lithological as well as palæontological characters. The grouping adopted by Dr. Barrois is as follows:—

Devonian	Upper.	Famennian.	
		Frasnian.	
	Middle.	Givetian.	
	Lower.	Eifelian	
		Coblenzian	Upper.
			Lower.
		Taunusian.	
		Gedinnian (not represented).	

The Carboniferous strata repose transgressively on Devonian, Silurian, and Cambrian rocks, but on the eastern borders of the Devonian area, where the oldest Carboniferous strata are met with, they rest conformably on the Devonian rocks.

The Carboniferous strata, which attain a thickness of upwards of 2000 mètres, are thus grouped:—

Carboniferous	Coal-measures (Houiller)	Upper Coal-measures.
		Middle Coal-measures.
	Anthraciferous Carboniferian (Sub-Carboniferous, or Bernician).	

On page 358, the Permian strata (*Mimophyres de Gargantada*) are bracketed with the Carboniferous system.

A concluding chapter is devoted to the phenomena which have modified the Palæozoic strata since the period of their formation. The former existence of glaciers, in the Quaternary period, on the Cantabrian mountains, as evidenced by the accumulations of drift, and various other agents of denudation, as well as those of disturbance, are briefly mentioned.

This is but a bald outline of a work which embodies the results not merely of extensive study in the field, and of very painstaking literary research, but also of much original work on the rocks and fossils and the problems connected with them. It is not without a slight feeling of amazement that we contemplate the many-sided labours of Dr. Barrois—the notes on the mineral characters of the various igneous rocks, and the formation of limestones, the general remarks on the deposition of the strata, and their relations to other groups in various parts of Europe, the full lists of fossils, and above all the descriptions of new species of organic remains belonging to so many different classes, indicate a range of knowledge that very few dare essay to attain.

H. B. W.

V.—De Svenska arterna af Trilobitslägtet Illænus (Dalman). Af Gerhard Holm. Med sex Taflor. Bihang till K. Svenska Vet. Akad. Handlingar, Band 7, No. 3. (Stockholm: Norstedt & Söner, 1882.)

The Swedish Species of the Genus Illænus (Dalman). By Gerhard Holm. Supplement to the Proceedings of the Royal Swedish Academy, Vol. 7, No. 3. 8vo. pp. 148. With 6 Plates.

This memoir covers wider ground than is implied in its title; for, besides a minute description of all the Trilobites belonging to this genus which are found in Swedish strata, it also contains a general history of the genus, and of all the known species placed under it, with references to the works in which they have been described and the strata and country where found, and also the known portions of the body of each species; so that in a sense it may be regarded as a condensed monograph of the genus.

The author follows Barrande in placing the genus under two subdivisions: (1) *Illænus* in the strict sense of Dalman, and (2) *Bumastes*, Murchison. Salter split this genus into eight sub-genera, partly according to the number of the body-segments; but with the exception of *Bumastes* and *Illænopsis* (probably a quite distinct genus) Dr. Holm rejects Salter's divisions.

To all workers in Ordovian strata the general features of the genus are well known. The body is oval or elliptic, strongly convex, the head and pygidium are about the same size, the thoracic segments vary from 8 to 10 in number, eyes are mostly present, though some species are destitute of them. The genus has its greatest development in the Ordovian period, it passes up to the Silurian proper, but not beyond. The author catalogues no fewer than 100 species; of which 85 belong to *Illænus* proper, and 15 to *Bumastes*. In North America 35 species are known, in Sweden 19, Great Britain 17, Bohemia 17, Russia 15, Norway 4, Spain and Portugal 3, France 2, Asia (Himalaya) 2, Bavaria 1, Australia 1.

Of the 19 Swedish species, 10 are here described as new; they make their first appearance in that country in the Orthoceras-kalk; then in the Chasmops-kalk, where they are most numerous; Trinucleus shales, the Brachiopoda shales with a single species, the Leptæna-kalk, and finally in the Silurian proper (öfver-silur), with two species of *Bumastes*.

Though written in Swedish, the generic and specific characters are also given in Latin. The new species, as well as some previously known, are figured.

G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 7, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read :—

1. "On Gray and Milne's Seismographic Apparatus." By Thomas Gray, Esq., B.Sc., F.R.S.E. Communicated by the President.

This apparatus was stated to have for its object the registration of the time of occurrence, the duration, and the nature, magnitude and period of the motions of the earth during an earthquake. The instrument was made by Mr. James White, Glasgow, and is to be used by Prof. John Milne in his investigations in Japan.

In this apparatus two mutually rectangular components of the horizontal motion of the earth are recorded on a sheet of smoked paper wound round a drum, kept continuously in motion by clock-work, by means of two conical pendulum-seismographs. The vertical motion is recorded on the same sheet of paper by means of a compensated-spring seismograph. In details these instruments differ considerably from those described in the Philosophical Magazine for September, 1881, but the principle is the same.

The time of occurrence of an earthquake is determined by causing the circuit of two electromagnets to be closed by the shaking. One of these magnets relieves a mechanism, forming part of a time-keeper, which causes the dial of the timepiece to come suddenly forward on the hands and then move back to its original position. The hands are provided with ink-pads, which mark their positions on the dial, thus indicating the hour, minute, and second when the circuit was closed. The second electromagnet causes a pointer to make a mark on the paper receiving the record of the motion. This mark indicates the part of the earthquake at which the circuit was closed.

The duration of the earthquake is estimated from the length of the record on the smoked paper and the rate of motion of the drum. The nature and period of the different movements are obtained from the curves drawn on the paper.

2. "Notes on some Fossils, chiefly Mollusca, from the Inferior Oolite." By the Rev. G. F. Whidborne, M.A., F.G.S.

The fossils described by the author are, with the exception of some in the British Museum and a few of his own collecting, in the collections from the Inferior Oolite which enrich the Bristol Museum. Several of the species are new; of these there are *Ostræa* 2, *Gryphæa* 3, *Exogyra* 1, *Pecten* 4, *Harpax* 1, *Plicatula* 1, *Placuna* 1, *Gervillia* 3, *Pinna* 2, *Lima* 11, *Mytilus* 2, *Arca* 3, *Nucula* 1, *Cardium* 2, *Cypricardia* 1, *Myoconcha* 2, *Astarte* 1, *Opis* 1, *Thracia* 1, *Pholadomya* 3, *Myacites* 1, and *Terebratula* 2, besides one or two more that are doubtful.

3. "On some Fossil Sponges from the Inferior Oolite." By Prof. W. J. Sollas, M.A., F.G.S.

Some fossil Sponges have been described from the Inferior Oolite of the continent, but hitherto none have appeared in the lists of fossils from this formation in British localities. The collection of Sponges described by the author was made by the Rev. G. F. Whidborne. The author described 11 species (6 of which he identified with those already described from continental localities) belonging to 9 genera, and concluded his paper with some general remarks. These Sponges are calcareous, but are considered by the author to have been originally siliceous, replacement of the one mineral by the other having taken place as already noticed by him. The beds in which these Sponges are found bear all the appearance of being comparatively shallow-water deposits.

4. "On the Dinosaurs from the Maastricht Beds." By Prof. H. G. Seeley, F.R.S., F.G.S.

In this paper the author described five fragmentary bones arranged among the remains of *Mosasaurus* in the Van-Breda collection when received by the British Museum. One of these is a femur wanting the distal end, and worn at the proximal extremity, 11½ inches long, with an average thickness of about 1½ inch, and "remarkable for its slender form, its superior bow-shape curvature, the lateral compression of the proximal articulation, and the extent to which it is directed inward, for the trochanter, which is separated from the proximal end of the bone in front, and for the proximal position and small size of the lateral trochanter." For the species indicated by this bone the author proposed the name of *Megalosaurus Bredai.*

Another femur, slightly imperfect at its articular end, 19½ inches long, has a remarkably straight and strong shaft, subtriangular at the proximal end, subquadrate in its lower part, and bearing the lateral trochanter in the middle, and has the proximal and distal ends modified on the Iguanodont plan. This form was considered by the author nearly allied to *Iguanodon*, and to approach *Hadrosaurus* in most points in which it differs from the former genus. He proposed to establish for it a new genus, *Orthomerus*, and to name the species *O. Dolloi.* The collection further included a tibia and metatarsal bone referable to the same form. These Maastricht Dinosaurs furnish the most recent known evidence of the existence of the order.

II.—March 21, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communication was read:—

"On the Supposed Pre-Cambrian Rocks of St. David's." By Archibald Geikie, Esq., LL.D., F.R.S. (Part I.)

The author began by briefly narrating the circumstances under which he had been led to study the geology of St. David's. He had visited the district twice, first in company with Mr. B. N. Peach, with whose cooperation nearly all the field-work was done, and again in conjunction with Mr. W. Topley. The paper was divided into two parts, the first being mainly controversial, and the second descriptive. Only the first part was read.

PART I.

According to Dr. Hicks there are at St. David's three distinct Pre-

Cambrian formations;—the "Dimetian," consisting of crystalline, gneissic, and granitoid rocks; the "Arvonian," formed of felsites, quartz-porphyries, hälleflintas, and other highly silicated rocks; and the "Pebidian," composed of tuffs, volcanic breccias, and basic lavas. He regards the "Arvonian" as later than, and unconformable to the "Dimetian," and the Pebidian as younger than, and unconformable to both; and he asserts that the basement conglomerate of the Cambrian system lies quite unconformably on all these rocks, and is in great part made up out of their waste.

Taking up each of these groups in the order of sequence assigned to them, the author maintained that the "Dimetian group" is an eruptive granite, which has disrupted and altered the Cambrian strata, even above the horizon of the supposed basal conglomerate. He described a series of natural sections where this relation is exposed, particularly one on the coast at Ogof-Llesugn, where the conglomerate has been torn off and involved in the granite, and has been intensely indurated, so as to become a kind of pebbly quartzite. No other rock occurs within the granite mass except dykes of diabase, which rise through all the rocks of the district, but are especially abundant in the granite. The veins of finer granite, so general in granite areas, are conspicuous here. In short, whether studied in hand-specimens or on the ground, the rock is so unmistakably an eruptive mass that the author could not understand how this view, which was that expressed on the Geological Survey maps, should ever have been called in question. The manner in which it has risen across the bedding of successive horizons in the Cambrian series proves that, instead of being a Pre-Cambrian gneiss, it must be much younger than all the Cambrian rocks of the district.

The "Arvonian group" consists of quartziferous porphyries, or elvans, associated with the granite, and of the metamorphosed strata in their vicinity. Reference was made to natural sections where the actual intrusion of the elvans across the bedding of the rocks could be seen.

The "Pebidian group" comprises a series of volcanic tuffs and breccias, with interstratified and intrusive lavas. The author maintained that this group forms an integral part of the Cambrian system as developed at St. David's. It has been broken through by the granite and porphyries, and is therefore of older date. Instead of being covered unconformably by the Cambrian conglomerate, as asserted by Dr. Hicks, the volcanic group is covered quite conformably by that rock; and seams of tuff are interstratified with the conglomerate and occur on various horizons above it. The conglomerate, instead of being mainly composed of fragments of the rocks beneath it, consists entirely of quartz and quartzite, only four per cent. of fragments having been found to have been derived from some of the projecting lava-islands underneath it.

From the evidence now brought forward, the author contended that as the names "Dimetian," "Arvonian" and "Pebidian," had been founded on error of observation, they ought to be dropped out of geological literature.

Norfolk and Norwich Naturalists' Society. — On Tuesday, Jan. 30th, a paper was communicated by Mr. C. Reid, of Her Majesty's Geological Survey, on a species of *Lithoglyphus* from the Weybourn Crag. Among the mollusca recently found in the Weybourn Crag, near Cromer, Mr. Reid discovered several specimens of a shell, which, when compared with *Lithoglyphus fuscus* in the British Museum, was found to correspond exactly with it. Mr. Reid said that the two Danubian species, *L. fuscus* and *L. naticoides*, were closely allied, but though one was figured in Woodward's Mollusca, they were neither of them included in any monograph on British shells. He considered the discovery of this freshwater shell associated with *Corbicula fluminalis* in England to be of special interest. *Lithoglyphus fuscus* is only found living in Europe in the present day in the river Danube; it is also said to be found in South America.—*Eastern Daily Press*, Feb. 5, 1883.

CORRESPONDENCE.

REPLY TO MR. MELLARD READE.

Sir,—The point near Aylmerton which Mr. T. M. Reade writes you (apropos of my objection to his view of the source of the masses transported into the Contorted Drift of North-east Norfolk), is the highest to which the Ordnance Survey has levelled in Norfolk, is near the Cromer Coast, and about two miles and a half from Cromer Lighthouse hill, mentioned by me as not much exceeded in elevation by any point in Norfolk. The whole (or very nearly so) of this 331 feet is, like Cromer Lighthouse hill, made up of the bed of the sea into which the ice in grounding thrust the masses of reconstructed, *i.e.* morainic, chalk which appear in the cliff section, and are worked in numerous pits inland (at Aylmerton among the rest); and the position of these masses show that their grounding took place up to the point when all, save the very uppermost part, of this sea-bed had accumulated.

The English Encyclopædia notwithstanding, West Norfolk is all below, and most of it much below this. How, therefore, could cliffs there, as Mr. Reade supposes, have furnished these masses to the transporting ice?

Great banks of the material of which these masses are composed, formed by extrusion from the land-ice where it at this time terminated at the sea, occur near (and in one place flush with and up to the top of) the west side of the Chalk Wold, in Central Lincolnshire; and it is there, and there only, that the conditions are to be found which answer to the source of these masses.

Searles V. Wood.

March 22nd, 1883.

THE

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No. VI.—JUNE, 1883.

ORIGINAL ARTICLES.

I.—Origin of Continents.

By W. O. Crosby, Esq.;

Of the Museum of he Boston Society of Natural History, etc., etc., Boston, U.S.A.

THE theory of the origin of continents and ocean-basins developed during the last third of a century, chiefly by Prof. Dana, and commonly known as Prof. Dana's theory, is now accepted by many geologists. The main points in this theory, as gathered from the latest expression of Prof. Dana's views, are the following:[1]—The earth, superficially at least, is, and was originally, before it had a solid crust, of unlike composition on different sides. This heterogeneity caused a corresponding difference in heat-conductivity. The more rapidly conducting areas cooled fastest and were the first to become covered with a solid crust. Solidification is attended by contraction; and therefore the newly formed crust must have been heavier than the liquid immediately beneath it. As a consequence, it broke up and sank until it reached a liquid stratum of the same specific gravity as itself; and afterwards the process of crusting and sinking went on until a solid crust was built up from this point to the surface. Through the continued escape of heat this primitive crust is thickened, and is still thickening by additions to its lower surface. These first formed portions of the crust became, and will always continue to be, the continents. The remainder of the earth's surface was still liquid, after the solidification of the continental areas was well advanced; and, of course, as long as it continued liquid, its surface was level with that of the crust-areas. Finally, it became the theatre of a similar process of crusting and sinking, and at last permanently froze over. Now the main point is that the contraction of this inter-continental crust during its formation caused its surface to sink below that of the continents; and the depressions thus developed became the future ocean-basins, which, like the continents, are necessarily of a permanent character. Indeed, it is a plain deduction from Prof. Dana's theory that the existing continents and oceans are as old as the earth's crust; and that during the course of geological time the continents have become constantly wider and the oceans deeper.

This hypothesis has to a considerable extent supplanted that held by Lyell and the earlier geologists, according to which the continents and ocean-basins are great upward and downward bendings of the earth's crust, and not necessarily fixed. Many of the ablest geologists, however, still hold that the old theory has

[1] Amer. Journ. Sc. (3), vols. v. and vi.

a far stronger claim than the new to the title of the true theory of continents and ocean-basins.

Many weighty objections to the modern theory have appeared in these pages within a few years. But it appears to the present writer that there are important arguments against this theory which have not yet been stated; and the object of this article is to bring forward some of these. Since, however, they bear with equal force against the theory advocated by Archdeacon Pratt and Prof. Joseph Le Conte, which differs in some important features from Prof. Dana's theory, I will first contrast these two theories, before pointing out the defects common to both.

The following statement of Prof. Le Conte's theory is given in his own words[1]:—"Continental surfaces and ocean-bottoms are due to *unequal* radial contraction of the earth in its secular cooling. It is evident that in such secular cooling and contraction, unless the earth were perfectly homogeneous, some parts being more conductive would cool and contract more rapidly in a radial direction than others. Thus some radii would become shorter than others. The more conductive, rapidly contracting portions, with the shorter radii, would become sea-bottoms; and the less conductive, less rapidly contracting portions, with the longer radii, land-surfaces. In other words, the solid earth becomes slightly deformed and the water collects in the depressions." Le Conte and Pratt further hold that the quantity of matter along each of the terrestrial radii was not only originally, but is yet, essentially equal; "the matter being denser along the shorter oceanic than along the longer continental radii."

Certain passages in Le Conte's writings lead one to infer that he regards his theory as essentially similar to Prof. Dana's. Nevertheless, the language quoted above shows that the difference is fundamental. They agree in requiring (1) an heterogeneous earth as a basis for unequal radial contraction, and (2) fixed continents and oceans; but beyond that they are diametrically opposed. For instance, Prof. Dana says that the more rapidly conducting and cooling areas form the continents; while Prof. Le Conte says they form the ocean-bottoms. Again, according to Prof. Dana's theory, the continents, during the course of geological time, have become higher and broader, and the oceans deeper and narrower. But just the reverse is an unavoidable deduction from Prof. Le Conte's theory; for, as the refrigeration of the earth continues, the contraction along the longer or continental radii must sooner or later begin to gain upon that along the shorter or oceanic radii; and from that moment the continents begin to subside, and are ultimately lost beneath the surface of the universal ocean.

Profs. Dana and Le Conte agree, however, upon the main point against which the following arguments are advanced, viz. that the continents and ocean-basins are permanent, their present positions being those which they occupied at the beginning of geological time.

These theories rest at the outset upon an assumption which is

[1] Elements of Geology; and Amer. Journ. Sci. (3) vol. iv. p. 352.

not supported by a vestige of evidence, viz. that the earth was originally, and is now, of unlike composition along different radii, or on different sides; the continental portions of the crust, according to Prof. Dana, being composed of denser materials than the oceanic, while according to Prof. Le Conte, the relation is just the reverse. If the liquid globe had possessed this constitution, the ellipsoidal form of the equatorial section, which under the most refined measurements of geodesy almost disappears, would, in obedience to the laws of hydrostatic equilibrium, be strongly marked.

It seems strange that an assumption so vital to these theories should have been made without any attempt to demonstrate its validity. What are the facts that support it? Where are the analyses showing an essential difference in composition between the continents and ocean-bottoms? We may safely say that the known facts and the probabilities are all against the supposition that such a difference exists. But without this unproved difference in composition there could be no difference in conductivity and radial contraction, and the theories entirely fail.

However, granting the possibility of this diversity of composition, it still fails as a foundation for the theory that the continents are fixed, since it could only have been a very transient characteristic of the crust. For, as Prof. Dana admits, the elevation or subsidence of large areas of the crust must involve a horizontal displacement of liquid material beneath, material under the Pacific, for example, being squeezed under the bordering continents. This process, of course, mixes up the matter which by cooling forms continents and ocean-basins through unequal contraction; and the areas of high and low conductivity are no longer kept distinct.

But we may grant farther the possibility of a permanent difference in composition, and still doubt the necessity of Professor Dana's inferences. As a rule, dense bodies are not only good conductors of heat, but also have low fusing points. This is eminently true of the main constituents of the earth's crust. The most favourable supposition that could be made for Prof. Dana's theory would be that the continents have, or had originally, the composition of basalt; and the sea-floors the composition of granite; and in any case the difference in composition must be regarded as similar to, but less rather than greater than, that between basalt and granite.

If, however, areas of liquid basalt and granite have the same initial temperature, and cool under identical conditions, it does not necessarily follow that the basalt areas will solidify first. The basalt, on account of its greater conductivity, loses heat more rapidly than the granite; and yet, in view of the higher fusing point of the granite, the probabilities are that it would first assume the solid state, the two rocks being wider apart in their fusing points than in their power of conducting heat. This conclusion is abundantly sustained by the observations made on the relative liquidity of basic and acidic lavas.

In this connexion, Prof. Dana offers the following explanation of the fact that the land is mainly in the northern hemisphere:—The southern hemisphere is composed of heavier material than the northern, and consequently the ocean is attracted in the former direction. But it will not escape observation that this admission that the densest matter is under the sea sustains the point made in the last paragraph, and is a direct contradiction of the most essential part of Prof. Dana's theory of the origin of continents.

Prof. Dana says that his theory accounts for the abrupt slopes of the continental borders, the oceans deepening rapidly and not gradually after we cross the true edge of the continents. But it seems to the present writer that this is just what Prof. Dana's theory does not account for. For, if we were to admit that the earth is of different composition on different sides, it would certainly be contrary to all analogy to suppose that the areas of different composition are sharply marked off from each other; and yet the steep slopes of the oceanic depressions, according to this theory, require an abrupt change in radial contraction, and consequently in conductivity and composition.

Let us next inquire whether unequal contraction of the continental and oceanic areas could produce the depressions of the earth's surface. We will suppose, with Professor Dana, that average rocks contract eight per cent. between the liquid and solid states, and make the extremely favourable supposition that the oceanic areas remained liquid until the continents became entirely solid. Now Prof. Dana says the average depth of the depressions is three miles, equal to the contraction resulting from the solidification of about thirty-eight miles of rock. There is one point of vital importance, however, which has been entirely neglected, viz. the transference of material, as the result of denudation, from the continents to the sea-floors. If the continents and oceans are fixed, this action must have been always in the same direction. Few geologists estimate the average thickness of the stratified rocks at less than ten miles; but it will be claimed by those believing in the theory that the sediments must be much thinner over the floor of the central ocean; therefore, we will assume five miles as the average thickness for the globe, and allow that they are three-fourths on the continents now. But to restore to the continents what they have lost according to this supposition would increase the height of the land and the general inequality of the surface at least five miles, which, added to the existing relief of three miles, gives eight miles as the excess of contraction of oceanic over continental areas, corresponding to a crust 100 miles thick. Remembering, however, that, according to Prof. Dana, most of this detritus was derived from much smaller continents, say one-half as large, and it is seen that the excess of contraction of the oceanic areas corresponds to a crust over 200 miles thick. It seems no exaggeration, therefore, to say that a clear statement of this part of the theory is sufficient to refute it.

No proposition in geology is more firmly established than this: during the whole of geological time the earth's crust has been subject to extensive and widespread oscillations, and we know beyond a doubt that these movements are still in progress. Geologists do not now generally believe that the profound subsidences permitting the deposition of thick sedimentary formations are produced by these same sediments; but they rather agree with Prof. Dana that the oscillations are due to lateral pressure and go on independently of the sedimentary process. But this view certainly does not harmonize well with the notion that these great vertical movements of the crust are merely local phenomena. On the contrary, all will concede that it is more reasonable to suppose that the area affected is, on the average, roughly proportional to the change of level.

Now the subsidence of 40,000 feet in the Alleghany region during Palæozoic time did not make a deep ocean *there*, because deposition kept pace with the downward movement. But where is the evidence that the subsidence was limited to the eastern border of that great Palæozoic sea? Are we not, in accordance with the foregoing, at liberty to conclude that it affected, perhaps in equal measure, the central portions of the sea, where the deposition was only one-tenth as rapid as in the east? To answer in the affirmative is to admit that a large part of the present continent was the site of the abyssal ocean. If, as we believe, the great oscillations of the crust go on independently of deposition, it is certainly strange that they should be limited to the neighbourhood of coast-lines. Prof. Dana admits that the important upward movements of the crust affect extensive areas, as witness the elevation of North America, Europe and Asia in the Tertiary period, and the elevation of South America at the present time; and no good reason is apparent for denying that the same holds true with important downward movements. But speculation is unnecessary here, because the coral-islands of the Pacific are monuments of a subsidence which is at once profound and widespread.

According to Prof. Dana and the great majority of geologists, the important movements of the crust are necessarily reciprocal, one part rising as the other sinks; and Prof. Dana says further that the oceanic crust is more flexible and rests on more mobile material than the continental. Why, then, should he, with the certain knowledge of a Palæozoic subsidence of 40,000 feet in the Alleghany region, a Mesozoic subsidence of 50,000 feet in Central Europe, and a subsidence in the Rocky Mountains, according to King, of 60,000 feet, etc., hold that it is extremely improbable that any part of the floor of the deep sea ever has been or will be elevated to form dry land? Again, what basis is there for the view that all extensive upward movements are confined to the land areas? It certainly is a strange doctrine that, while the stable continental crust is subject to repeated up and down movements of from *one to ten miles*, the (according to Prof. Dana) comparatively flexible oceanic crust is only susceptible of slight oscillations, in addition to a slowly progressing subsidence covering the whole of geological time.

As Prof. Dana has shown, however, the coral-islands testify that a large part of the floor of the Pacific has subsided from 3,000 to at least 10,000 feet in quite recent geological times. He also insists that this subsidence is a true downward *bending* of the crust, that the ocean-floor moves as a unit, and that the entire crust of the earth is involved in the movement. But 10,000 feet subtracted from the depth of the Pacific would make it a very shallow ocean; and its islands would be vastly more numerous and larger than they are now. In fact, the central Pacific, before the subsidence began, was probably as continental as the major portions of Europe and Asia during the early Tertiary epochs. Now, since this coral-island subsidence is not the result of radial contraction, what large element of improbability is there in the supposition that it may some day be reversed to the extent of 10,000 or even 20,000 feet? Nearly all the land bordering the Pacific is rising, and rising probably (as Prof. Dana has suggested) as a joint and complementary effect of the same great cause that produces the oceanic subsidence. It is safe to assume, however, that these continental movements will, sooner or later, be reversed; and when that happens, will not the Pacific subsidence be almost necessarily reversed too?

The formation of extensive deposits of sediments requires a continent as well as an ocean. So far as our present purpose is concerned, we may say that the continents are entirely composed of stratified rocks, there being no igneous rocks, except such as have come up through the stratified series. In other words, no part of the primitive or unstratified crust is anywhere exposed. Furthermore, the old crystalline or Eozoic formations, which, according to Prof. Dana, formed the first land, and the nuclei about which the present continents have been developed, are of enormous thickness. Where was the land whose waste afforded the material for building these tens of thousands of feet of strata? It is clear that extensive bodies of land, in other words, *continents*, were in existence before any part of the land of to-day had appeared above the sea. But, without pressing farther the question as to how, if the theory is correct, the modern continents ever came to have a beginning, let us advance a step and look for the source of the materials composing the subsequent additions to the continents, including the Palæozoic and all later formations. According to Professor Dana, they were derived entirely from the comparatively small Eozoic areas. This, however, means many miles of erosion, and necessarily implies either that this primitive land had originally an incredible height, or that during the course of geological time it has been constantly renewed by elevation as fast as worn away. But what are we to think of the original volume of formations which could suffer this enormous waste and still have a thickness measured by miles? We could not emphasize more strongly the absolute necessity of extensive Pre-Eozoic continents to serve as a source of Eozoic sediments.

It is said that all the stratified rocks exposed on the continents are shallow-water deposits, and consequently that the floor of the deep sea has never been elevated to form land. This proposition is more easily stated than demonstrated. Among the crystalline sediments, especially, there are many kinds which, for aught that we can now determine, may very well have had a deep-sea origin; but the subsequent development of crystalline characters has, in most cases, made it impracticable to trace their histories. There is nothing in our great formations of white crystalline limestone indicating that they are shallow-water deposits; and it is simply begging the question to set them down as such. Their purity and uniformity are favourable to the view that they have not been formed near the land.

The Radiolarian and Diatom oozes and glauconite now accumulating in the deep sea are fairly represented among the formations exposed on the land. And Mr. Wallace's arguments against the identity of the Globigerina ooze and chalk have been, to a great extent at least, satisfactorily answered by Mr. Gardner and other writers. The chief objection which Mr. Wallace raises is that the chalk and ooze differ widely in composition. But the silica in the ooze is sufficiently accounted for in the flints of the chalk. And as for the other constituents, it may be said that the Cretaceous age closed several millions of years ago, a time long enough to permit considerable changes in the character of the deep-sea oozes. The alumina and iron in the ooze are chiefly the insoluble residue of the volcanic dust spread everywhere over the ocean-floor; they form a part of all marine formations, and the fact that they are conspicuous constituents of the calcareous ooze simply implies that the Foraminifera shells accumulate with extreme slowness at the present time. To make the ooze chemically identical with the chalk, we have only to increase the rate of the organic deposition. But Mr. Wallace has already done this for the Cretaceous period; for he shows, first, that the abundance of the pelagic Foraminifera, of the calcareous tests of which both the chalk and ooze are mainly composed, is, other things being equal, proportional to the temperature of the water; and, second, that the Cretaceous seas of Europe were very warm. He conceives that a land-barrier stretched from Scandinavia to Greenland, concentrating the Gulf Stream and directing it across the site of modern Europe.

Mr. Wallace's explanation of the chalk of Europe embraces propositions that are not easily reconciled. For he insists, and rightly, upon the great purity of the chalk, and yet holds that it was deposited in a shallow and narrow sea. He derives the chalk in large part from the comminution of coral-rock, and yet names only two points in Europe where coral-reefs of Cretaceous age may be observed; and refers to no modern coral-reef where chalk is now forming in this way. The Oahu deposit belongs to the past, and is very small, twenty to thirty feet across, and eight to ten feet thick, and entirely destitute of Foraminifera. The chalk contains no corals nor fragments of corals, nor does it shade off at the borders into coarser calcareous rocks composed of broken coral; and in no modern ocean are the coral-reefs entirely converted, as fast as formed, to an impalpable slime or ooze.

The truly abyssal deposit of the modern ocean is the red clay which is found at nearly all depths below 2,500 fathoms, and, according to Sir Wyville Thomson, covers not less than ten million square miles of the ocean-floor. We have been told by Sir Wyville and others that this red clay is not matched by any rock now exposed on the continents, although Sir Wyville earlier expressed the opinion that a deposit of this red clay might come to be very like one of the ferruginous Palæozoic schists.

But the point that I wish to raise now is embodied in the following question: Are there any deep-sea deposits? If, as I believe, this question may be fairly answered in the negative, then the argument that these sediments are not represented on the continents ceases to have any weight. Now nothing has been more clearly demonstrated by the deep-sea explorations of the last fifteen years than that the abyssal sediments, and especially the red clay, are accumulating very slowly. Over the red clay areas, the dredge brings up large numbers of nodules of the iron and manganese per-oxides; and Sir Wyville Thomson has shown that we have in these nodules and in some of their nuclei "ample evidence that this abyssal deposit is taking place with extreme slowness; for the nodules are evidently formed in the clay, and the formation of the larger ones and the segregation of the material must have required a very long time; while many of the sharks' teeth forming the nuclei of the nodules belong to species which we have every reason to believe have been extinct since early Tertiary times. Some teeth of a species of Carcharodon are of enormous size, four inches across the base, and are indistinguishable from the huge teeth found in the Eocene beds." On this point Mr. John Murray says: "When there has been no reason to suppose that the trawl has sunk more than one or two inches in the clay, we have had in the bag over a hundred sharks' teeth, and between thirty and forty ear-bones of whales."

The time since the Eocene, when the Carcharodons lived, is estimated by geologists at more than a million years, and yet enough clay has not been deposited during this immense period to bury the teeth of this giant shark beyond the reach of the dredge! the rate of increase of the sediments being probably less than one foot, and possibly not more than two or three inches, in a million years. Now suppose that after a submergence of ten million years the floor of the deep ocean is slowly raised to form dry land. Is it surprising that a bed five or possibly ten feet thick of ferruginous clay, containing organic remains similar to those found in shore deposits, is not recognized as of abyssal origin, but is completely lost among the miles of marginal sediments composing the new continent? In the ordinary sense, there are no abyssal sediments, but we find over these oceanic wastes merely the impalpable dust which slowly settles during the lapse of countless ages from the limpid water of the central sea. The land is the great theatre of erosion and the sea of deposition; but just as there are extensive rainless tracts on the continents where there is practically no erosion, so there exist still larger areas of ocean-floor over which the complementary process, or deposition, approaches the vanishing point. On both land and sea the main field of geological operations is marginal, following the shore-line; but nowhere does the earth's crust experience such perfect rest as under the deep sea.

A large proportion of the volcanoes of the globe are in the central portions of the ocean, nearly all the oceanic islands being either volcanic, or consisting of coral-rock resting upon old, submerged volcanoes. While of the submarine volcanoes which have never reached the surface, we of course know nothing, but it is probable that such exist, and possible that they outnumber those whose craters are dry land. Now on the land we observe no important exception to the rule that volcanoes are situated upon, or in the immediate neighbourhood of, thick deposits of recent sediments—Tertiary or Secondary. And we also observe that in the earlier periods of the earth's history the same law held good.

Are the oceanic volcanoes to be regarded as exceptions to this general law? If so, upon what grounds? If not, then the inference is at least probable that the great volcanic archipelago of the Pacific, as well as the numerous volcanic islands of the Atlantic and Indian Oceans, rests upon extensive stratified formations of no great geological age. But the deep-sea sediments, as we have seen, are of very trifling thickness, with the exception of the coral-limestone, and this rests upon and is newer than the volcanoes. Hence the implication is plain that the floor of the central ocean has been at one time a marginal sea-bottom, forming the shoulders, if not the dry land of the continents.

If, as those believing in stable continents and oceans virtually claim, the oceanic portions of the earth's crust have been covered since the beginning of geological time with a sheet of cold water, the frigid zones extending along the ocean-floor through all latitudes to the equator; and if, as necessarily follows, during the whole of geological history, deposition has been almost entirely suspended over these vast areas; then since the strength and thickness of the earth's crust are, in the main, due to, and are a measure of, the refrigeration which it has experienced, it must be admitted that the oceanic crust is very thick and stiff. That sediments are in general a source of weakness rather than of strength in the crust is the testimony of the ablest students of structural geology; and this proposition forms the basis of the generally accepted explanation of the origin of mountains.

Now, if volcanoes are evidence of anything, they are evidence of weakness in the earth's crust. They prove the existence of fissures reaching down to a plastic zone in or beneath the crust; and, as already noticed, they are, on the land, intimately connected with thick deposits of recent sediments—with what are generally recognized as weak places in the crust. But it is a logical deduction from the hypothesis here combatted that the numerous oceanic volcanoes do not stand on thick accumulations of sediments—for no deposits of sensible thickness are formed in the deep sea; and that they occur on the strongest, rather than the weakest, portions of the earth's crust—for nowhere are the conditions more favourable for deep and permanent refrigeration than under the oceanic abysses, and according to Mr. Wallace and Prof. Dana the site of the deep sea has remained unchanged during all the changes of which geology furnishes a record.

Prof. Dana says the oscillations of the sea-floor are slight compared with those of the land, the principal movement being a slow subsidence running through the ages, which may be reversed to the extent of a few thousand feet, but never sufficiently to convert the sea-bottom into dry land. Yet this cold, thick, stable, oceanic crust, which has never been weakened by thick sedimentary deposits, is an area of wide-spread and intense volcanic activity; while the continental interiors, which, according to the theory in question, have experienced far greater changes of level, and are covered by immense thicknesses of stratified rocks, are almost entirely free from active volcanoes.

Volcanoes have burned, and poured out their floods of rock, over nearly all parts of the continents. But all land volcanoes are, in a geological sense, short-lived; and, ere the sediments through which they reach the surface have become old, their energy is exhausted. There can be little doubt that active terrestrial volcanoes follow the sea-shore simply because it is there, chiefly, that thick deposits of recent sediments are found. It is a natural inference from these considerations that the volcanoes of Polynesia, for example, are piled upon thick sedimentary formations, deposited, perhaps, during the slow subsidence of a great Pacific continent. But, according to Professor Dana, they are quite unlike terrestrial volcanoes, having no necessary connexion with sediments, and being as old as the earth's crust.

The submarine mountain-ranges are, equally with the oceanic volcanoes, an argument against the immutability of oceanic conditions. Few geological theories are now more generally accepted than the theory that mountains are formed by the horizontal mashing up of thick deposits of sediments. These stratified formations of immense thickness—five to ten miles for most important mountain systems—can only be formed on a marginal sea-bottom. Hence it is impossible to avoid the conclusion that mountains are of sea-shore origin. But an application of this theory to the submarine mountain-ranges is fatal to the notion that the oceanic abysses are permanent.

As an argument in favour of the permanence of continents and oceans, Mr. Wallace attaches great importance to the supposed fact, first mentioned by Darwin, that, with the exception of New Zealand and the Seychelles Islands, none of the truly oceanic islands contain either Palæozoic or Mesozoic rocks; the inference being that during the Palæozoic and Mesozoic eras neither continents nor continental islands existed where the oceans now extend, for, had they existed, Palæozoic and Mesozoic formations would in all probability have been accumulated from sediment derived from them.

This argument is not so formidable as it at first appears. Mr. Wallace thinks it is doubtful if New Zealand can be properly called a true oceanic island. But it is difficult to see how it can be differently classified, since the ocean between it and Australia is one thousand miles broad and three miles deep. But there are other exceptions to the law which he formulates. New Caledonia is an oceanic island, over 700 miles of deep water separating it from

Australia, while the sea in its near neighbourhood has a depth of from 15,000 to over 17,000 feet; and yet it is composed of stratified Eozoic, Palæozoic, and Mesozoic rocks. The Salomon Islands, 500 miles from New Guinea, and nearly twice that distance from Australia, are, according to Garnier, composed of rocks similar to those found in New Caledonia. Kerguelen Island, in the southern part of the Indian Ocean, and 2,000 miles from the nearest continent, is certainly a true oceanic island; and yet it is composed, in large part, of stratified rocks, both fossiliferous and crystalline. The Philippine Islands contain Secondary, if not Palæozoic, strata; and, although only separated by from 300 to 500 miles from Borneo and the continent of Asia, they are surrounded on all sides by water from two to three miles deep. Naturalists are generally agreed that the true borders of the continents are not the actual shore-lines, but the lines, sometimes one to two hundred miles from shore, where the water commences to deepen rapidly and the abysses of the ocean begin. All land beyond this true continental edge is oceanic. Now, judged by this criterion, the Philippines are, apparently, oceanic islands. It is certainly unreasonable to say that all oceanic islands must be remote from the continents. As well might it be claimed that all the higher parts of the continents, or mountains, must be remote from the sea. I have been informed by Prof. Jules Marcou that the Marquesas Islands, lying on the eastern border of Polynesia and near the centre of the Pacific, contain representatives of the older stratified formations. Palæozoic and Mesozoic rocks are well developed in Spitzbergen, which, it would seem, may be fairly classed as an oceanic island. Again, many oceanic islands have not been examined geologically with sufficient care to justify Mr. Wallace's sweeping and positive statement that, with two exceptions, none of them contain any traces of the older stratified formations.

With the exceptions noted, the oceanic islands are nearly all small, and are composed of eruptive rocks or of coral-reefs resting, presumably, upon a volcanic foundation. The oceanic islands are, of course, merely the tops of submerged mountains; and it is only with the highest points of the continents that they can be properly compared. Now, supposing the existing continents were submerged to an average depth of 15,000 feet, what would be the geological character of the land remaining above the sea? Palæozoic and Mesozoic rocks would probably be about as scarce in it as in modern oceanic islands. As a rule, the loftiest mountains of the globe are composed of eruptive rocks, and in many cases they are extinct, or even active, volcanoes; although the main mass of every mountain system is formed of stratified formations. The volcanic materials usually constitute but a small part of the whole; but they are the cap-sheaf.

Granting, however, for the sake of the argument, that the older fossiliferous formations would be left above the water in some cases; if the islands of this class were large, they are fairly represented in the modern ocean by New Zealand, New Caledonia, and Spitzbergen, and, if small, by the Seychelles, Salomon and Marquesas Islands and

Kerguelen Island. The smaller stratified islands, however, would usually be short-lived, being destroyed by erosion. Volcanic and coral islands, on the contrary, are constantly growing and making good the loss by erosion. Submarine volcanoes suffer no erosion, until their summits reach the surface of the water; and their growth is mainly vertical, since the water must ordinarily prevent the lava from flowing far from the outlet or crater. Consequently, if a continent, the stratified summits of which are high and the volcanoes low, is submerged; the former will be soon swept away by erosion, and the lavas ejected by the latter will be piled up, monument-like, until they reach the surface, when, although erosion checks the upward growth, its ravages are constantly made good by fresh outflows of lava.

In the opinion of the writer, these considerations materially diminish the surprise which one feels on first observing that the oceanic islands are mainly volcanoes and coral-reefs. For in no other class of islands do we find those elements of growth which enable them to keep pace with the increasing subsidence and to make good the encroachments of the sea. An active volcano cannot be permanently submerged, and the same is true of a coral-island, provided the subsidence goes on slowly enough. In short, nearly all the larger oceanic islands do embrace considerable masses of the older stratified formations; and the fact that the smaller ones do not as a rule is satisfactorily explained by a comparison with the highest points of existing continents, and a due consideration of the facts that small stratified islands would necessarily be short-lived, and if submerged only one hundred feet would be for ever lost as land, and that the volcanic and coral islands cannot usually be either submerged or worn away, possessing a power of growth which makes them eternal.

II.—Notes on the Cheviot Andesites and Porphyrites.

By J. J. Harris Teall, M.A., F.G.S.

(*Continued from* p. 152.)

[PLATE VI.]

THE *Coquet.—Blindburn.*—A dark-grey compact rock with an irregular fracture. A few small scattered felspars may be recognized. Red streaks and blotches occur. Under the microscope two generations of felspar may be recognized; the larger porphyritic crystals abounding in inclusions of the ground-mass of the rock, while the smaller and later crystals are comparatively free from inclusions. Both kinds are somewhat altered, small portions here and there showing aggregate polarization, while the main mass of the crystals gives definite extinctions. The pyroxene has almost entirely disappeared. Sections of characteristic form may however be distinctly recognized. These are now principally occupied by an aggregate of quartz granules or a mixture of quartz and chalcedony; but here and there fibres of a brilliant and peculiar green mineral occur scattered throughout the quartzose aggregate, and these doubt-

FIG. 1. ×8.

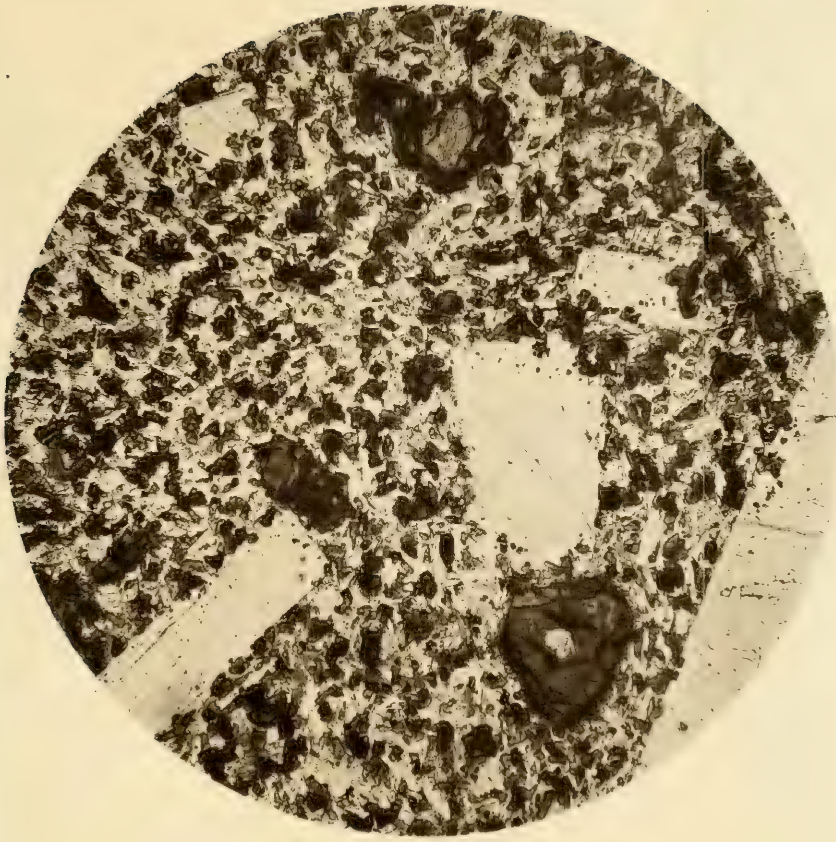
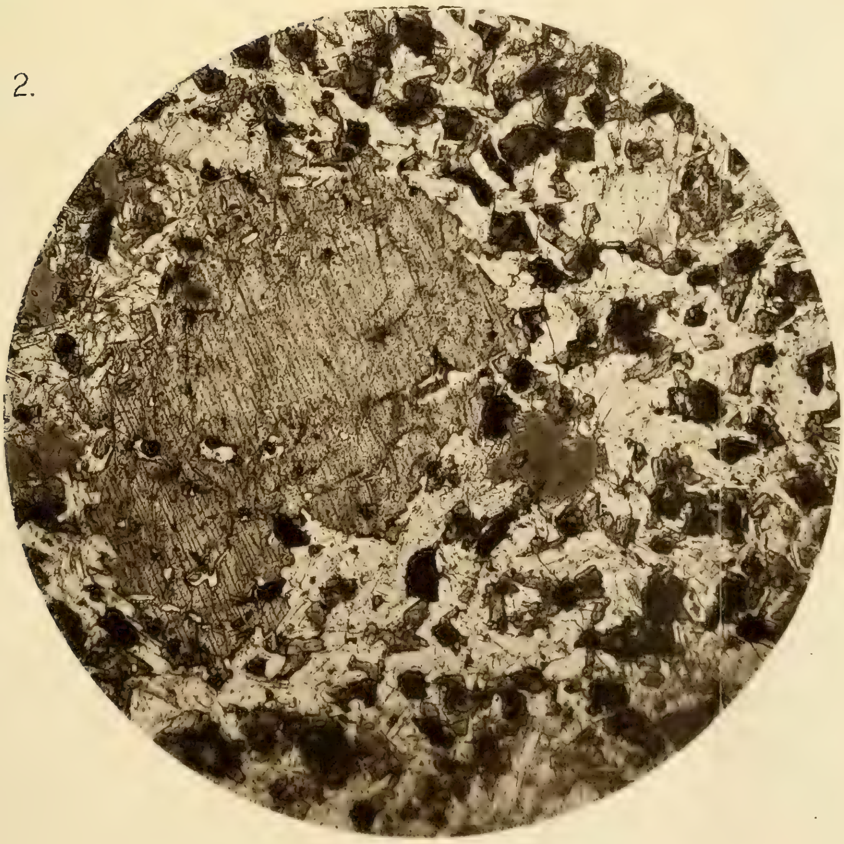


FIG. 2. ×16.



KELSO "PORPHYRITE," STICHILL.

less are an alteration product of the original pyroxene. Iron oxides are comparatively rare in this rock. The ultimate base is a brownish isotropic and minutely granulated substance. Under the highest power at my command (1000 diameters) the granulation cannot be resolved, and I am therefore not able to say that any clear homogeneous glass is present. Veins containing quartz and calcite occur in the rock.

The Coquet, a short distance above Blindburn.—A somewhat light-brown rock, evidently much altered. The ground-mass appears compact. The porphyritic felspars are somewhat kaolinized. This rock is essentially similar to the last in character and composition, except that it was in the first instance vesicular. The vesicles are now occupied by an intimate mixture of quartz and chalcedony.

Banded Porphyrite between Phillip and Blindburn.—This consists of alternating bands of lighter aud darker material, the darker bands standing out on the weathered surfaces in the form of ridges. The prevailing colour is a dull grey. Macroscopically the rock consists of a compact matrix, throughout which are scattered small porphyritic felspar crystals. Microscopically, the rock is an altered andesite, essentially similar, as far as the distinctly recognizable constituents are concerned, to that described on page 152 of the April Number of the Geological Magazine. The microscopic ground-mass in the thinnest sections is brownish in colour on account of innumerable granules and indistinct fibres; under crossed Nicols, a large portion of this remains persistently dark, and is therefore doubtless to be referred to the microfelsit of Rosenbusch.

Vesicular Porphyrite, Coquet, near Carl Croft.—A somewhat light-coloured rock with a slight purplish tint. The ground-mass is compact, and contains the usual felspar crystals. The vesicles are very numerous and of tolerably uniform size, measuring in their longest diameter about one-fifth mm. They are now more or less occupied by silica, in the form of opal, chalcedony and quartz, a deep rich green mineral, and occasionally by limonite, the latter substance apparently arising from the alteration of the green mineral. Microscopically, the rock is seen to be an altered porphyrite of the typical andesitic variety, and does not call for special description. The specimen is doubtless the vesicular portion of one of the andesitic lava flows.

Amygdaloidal Porphyrite, Ridlees Burn, near Alwinton.—This is a portion of the well-known agate-bearing rock. Originally it appears to have been a vesicular andesite with a microlitic ground-mass. The cavities are now occupied by silica in its various forms, and a green mineral which frequently occurs in radiating fibrous aggregates, and gives brilliant chromatic polarization in those portions in which the axes of the fibres are inclined to the vibration planes of the crossed Nicols. The rock is also traversed by numerous irregular cracks full of similar products of secondary origin. The pyroxene cannot now be recognized in the original rock, and one may therefore conclude that it has supplied the material for the green alteration product which occurs in the amygdules.

Rock forming crags above Langlee Ford, south side of Harthope

Valley.—This is an interesting rock, to which my attention was first called by my friend, Mr. James Watson, of North Shields. Macroscopically it consists of porphyritic felspars, measuring from two to three mm. across, imbedded in a very dark compact matrix. The specific gravity is 2·74, and the silica per-centage slightly over 60. Under the microscope it is seen to contain mica, a colourless pyroxene, magnetite, and apatite, in addition to the felspar. The ultimate base of the rock is a clear isotropic glass, but this is thickly crowded with minute granules, some of which appear opaque, while others have a deep reddish-brown colour.

The Felspars.—These occur for the most part in the form of more or less broken crystals. Both large and small have the same general character, and I am therefore inclined to refer them all to one and the same stage of rock consolidation.

They are frequently honeycombed with irregular inclusions of the ground-mass, but their most striking peculiarity is a remarkable cloudy appearance which can be shown, by means of a magnifying power of 1000 diameters, to be due to minute inclusions and not to alteration. The sections at right angles to the twinning plane are seen also under ordinary light to be very finely striated in consequence of the arrangement of the extremely minute inclusions in lines, or rather planes parallel with the brachypinakoid. Under polarized light, the same sections show the characteristic banding of plagioclase, and the maximum angle which has been observed between the extinction positions of adjacent lamellæ is 34° (maximum for oligoclase 37°). The number of sections examined is, however, too small to warrant a definite conclusion.

The Pyroxene.—This occurs in good-sized crystalline grains, having the cleavages and extinction angles of augite (monoclinic) and also as minute crystalline granules in what may be called the microscopic ground-mass. The larger grains rarely show any traces of definite geometric form, but they are frequently twinned. The absence of colour appears to suggest that we are here dealing with the variety of augite known as salit.

I may mention in passing that this pyroxene occurs in almost all the quartz-bearing holocrystalline rocks of the Cheviot district; at least in almost all those which have passed under my notice. Prof. Rosenbusch calls this rock an augite-porphyrite.

Mica.—A mineral having the dichroism of biotite, and therefore presumably to be referred to that species, occurs in extremely minute crystals and crystalline particles. The dimensions of an average section taken at right angles to the vertical axis are ·002 × ·007 mm. In some portions of the ground-mass this mineral occurs in great profusion, two or more crystals lying over each other in the thickness of the preparation, whilst in other portions it is entirely absent.

Apatite occurs in abundance. It is clear and colourless, and an average longitudinal section measures ·07 × ·25 mm.

Magnetite is present in the form of irregular grains of considerable size and also as minute granules in the ground-mass. It is, however, not very abundant.

The microscopic ground-mass consists of an ultimate base of clear isotropic glass, which is thickly crowded with opaque and reddish-brown granules, minute crystalline grains of pyroxene, and in places with the mica above described.

Mica Porphyrites.

These rocks are reddish-purple, and sometimes even brick-red in colour. The ground-mass is compact, and contains more or less altered felspars, usually of the same colour as the matrix, and either biotite or its chloritic alteration product.

Red porphyrite, Alwin, one-third of a mile below Kidlandlee Dene.—This rock is exposed on the left bank of the Alwin for a distance of about 24 yards, and it appears to form a dyke intersecting the ordinary porphyrites. Specific gravity 2·52. The porphyritic felspars and the ground-mass are now brick-red in colour, and the mica has lost its lustre, but in many cases retains its characteristic form. Under the microscope the felspars are seen to have the turbid aspect of the orthoclase of granites and to contain specks and patches of ferrite. They have lost to a great extent their original homogeneous character, but still retain a sufficient amount of individuality to show that they are closely striated, and that the extinction positions of adjacent lamellæ in sections taken at right angles to the twinning plane make extremely small angles with each other (? oligoclase). Apatite prisms occur as inclusions in the felspar. The altered biotite is extremely characteristic; thus in the sections more or less at right angles to the vertical axis narrow, irregular, alternating bands and patches of chloritic substance, brown comparatively unaltered mica, and opaque iron oxides may be observed. The chloritic bands usually have a wavy aspect. The iron oxides are partly in the condition of ferrite, partly in that of opacite.

The ground-mass appears a bright-red colour by reflected light, owing to the abundance of ferrite. Its true nature is very difficult to make out. Quartz is certainly present in considerable abundance, and is probably to a great extent, if not entirely, of secondary origin. Scattered specks of opacite also occur.

Red Porphyrite, Biddleston, near Alwinton.—This rock is exposed in a quarry about 100 yards from the road and on the north side, near the final *e* of the Biddlestone of Biddlestone Hall, in Ordnance Map 108 N.E. It is very similar to the rock just described, but the mica is in a fresher condition and shows the characteristic lustre. This may be simply owing to the fact that as this rock is quarried, one is able to get better preserved specimens. The microscopic characters do not require any special description.

Purple Micaceous Porphyrite, Skirlnaked, near Wooler.—This rock is exposed close to a bridge near the point where the Carey Burn joins the Harthope Burn. My attention was called to it by Mr. J. Watson, of North Shields. I think it forms a dyke in the porphyrites of that district, but I cannot speak positively on this point. The ground-mass is compact and is of a reddish-purple colour; it contains pink felspars and a considerable amount of biotite and its chloritic alteration product. Under the microscope, the porphyritic felspars are seen to be plagioclase, at any rate for the most part, and they give very low extinction angles in the zone of the macro-diagonal axis. The biotite is frequently very fresh, and in sections more or less parallel with the principal axis varies in tint from a deep rich brown to a pale yellow, as the polarizer is rotated. In the rock last described the mica occurs as large flat plates, but in the one now under consideration it occurs as short stumpy prisms. Various stages of alteration may be traced in the thin section; thus some crystals have been attacked at their edges, others have been altered along definite bands, and some are in the condition described as characteristic of the mica in the specimen of red porphyrite from the Alwin.

The other distinctly recognizable constituents are quartz, a mineral of pyroxenic aspect, magnetite or ilmenite and apatite; the last mentioned occurring as inclusions in all the other definitely crystalline constituents, and also in the ground-mass.

Under a high power the ground-mass is seen to be thickly charged with extremely minute indistinct granules and fibres, together with larger irregular patches due to collections of ferrite granules. With crossed Nicols it presents the appearance of a confused mass of irregular crystalline particles, in which quartz may be distinctly recognized. Much of this quartz is doubtless secondary.

A rock of precisely similar character to the one above described occurs on the S.W. face of Goldsmouth Hill, near Yetholm, where it also probably forms a dyke.

An allied rock also occurs one mile below Langlee Ford, in the Harthope Valley. The mica, however, is not so abundant here, and the micro-crystalline character of the ground-mass is much more pronounced, and in many places puts on the aspect of micro-pegmatite.

Reddish-purple Porphyrite, one mile up Allerhope Burn and a quarter of a mile below Kidlandlee Dene, in the Alwin.—The specimens from these two localities are, for purposes of description, identical. The ground-mass is compact, and gives its colour to the rocks. Throughout it are scattered lighter felspars and dark-green patches of somewhat irregular shape. Under the microscope the felspars are seen to be saussuritic, but they retain sufficient individual action on polarized light to show that they are twinned on the plagioclase type, and that the extinction angles are low. The green mineral gives aggregate polarization, and is frequently associated with quartz. Calcite also occurs, and is usually inter-crystallized with quartz. The ground-mass is micro-crystalline, and together with felspars is charged with ferrite. A few parallel bands of inclusions occur near the edges of the felspar sections. Apatite crystals and opacite grains occur sparingly. It is difficult to say what the original ferro-magnesian mineral was, but I am inclined to regard it as mica. Specific gravity of Allerhope specimen 2·59.

Reddish-purple Porphyrite, the Alwin, 100 *yards above Allerhope Burn.*—This is almost certainly a true lava, as it shows well-marked fluidal structure in the thin sections. Macroscopically the rock is seen to consist of biotite and felspar in a compact reddish-purple matrix. Under the microscope the felspars are seen to be wonderfully fresh and well striated, at any rate for the most part. The two sets of lamellæ in sections more or less at right angles to the twinning plane extinguish within a few degrees of each other, and nearly parallel with the longer diameter of the crystal section. The other distinctly recognizable and undoubtedly original minerals are biotite, magnetite or ilmenite and apatite. Patches of granular and sphærulitic quartz are also seen here and there in the section. The ground-mass is crypto- or micro-crystalline, and contains both opacite and ferrite, distributed in a somewhat irregular manner. The ferrite is especially abundant in fluidal bands and stripes which curve round the larger crystals in a very characteristic manner. Vogelsang[1] describes a similar distribution of ferrite in certain of the Hungarian quartz-trachytes.

In certain parts of the section the ferrite is collected in ill-defined spherical masses (cumulites) of uniform size, and where this takes place in the presence of opacite, the latter mineral is absent from the cumulites. The red bands and patches frequently have the same sort of outline that they would have if they were made up of collections of cumulites, but the ferrite is distributed in a uniform manner in their interior portions.

The Tuffs and Breccias.

Good sections of the bedded tuffs and agglomerates are exposed on the left bank of the Alwin, immediately below Allerhope Burn, and again at a point half a mile below Kidlandlee Dene, and on the same side of the valley. The coarse breccias may be examined in the bed of the Alwin, about a quarter of a mile above Windy Haugh, and again at Blindburn. Doubtless there are many other equally good exposures.

Fine ash, the Alwin, below Kidlandlee Dene.—The rock is of a greenish-grey colour, and the constituent particles are just recognizable with a hand-lens. The microscope reveals the presence of small fragments (lapilli) of andesitic porphyrite and broken felspars, in what may be called a ground-mass of somewhat indefinite character, doubtless due to the alteration of fine volcanic dust. Opacite, ferrite, and viridite are scattered throughout the section.

Coarse ash, the Alwin, below Kidlandlee Dene.—This specimen shows alternating bands of coarser and finer material, the larger fragments frequently attaining the size of peas, and sometimes that of beans. Under the microscope the larger fragments are seen to consist of the typical andesitic porphyrites of the district, and frequently give evidence of an original scoriaceous or vesicular character by the presence of amygdaloids of green earth and chalcedony. The fragments are mostly of irregular form, but in one or two instances the angles are fairly well rounded. Broken felspar crystals are present in this, as in the previous rock, together with a small quantity of indistinctly characterized ground-mass.

[1] Die Krystalliten, p. 151.

Very coarse breccias containing angular fragments of the normal porphyrite, measuring many inches in diameter, occur at a point in the Coquet, about a quarter of a mile above Windy Haugh, and again at Blindburn. At the former locality the matrix is fine-grained and green in colour. It is composed largely of quartz grains and a chloritic mineral which appears, in part at any rate, to arise from the alteration of mica. A little felspar is also present. The included fragments of porphyrite contain veins of quartz and chalcedony, which are not continued into the matrix, thus showing that these veins were produced in the porphyrite before it was broken up to form the breccia. A portion of the green matrix yielded 77·4 per cent. of silica. At present I am not able to give a satisfactory account of the origin of these coarse breccias.

Tuedian "Porphyrites."

My knowledge of the igneous rocks of Tuedian (Lower Carboniferous) age, which occur in the neighbourhood of the Cheviot district, is solely derived from the examination of a specimen kindly given to me by Mr. Clough. It is labelled bedded-porphyrite, Stichill. Macroscopically it consists of a compact dark-purplish ground-mass, with reddish patches and blotches, throughout which are scattered large glassy felspars, measuring sometimes 3 or 4 mm. across, and a few black crystals of pyroxene. The specific gravity of the rock is about 2·95. Its microscopic structure is represented in Plate VI.

The rock is holocrystalline, and the original constituents, mentioning them in the order of their probable formation, are apatite, magnetite, olivine, anorthite or bytownite, felspars of the ground-mass (? labradorite), and pyroxene. The secondary products are serpentine and related minerals and iron oxides. They result mainly from the alteration of olivine. Apatite occurs in long acicular prisms. Magnetite in crystals and grains of tolerably uniform size. It is abundantly and evenly scattered through the rock, and its relation to the other constituents is well shown in the Plate. The olivine was present originally both in the form of good crystals with definite boundaries and as grains. It is now represented by the usual serpentinous pseudomorphs containing irregular cracks filled with iron oxides. Kernels of the unaltered mineral may frequently be observed. Three good sized olivines are shown in the upper figure, and in two of these unaltered portions of the original mineral may be recognized by the lighter shade.

The large porphyritic felspars occur both as fairly good crystals and as fragments. They show the usual polysynthetic twinning, and are comparatively free from inclusions. Now and then magnetite, and more rarely small augite granules, occur as inclusions. The latter, however, when present, are near the margin of the felspar, at least in the few cases I have observed, and I am inclined to explain this by supposing that the marginal zone of the felspar substance has been added during a later stage in the process of rock consolidation than that in which the main growth of the crystal took place.

Such an explanation is certainly true of similar cases in the rock forming the Cleveland Dyke, in which the outer zone of felspar substance in the porphyritic crystals frequently contains minerals of the ground-mass, and extinguishes at different angles from the central portions.

I submitted a fragment of one of these large crystals to Mr. Waller, of Birmingham, for examination by Szabo's methods, and he reports that both the flame reactions and fusibility, or rather infusibility, show that it is practically identical with the porphyritic crystals of the Tynemouth dyke, portions of which isolated by myself have been kindly analysed for me by my friend Mr. J. E. Stead, of Middlesborough, with the following result:—

SiO_2	47·30
Al_2O_3	31·50
Fe_2O_3	1·85
CaO	14·88
MgO	0·93
K_2O	·38
Na_2O	1·22
Loss	1·80
	99·86

It is impossible to obtain the felspars in a state of absolute purity, on account of the numerous inclusions which they contain, and also on account of slight alteration; nevertheless the analysis clearly proves that we are dealing either with anorthite, or the more doubtful species bytownite. With considerable difficulty I have prepared a section of this felspar approximately parallel with the basal plane. In this section the angle between the extinction positions of adjacent lamellæ is 55° 10′.

The corresponding angle in anorthite, according to Levy and Fouqué,[1] lies between 57° and 74°, and in labradorite between 10° and 14° 30′. Assuming Schuster's interpretation[2] of Tschermak's theory to be correct, then these figures correspond to about 90 per cent. of anorthite in the mixture.

It thus appears, both from the chemical and optical examination, that the Tynemouth felspar is either bytownite or anorthite.

A few crystals which had weathered out were submitted to Dr. Trechmann of Hartlepool for crystallographic examination. He writes, "I have now measured two of your crystals successfully. Though unpromising in appearance, yet one gave good reflections and the other fair ones. The angle measured was the inclination of the basal planes to one another in the twins. The brachypinakoid was not suitable, it is inclined to irregularities, *i.e.* the two corresponding faces of $\infty P \breve{\infty}$ are not strictly parallel, a frequent occurrence in nature. I found

Crystal No. 1.

$$o P : \underline{o P} = 171° \cdot 58' \quad \text{from which}$$

$$\overline{o P} : \infty P \breve{\infty} \text{ (acute angle)} = 85° 59'$$

[1] Min. Mic. p. 230.
[2] Ueber die optische Orientirung der Plagioclase, T. M. M., 1881, p. 254.

Crystal No. 2.

$$o\,P : \underline{o\,P} = 172^\circ{\cdot}\,27\tfrac{1}{2}' \quad \text{1st reflection.}$$
$$172^\circ{\cdot}\,20' \quad \text{2nd reflection.}$$
$$172^\circ{\cdot}\,23\tfrac{3}{4}' \quad \text{mean.}$$

or $o\,P : \infty\,P\breve{\infty} = 86^\circ{\cdot}12'$.

"Now according to Naumann-Zirkel we have:—

	$o\,P : \infty\,P\breve{\infty}$
Albite	86°·24
Oligoclase	86°·10
Anorthite	85°·50
(Labradorite)	(86°·40)

"The first crystal, the more reliable, is within 9′ of anorthite; the second one very near oligoclase. The balance of evidence is therefore in favour of a felspar nearly allied to anorthite."

Although these facts with regard to the chemical, optical and crystallographic characters of the Tynemouth felspars should properly appear in connexion with a description of the rock in which they occur, I have inserted them here because Mr. Waller's observations appear to prove that the Stichill felspar belongs to the same species.

To proceed with the description of the Stichill rock. The general characters of the felspars of the ground-mass are well represented in the Plate. Many of them appear as short, lath-shaped forms, which show the usual multiple twinning under crossed Nicols. The pyroxene occurs both in small grains and in large irregular plates with characteristic cleavages and extinctions. Its colour is a pale brown. It is interfered with by all the other constituents of the rock, and was evidently one of the last minerals to separate out.

The alteration products have been already referred to in describing the olivine, and the only additional fact to be stated with regard to them is that the green substances have sometimes segregated in the form of irregular patches, one of which may be seen to the S.E. of the centre of the lower figure, and that in these an indistinct radial fibrous structure may be made out (? Delessite). I have analyzed this rock with the following result:—

S_1O_2	47·53
Al_2O_3	14·95
F_2O_3	6·73
FeO	8·04
MnO	·73
CaO	8·50
MgO	7·41
Na_2O	2·98
K_2O	1·12
P_2O_5	traces
Loss on ignition	1·95
	99·94

Specific gravity, 2·95

It thus appears, both from the microscopic and chemical examination, that the rock is not a porphyrite, but a representative of the basaltic family. It is pronounced a melaphyre by Prof. Rosenbusch, and would doubtless be called a dolerite by Mr. Allport. A rock of similar character occurs in the crag overlooking Dunsapie Loch, Edinburgh, where it is mapped as greenstone, the Stichill district being coloured porphyrite.

Conclusion.

The most important result of this examination of the volcanic rocks of the Cheviot district has been the recognition in the pitchstone-porphyrite of a rock bearing the closest possible relations structurally, mineralogically, and chemically, to certain of the so-called augite-andesites of Hungary, Transylvania, Servia, Santorin, and America.[1] Since my last paper was published, the first Bulletin of the U.S. Geological Survey has appeared, and it contains a full account of the researches of Mr. Whitman Cross on hypersthene-andesite, together with a sketch of the geology of Buffalo Peaks, by Mr. S. F. Emmons. The facts cited in this Bulletin appear to prove conclusively that andesites having a rhombic pyroxene as the predominating bisilicate, are very widely distributed in space, and form a tolerably well-marked petrological group. It is not a little interesting that, just as the true character and wide distribution in space of this rock type is beginning to be recognized, evidence of its existence as far back in geological time as the Lower Old Red Sandstone period should be forthcoming. Thus suggesting the generalization that in petrological, as in organic types, a wide distribution in space is associated with a wide distribution in time.

We do not yet appear to have found in the Cheviot district the plutonic representative of these andesitic lavas. If they could be found, they would probably resemble some of the rocks described by F. Teller and C. v. John in their paper entitled "Geologisch petrographische Beiträge zur Kenntniss der dioritischen Gesteine von Klausen in Südtirol."[2] Typical norites are far too basic to have supplied the materials for these Cheviot lavas and tuffs.

The igneous rocks near Klausen are intrusive in phyllite and gneiss, and are described by the authors above referred to under the terms norite, norite-porphyrite, quartz-norite, and quartz-mica-diorite. The rhombic pyroxene in the norites includes both hypersthene and enstatite, the former mineral being distinguished from the latter only by its more marked pleochroism.

The norite-porphyrites occur at the boundaries of intrusive masses of the ordinary norite, and therefore differ in their geological relations from the Cheviot andesite. They also differ from this rock in having a micro- or crypto-crystalline ground-mass, and not a glassy base.

Chemically, however, the norite-porphyrites and the quartz-norites approximate in character to the Cheviot and other hypersthene-ande-

[1] Professor Bonney states that the rhombic pyroxene occurs in andesites from Pichincha, Antisina, and probably also Chimborazo. He is now engaged in an examination of the specimens collected by Mr. Whymper from these and other localities in South America.

[2] K. K. Geol. Reich. 1883, Heft 4.

sites, as will be seen from the following analyses, and may probably be regarded as the plutonic representatives of these rocks.

	A	*B*	*C*
SiO_2	63·0	64·12	56·85
Al_2O_3	14·9	16·50	16·70
Fe_2O_3	4·7	2·71	5·92
FeO	—	4·26	7·13
CaO	4·8	4·76	5·97
MgO	2·8	2·34	3·25
Na_2O	4·0	3·92	2·78
K_2O	1·9	1·92	1·91
Loss	4·0	0·73	0·54
	100·1	101·26	101·05

A Cheviot andesite. Analysis by T. Waller.
B Quartz-norite, between Johannsen and Muttler.
C Norite-Porphyrite from Tinnebach.
B and *C* are quoted from the paper by Teller and von John.

It seems strange that rocks of the Cheviot type have not been previously recognized among the older formations. It is not likely that they are as rare as this would seem to imply. A rock from Steinerne Mann, Nahe, bears a close resemblance, both macroscopically and microscopically, to the Cheviot andesite. I have examined three slices, and in these there are 38 sections of pyroxene cut approximately parallel with the vertical axis of the prism; 35 of these extinguish parallel with the length of the section, a fact which seems clearly to prove the rhombic character of the predominating bisilicate. The pleochroism of these sections is much fainter than that of the corresponding sections in the Cheviot rock, but of the same character, and I am therefore inclined to regard the mineral as enstatite and the rock as enstatite-andesite; or, if the term andesite is to be denied to it on account of its Pre-Tertiary age, enstatite-porphyrite.

This rock is labelled proterobase (melaphyre) by H. B. Stürtz, of Bonn, from whom I have obtained specimens, and proterobase by Mr. Samuel Henson, who also supplies the rock.

SiO_2	56·90
Al_2O_3	17·44
Fe_2O_3*	6·50
MnO	trace
CaO	7·82
MgO	3·73
K_2O	1·98
Na_2O	3·80
Loss	2·76
	100·93

In conclusion, I would call attention to two other points of some importance in connexion with this examination of the Cheviot rocks, viz. first, the recognition of the fact that some of the normal porphyrites are merely altered andesites; and secondly, the proof that in part at any rate the igneous rocks of Tuedian age, which occur in the neighbourhood of the Cheviots, belong to the basic series, and are therefore sharply to be distinguished from the rocks of intermediate composition which form so large a portion of the Cheviot district proper.

* The total iron is estimated as $Fe_2\ O_3$. If allowance be made for the amount of iron undoubtedly present in the ferrous condition, then the excess in the analysis will be considerably reduced.

III.—Origin of the Archæan Rocks.

By John E. Marr, M.A., F.G.S.;
of St. John's College, Cambridge.

It is somewhat remarkable that, just as physicists are assuring geologists that the latter will have to quicken their forces, so as to bring the geological history of the globe within the definite limits assigned by the physicists themselves, the geologists reply by adding several thousand feet more rock in various parts of the world to the already thick column of sediment, and many would assure us that these 'Archæan' rocks were produced in a manner similar to the fossiliferous rocks, from which they differ in such important particulars.

Various attempts have been made to account for the mode of formation of these Archæan rocks under conditions different from those prevalent in later times, but little notice has been taken of these theories. The two extreme views are perhaps those of Mr. Mallet and Dr. Sterry Hunt; but although these authors attempt to explain the phenomena of regional metamorphism, they give us no clue whatever to many of the other difficulties connected with the Archæan rocks. Some of these difficulties may be here enumerated.

1. The amount of time required to accumulate the great thickness of Archæan rocks, to metamorphose them, and to denude so great a quantity of material as to expose the metamorphosed rock at the surface would be very great, if these rocks were originally deposited as ordinary aqueous sediments. True, according to Mr. Wallace's calculations (Island Life, p. 203), the whole thickness of sedimentary rocks could be formed in a time much shorter than that which physicists are disposed to allow us. But even admitting the accuracy of Mr. Wallace's data for estimating the comparative rates of removal of a thickness of material from our continents, and its settlement upon areas receiving sedimentary deposits at the present day, there are many possibilities to be taken into account which might seriously alter his results. If denudation acted more rapidly in past times, deposition on the other hand would probably take place over areas more remote from the land than those to which it is confined at the present time. Again, if we suppose that continents have gradually grown in size, a far smaller amount of land-surface would have been exposed to denudation in past times than at present.

2. The evidence in favour of the permanence of our ocean basins is now very strong, gathered as it is from considerations stratigraphical, palæontological, physical, and founded upon the geographical distribution of life. Mr. Wallace may well say, whilst commenting upon this theory, that Mr. Charles Darwin's argument, framed on the absence of Palæozoic and Secondary rocks upon oceanic islands,[1] "coming in support of the long series of facts of an altogether distinct nature, going to show the permanence of continents, the cumulative effect of the whole must, I think, be admitted to be irresistible" (*Island Life*, p. 98).

[1] See *antè*, Mr. Crosby's article, p. 251.

If this theory be accepted, it raises very serious difficulty in the way of accounting for the Archæan rocks, upon the supposition that they were deposited in the sea. Mr. W. K. Gilbert (*Nature*, vol. xxvii. p. 262) has insisted upon the fact that wherever the Archæan rocks are found, succeeded by newer formations, there is an unconformity between the two. This means that in early Cambrian times, the localities where Archæan rocks are found succeeded by Cambrian rocks (and they are many, and widely distributed) were occupied by land. On the other hand, in Pre-Cambrian times, these areas were occupied by ocean, if the Archæan rocks are oceanic deposits. But since the Archæan rocks are so widely spread over our present continental areas, where was the land, the denudation of which supplied the material for these rocks? It must almost necessarily have occupied the sites of our present oceans, unless we suppose that these land surfaces lay in every case in those areas which are now covered by newer rocks. This goes against the theory of the permanence of the sites of oceans and continents, for in Archæan times the present continental areas were occupied by great oceans (always assuming the oceanic formation of these rocks), and the present oceanic areas by land, whilst at the end of Archæan times, our present continental areas were converted into land.

Objection may be raised that the Archæan rocks were not being formed simultaneously in different areas. If this be so, the occurrence in so many areas of a series of highly altered gneissose and other rocks, succeeded by a less highly altered series of green more or less schistose rocks, is a singular coincidence. Again, it may be objected that newer rocks of different ages were deposited unconformably upon the Archæan rocks, for instance, in Westrogothia, the Fucoid sandstones rest unconformably upon them; in parts of Bohemia, the sandstones below stage *C*, and in other parts the band *D. d* 1*a.*; whilst in Britain, we find Harlech beds at St. Davids, Lingula flags at Malvern, Arenig rocks at Carnarvon, etc. But this, as shown by Dr. Hicks (Quart. Journ. Geol. Soc. vol. xxxi. p. 552), indicates the submergence of successive portions of a sloping Archæan land, rather than successive upheavals of different parts of an Archæan ocean-floor. If the break were not produced in all areas simultaneously, it is exceedingly difficult to account for the entire absence of ordinary unmetamorphosed marine sediments of Archæan age.

3. The theory of the growth of continents by successive additions along their borders, advocated by Dr. Dana in North America, seems with slight modifications to be applicable to the European continent also. The Cambrian and Silurian rocks stretch far eastward into Russia, and are found north as far as Jemtland in Sweden, and above Bergen in Norway, and as far south as Spain and Sardinia, usually as wide-spread marine deposits. In Devonian and Carboniferous times, various ridges of land existed in this ocean, and in Mesozoic times the site of the European continent was occupied by wide Mediterranean Seas, as shown by Mr. Wallace (*Island Life*, p.87). In Tertiary times, the continent was so far compacted, that it was

occupied by more contracted seas in the early Tertiary times, and by gulfs ramifying through the centre of the continent in still later times.

The unconformities separating different systems show that the growth was not continuous, the continent being sometimes larger at an earlier than at a later period, but in no case are these unconformities spread all over the continent with great discordance of dip and strike, except at the end of Archæan times. This is remarked by Mr. Gilbert in the place alluded to before. The break at the top of the Archæan rocks is not only shown by great discordance of the strata above and below, but is also marked by the immense amount of denudation which took place at the end of Archæan times: this will be considered shortly. Such being the case, if the theory of growth of continents be true for later times, it will not hold good for Archæan times, if those rocks are of marine origin.

It is worthy of notice that the two theories just considered—that of the permanence of the site of ocean basins, and that of the growth of continents—receive much support from the evidence furnished by the newer rocks, but are confronted with serious difficulties by the theory of marine origin of the Archæan rocks.

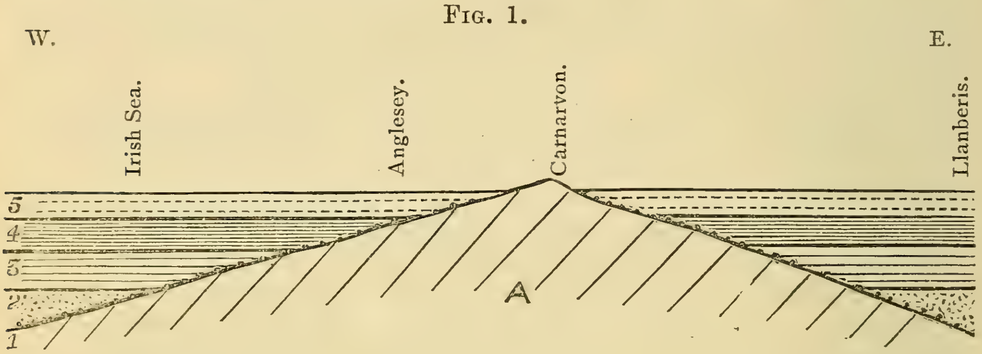
4. The vast amount of denudation which took place at the end of Archæan times has hardly received the notice it deserves. This denudation is shown to have been very great by distinct kinds of evidence.

Whatever the cause of production of the regional metamorphism of these old rocks, the fact remains that the most altered rocks are extensively penetrated by granitic masses. In Scandinavia the schists are in many places so traversed by granites that it is exceedingly difficult to separate granite from metamorphic rock, and the same may be remarked in Bohemia, and judging from published accounts, in many other areas where Pre-Cambrian rocks occur. In Scotland, the great quantity of pegmatite may be judged from the descriptions in Dr. A. Geikie's Text Book of Geology, p. 640. In North America also, granites are abundant, and whether or not these granites produced the metamorphism, they show that *at the time they were intruded, the rocks which they penetrated were at a considerable depth below the surface.* The abundance of these granites in Archæan rocks has been explained by the age of the rocks, and therefore their greater likelihood of being penetrated by granite than newer formations. However, a great deal of this granite is undoubtedly of Archæan age, as shown by the occurrence of granite pebbles in the conglomerates of the Cambrian system, and by the comparative rarity of granites in Cambrian rocks resting immediately upon Archæan rocks, which are very largely penetrated by that rock.

It follows that the denudation at the end of the Archæan times was sufficient to lay bare a great quantity of granite formed at a considerable depth, and that such granite has been more rarely exposed in later times.

The great denudation of the rocks is also shown by the extreme irregularity of the submerged land upon which the Cambrian rocks were deposited. This irregularity might be due to the inequality of earth-movements at the commencement of Cambrian times, a thing rendered extremely unlikely by the great uniformity of character of many Cambrian deposits over wide areas, and its improbability may also be judged of, by attempting to apply this explanation to two particular cases which may be taken from many others by way of illustration. The first is the mode of occurrence of the Cambrian rocks of North Wales and the East Coast of Ireland, as shown in Fig. 1, which indicates the manner in which the Cambrian deposits overlap one another against the old Pre-Cambrian ridge.

Fig. 1.



A. Archæan Ridge.

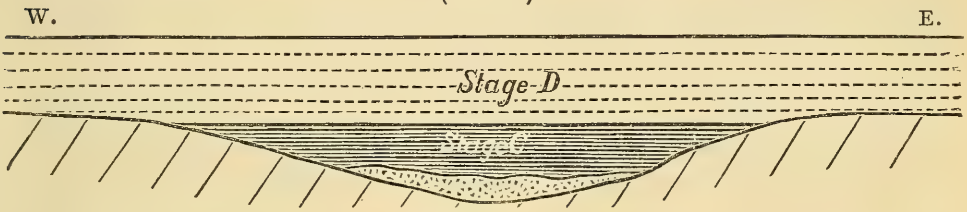
5. Arenig Beds. 4. Tremadoc Slates. 3. Lingula Flags. 2. Harlech Series.
The dotted part indicates shore deposits. Vertical scale much exaggerated, and part W. of Carnarvon much shortened horizontally.

In tracing the Cambrian beds from Llanberis to Carnarvon, a thickness of several thousand feet of rock is found to thin out and disappear in a horizontal distance of about eight miles, as shown by Sir A. Ramsay (Mem. Geol. Survey, vol. iii.), and the same thing is seen in tracing the rocks from Ireland towards Carnarvon, only the thinning out here takes place more slowly. The inequality of movement would have to be very great if this distribution of the beds is to be explained in that way, whilst the Llanberis and Irish areas were depressed, the narrow ridge between would be kept continuously above water. A similar change is shown to occur between the Longmynd Hills and the Wellington area, where the Hollybush sandstone rests on the Archæan rocks, and other phenomena of the same nature are found in Sweden. They appear to point to the submergence of great mountain masses sculptured by subaerial denudation, and this would also account for the remarkable character of the boulder conglomerates found in Cambrian beds of different ages, where they rest upon the Archæan rocks, as those described by Dr. A. Geikie in the north of Scotland (cf. "Geological Sketches at Home and Abroad"), and by Prof. Lapworth in the Girvan district (Quart. Journ. Geol. Soc. vol. xxxviii. p. 537).

The high mountains would give rise to glaciers and Boulder-clays formed upon their flanks; upon the submergence of these tracts, the clays would be re-sorted, and the boulders somewhat rounded. Some such explanation as this is required to account for the great size of the stones in many Cambrian conglomerates of different ages, in various parts of Europe, and the absence of large pebbles in the basement beds of different age in many other parts of Europe. The large boulder conglomerates would be formed where Boulder-clay was found to supply the pebbles.

Another illustration of the irregularity of the Archæan land-surface is still more difficult to explain by irregular earth-movements, but presents all the appearance of a large submerged valley. This is furnished by the distribution of the stage *C* in Bohemia. The beds of this stage are found at Skrey on the north side of the basin of Lower Palæozoic rocks, and at Ginetz on the south side, and they rapidly die out in an east and west direction at both these places. They rest upon conglomerates and sandstones, whereas in other parts of the basin the conglomerates and sandstones of stage *D* rest upon Archæan rocks, so that a section across this part of the basin before the disturbance of the Cambrian rocks would be somewhat as shown on Figure 2.

(Fig. 2.)



Archæan Rocks.
The dotted part indicates shore deposits.

The beds of stage *C* extend for a distance of about thirty kilomètres on the north side of the basin, and a little less than this on the south side, and the deposits of *C*, and the underlying sandstones and conglomerates are many hundreds, and probably thousands, of feet in thickness. It seems that here a large valley was submerged in Cambrian times, and that the valley was one of denudation, and not produced by earth movement, for *the direction of the depression is about at right angles to the direction of strike of the Archæan rocks in which it occurs.*

From all these considerations, it would seem to follow that an enormous amount of denudation took place at the end of Archæan times, quite sufficient to bring to the surface great masses of rock which were metamorphosed at a considerable depth below it.

5. An abnormal amount of volcanic activity appears to have occurred during Archæan times. Where the rocks are comparatively unaltered, the volcanic rocks are readily recognizable, as at St. Davids, Bangor, the Wrekin, and other places (*cf.* papers by Messrs. Hicks, Hughes, Bonney, Callaway, and others in the Geological Society's Journal), and it seems to be recognized more and more, that some at least of the highly altered rocks are also of volcanic origin. Professor Bonney, for instance, speaks of certain Cornish hornblende schists as possibly "having been basaltic tuffs with which in chemical composition they would agree fairly well" (Quart. Journ. Geol. Soc. vol. xxxix. p. 19). Mr. Reusch also (Silurfossiler og Pressede Konglomerater i Bergenskifrene) considers that the

gabbros, diorites, dioritic schists, hornblendic schists, and other metamorphic rocks of the Bergen district, are altered tuffs and eruptive rocks. He gives two alternatives as to their age (p. 105), one that they are Silurian, and interstratified with the somewhat altered fossiliferous rocks; the other, that they are inverted anticlinals, with the fossiliferous rocks occurring as synclinals between them. In either case, they seem to give evidence that regionally metamorphosed rocks of similar character to those found in the Archæan systems may be produced by the alteration of possible volcanic rocks. Whilst alluding to this work of Mr. Reusch, it may be further noticed that great interest attaches to the fossils of Silurian age occurring in such highly altered rocks as those described by Mr. Reusch. When we hear of fossils preserved under these circumstances, it is noteworthy that the limestones in the Archæan rocks, which have been examined so carefully, have yielded nothing more satisfactory than the dubious Eozoon. Professor Heddle, in his descriptions of "the County Geognosy and Mineralogy of Scotland" concludes that among the most metamorphic rocks of Sutherland is a series of contemporaneous volcanic sheets.

The occurrence of so much volcanic matter, so widely spread among the Archæan rocks, is difficult to explain, if we suppose that the great bulk of the Archæan rocks was formed under conditions similar to those under which the ordinary fossiliferous rocks were produced.

6. The Archæan rocks present many peculiarities which it is exceedingly difficult to explain, if they be considered as marine deposits, whereas many at any rate of the types found might be produced by the alteration of ordinary pyroclastic rocks. The Cornish rocks do not appear to have yielded to Prof. Bonney's searching microscopic examination any convincing proofs of their marine origin, for in a footnote on p. 19 of the paper referred to above he says, "While examining this hornblendic group I had always present to my mind the possibility that the more massive varieties might be really metamorphic igneous rocks, but I obtained no evidence in favour of this view, and am disposed to regard the group as, at any rate in the main, of sedimentary origin." The cautious way in which Prof. Bonney speaks of them would seem to allow of the possibility that they may be of pyroclastic origin.

Many of the green schistose rocks would appear to be of such a composition as is quite in accordance with their pyroclastic origin, but when we remember the difficulty of distinguishing in some cases a comparatively unaltered pyroclastic rock, from the grits derived from the denudation of such rocks, it will prevent us from laying much stress upon this point. However, if so many Archæan rocks can be proved to be of volcanic origin, it is quite as legitimate to conclude that others also are of volcanic origin, where the original nature is nearly obliterated, as to suppose that these latter are marine sediments, unless we can point to undoubted marine sediments in the Archæan rocks. Once granted that volcanic action was more powerful in Archæan times than in later times, and we admit that the conditions under which the Archæan rocks were produced were somewhat different from those under which later rocks were produced, and this difference may have been very great. What actual evidence have we, then, of marine or fossiliferous rocks of Archæan age? The cases usually cited are:—

(i.) Crystalline limestones, some containing Eozoon.
(ii.) Beds of graphite.
(iii.) Beds of hæmatite.

As to Eozoon, we know that "doctors disagree," and it can hardly be brought forward as an argument in favour of the marine origin of the rocks in which it occurs, if other facts are opposed to this. It is unnecessary to quote the numerous authorities who are opposed to the organic nature of this structure.

With regard to the rocks themselves, these facts are worthy of consideration:—The crystalline limestones appear to be mainly lenticular masses of small extent. This is the case in all areas where the writer has had an opportunity of examining them. The presence of these very lenticular patches and the absence of wide-spread beds of limestone would point to this rock not having originated in an Archæan sea, but in some other manner, as by precipitation from calcareous springs, such as are found in most volcanic districts. The graphite also has been appealed to, as proving the former existence of organisms, but we know that graphite is also formed under other circumstances. It is found disseminated as scales, as well as occurring in pockets in the Borrodale beds of the Lake District; it occurs in the same way in Bohemia, not only in apparent or real layers, and pockets, but also disseminated as scales in the gneissose rocks, forming in places actual graphitic gneisses. The hæmatite is supposed by Dr. Sterry Hunt to have been produced by precipitation of iron by vegetable matter; in these same Borrodale beds, we meet with masses of hæmatite, which could hardly have been formed by filtration from rocks above them. Certain white flinty rocks occurring among the green schistose rocks in Bohemia bear a striking resemblance to siliceous sinters, but this may be only superficial.

These rocks, then, need not necessarily have been formed in the sea, as similar rocks are formed on land, in volcanic regions. Furthermore, the different varieties of rock do not occur in the same relative abundance as one would expect, if they were ordinary marine sediments which had been subsequently altered. In all newer systems we find great masses of limestone somewhere or other, *e.g.* the Cambrian limestones of Russia and Eastern Sweden; the Silurian of Russia, Sweden, Bohemia, Niagara, etc.; the Devonian of Devonshire, and the Eifel; the Carboniferous of Western Europe; the New Red of the Alps; the Jurassic and Cretaceous of Western Europe; and the Tertiary of Europe, the Himalayas, etc. In the Archæan rocks, on the other hand, although such large areas are exposed, we never seem to get large masses of limestone, but merely these lenticular patches. A glance at the Geological Survey Map of Anglesey will show the great contrast which these Archæan limestones show to other limestones.

The difficulties above considered are suggested, if the marine origin of the Archæan rocks be adopted; but if they were formed on land, the difficulties disappear, and the feasible way of accumulating such rocks on land is by volcanic action.

The researches of Prof. George Darwin upon the tides, and the geological bearings of his investigations, have been singularly little heeded by geologists, who are apparently content with the proofs that the earliest fossiliferous rocks present the appearance of having been accumulated under tranquil conditions similar to those now obtaining in our oceans, and ignore the fact that the reverse appears to be the case when we examine the Archæan rocks, and that a strict comparison betwixt these and the ordinary rocks cannot be successfully established.

Let us consider the changes which might take place after the separation of the moon.

1. Prof. Darwin, I believe, considers that a scar would be left where the mass which formed the moon separated from the earth, which might still be occupied by part of our oceans; he also says (Proc. Roy. Soc. vol. xxviii. p. 196), that wrinkles running in a general north and south direction might be raised in the earliest stages after separation, by disturbing force, and he points out that the present continents or large wrinkles conform more or less to this law, and adds, "it must be supposed that the general direction of the existing continents has lasted through geological history," a supposition to which the marine origin of the Archæan rocks is, as already explained, opposed.

2. Prof. Ball ("A Glimpse through the Corridors of Time,") considers that the water condensed upon the earth after the separation of the moon's mass. It would occupy the scar left by the separation, and perhaps parts of the depressions, forming somewhat small primæval oceans. The pressure caused by the watery atmosphere before its condensation would be, as Mr. Fisher states in his "Physics of the Earth's Crust," very great; consequently, when this pressure was removed by condensation, there would be removed an obstacle to the outburst of vulcanicity. There would be, therefore, a tendency to volcanic activity of considerable, and perhaps paroxysmal violence. (The occurrence of such paroxysmal eruptions at some period or other in the moon itself is worthy of recollection in connexion with this.) If the outbursts were paroxysmal, the result would be the production rather of pyroclastic rocks than of lava-flows, and these pyroclastic rocks would not necessarily be coarse because of the violence of the action, for we know that during violent outbursts many of the fragments fall back into the crater, and are thrown out again and again, until at last they are reduced to an exceedingly fine state of division (Cf. Judd, "Volcanoes," p. 174). In this way the fine false-bedding described by Dr. Sorby and more recently by Prof. Bonney as occurring in these rocks might be produced, just as similar false-bedding is found in pyroclastic rocks at the present day, and in many ancient volcanoes. A peculiarity of the Archæan rocks noticed by Dr. A. Geikie (Text-Book of Geology,

p. 637), viz. that "the rocks have a general stratified structure, but the individual beds often present great irregularities of thickness, being specially prone to lenticular development," is quite explicable if we suppose they were volcanic products, but otherwise is only accounted for on the supposition that they were all shallow-water deposits, which seems somewhat improbable.

3. The rapid accumulation of great masses of volcanic matter would cause the first formed outpourings to become deeply buried, so as to be brought within the influence of metamorphic action, whether produced by heat, pressure, and water, or by intrusion of granite and other plutonic rocks, or by both causes. The metamorphosed rock becoming denser, would contract, and cause puckerings.

4. At first, as volcanic activity was more violent, denudation could not take place so rapidly as accumulation, but as the volcanic forces died out, the intensified denuding forces supposed by Prof. Darwin to have been brought into play would remove much of the accumulated material, lay bare wide areas of the once deeply buried rocks which had become greatly metamorphosed, leave here and there some rock only partially metamorphosed, but remove all or nearly all the unaltered rocks at the top, and would carve out the system of hill and valley described in a former part of the paper. On these hills glaciers might be formed.

5. As this great denudation removed large masses of rock, it would again relieve the pressure, and some of the quartz felsites intruded in the newer Archæan rocks might be thus permitted to force their way up, and perhaps give rise to those comparatively unaltered rhyolitic rocks and ashes which occur at the summit of the Archæan rocks in some places.

6. We know that volcanic areas have a tendency to subside, on the dying out of volcanic activity. For this reason (and also because the rapidly denuded materials of the land would be washed into the scar left by the moon's separation, and tend to fill this up), the seas would gradually encroach upon these irregular Archæan lands, and so the Cambrian rocks would commence at different times to be formed against different levels of this subsiding land surface, generally being formed sooner in the west of Europe than in the east, as explained by Dr. Hicks in a paper already referred to, but the oldest of these rocks in Europe being always of comparatively local distribution, because they were deposited in wide submerged valleys, whilst the intermediate mountain ridges received no deposits at that time.

The terrestrial and volcanic origin of the Archæan rocks, if it can be maintained, would dispose of most or all of the difficulties hitherto discussed. The great difficulty in the way of the ordinary metamorphic theory of these rocks, namely; the wide-spread occurrence of regional metamorphism in Archæan times, and its rarity in later times, is accounted for, as similar metamorphism would be going on at later periods, but the exceptional violence of denudation, and its long continuance, would explain the exposure at the surface of so much Archæan rock altered at a great depth. This exceptional wide-spread denudation no longer occurs with such violence, but great denudation for long periods still goes on in mountain chains, and there we should expect to find regionally metamorphosed rocks of later age.

One or two objections to the view of the volcanic origin of the Archæan rocks may be here discussed. Of course, any convincing proofs of the marine origin of beds of this age would be fatal to their terrestrial and volcanic origin in the manner above suggested. At the same time, it may be pointed out that local aqueous deposits might be formed in lakes upon the land, or that moyas poured out from craters would form layers of argillaceous sediment, which would resemble marine deposits. Such an argillaceous band has been mentioned by Prof. Bonney as occurring amongst the quartz felsites at the foot of Llanberis lake, but it is very thin.

A very great difficulty is that connected with the evolution of life. A large part of the earth would be absolutely unfitted for life when the volcanic rocks were being accumulated, consequently the rich variety of forms in the Harlech rocks of St. Davids is very perplexing. It may be remarked, however, that according to the views above advanced, great deposits of sediment would be formed in the ocean basins long before the present continental areas had become submerged, and there would be a violent struggle for existence in these oceans, owing to the abnormal rate of physical change; these rocks, if thus formed, are for ever lost to us, and we can never hope to find traces of the earliest organisms, buried beneath our present oceans. It by no means follows that we need despair of finding organisms older than those of the Harlech rocks of St. Davids. It has been pointed out with what great irregularity the earliest Cambrian sediments were deposited, so that somewhere or other in our present Continental areas, rocks of Cambrian age, and earlier than the Harlech beds of St. Davids, may be discovered. The great thickness of rocks in North Wales and the Longmynd Hills, as compared with those of St. Davids, is doubtless partly due to their shallow-water character, but perhaps also to the lowest rocks in these areas having been formed before the St. Davids area was submerged, and where such rocks have not had their organisms obliterated by subsequent cleavage, we may hope to find less differentiated forms than those of the Caerfai rocks of St. Davids.

Again, there are many other difficulties besides the one here raised, against the acceptance in full of the theory of natural selection, which have been noted by various palæontologists, among whom may be mentioned Barrande, Carruthers, and Blake; and I find the following remark in a lecture recently delivered by a biologist and palæontologist (Prof. L. C. Miall, "The Life and Work of Charles Darwin," Leeds, 1883, p. 31):—"The Darwinian has to make much of the imperfections of the geological record, in order to avoid the inference that the divergence of animal forms has seldom extended to classes; seldom, indeed, to orders. I am willing to concede all that is asked on this head; but I cannot as yet find in Palæontology the proof, and, indeed, hardly the possiblity, that all animal life has had a common origin."

It has been observed in all areas where the Archæan rocks are developed that no minute order of succession can be made out, but in many areas the following general succession occurs in ascending order:—

1. Highly metamorphosed, often foliated rocks.
2. Less highly metamorphosed rocks, rich in green silicates, and often foliated.
3. Unmetamorphosed lavas and ashes.

The rocks (2), according to the supposition of their volcanic origin above advocated, would, as already explained, be merely the same rocks as (1) which had not been sufficiently deeply buried to become so highly altered, and it is noticeable in connexion with this that they are usually less penetrated by granites.

The rocks (3) would be formed, as described, after the removal of much of (2) and some of (1) by denudation, and we may therefore expect to find them resting sometimes on (2) and sometimes on (1) and presenting discordance of dip with these.

Lastly, the various doubtful unconformities which have been recorded in the Archæan rocks may be in many cases due to denudation of the volcanoes during periods of comparative volcanic quiescence, and the accumulation of agglomeratic fragments perhaps rounded by pluvial action upon the eroded surfaces of the older pyroclastic rocks.

This view of the origin of the Archæan rocks is of course only to be confirmed or otherwise by rigid microscopic examination of the rocks themselves, but I have thought that it would be useful to draw up these notes in order to show how many actual difficulties do occur, which there is often a tendency to overlook.

REVIEWS.

I.—Dr. Barrois' Geology of the Older Rocks of the Asturias and Galicia.

(Second Notice.)

The Lithology of this fine work has evidently received most careful attention on the part of the author, and hence we find that this portion of the subject has the post of honour assigned to it, whilst the book itself is dedicated to the well-known petrographers, Messrs. Fouqué and Michel-Lévy, in acknowledgment of the assistance obtained from the College of France in this department. Dr. Barrois chiefly concerns himself with the lithology of the palæozoic schists and quartzites, and with that of the massive crystalline rocks; but in the stratigraphical portion of the work the description of the "*terrain primitif*" (Archæan) is so essentially based on its mineral composition and rock structure, that this also falls within the lithological section, although relegated to an entirely different chapter (pp. 387–406).

We have then to consider three divisions of the subject, and it may be convenient to take them in the order of time, rather than to follow the arrangement adopted in the work itself.

"*Terrain primitif.*"—Some of the Spanish geologists have divided the Archæan masses of the province of Salamanca into nine distinct stages, thus eclipsing the achievements of Dr. Sterry Hunt in America, and of Dr. Hicks in the British Isles. The author is not prepared to accept these stages. After referring to the importance of Macpherson's work in Western Galicia, he gives his own views of the "*terrain primitif*" in that province.

The granitoid gneiss, which forms the lowest known stage of the Archæan system, is wanting in Galicia, where the system is represented by two principal groups of distinct beds: the lower is formed essentially of mica schists, the upper one of green schists, which are chloritic, hornblendic, talcose, or micaceous, along with beds of quartzite, serpentine, etc. Subordinate to the preceding, occur thin beds of gneiss, and of garnetiferous hornblende-rocks: the mineral composition of these is most elaborately described (pp. 398-406).

The elements of the crystalline schists (page 393) are entirely crystallized, there is no vitreous or amorphous magma. In fact, Dr. Barrois' observations as to their structure correspond with what has been noted by M. Michel-Lévy in treating of the gneissic formation of Morvan in France. The black mica has no regular crystalline outline, and possesses a characteristic arrangement, as seen under the microscope; the felspars are irregularly distributed, triclinic felspars being rare, whilst quartz constitutes the greater part of the rock.

"*Roches sédimentaires.*"—With respect to the Cambrian and Silurian systems, the following table will best explain the lower portion of the Palæozoic column, as developed in the Cantabrian Chain.

SILURIAN SYSTEM in Asturias.	1. Schists and grit of Corral. Upper Silurian.	Schists and Quartzites of Corral, *Ampelites*.
	2. Schists of Luarca. Middle Silurian (2nd fauna). The fauna at p. 457.	Calcareous Schists of El Horno, with *Endoceras duplex*. Slates of Luarca with *Calymene Tristani*. Bed of Iron Ore.
	3. Grès de Cabo Busto. Lower Silurian.	Grès de Cabo Busto à scolithes. Variegated grits. Conglomerates and schists.
CAMBRIAN SYSTEM in Galicia and Asturias.	1. Limestones and schists with *Paradoxides*, of La Vega, 50–100 m. (1st fauna.)	*a.* Rough greenish Schists. *b.* Limestones (20–60 m.). *c.* Schists and Iron Ore (1–2 m.).
	2. Schists of Rivadeo, 3000 m.	*d.* Greenish Schists. *e.* Bluish "Phyllades."

This terrane is conformable to the underlying "primitive formations": there is no dislocation, disturbance, nor marked lithological change.

At page 408 we are favoured with an insight into the stratigraphy of the Cantabrian Chain, which is illustrated by two large sheets of sections in the Atlas, and a sheet of geological sketches. The entire coast-section from Villalba to the frontier of the province of

Santander occupies one of these sheets, and affords a curious illustration of the loops and folds into which the strata have been pressed.

In connection with the subject of the general folding of the country, there is an instance—selected out of several—of a pair of synclinal folds of the Cambrian beds, which embrace within them the *Scolithes*-grit of the Silurians in such a way that, on one side, the relative positions are completely reversed, and the older becomes the upper rock. Such sections help to explain the causes which have been fruitful of much mystification in former times. Still the doctrine of pseudoclinal structure or the "oldest uppermost," must be used with moderation and only on the clearest evidence, or it may lead to very serious results.

The superficial extent of the Cambrian schists and "phyllades" is very considerable, but the basal grits and quartzites of the Silurian form the prominent crests, and the naked and desolate ridges which have arrested the attention of the first observers. This Grès de Cabo Busto, or *Scolithes*-grit, has strong features of resemblance to the corresponding deposit in Brittany, whilst its orographical importance in other parts of Spain is very considerable. In the province of Toledo it rests directly on the crystalline primitive schists, without the interposition of the Cambrian "phyllades." Its position in the general stratigraphical column, as may be seen in the table, is between the beds of the primordial fauna with *Paradoxides* and the schists of the second fauna, and thus at present Dr. Barrois is satisfied to place it at the base of the Silurian in Spain.

The amount of calcareous beds in these lower formations is relatively small, but there is a great increase of limestone in the Devonian, and especially in the Carboniferous, corresponding to a great increase in fossils. The *Calcaire des cañons*, belonging to the latter system, gives rise to some remarkable scenery.

Such is a brief outline of the stratigraphical position and general aspect of the sedimentary rocks, whose lithology is described in the first chapter (pp. 21–62), which is devoted to the mineral and microscopical characters of the ordinary argillaceous schists, "phyllades," quartzites, and limestones of Palæozoic age in the Cantabrian mountains.

As regards the schists no general relations can be detected between their lithological classification and their age (p. 20). The exogenous or clastic elements are quartz, felspar, and white mica, the endogenous ones being quartz, rutile, tourmaline, white mica, chlorite (p. 31): as a rule endogenous felspars are absent. In the Asturias schistosity corresponds generally with the stratification, and whilst molecular movements have given rise to spangles and needles of crystallization, the traces of organisms have not been destroyed.

The author concludes that endogenous elements predominate in the composition of these schists. But, since rutile and tourmaline cannot form a very large percentage of the mass, we must suppose that what he identifies as "white mica" and "chlorite" are, in conjunction with quartz, the prevailing minerals. A little laboratory work at this point would have been a very useful adjunct to investigations which seem wholly based upon the microscope. We should then learn how far the "white mica" and chlorite" of Dr. Barrois are identical with the "sericite" and "chloritoid" of Mons. Rénard.

The quartzites of the Cambrian system are subordinate to the schists, "phyllades," etc., so enormously developed in the lower beds, but the base of the Silurian is formed by a thick mass of whitish grit—the "Grès de Cabo Busto" previously mentioned—with its beds of "Grès *à scolithes*," whose description strongly reminds one of the "annelid" or "pipe" rock of the N.W. Highlands, which is probably not far from the same geological horizon. In the quartzites the author recognizes two principal varieties: the one is obviously clastic in its elements, though part of the mica may be endogenous; as regards the other, irregular fragments of quartz are enveloped in a subsequent deposit of the same mineral

Some of the limestones, such as the *Calcaire des cañons*, are characterized by many crystals of quartz similar to those described by Rénard as occurring in the *Carboniferous Limestone* of Belgium, and by Wardle, Clifton Ward, and others, in limestones of that age in England; but which do not occur in the *Devonian Limestone*. The latter is also wanting in Foraminifera, their absence being explained by Dr. Barrois as owing to the changes which this porous coral limestone has undergone, and which have not affected the more solid rocks of the Carboniferous Limestone. The coccoliths of these beds are described as of inorganic origin, and their mode of formation explained (pp. 46–47) as resulting from the combination of organic matter with carbonate of lime.

"*Roches crystallines massives.*"—The chapter on the massive crystalline rocks completes the more especially lithological portion of the work, and is a valuable contribution to this interesting subject. Dr. Barrois has been doing for Galicia and the Asturias what Rosenbusch and many well-known authors have done for the Vosges and other classical districts, where similar phenomena have been studied. If anything is to be desired where all is so good, we may again remark that a few analyses, though less indispensable here than when treating of the phyllades, would have served to control the inferences derived from the microscope in the study of the granites, quartz-porphyries, diorites, diabases, and recent quartz-kersantites.

There are two masses of eruptive granite posterior to the Cambrian schists: that of Boal has a length of only three kilomètres on the surface, that of Lugo in Galicia is much more extensive. An absence of white mica is one of the features which distinguishes this larger mass of granite from the other, which latter would come under the heading "granulite" of Michel-Lévy. The contrast between the schists and the granites is most marked, nothing in the nature of a passage can be seen, nor do the schists ever contain a crystal of felspar.

As regards their age, these granites penetrate the Archæan rocks (couches strato-cristallines primitives), and the Cambrian schists, but the author has never found any reason for supposing that they are posterior to the Silurian, although certain elvans, which may be in connexion with these granites, are seen to traverse the Coal-measures (p. 91). The question can only be decided by further examination. There is no trace of a single vein of granite penetrating any of the Secondary formations, which are so well developed in the Asturias. Since, therefore, the Cantabrian Chain is but a continuation of the Pyrenees, this fact seems unfavourable to the notion that any of the granites in the great frontier chain are even comparatively recent.

The character of the metamorphism in contact with the granites is very similar to what occurs in other areas under similar or analogous circumstances.[1] The Cambrian clay-slates (schists argileux) are rendered foliaceous, micaceous, and finally transformed into veritable mica-schists, whilst some banks of schist are charged with crystals of garnet. The order of metamorphism is somewhat analogous to what obtains in Skiddaw Forest. The outer ring consists of crumpled schists, the middle ring of macled schists, the inner ring of leptynolites. In Skiddaw Forest these three zones of contact metamorphism, which has involved the Graptolite-bearing beds of the second fauna, are represented from without inwards by the Chiastolite Slate, containing Trilobites and Graptolites, secondly by the Spotted Schist, finally by the Micaceous Schist.

The author carefully traces the order of these changes. *First*, there is an alteration of structure without any fresh mineral combinations of importance, but the carbonaceous matter and the limonite tend to pass into graphite and magnetite. *Secondly*, there is a substitution of a brownish biotite for the hydrated green silicate which envelopes the quartz grains of the less altered rock: at the same time, there is a more decided development of chiastolite and andalusite. *Thirdly*, the andalusite schists become more and more micaceous on approaching the granitic mass, but still there are no felspars.

He argues that the granite has not generally effected any material change of substance, since the fluorine and titanium minerals occur alike in the unaltered argillaceous schists, and in the macled schists. The excess of alumina has gone to form andalusite in distinct crystals, which envelope in their formation the *older minerals* of the rock, such as graphite, tourmaline, rutile. The absence of these minerals in the intercalated grits is worthy of remark.

Metamorphism of this kind, then, consists in a series of molecular changes, diminishing irregularly in intensity on receding from the centre of promotion. Such chemical changes as have taken place consist, Dr. Barrois thinks, in a loss of constitutional water and carbonaceous matter and a gain in silica. This is also the conclusion, he tells us, at which Fuchs and Rosenbusch arrived with regard to the metamorphic schists of the Pyrenees and the Vosges. We should rather like to see some further confirmation of this view, viz. that an increase of silica in the beds accompanies the genesis of the sub-silicate, andalusite. Moreover, it is contrary to the analyses

[1] It should be noted that both these granites contain black mica, and both produce contact metamorphism. Those granites which contain no other than white mica are said to produce no contact metamorphism.

published by the late Clifton Ward, which show a diminution of silica and increase of alumina in the zones of more intense metamorphism.

The quartz-porphyries, diorites, and diabases do not seem very abundant, and call for no special remark, but the recent quartz-kersantites form a curious group which, although they go into a small compass, have an extensive range. The rock is essentially a crystalline compound of triclinic felspar, and black mica in a finely-granular or compact ground-mass, where there are generally grains of granulitic quartz, hornblende, and a pyroxenic mineral. Recent quartz plays a very important part, and titaniferous iron abounds; the occasional minerals being molybdenite, zircon, tourmaline, and even cassiterite. The latter is said to be abundant and to have been worked since the time of the Phœnicians. The occurrence of this mineral in so recent a rock Dr. Barrois (p. 138) regards as a singular circumstance, having an important theoretical bearing.

These kersantites he divides into (1) the granitoid, which are the most acidic, (2) the porphyroid, and (3) the compact. They differ in several important particulars from the old kersantites; the felspars, for instance, are fresh, and the iron mineral not hydrated. They are eruptive rocks, and their veins cut transversely and in all directions. Their geological age is discussed in pp. 160–161, and the author finally concludes that they must have "made their appearance at the epoch of the great terrestrial dislocations which gave birth to the Pyrenees between the Eocene and the Miocene."

It is only just to remark that the mineralogical composition of several of the rocks, the kersantites especially, is beautifully illustrated in plates i.—iii.

Phenomena of modification.—Having interested his readers in the lithology, palæontology, and stratigraphy of the palæozoic and crystalline masses which aid in forming the Cantabrian Chain, Dr. Barrois finally discusses the influence of earth-movements and of denudation in fashioning the range itself. The history of earth-movements in times past must, in a great measure, be sought in mountain ranges, and in working out these fascinating speculations the author, as he admits, could have no better or more philosophical guide than M. de Lapparent.

In the north of Spain the great earth-creep, whose effects can clearly be traced as having folded the strata, took place towards the close of the Palæozoic period, and there is no mention made of any previous movement of the first magnitude similar to that known in Belgium as the folding of the Ardennes, which occurred in Lower Silurian times; although minor oscillations are admitted to have taken place throughout the Palæozoic period. As a consequence of this freedom from movements of the first magnitude previous to the close of the Carboniferous, the lie of all the Palæozoic beds, including such portions of the Archæan as are visible, is mainly N.—S., with prevailing dips to the W. The lie of the secondary formations on the contrary is E.—W., with prevailing dips to the N. The granite masses appear not to have influenced the position of the beds which inclose them.

The traces of the first movement may, to a certain extent, have been obscured by the second great earth-creep of this region, which took place between the Nummulitic and the Miocene, and is evidently the same as that to which the Pyrenees and Alps are mainly due. Its direction was at right angles to the previous one, and this difference of direction constitutes an important anomaly when compared with such ranges as the Hircynian, Appalachian, etc., where these periodic tangential thrusts have generally operated in the same direction on each successive occasion. The existing relief of the country is mainly due to this latter event (*accident géologique*), in conjunction of course with the ordinary processes of denudation, which a rainfall, at present not much less than 80 inches annually on the northern slopes, serves to emphasize in a remarkable manner. Indeed, the author questions whether there is any country where the action of running water has been more complete and extensive than on the northern slopes of the Cantabrian Pyrenees. Between these weather-beaten mountains and the Bay of Biscay is a platform of marine denudation, varying in width, which helps to show the difference between the action of meteoric waters and that of the ocean.

There are many geologists in this country to whom Dr. Barrois is personally known, whilst a still larger circle is acquainted with his works. That he continues to evince the same ardour, the same powers of observation, and the same philosophical spirit as of old, will be clear to all who have perused these Researches; nor must we forget to congratulate the Société Géologique du Nord on a publication which does so much honour to its Memoirs. W. H. H.

II.—Science in our Public Schools.

Fifth Annual Report of the Dulwich College Science Society for 1882. (Issued January, 1883.) 8vo. pp. 48.

It is highly gratifying to find that the scholars of Dulwich College are determined not to be behind those of other public schools in their pursuit of science; and the present report of their "Science Society" speaks well for the interest its members take in all branches of scientific study. Besides the Museum Report, Meetings, etc., we have papers read on "The Voltaic Cell," by S. Skinner; on "Zoological Classification," by H. Bedford Pim; on "Astronomy," by G. E. Crawford; on "The Geographical Distribution of Animals," by J. Robinson, M.A., F.R.G.S. (Honorary Member); "Central America," by Captain Bedford Pim, R.N. (Hon. Member); "Delusive Evidences of the Senses," by G. E. Crawford; "The Geographical Distribution of Plants," by T. Lattimer, M.A., B.Sc. (Hon. Member); "The Natural History of Bournemouth," by S. Skinner; "The Frog: a Study in Evolution," by H. Bedford Pim; "Modern Methods of Electrical Communication," by G. E. Crawford; "The Inorganic Impurities of Water," by J. W. Stephens; "Coral," by W. H. Hillyer. The notes at the end of the Report comprise Botanical, Entomological, Ornithological, Chemical and Geological Notes. The following note, by S. W. Carruthers, we give as deserving a wider circulation.

"In a section of the London Clay exposed during building operations about 200 yards south of Gipsy Hill Station, I noticed scattered through the clay some small masses of free angular siliceous sand. These were of irregular shape, 1 to 2 inches in diameter, and the clay around them was perfectly homogeneous, and free from siliceous grains, no difference being noticeable in its texture or colour. Afterwards I observed the same bodies in clay thrown out from an excavation for drainage purposes, nearly a quarter of a mile away. The masses were distributed in great numbers horizontally through the clay, occupying a thickness of about eighteen inches; but not deposited in layers, and without any special indication of stratification within that part of the bed. The London Clay was deposited in the nearly still-water of a large estuary; and the question arises, how did these masses of sand come there? It is evident that they could not have been carried by the water which brought the fine sediment forming the clay of the bed; and as it is in well-defined masses, it must have been held together in some way. Considering the high temperature which the fossils of the London Clay indicate, one cannot consider ice as the cause of holding the sand together. If the cement, then, was mineral, it must have been re-dissolved and removed at a later stage, so as to leave the sand free. If it had been iron, we might expect that it would have specially coloured the surrounding clay, but of this there is no trace. It appears to me that carbonate of lime was probably the material which cemented the masses; but I have not been able to find a satisfactory explanation as to the means of its carriage and causes of its deposition. The cause of deposition may have been extremely local, as there is no evidence of the deposit being continuous between the two points observed" (p. 43).

We cannot close this brief notice without wishing the members of the Dulwich College Science Society the success they merit, and trust they will persevere in the pursuit of science in all its branches.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 11, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communication was read:—

"On the Supposed Pre-Cambrian Rocks of St. David's." Part II. By Archibald Geikie, Esq., F.R.S., F.G.S.

In this second part of his paper the author gave the results of the survey which he had made of the district with Messrs. Peach and Topley, and of his study of a series of more than 100 thin slices of the rocks collected at St. David's. He found that he could corroborate generally the descriptions of previous writers on the microscopic structure of the rocks, and that investigation with the microscope amply confirmed the deductions he had drawn from observations in the field.

1. *Order of Succession of the Rocks.*—The following rock-groups in

the Lower Cambrian series are recognizable at St. David's, and are given in descending order:—

4. Purple and greenish grits, sandstone, and shales.
3. Green and red shales and sandstones, with true tuffs (*Lingulella primæva*).
2. Quartz conglomerate.
1. Volcanic group (tuffs, schists, lavas).

The volcanic group forms the oldest part of the Cambrian series at this locality. The bottom is not reached; but about 1800 feet are visible. It consists mainly of purplish-red, green, grey, and pale tuffs, with occasional breccias and bands of olivine-diabase. Analyses of some of these rocks had been made for the author by M. Renard, of Brussels, and Mr. J. S. Grant Wilson, of the Geological Survey of Scotland. The tuffs are partly basic, derived from the disruption of diabase lavas (48 per cent. of silica), partly acid, from the destruction of fine felsites (72—80 per cent. of silica). The microscopic structure of the tuffs was described, and slides and drawings were exhibited. The lavas are varieties of olivine-diabase. Their augite is remarkably abundant and fresh, and they contain scattered larger, well-formed, as well as imperfect crystals of olivine, generally in the form of hæmatitic pseudomorphs. No instance was observed of a siliceous lava having been erupted at the surface. The felsitic fragments in the tuffs must have been derived from the explosion of lavas that do not seem to have flowed out above ground. It was pointed out that this fact is exactly paralleled in the case of the volcanic group of the Lower Old Red Sandstone in the Pentland Hills.

In relation to the quartz-conglomerate, allusion was made to the constant recurrence of such conglomerates in the series of geological formations, and to the fact that they do not necessarily mark unconformability or the natural base of groups of sedimentary rocks.

2. *Geological Structure of the District.*—It was shown that the rocks have been folded into an isocline or inverted anticline, so that in one half of the plication the dip of the strata is reversed.

The groups above mentioned are found in their proper order on both sides of the axis which runs through the volcanic group. The granite has risen irregularly through the eastern limb of the isocline. Small faults may occur here and there along the edge of the granite, but they do not in any way affect the general structure.

3. *The Foliation of the District.* — There has been extensively developed at St. David's a fine foliation of particular kinds of rock, more especially of certain fine tuffs and shales, which have passed into the condition of fine silky unctuous hydro-mica-schists or sericite-schists. A series of microscopic slices was described which showed that the original clastic structure of the beds remains quite distinct, though an abundant development of fine flakes of a hydrous mica has taken place. This structure more particularly characterizes the fine parts of the volcanic group, but it occurs also on various horizons in the groups above the conglomerate, thus linking the whole as one great continuous series of deposits. The author connected it with the plication of the district, and pointed out the great interest attaching to these fine schistose bands as revealing some of the incipient stages of

the same process that had changed wide regions of sedimentary strata into crystalline schists.

4. *The Granite, Quartz-Porphyries, and accompanying Metamorphism.*—The petrographical characters of these eruptive rocks were described, and their perfect analogy to the familiar granites and elvans of other districts was pointed out. Specimens were shown illustrating the gradation from a true granite into spherulitic quartz-porphyry. The quartz-porphyries of St. David's (described by Mr. Davies and Dr. Hicks, and others) exhibit spherulitic structure in an exceptionally perfect manner. Between the felso-spherulites the base is thoroughly micro-crystalline and not felsitic. The rocks belong to a group intermediate between granites and felsites. They occur in bosses, elvans, or dykes round the granite, cutting through all horizons of the volcanic group, and approaching, if they do not actually intersect, the quartz-conglomerate. The metamorphism associated with the granites and porphyries is best seen near the latter. It consists chiefly in the intense induration of certain bands of rock which have been converted into flinty aggregates (adinole). The alteration takes place usually along the bedding, which is nearly vertical; but veins of the same siliceous material ramify across the stratification of the shales. Examined microscopically, the adinole is found to have acquired a micro-crystalline structure, nests of quartz and orthoclase and porphyritic crystals and plagioclase having been developed, together with fine veins and filaments of crystalline quartz. These veins are here and there crowded with approximately parallel partitions of liquid inclusions showing freely moving bubbles. An analysis of a portion of the adinole, made for the author by M. Renard, shows the percentage of silica to be 78·62 with 5·80 of soda, indicating possibly the formation of albite. The author deferred generalizing on the question of the metamorphism he described, but pointed out that a further study of the St. David's rocks could hardly fail to throw important light on the theory of metamorphism.

5. *The Diabase Dykes and Sheets.*—These are the latest rocks at St. David's, as they traverse all the others. Their macroscopic and microscopic characters were described, and allusion was made to the perfect fluxion-structure found in many of the dykes.

The paper closed with a summary of the geological history of St. David's. The earliest records are those of the Volcanic group, which show the existence of volcanic vents in that region in an early part of the Lower Cambrian period. The volcanic accumulations were covered conformably by the Conglomerate and succeeding Cambrian groups; but the same kind of tuffs continued to be ejected after the deposition of the Conglomerate. At a later time this thick conformable succession of beds was plicated, and underwent a partial metamorphism, whereby some of the fine tuffs and shales were converted into sericite-schists. Subsequently a mass of granite rose through one side of the fold, accompanied by elvans of spherulitic quartz-porphyry, whereby a second, different, and feebler kind of metamorphism was induced. The last episode was that of the diabase dykes, which, crowded together in the granite, suggest that the granite boss stands on an old line of weakness and of escape for eruptive material from the interior.

II.—April 25, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Skull of *Megalosaurus*." By Prof. R. Owen, C.B., F.R.S., F.G.S.

The specimens described in this communication were obtained by Edward Cleminshaw, Esq., from the freestone of the Inferior Oolite near Sherborne (Dorset) from some blocks which had been quarried for building-purposes. These were sent by him to the British Museum, where the remains have been developed. One block includes a great proportion of the right side of the facial part of the skull, the missing parts being the fore end of the premaxillary, the suborbital end of the maxillary, and the upper hinder pointed termination of the same bone. Ten teeth are preserved in the maxillary bone. Another block contains the outer side of the right mandibular ramus, with teeth, and with some other fragments. In a third block is the anterior part of the left mandibular ramus, with portions of the teeth. These remains were described in detail; and in conclusion the author discussed the bearing of these and other Megalosaurian remains upon our knowledge of the structure of that animal and its affinity to existing Reptilia, and criticized some of the evidence on which the relationship of the Dinosauria to birds is inferred, a relationship which he had suggested in 1841, but upon grounds which appeared to him to be more satisfactory.

2. "Notes on the Bagshot Sands." By H. W. Monckton, Esq., F.G.S.

The author explained that his paper related to the series of Bagshot Sands on and around Bagshot Heath, which forms what is termed "the main mass" of the Bagshot beds in the memoirs of the Geological Survey.

The railway-cutting at Goldsworthy Hill, described in 1847 by Prof. Prestwich, is still the best type-section of the Middle Bagshot Sands, and the succession of strata seen there was illustrated by reference to newer sections near Ascot and Wellington College. It was pointed out that the most marked feature in this part of the series is very pure greensand, containing casts of shells of Bracklesham species, that a pebble-bed is found at nearly the same relative level over a large area, and that this pebble-bed forms the most convenient and natural line of division between the Upper and Middle Bagshot.

The Upper Bagshot Sands were then described, and attention was drawn to the abundance of fossils in some of the higher beds.

The author then referred to the correlation of the Bagshot beds with the Hampshire series, and stated his conclusion that the Middle Bagshot beds are of Middle Bracklesham age, whilst the Upper Bagshot Sands are nearly equivalent to the Lower Barton of Hampshire, and are in no way equivalent to the so-called Upper Bagshot Sands of Long Mead End.

3. "Additional Note on Boulders of Hornblende Picrite near the Western Coast of Anglesey." By Prof. T. G. Bonney, M.A., F.R.S.

In the xxxviith volume of the "Quarterly Journal" the author described a large boulder of Hornblende picrite which he had discovered near Pen-y-carnisiog. During an excursion last summer to Porth-nobla he had found in that neighbourhood at least eight more.

The rock then clearly was not very rare in this part of Anglesey. These exhibited some varietal differences. The author gave some details of their microscopic structure, and an analysis of one identical with the Pen-y-carnisiog rock, kindly made for him by Mr. J. A. Phillips, F.R.S., from which it appeared that this British picrite corresponds fairly well with the picrite of Schriesheim in the Odenwald, to which in other respects it bears so close a resemblance. Mr. J. J. H. Teall recently called the author's attention to a rock which he had collected on Little Knott, east of Bassenthwaite, which appeared to him to resemble the description of the Anglesey picrite. The author had examined a series of specimens from that locality, and found that macroscopically and microscopically there was a marked resemblance, while the per-centages of silica and magnesia were not very different. He thought, then, it was very probable that the Anglesey boulders came from the Little-Knott district.

CORRESPONDENCE.

M. GAUDRY ON THE CLIMATE OF THE QUATERNARY PERIOD.

Sir,—I beg to call your attention to M. Albert Gaudry's valuable contribution to geological science.[1] It appears to me to establish the correlation between the Glacial and Interglacial formations of this country and near Paris. The reappearance of the Hippopotamus, and the return of warm period in both, if true, are of the highest interest. John Gunn.

All geologists know that in England there is, above the Forest-bed, the Boulder-clay, which represents that which is called the great Glacial epoch. We cannot study the Cliffs of Norfolk, near Cromer or Happisburgh, without being impressed with the importance of the deposits of Boulder-clay. We were ignorant up to the present time of what had passed at Paris during the continuance of the Glacial phenomena, which English savants have so well described in Norfolk, in Wales and Scotland.

To this day, I conceive that the bed on the summit of Montreuil, about 100 mètres high, is one of the representatives of the great Glacial Epoch of the Boulder-clay. The presence of the Reindeer ought not to cause astonishment, for that animal is pointed out in Scotland beneath the Boulder-clay.

If my supposition be correct, with these palæontological data, the history also of the Quaternary period may be traced in the Paris basin.

1. Phase Warm—the deposits of St. Prest—*Elephas meridionalis*—transition between the Tertiary and the Quaternary Periods.
2. Great Glacial Phase—deposit on the summit of Montreuil, at the height of 100 mètres—herds of Reindeer, *Rhinoceros tichorhinus*.
3. Phase Warm—diluvium *below* Montreuil at the height of 53 mètres—*Hippopotami*, *Cervus*, *Rhinoceros Merckii*, *Elephas antiquus*. Possibly the Fig-trees and the Laurels of La Celle, near Moret, pointed out by MM. Chouguet, de Saporta, and Tournouër, belong to the same phase.
4. Phase Temperate—Diluvium of the low levels of Grenette and of Levallois-Perrots, at the height of 30 mètres—*Elephas primigenius*, *Rhinoceros tichorhinus*, and the Reindeer have returned. A mixture of warm and cold species.
5. A sudden return of cold—age of the Reindeer; the *Rhinoceri* have disappeared.
6. Present age—age of the "Polished stones."

[1] "Sur un gisement de Rennes auprès de Paris," par M. A. Gaudry.

THE TERTIARY FLORA OF AUSTRALIA.

Sir,—In the interesting paper on the above subject which appeared in the April Number of this Magazine, p. 153, Prof. von Ettingshausen describes the flora of the Travertin near Hobart Town, and refers to previous investigations on this deposit, specially those of Mr. Johnson. He appears to have overlooked, or at least does not allude to, two short notices on this limestone published about 40 years since, which however are referred to by Mr. Johnson (Roy. Soc. Tasm., 1879, p. 81).

The first notice is by Mr. C. Darwin, who states :—

"Behind Hobart Town is a quarry of hard travertin, the lower strata of which abound with distinct impressions of plants. Mr. Robert Brown looked at my specimens, and he informed me that there were four or five kinds, none of which he recognizes as belonging to existing species. The most remarkable leaf is palmate, like that of a fan-palm, and no plant having leaves of this structure has hitherto been discovered in Van Diemen's Land. The other leaves do not resemble the most usual forms of Eucalyptus (of which tribe the existing forests are chiefly composed), nor do they resemble that class of exceptions to the common form of the leaves of Eucalyptus, which occur in this island. The travertin containing this remnant of a *lost* vegetation is of a pale yellow colour, hard, and in parts even crystalline ; but not compact, and is everywhere penetrated by minute, tortuous, cylindrical pores." [Volcanic Islands, 1844, p. 140, also Journal of Researches, p. 448.]

The second notice is in Strezelecki's New South Wales. Having been requested by Count Strezelecki to examine his collection of fossil plants and invertebrata, with the exception of the Corals and Bryozoa described by Mr. W. Lonsdale, I found among them a few specimens of plants and shells which were thus referred to under the Pliocene Flora :—

"The two specimens of leaves and another peculiar form represented on Table vii. figs. 5—7, are from the yellowish compact limestone near Hobart Town which has been described by Mr. C. Darwin. These impressions have been submitted to Mr. R. Brown, who is unable to refer them to any species known to him, although one specimen has somewhat the aspect of a Proteaceous leaf. This fact is interesting because associated in the same limestone are two species of land testacea, a *Helix* and a *Bulimus*, which Mr. G. B. Sowerby cannot at present identify with any existing analogue.

"These observations, taken in conjunction with the discovery by Mr. Darwin of a palm-like leaf in the same deposit (of which no similar leafy structure has been hitherto found in Van Diemen's Land), may lead us to infer that the species imbedded in the travertin probably represents the fauna and flora of a period slightly anterior to the present." [Physical Description of New South Wales, 1845, p. 254.]

The two species of shells, *H. Tasmaniensis*, and *B. Gunnii*, G. B. Sow., have been also described by Mr. Johnson, who has added three more species from the yellow limestone of Geilston, near Hobart Town.

The above notices may perhaps be of interest as supplementary to Baron C. von Ettingshausen's paper. J. Morris.

April 11th, 1883.

THE PEBBLES OF THE BUNTER SANDSTONE.

Sir,—The papers on the subject of the origin and composition of the pebbles in the Bunter Sandstone which have recently been contributed to the Geological Magazine give me an opportunity of briefly explaining my present views on this interesting problem.

Having been answerable for the theory which attributes the origin of these pebbles (I mean the quartzite pebbles chiefly) to the Old Red Sandstone of Scotland—to which they bear a remarkable resemblance —I wish now to state that I have abandoned the view of their North British origin altogether in favour of that proposed by Mr. J. W. Harrison, who considers them to have been derived from the concealed ridge of older Palæozoic rocks, which we now believe to underlie the Mesozoic strata of the Centre and East of England. At the time I suggested the Scottish source, I was freshly and vividly impressed with the resemblance of the reddish or "liver-coloured" quartzite plebbles to those of the Old Red Conglomerate of the Lesmahago and other districts. But I all along felt the difficulty (on which Mr. Harrison lays just stress) that the number and size of the Bunter pebbles decreases from the Central District of England towards the North-west, which ought not to be the case if they had had the origin I attributed to them. Further reflection leads me to think that the objection is fatal to the view either of myself or of Professor Bonney, notwithstanding the microscopic resemblance which he points out to the quartzites of the Highland rocks. Indeed, it is difficult to picture to one's self how the pebbles could have "got round" the promontory and barrier formed by the Silurian rocks of the S. of Scotland without having been very thickly strewn over the submerged tract of the N.E. of Ireland and of N. Lancashire; but such pebbles are almost entirely absent from the Bunter Sandstone of Antrim and Downshire.[1]

A reference to Plate IX. of my Palæo-physiographical maps will assist in making this tolerably clear. The ridge of old rocks which occupies the Eastern Counties and ranges as far North as a line drawn from the Wash to the mouth of the Avon, shown on the map, very probably contains beds of quartzite, porphyry, and hornstone, etc., such as are found in the Bunter of Staffordshire; and the supposition of such a source seems to be attended with less difficulty than that of any other yet proposed.

5, Raglan Road, Dublin, *5th May*, 1883. — Edward Hull.

ON THE SO-CALLED PLANT-FOSSILS FROM CENTRAL WALES.

Sir,—In his recent communication on this matter (Geological Magazine, April, 1883, p. 192) Mr. W. Keeping expresses the opinion that *Nematolites Edwardsii* "is a Coralline Alga." That object has formerly been described as "solid bodies of pale-chocolate colour and earthy constituency." Now, it seems difficult to understand why a Coralline Alga should be more easily converted into earthy matter of pale-chocolate colour than branched burrows and tunnels of annelids should be filled up by such a sediment, and I consequently fail to see any evidence whatever why the opinion which has been expressed in my former communication should be altered. As to *Nematolites dendroideum*, I have not hitherto said anything on it, and

[1] It may be objected, truly, that the stage of the "Pebble Beds" is but sparingly represented in N.E. Ireland.

Mr. Keeping might be quite right that it cannot be a worm trail. But, to conclude from the poor specimen hitherto described, its mode of branching is so very unlike that of a true plant, that it seems very difficult to believe that it should be of vegetable origin—at least until better specimens should have proved it. Concerning *Buthotrephis major*, its different modes of occurrence (usually "as a delicate impression, or as half-compressed solid bodies," sometimes upright in the sediment, "when the circular sections and tip end of the branches come to resemble rain pittings") harmonizes so perfectly with the branched trails and burrows of some annelids—which now creep on the surface of the mud, now make burrows in it—that there is no reason why that object should be regarded as something else. And Mr. Keeping has failed to give any satisfactory statement to prove its true plant-nature. Lastly, as to *Myrianites Lapworthii*, it might perhaps in some cases be convenient that such bodies should have their names, but it ought not to be forgotten that the specific value of such a name is *nil*.

STOCKHOLM. A. G. NATHORST.

CHALK MASSES IN THE CROMER DRIFT.

SIR,—To properly deal with all the questions raised by Mr. Searles Wood's letter in the May Number of the GEOLOGICAL MAGAZINE, would be more than is possible within the limits of a letter. I may, however, be permitted to observe that if the Chalk Masses, in which term I include the whole, whether of solid or reconstructed chalk, from the western side of the Wolds of Central Lincolnshire, as supposed by Mr. Wood, it ought to be possible to trace them up their origin through a train of such blocks. Has Mr. Wood done this?

There is no difficulty whatever as regards levels in the derivation of the great mass of Chalk Boulders in the Cromer Drift from the Norfolk Chalk. To use a harmless expression, it seems like "taking coals to Newcastle" to bring chalk boulders from Lincolnshire into Norfolk. But it is far from me to deny the possibility of such an origin, if sufficient evidence were adduced in its favour, which I venture to think has not yet been done. Mr. Wood, to say the least, is peculiar in his view that all the large masses are not genuine, but "reconstructed" chalk. In this opinion I differ from him along with some pretty good authorities, both old and new. Does he affirm that the Old Hythe Pinnacle of Chalk, from 70 to 80 ft. high, figured by Sir Chas. Lyell, was of "reconstructed" material, or—what can be tested at the present moment—that the boulder figured in my paper (page 231) is not of solid chalk, or that those shown in Clement Reid's careful survey section are not genuine? In conclusion, I may add that whatever may be the exact locality or localities of the Chalk Cliffs to which the boulders may eventually be traced, it cannot invalidate my reasoning as to the mode in which they have been quarried, detached, rafted off, and stranded.

May 5, 1883. T. MELLARD READE.

OBITUARY.

JOSEPH O'KELLY, M.A., M.R.I.A., ETC.

Joseph O'Kelly died at his residence, 72, Eccles Street, Dublin, on April 13th. He was born in Dublin in 1832, being the second son of Matthias Joseph O'Kelly, who was well known as an ardent supporter of Natural History when few thought anything about it; his private collection of shells being one of the best then in existence.

Joseph O'Kelly matriculated in Trinity College, Dublin, in 1852, from which he also obtained a Diploma in Engineering, and after spending a few years with Sir R. Griffith, Bart., engaged on the General Valuation of Ireland, he joined the Irish branch of H. M. Geological Survey, 1854, Sir H. de la Beche being Director-General, and Prof. J. Beete Jukes Local Director. In the publications of that service his name appears in many of the memoirs and maps; his more important work being the examination of the Cork Rocks. He was subsequently selected by Jukes to visit with him and examine the rocks of Devonshire and Cornwall; the Igneous Rocks of Limerick, and the Coal-fields of the Queen's County and Tipperary. The Tipperary Coal-field was examined most minutely, and he made some important discoveries therein, while his Memoir is very exhaustive and most trustworthy, and forms a lasting record of his energy and research. This work was carried out with his then colleagues, Messrs. A. B. Wynne and G. H. Kinahan, who were present while every bed in this great and important section was examined and measured; furthermore, the continuous surface section, which was also carefully examined by Jukes, proves the accuracy of their under-ground work. It was during the progress of this work that O'Kelly contracted the ill-health he subsequently suffered from; on account of the exposure and hardships he had to endure, often living for weeks in houses very little better than sheds, into which the wind and rain freely entered. His last regular work in the field was in the Co. Galway, after which he was transferred to Dublin, on the retirement of Mr. John Kelly, to occupy the post of Secretary, which he held till the time of his death. On this account of late years his name does not often appear in the Survey publications, but at the same time his great knowledge of Irish geology was surpassed by few. His affability, honesty, and straightforwardness made him a favourite with all, and a dear and trusted friend of many. He was only in his 51st year, and might reasonably have hoped to have lived longer, had not his constitution been impaired by his previous field-work, having since then been subject to attacks of acute bronchitis, one of which in the end suddenly carried him off. He had served 30 years as an officer of the Irish branch of the Geological Survey.

BASAL OR PALATAL VIEW OF SKULL OF

THYLACOLEO CARNIFEX, OWEN.

FROM QUEENSLAND, AUSTRALIA.

E. C. Woodward del. *G. Shayler sc.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. X.

No. VII.—JULY, 1883.

ORIGINAL ARTICLES.

I.—On an Outline of the Skull, Basal View, of Thylacoleo.

By Prof. Owen, C.B., M.D., D.C.L., F.R.S., etc., etc.,
Superintendent of the Natural History Departments in the British Museum.

(PLATE VII.)

I HAVE just received from Mr. C. H. Hartmann, of the "Range Nurseries, Toowoomba, Queensland," a neighbour of my friend Mr. G. F. Bennett, to whom I am indebted for fossil remains from that locality (*Megalania, e.g.*), an outline of the entire skull of a *Thylacoleo.* It is a basal view of the skull in which the teeth of the upper jaw are indicated *in situ,* determinative of the genus and apparently species. The writer states, "I have only just drawn a pencil outline round the skull so as to give you the right dimensions[1]—the most remarkable appearance is that there is scarcely any brain, but very strong and thick bones."

The space left for the cranial cavity indicates the small relative size of its contents, characteristic of the marsupial Order, and, in this large Carnivore, of unusually diminutive proportions. The contrast is great with the expansion of the "temporal fossæ" for lodgement of the powerful "biting muscles," these cavities being bounded by correspondingly strong and convex zygomatic arches. The latter are features which had not before been shown in cranial fossils of *Thylacoleo*, the least mutilated of which is the subject of plate xvii. of my "Extinct Mammals of Australia," but which, in comparison with the outline of the base of the skull transmitted by Hartmann, permits no doubt of the accuracy of his ascription of that fossil, which he terms "the head of the Marsupial Lion in my possession."

I am in hopes of receiving photographs or casts of this unique fossil, if not the specimen itself, but meanwhile wish to record this additional evidence of the carnivority of *Thylacoleo.*[2]

[1] The details, wanting in the outline figure sent by Mr. Hartmann of the palatal view of the skull of *Thylacoleo*, have been, as far as it was possible, carefully filled in by the artist, Miss Woodward, from the actual specimens in the British Museum (Natural History).—H.W.

[2] For further references to *Thylacoleo* see the following papers:—R. Owen, On the Fossil Mammals of Australia. Part I. Description of a mutilated skull of a large marsupial carnivore (*Thylacoleo carnifex*, Owen) from a calcareous conglomerate stratum, 80 miles S.W. of Melbourne, Victoria (1858), Phil. Trans. 1859, pp. 309-322; Ann. Nat. Hist. iv. 1859, pp. 63-64. Part II. Description of an almost entire skull of *Thylacoleo carnifex*, Owen; Roy. Soc. Proc. xiv. 1865, pp. 343-344; Phil. Trans. 1866, pp. 73-82; Ann. Nat. Hist. 1865, pp. 130-131. Part IV. Dentition and Mandible of *Thylacoleo carnifex*, with remarks on the arguments for its herbivority (1870), Phil. Trans. 1871, pp. 213-266; Dentition and fore limb, Phil. Trans. 1883, Proc. Roy. Soc. No. 224, 1883, and on Pelvis of *Thylacoleo*, Roy. Soc. April 26, 1883.

II.—A Lava from Montserrat, West Indies.

By Thomas H. Waller, Esq.

In the March and April Numbers of the Geological Magazine, Mr. J. J. Harris Teall describes some beautiful rocks from the Cheviots, containing a rhombic pyroxene with well-marked pleochroism, and as there seems little doubt that this mineral, which we must consider hypersthene, has been hitherto overlooked in a good many rocks, another note of its occurrence may perhaps possess some interest.

My friend Mr. Joseph Sturge, who visited the West Indies during the past winter, kindly brought me some specimens of lava from one or two localities. One of these, from St. Lucia, presents no feature of special interest. It consists of a triclinic felspar, augite and olivine imbedded, as crystals more or less fully developed, in a very opaque ground-mass, which, where it forms thin inclusions in the felspar, is seen to be a brownish-grey glass. The augite is very frequently twinned, and one crystal shows a pleochroism similar to that of hypersthene and extinguishes parallel to its cleavage striation; but I have not been able to detect any more instances of such properties. The piece I had was very small, and only served for the preparation of two slides; possibly a more extensive set would reveal further points of interest.

The other lava from the island of Montserrat is a far more beautiful rock. It presents the appearance of a mass of very light-grey colour, so vesicular as almost to deserve the name of a pumice, containing obvious crystals of hornblende. The felspar crystals only show themselves by the reflections from their cleavage faces. The whole is so incoherent that the preparation of slides for microscopical examination proved an extremely difficult task, and the best that I have been able to make leave much to be desired in the matter of thinness. They are, however, sufficient to establish the following conclusions.

The hornblende is in well-defined crystals, though some of these would appear to have been afterwards subjected to some agency which has rounded off their angles and edges, leaving their sections almost elliptical in outline. The crystals show the characteristic cleavages well developed, and are of a very dark colour, showing the following axis tints: a and c brown and yellow, b a greenish-brown. But the absorption $c = b > a$ is so strong that where the sections are moderately thick, they appear perfectly opaque. In one instance it is strong enough to enable the hornblende crystal to act as an "analyzer," a little felspar running obliquely through the hornblende, showing the usual play of colours when only the polarizer is employed.

Fragments detached by cleavage showed an angle of extinction referred to the prism edge, averaging just over 10°, agreeing with F. Becke's remarks in his paper in Tschermak's Mittheilungen für Mineralogie und Petrologie on the Gneiss formation of Western

Austria on the low extinction angles of the dark brown hornblendes when thus examined, as compared with the paler and green varieties. A few cases of twinning occur, in one case the orthopinacoid is evidently the composition plane according to the usual law.

The crystals contain inclosed in them grains of the rhombic pyroxene, to be next mentioned, felspar, opaque grains with no apparent crystalline form, and some little rounded inclosures, which, however, do not appear to be portions of the glassy ground-mass, such as are contained in the felspars, since they have no bubble and no microliths.

I have detected a few crystals of a green mineral showing no pleochroism and possessing *oblique* extinction at considerable angles with the length of the crystals. It has rather the look of augite, but I have not been able to come to any certain conclusion about it.

A truly rhombic pyroxene is however certainly present in considerable quantity, partly in well-formed crystals, partly in grains of irregular outline, which however frequently show cleavages. The crystalline sections across the prism show rectangular forms with the prismatic faces only very slightly developed, only appearing in fact as slight truncations of the edges formed by the pinacoids. This it may be mentioned is exactly contrary to the habit of the augite in the lava from St. Lucia, mentioned above. In this the prismatic faces are most developed, and the pinacoids simply truncate their edges. The cleavage parallel to the prism is constant, that parallel to the brachypinacoid is frequent, while there are a few instances of the other pinacoidal cleavage.

In these sections the colours of the two axes of elasticity a and b are almost exactly the same, viz. a reddish-yellow, only differing in depth of tint as the object is rotated over the polarizing Nicol, one of the axes showing a slightly redder colour with a little more general absorption.

In those sections, on the other hand, which show by their longer shape and the striation due to cleavage that they are more or less parallel to the vertical axis, the colour is a bright green when the length of the crystal (the vertical axis) is parallel to the principal section of the polarizer, and reddish yellow when the direction is at right angles to this. The extinction is always such as shows rhombic symmetry. This is most conclusively shown in the case of fragments picked out from the rock and examined both fixed by wax on the point of a needle so that they can be rotated, and also mounted in balsam. The difference in appearance between this pyroxene with its glassy *transparent* fracture and the hornblende with its brilliant opaque almost metallic lustre made the selection easy.

I conclude, therefore, that the mineral is hypersthene. Allowing for its perfectly fresh unaltered condition, it is wonderfully similar to the mineral in the Cheviot porphyrite previously mentioned, with the possible exception of a somewhat more pronounced pleochroism. This, however, may be due to the fact that my slides of the English rock are too thin to show the phenomenon in question to perfection. The similarity extends to the inclusions, which are ill defined, rounded, apparently crystalline masses, and a few needles of some rather opaque substance in addition to the opaque grains mentioned as occurring in the hornblende.

The felspar mostly presents the usual twinning of the plagioclases, but some of the crystals are simple. Seeing that in 14 measurements of the angle between the extinctions in a zone approximately perpendicular to the plane of twinning, as shown by the equality of the extinction angles on both sides of the plane, this angle varied between $33\frac{1}{2}°$ and 73°, mostly much more nearly the latter, it is pretty sure that the felspar is either labradorite or anorthite. Indeed, I believe that both are present, for some of the grains show the brilliant hard contrasts in polarized light which Fouqué and Levy speak of as characteristic of the more basic felspar, and in applying Szabó's flame reactions to fragments picked out of the rock some were less fusible than others. I may say that the flame reactions point to a lime felspar containing about 3 per cent. of soda and $\frac{1}{2}$ per cent. of potash; that is, the potash colouration seemed very slightly more, and that due to soda considerably more than in the case of an anorthite containing 0·38 of the former and 1·22 of the latter.

The probability of the presence of two felspars is increased by the fact that in one crystal which gave extinctions of 24° and 24° in two twin lamellæ, there were portions which extinguished 41° from the trace of the twinning plane. The central part did so, then there was a zone extinguishing at 24°, then another at 41°, and then an outer one at 24°. The various zones were not very sharply divided from each other, but seemed to pass gradually from one to the other.

The zonal structure is quite common, and in the case of many of the crystals no position can be found in which the whole area is dark between crossed prisms.

Compound twinning is present, in some cases two systems of lamellæ cross nearly at right angles, while in others two individuals showing the ordinary albite twinning are compounded after the Carlsbad system.

The inclusions consist partly of microliths, and partly of the glassy ground-mass of the rock. The microliths are in many cases arranged approximately parallel to the faces of the crystals, and are crowded together in some bands, while they are nearly or altogether absent from others. The "glass cavities" are very numerous, and are wonderfully beautiful. They are of all shapes and sizes, a few being "negative crystals," the others quite irregular. Crowded into zones when minute, more evenly distributed when large, in some places they form by far the greater part of the crystal section, the actual felspar substance being only the connecting matter quite subordinate in quantity. Even when quite small they contain a cavity, mostly spherical, though sometimes elliptical in outline or somewhat irregular. In one case a little drop of glass has adhered to a microlith, like a drop of treacle to a glass rod, but it nevertheless contains its cavity. The glass of the inclusions is apparently slightly brown, and is filled with dark slender acicular microliths, in many cases attached by one end to the crystalline walls, while the other end is directed towards the central parts of the inclusion.

In among the larger crystals are many smaller ones, especially of felspar.

The residual glass which binds the other constituents together is filled with the same hair-like microliths mentioned as occurring in the glass inclusions in the felspars, and in some parts they show fluidal structure. The glass fuses in the Bunsen burner with considerable intumescence.

On the whole, the rock is very similar to some of the hornblende andesites of the Philippine Islands described by Oebbeke in the Neues Jahrbuch, Beilage Band I. 1881, but with the exception that the accompanying pleochroic pyroxene is rhombic instead of monoclinic, hypersthene instead of augite.

74, Gough Road, Birmingham.

III.—On the Cause of the Glacial Period.

By Searles V. Wood, F.G.S.

In concluding an article on "The Climate Controversy" in the Geol. Mag. for September and October, 1876, I observed (p. 451) that it had long appeared to me that the "Glacial period proper" was due neither to a change in the earth's axis, nor to any variation in the eccentricity of the earth's orbit, nor to any changes in the distribution of land and water, but to a diminution in the heat-emitting power of the sun. In a memoir on the Newer Pliocene period in England, published in the Quarterly Journal of the Geological Society for Nov. 1880, and Nov. 1882, wherein I have endeavoured to trace in detail the succession of events in this country from the commencement of the Red Crag down to the close of the Minor Glaciation, I have reiterated that view, as being the only one that is reconcileable with the succession thus traced; for with the exception of the single interval of warmer climate in which the beds termed by me the "*Cyrena fluminalis* formation" accumulated, and which was succeeded by the renewed refrigeration that I have termed the "Minor Glaciation," and regarded as coincident with the second advance of the Alpine glaciers long ago detected by Continental geologists, I have not been able to discover any indication of those alternations of warm and cold climate, which form an indispensable part of the eccentricity theories of Adhemar, Croll, Murphy and others.

In the case of North America, there has also been a failure altogether, on the part of the geologists of that country, to detect evidence of more than one alternation of climate during the Glacial period; and this one seems to be precisely that to which I have referred.[1]

[1] For evidence of this single alternation in the States of Iowa and Illinois, see McGee in Amer. Journ. of Sci. 3rd series, vol. xv. p. 241; in Nebraska, see Hayden's Report on the superficial deposits of Nebraska for 1874; and in British Columbia, see G. M. Dawson in Q. J. G. S. vol. xxxiv. p. 122. G. K. Gilbert (of the

A dictum, however, of Dr. Tyndall that a mere refrigeration could not have caused the Glacial period, because by diminishing the evaporation it would, so to speak, have cut off glaciers at their source, and that greater condensation was the essential factor in the problem, appears to have disinclined geologists to accept, what I believe to be, the only true explanation of the cause of this important episode in the earth's history; and therefore, as in my memoir "on the Newer Pliocene Period in England," a regard for the space I was occupying in the Journal of the Geological Society precluded my examining, and endeavouring to show there, why the view at which I had arrived of the cause of the Glacial period was not impaired by this (erroneous as I regard it) dictum of Dr. Tyndall, I propose doing this as briefly as I can in the pages of the Geological Magazine.

The view adopted by some that the Glacial period was one in which ice caps were formed at the poles, whether synchronously or alternately with each other, is founded on the assumption that the poles, and the area immediately around them, must be the parts of the earth on which the greatest quantity of ice accumulates. This, however, though probably true of marine (or floe) ice, is pretty clearly not so of land ice at the Arctic, whatever may be the case at the Antarctic pole. The exploration of the north side of Greenland, by Smith's Sound, has disclosed that this extremity of that region, although it is 20° of latitude nearer the pole, and has a much colder climate, is rather less, than more, buried under land ice than is South Greenland, so far as that can be seen from the Davis' Strait side; while the existence of sea, though this be ice-bound, on the north side shows that the Greenland ice is in no way connected with a polar cap. Where the German Expedition of 1869–70 was able to penetrate the floe-blocked sea on the east side of Greenland, and to land, they found that part of the region to be less buried under land ice than is the west side between Cape Farewell (which is 13° of lat. to the south of the place where they landed), and Disco;[1] and it has long been known that the main land of North America, lying West of Davis' Straits and Baffin's Bay, in latitudes corresponding to the deepest buried parts of Greenland, is almost free from land ice.

While it is thus clear that land ice is but subordinately dependent on the intensity of the cold, and essentially on the amount of snowfall,

U. S. Geological Survey) writing in "Nature" of 18th January, 1883 (p. 262), observes that "in America, where there is now great activity in the investigation of glacial phenomena, the evidence of a *single* interglacial period is cumulative and overwhelming, while there is no evidence whatever of more than one."

[1] A sketch of the country taken by Payer from Payer's Spitze (a peak 7000 feet high in lat. 73° N.) is published in the "Leisure Hour" for Nov. 1871. Instead of the uniformly level pall of ice burying everything as far as the eyes of observers who have penetrated 30 miles inland upon it can reach (and which from its elevation buries the highest of such hills as those which lie as islands uncovered by it between this ice pall and the sea, and rise to 2000 feet), in West Greenland, this view shows the snow-covered area of East Greenland as everywhere peaked, with the rocks in some parts protruding. A range of mountains in the furthest west that could be seen, bounded the otherwise almost boundless view, the principal peak of which range the explorers estimated to be 14,000 feet high.

in excess of the sun's melting power, *in or contiguous to the particular region in which it is found*, no evidence of an ice cap having occupied the Arctic circle during the Glacial Period has been detected by the geologists whose attention has been directed to the most northern parts of America yet examined geologically, with any approach to minuteness.[1]

It was thus therefore that the areas of greatest present rainfall in Britain, viz. Westmoreland, Cumberland, Wales, and West Scotland, becoming by the refrigeration of the Glacial period those of greatest snowfall, were those in which originated the British land ice; and so far from this ice being any offshoot from a polar cap, it is probable that Greenland was less buried in land ice at that time than it now is, because some, and possibly much, of the vapour from the Atlantic which now reaches that region, to fall in snow there, must, I infer, have then been precipitated in the Atlantic before it could arrive there.

It has been the land ice to which the extensive phenomena of glaciation that arrest the attention of geologists have been almost wholly due, while the sea-formed (or floe) ice has, with slight exceptions, left its deposits so little marked by evidences of a strikingly glacial character, that gravel due to it, though contemporaneous with the morainic formation indicative of the land-ice, has been in part seized upon to support the hypothesis of interludes of warmer climate, and in other part regarded as posterior to that formation. Nevertheless the land-ice represents but a small portion of the total snowfall, for the greater part of this takes place over the sea, disappearing directly where this is unfrozen, and where frozen forming a cake over the floe ice which eventually disappears in the sea, without leaving a trace of its existence. Another large part is that which falling now on extensive continental tracts, such as are represented by Siberia, Russia, Scandinavia (save its northernmost extremity), the northern parts of the east and centre of the United States, Canada, and the Hudson Bay territories up to the very shore of the Arctic Ocean, disappears by the summer thaw; and it is that only which from meteorological causes falls in such volume on particular places as to exceed the solvent power of the sun there during the year which gives rise to land-ice. These places extend many degrees of latitude beyond the Polar circles in both hemispheres—considerably furthest in the southern, owing to the great extent of the maritime area there; and in South Greenland, which is several degrees of latitude equatorwards of wide continental expanses where there is no land-ice, this ice reaches the sea, and fills and buries channels, and probably straits also, much beneath the sea-level, which were it absent would be filled by the sea.

It is clear that by the Arctic Ocean being frozen over nearly all the year, save in that part which is kept more or less open by the Gulf Stream, or its influence, it can in all save that part supply but little vapour; and that most of the snow which falls within

[1] Mr. G. M. Dawson indeed, in his paper on the superficial Geology of the Winnipeg and Saskatchewan region (Q. J. G. S. vol. xxxi. p. 620), insists that the features of this region conflict with the hypothesis of a polar ice cap.

the Arctic circle on the Greenland side of the pole must come from the water of the Gulf Stream itself, or from water which is kept unfrozen by the influence of this stream. This part is a strip of sea stretching further and further away from Greenland as it extends north-eastwards to Spitzbergen, so that, while the sea is almost permanently ice-covered off East Greenland, on the eastern coast of Spitzbergen navigation is open during several months to within fifteen, and for some time to within ten, degrees of latitude from the Pole. In the Southern Hemisphere the enormous disproportion of sea to land compensates for the absence of so decided an influx of warmer water from lower latitudes, while the vast expanse of the sea keeps it more open, proportionately to the greater distance equatorwards in which land-ice reaching the sea occurs in that hemisphere (which is 16° of latitude on the equator side of the Antarctic circle, or 10° more than is the case in the northern), and so furnishes the snow that makes that land-ice.

A diminution of the sun's heat would diminish the total amount of vapour over the world, necessarily; yet since the area where this vapour is precipitated as snow would be proportionately extended, the total amount of snowfall might not be lessened, the deficiency in precipitation taking place only as rain; so that even if as great a snowfall as now occurs were necessary to explain the phenomena of the Glacial Period, there might yet have been snow enough to give rise to all these phenomena, especially if those regions which now receive the principal part of the snow then received less than they now do.

The case, however, when examined by the light afforded by the past glaciation and existing precipitation of the United States, as compared with the existing glaciation and precipitation of Greenland, goes much further than this, and appears to me to bear out the proposition I now venture to put forward; which is that the stupendous mass of land-ice under which the basin of the St. Lawrence, and parts adjacent thereto (*i.e.* the glaciated area of Eastern North America,) were buried may have accumulated under a precipitation less than that which now takes place in the same region. But first let me explain how the phenomena of the North American glaciation are connected with the precipitation of that country.

Jas. D. Dana has shown, by reference to Schott's memoir on the Precipitation of Rain and Snow in the United States, that the glaciation of the eastern side of North America, and the presence of the great unglaciated region of the central part of that continent, is intimately connected with the *present relative* precipitation of the respective areas, and is proportional thereto.[1] The cauldron in which is brewed the rain which falls on the eastern side of the United States is, as Asa Gray observes,[2] the Gulf of Mexico. The great ocean current originating under the equator in mid-Atlantic, and which Croll in his hypothesis contends did not when aphelion occurred in mid-winter of the Northern Hemisphere enter the Gulf

[1] Amer. Journ. of Science, third series, vol. ix. p. 312; vol. x. p. 385; vol. xiii. p. 80; and vol. xvi. p. 250.

[2] Same Journal, vol. xvl. p. 88. His remarks are in reference to the forest growth, and not to the glaciation.

of Mexico, and hardly that hemisphere at all, now pours its heated water into this Gulf; and there, and also as it issues thence and runs northwards along the east side of America, before flowing away from that continent to Europe, it gives off the vapour which is precipitated on the eastern side of the United States. This precipitation is greatest in the States surrounding the Gulf, where the annual fall ranges between 45 and 60 inches. From these there stretch northwards, in the order of their names, the States of Georgia, the two Carolinas, Virginia, Maryland, Delaware, New Jersey, Pennsylvania, New York, the five New England States and Maine. The northernmost of these, viz. Maine, New England, and New York, embrace, with part of the Dominion of Canada, the eastern and south-eastern side of the St. Lawrence, or Lake basin; and with that Dominion are glaciated; the eastern extremity of the glaciation reaching the Atlantic from Newfoundland to the mouth of the Hudson. The States, or portions of States, which embrace the same side of the basin, south and south-west, and all but the extreme southern and western parts of the country lying between the great lakes and the Missouri river, together with so much of the rest of the Dominion as forms the northern side of this basin, are glaciated also, the north-western extremity of the glaciated area extending into the region of the drainage to Hudson's Bay, by way of Lake Winnipeg.[1] Though its northern extension is as yet unknown, the southern and western limit of this glaciated area appears to have been well worked out within the United States boundary.[2]

This great basin of the St. Lawrence and the Lakes was filled with land-ice so thick, as to override the parting between the drainage now flowing to the St. Lawrence and that flowing to the Mississippi, as well as that between the drainage now flowing to the St. Lawrence and that flowing by various rivers in the New England States, and in the country north of them, and by the Hudson, Delaware, and Susquehanna, direct to the Atlantic, enveloping as it did so the Catskill, Adirondack, Green, and White mountains (the highest of which last rise to more than 6000 feet[3]), to their summits; but, with the exception of these mountains of relatively small extent and elevation, the whole of this area is comparatively low ground, nearly all of the Alleghany mountains lying to the south, and the much more elevated region of the Great Divide to the west of it.

In this, I believe, all or nearly all of the American geologists are

[1] Dawson, Q. J. G. S. vol. xxxi. p. 620, *et seq.*

[2] Insulated within this glaciated area, near to its south-western extremity, is an unglaciated space called "the driftless area of Wisconsin," due to the furcation and subsequent coalescence of this extremity of the ice-sheet as it issued to the Mississippi drainage region from Lakes Michigan and Superior, which, as well as the other lakes, it filled. This small insulated area, as it does not concern my argument, I have not noticed in the text.

[3] Mount Washington, the highest (6,293 feet), has its summit, according to Hitchcock in Amer. Journ. 3rd series, vol. x. p. 383, covered with debris transported from distances of not more than three miles, but with "Bethlehem gneiss" brought from a distance of twelve miles.

agreed, but J. D. Dana has acutely perceived that this ice-mass was due, not to any invasion of the area by ice from the Polar region, but to the fall of snow over the area itself,[1] *proportionally to the existing precipitation in the different States*, as shown by Schott's rain-map; its greatest thickness being, in Dana's view, "over the region of greatest precipitation somewhere between the line from Wisconsin to Lake Winnipeg, and beyond, and that of the Atlantic coast."[2]

West of this glaciated area, the whole of the Central part of the Continent, *i.e.* "the great region between Western Iowa and the Sierra Nevada in California and the country north to an unknown distance,"[3] is unglaciated, the higher valleys only of the mountain portion of this region, and of the Sierra itself, where the peaks range between 12,000 and 14,500 feet of elevation, having during the Glacial period been occupied by ice. That ice was, however, in the condition of local glaciers, and unconnected with the great Laurentian mass to which the glaciated area just defined owes its features.

Now the present precipitation of the Eastern side of North America does not diminish much from what it is in the area immediately surrounding the Gulf of Mexico, being between 40 and 50 inches annually throughout the States of Indiana, Ohio, Pennsylvania, New York, New Jersey, the New England States, and Maine, which, together with the corresponding part of Canada, was

[1] Otto Torrell, the Scandinavian glacialist, tried in a paper before the meeting of the American Association in 1877 (American Journal of Science, series iii. vol. xiii. p. 76) to show the contrary of this, insisting that Greenland was the source of the American ice, and observing, "that if we bear in mind the certainty that during the Glacial period the glaciers moving from the heights of Greenland towards the sea could not have formed detached icebergs as now, but must have for the time blocked up all avenues except the one of easiest escape for the immense accumulations of ice, we may easily assume that this avenue was south-westwards across British America and the north-eastern part of the United States." As Prof. Torrell supports this view with a statement that "the Scandinavian Glacier crossed the Baltic and German Ocean, and extended its moraines into the suburbs of London," which (without trenching on the moot question whether the Scandinavian ice reached the Orkneys or Shetlands) my intimate knowledge of the Glacial beds of East Anglia tells me is utterly contrary to the fact, I do not attach any weight to his view of the source of the American ice. Moreover, as explained in the text, I doubt the great volume of the Greenland ice during the Glacial period.

[2] Same Journal, vol. xv. p. 250.

[3] Dana in same Journal, vol. xv. p. 250. G. W. Dawson speaks (Q. J. G. S. vol. xxxi. p. 617) of a drift occurring over the region between this western edge of the glaciated area and the Rocky Mountains, but he explains that it is drift mainly derived from those mountains, and but subordinately from the glaciated area to the east and north-east. This he attributes to ice floating in water of some kind, and it has occurred to me that such water may have originated in part from the drainage from the Rocky Mountains, which now reaches Hudson's Bay, through Lake Winnipeg, having been blocked from this escape by the Laurentian ice thus filling that and the other lakes, and in other part from the effluent water of this edge of the ice-mass; the combined water thus resulting rising above the level of the low parting between the Red River (which now drains to Winnipeg and Hudson's Bay) and the Minnesota River (which runs into the Mississippi), and so escaping by the Mississippi to the sea. Gen. Warren (Amer. Journ. of Sci. vol. xvi. p. 417) shows that the Red River once flowed this way, though he places the time of its doing so as subsequent to the Glacial period. I have, however, found phenomena in England which have been regarded as posterior to the Glacial period to be really coeval with it, and it may be the same in America.

the part of the glaciated area where the ice was thickest, diminishing gradually westwards through Illinois, Iowa, and Minnesota, to 12 inches as the unglaciated region is reached; the line of small precipitation thus marking the beginning of the unglaciated region bending northward with the isothermal.

It is evident that the precipitation to which the glaciation of the Eastern side of North America was thus due could have arisen only from the Gulf Stream, which follows the American coast up to Newfoundland, because the dryness of the central region shows that the precipitation on this side cannot be due to vapour coming across the continent from the Pacific, and the Atlantic as far south as the Gulf Stream must during the Glacial period have been, as Hudson's Bay and Davis' Straits now are, frozen over during most of the year; so that the only sea which could supply much vapour to this side of the continent was that occupied by the Gulf Stream.

The Pacific coast west of this great unglaciated area of the United States has, south of latitude 40°, a small rainfall only, and is unglaciated except in the mountain valleys; but northwards of this the precipitation increases rapidly, so that from being only 9 inches at St. Diego (in lat. 31° 30′), and 20 inches at St. Francisco (in lat. 35°), it ranges, save at some exceptionally dry stations, from 55 to 123 inches between lat. 40° and 49°;[1] and as this precipitation becomes great, the evidences of former glaciation present themselves.

The glaciation of North America therefore so far from being connected with the diversion into the southern hemisphere of the ocean currents of the northern, was the direct result of the precipitation engendered by these currents having taken place under a refrigeration of climate produced by some cosmical cause that did not interfere with them; and so far from the theory of the late Mr. Hopkins (which thirty years ago found as much favour as Dr. Croll's has at a later date), that the Glacial period was caused by a diversion of the current from the Gulf of Mexico up the valley of the Mississippi, and "into the Arctic sea along the eastern base of the Rocky Mountains," by the submergence of that valley, having any foundation, geological research since then has shown the exact contrary to have been the case; for if such diversion had occurred, the regions of greatest precipitation and glaciation, and the regions of dessication and non-glaciation would have changed places, and the unglaciated centre of the United States been glaciated down to the edge of this supposititious strait, while the north-easternmost States and Eastern Canada would have been much less glaciated than they are, if not altogether unglaciated. So far also from the glaciation of Europe having been due to this diversion, as Hopkins suggested was the case,[2] the evidence of the land-ice in both Britain and Scandinavia shows that the glaciation of both these countries was the result of the vapour of the Gulf Stream precipitated upon them under the conditions of this cosmical refrigeration.

It is to my mind therefore clear that the Glacial period was in no

[1] Schott's tables, pp. 77–79.
[2] See Hopkins in Q. J. G. S. vol. viii. pp. 89 to 92.

way whatever connected with any diversion of the ocean currents; and without such a diversion Croll freely admits that variations in the eccentricity of the earth's orbit, and in the position of the aphelion point, could have had no effect on the mean annual temperature of either hemisphere; because whatever be the amount of this eccentricity, and wherever be the position of the aphelion in the orbit, equal quantities of heat must, as D'Alembert showed, and as has always been conceded, reach both hemispheres alike during every revolution of the earth round the sun, the deficiency of one part of the year being made up by the excess of the other.

Since the ocean currents were thus unaltered, and the glaciation of Europe and North America follows (as Dana justly observes) the present isothermals, it results also that neither geographical changes, nor any alteration in the position of the earth's axis, nor in the obliquity of the ecliptic, can have been the cause of the Newer Pliocene refrigeration; but my present concern is to examine how the land ice, due to the action of this refrigeration upon the precipitation, is consistent with that reduction in the evaporation, and consequent precipitation, which is involved in a decrease of the sun's heat.

Rink, whose long residence in Greenland, and observation of the phenomena there, has been the means of much of our present knowledge of glaciation, estimates the annual precipitation on that region (inclusive of what rain falls there in summer) at only 12 inches;[1] so that to this small precipitation is due the mass of ice under which West and South Greenland is buried—a mass, which, from the depth Sutherland[2] considers it must descend *below the sea-line* in the buried channels (2000 feet), cannot be much, if at all, inferior in thickness to that under which the glaciated area of North America was buried. Therefore, as this precipitation is but little more than a quarter of that which now takes place over the North American area, we may, after allowing liberally for any under-estimate in Rink's figures, admit that the land-ice to which the glaciation of North America was due arose from a much less evaporation than that to which the present heat of the sun gives rise, the ocean currents flowing then as they now do. This comparison applies with even greater force to Britain, because the present precipitation of

[1] Proc. Royal Geographical Soc. for 1862-3, p. 76; also (but I quote this only from Brown's Physics of Arctic Ice, in Quart. Journ. Geol. Soc. vol. xxvii. p. 681, note) Naturhistorisk Tidsskrift, 3rd series, vol. i. part 2, 1862. Of this 12 inches he estimates that only two are represented by the actual ice escape as glaciers to the sea, the rest, beyond the insignificant amount represented by evaporation, passing off by melting as water through the ice in the form of sub-glacial rivers, which boil up in copious springs of freshwater through the sea in front of the glaciers. I think, however, that perhaps it may not all pass off, and that the overwhelming of Reindeer pastures by the ice during the centuries of Danish occupation, and the indications of subsidence afforded by the position of ancient dwellings, may show that the ice is now augmenting and the land sinking under its weight. If so, this probably has been going on since the close of the Minor Glaciation, from the change in the places of greatest snow precipitation discussed in the text; and the ancient depression indicated by marine shells high above present sea-level in Greenland may possibly have been due to a similar augmentation of the ice in the interval between the Major and Minor Glaciations, to that which is thus now only in progress.

[2] Quart. Journ. Geol. Soc. vol. ix. p. 301.

those parts of Britain where the land-ice which glaciated our island was engendered is larger than that over the glaciated area of Eastern North America.

As regards the isolated ice of the mountain regions of the world which underwent a great extension, and to explain which an increase of precipitation has been similarly assumed, the question presents itself whether this extension could not have taken place by an increase of the cold, though with a diminished precipitation. I can see no reason why it would not. So long as the snowfall on the mountains is more than the sun can melt in the year, the excess, whether great or small, must go on accumulating until the onward movement of the resulting ice-mass becomes balanced, and the lower limit of the mass defined by the wasting power of either the atmosphere or sea; and as by the lowering of the sun's heat during the Glacial period this excess of unmelted snow increased, notwithstanding that the actual snowfall may have diminished, the glaciers of the mountains increased in thickness as well as advanced. It was, I think, *to the long duration of the major glaciation* that the magnitude of the land-ice of that glaciation was due; for though I can see no indication of the cold of the minor glaciation in England having been less, the evidence which the land ice of this glaciation has left[1] indicates that the volume of this ice was very much less than was that of the major glaciation here.

The advocates of the dynamical theory of the sun's heat, finding their hypothesis inconsistent with the great lapse of time involved in the slow and gradual evolution of organic life, have called upon Geologists and Evolutionists to "hurry up their phenomena"; but the view that the sun's heat is maintained by chemical action upon material diffused through the medium, in which are moving the sun and all the other members which make up the sidereal agglomeration of which the Milky Way affords a longitudinal view, involves no such inconsistency. Thus while on the one hand the chemical theory does not clash, as the dynamical does, with the reasonable inferences to which the study of Geological and Biological phenomena have led us, it is on the other, the only one which is consistent with the conclusion to which it seems to me all the phenomena of the Newer Pliocene period point, viz. a variation during that period in the heat emitted by the sun; for it is reasonable to suppose that the material thus diffused may vary in different parts of space, and the chemical action vary in its intensity accordingly. The many instances which have of late years been observed of coruscations or changes in the brilliancy of several stars (as distinguished from the periodical changes of many, such as Algol), and the short duration of some of these changes, strengthen the chemical theory. That theory has had the support of more than one chemist of reputation,[2] though they

[1] See pp. 714 and 716 of my Newer Pliocene Memoir, in Q. J. G. S. vol. xxxviii.

[2] It seems to have originated with Grove 40 years ago, and been recurred to by him in his Address as President of the British Assoc. in 1866. It has been made the subject of an Essay by W. Mattieu Williams on "The Fuel of the Sun," and in another form was last year advanced by C. W. Siemens. Sterry Hunt has also supported it.

have not each taken precisely the same view of the process by which the result ensues; but whatever the precise process may be, the chemical theory, if true, removes the objection made by Croll to Hæckel's contention as to the immensity of time, which the phenomena of Evolution show must have elapsed since the dawn of life upon the earth.[1]

IV.—On Accumulation and Denudation, and their Influence in Causing Oscillation of the Earth's Crust.

By Charles Ricketts, M.D., F.G.S.

No fact in Physical Geology is more frequently recorded than a simultaneous occurrence of subsidence of the earth's crust where deposition of sedimentary strata has been in progress. Reference is often made to the fact that the basement beds of different sedimentary formations were deposited in shallow water, and to the indications presented by subsequent deposits that they were accumulated in a sea of moderate depth. On them immense accumulations may have been deposited in successive strata, amounting even to miles in thickness; showing that with the deposition there has been a corresponding depression of the original surface. Though these phenomena are so inseparable in their occurrence and so well known, English geologists, until the last few months, have made little, it may even be said no endeavour, to determine whether they should be associated as cause and effect. This has not been the case with American geologists.

In 1859 Professor James Hall of the United States determined that "the removal of large quantities of sediment from one part of the earth's crust, and its transportation and deposition in another, would produce oscillation of level. When these are spread along a belt of sea-bottom, the first effect of this great augmentation of matter would be to produce a yielding of the earth's crust beneath, and a gradual subsidence would be the consequence." He founded this opinion on the results of an examination of Palæozoic strata along the Appalachian chain, of which strata the Carboniferous formation alone reaches to a thickness of 14,000 feet. It is evident "that the depth of the sea was not originally so great as the thickness of these accumulations, and the occurrence of ripple marks, marine plants, and other conditions prove that the sea in which these deposits were made was at all times shallow or of moderate depth."[2]

In North America it is so generally accepted that the phenomena

[1] The following are Croll's words: "Prof. Hæckel may make any assumption he chooses about the age of the sun, but he must not do so in regard to the sun's heat. One who believes it inconceivable that matter can be created or annihilated may be allowed to maintain that the sun existed from all eternity, but he cannot be permitted to assume that our luminary has been losing heat from all eternity."—"Nature" for Jan. 10, 1878.

[2] Palæontology of New York, vol. iii., Introduction. An account of Professor Hall's opinions is given in Chemical and Geological Essays, Essay V., by T. Sterry Hunt, LL.D., F.R.S.

of subsidence and accumulation are dependent the one upon the other, that Captain C. E. Dutton of the United States Ordnance Survey considers that "few geologists question that great masses of sedimentary matter displace the earth beneath them and subside."[1] This statement by Dutton cannot refer to geologists on this side of the Atlantic, by whom, it may be said, the subject has hardly been taken into consideration.

Sir John Herschel, in a letter to (Sir) Charles Lyell, dated 1836, made slight allusions to the effect which "the transfer of pressure from one part of the earth's surface to another would have on the fluid or semi-fluid matter beneath the outer crust." He supposed that "if the whole floated on a sea of lava, there would merely be an almost infinitely minute flexure of the strata."[2] He subsequently (in 1859) showed that "the bed of an ocean supported on a yielding substratum may be depressed, without a corresponding depression of its surface, by the simple laying on of material;"[3] and in a popular lecture illustrated the consequences resulting from the increase of pressure in one place and relief in others by what would occur to a ship floating even on her keel. "If the weight on the starboard be transferred to the port side, she will heel over to port; so if the continents be lightened, they will rise; if the bed of the sea receives additional weight, it will sink."[4] The theory did not receive such attention as was due to the great authority from whom it emanated; perhaps because the illustrations advanced did not afford sufficient or conclusive proof.

In the Geological Record for 1877 (p. 173) a French geologist is stated to regard the increasing weight of deposits in areas of subsidence as the chief factor of geological change.[5]

Besides these authors, no one having authority such as would influence geological opinion has, until within the last few months, considered the subject, though the records of the simultaneous occurrence of accumulation and subsidence are almost innumerable. Those who have watched the progress of geology must with Darwin "have been surprised to note how author after author, in treating of this or that great formation, has come to the conclusion that it was accumulated during subsidence;"[6] and it appears to me equally as great a wonder that so little endeavour has been made by these authors to determine whether the two classes of phenomena should be associated as cause and effect.

Mr. J. Starkie Gardner, F.G.S., in the Geological Magazine for June, 1881,[7] and the Rev. Osmond Fisher, F.G.S., in his book

[1] The Geological History of the Colorado River and Plateaus, *Nature*, vol. xix. 1879, p. 251.

[2] Proceedings of the Geological Society, vol. ii. p. 548.

[3] Physical Geography, by Sir John F. W. Herschel, Bart., F.R.S., etc., § 132.

[4] About Volcanos and Earthquakes, Familiar Lectures, Lecture I. p. 11.

[5] V. H. Hermite, Sur l'unité des forces en Géologie, *Compt. Rend.* t. lxxxiv. pp. 459-461, 510-512.

[6] On the Origin of Species, by Charles Darwin, F.R.S., chap. ix., third edition, p. 313.

[7] Subsidence and Elevation, and on the Permanence of Continents, Geol. Mag. Dec. II. Vol. VIII. p. 241.

entitled "Physics of the Earth's Crust," 1881, have commented on the occurrence of subsidence during the deposition of the different geological formations; and also where accumulations are in progress at the present time under the sea; or on land covered with a heavy load of snow, as in Greenland. They agree with me in considering the depression as the result of and caused by the weight of the accumulations. (I must express how greatly I feel indebted to these authors for the courtesy with which they have recognized such deductions made by myself as far back as 1865,[1] and more especially at various periods since 1871.[2]) They agree with me in considering the depression as the result of and caused by the weight of the accumulations. Mr. Fisher considers "it requisite for the explanation of the phenomena that there be a liquid, or at least a plastic substratum for the crust to rest on; nor is it easy to explain the sinking of areas in proportion to their becoming overloaded with sediment upon any other supposition; but if such a liquid substratum be granted, many of the facts are more easily explained. If the present configuration of the Himalayan region be one of approximate equilibrium, if much sediment be brought off the mountains and spread over the plains, the mountains must become after a while too light and the plains too heavy; and accordingly the mountains rise and the plains sink to restore the contour"[3] (or equipoise).

It is now almost universally acknowledged that valleys have been excavated by subaerial agencies, and that the materials which once filled up the vacancies have been removed by rain and rivers, and carried down and deposited near the mouths of their respective rivers and neighbouring parts of the sea. Towards the mouths of large rivers every one knows the bottoms of the valleys are filled with detritus brought down by the stream; these deltoid accumulations being often not only of great width, but also of very considerable thickness. According to Sir Charles Lyell,[4] the thickness has been proved by borings to be more than 630 feet in the case of the Mississippi; but he considers it probable that it may have attained to twice or thrice that thickness; in the case of the Ganges, the depth reached was 481 feet; and in the Po 400 feet; each example afford-

[1] A Ramble in Shropshire, Proc. Birkenhead Lit. and Scient. Soc. 1865; A Wooden Implement found in Bidston Moss, Proc. Liverpool Geol. Soc. 1865–66.

[2] President's Address, by Charles Ricketts, Proc. Liverpool Geol. Soc., Session 1871–72. Also an abstract of the same, entitled "On Subsidence as the Effect of Accumulation," Geol. Mag. Vol. IX. p. 119, etc.

[3] Physics of the Earth's Crust by the Rev. Osmond Fisher, M.A., F.G.S., p. 83. Referring to the Himalayan region, it was stated by myself in 1875, when replying to objections which had been raised, that the removal by denudation of those portions of the mass which once filled up the spaces now forming the valleys and passes of this great mountain range, must have diminished proportionately the amount of weight pressing upon the fluid substratum. Should the sediment brought thence by the Ganges and Brahmapootra, and deposited in the Bay of Bengal, cause subsidence by its weight, it follows that the area from which the sediment has been derived must rise in proportion to the amount of material removed.—The Cause of the Glacial Period, by Charles Ricketts, Geol. Mag. Dec. II. Vol. II. p. 574, foot-note.

[4] Principles of Geology, vol. i. chapters 18 and 19.

ing indications of ancient land surfaces now situated at great depths. It is more than probable that the amount of deposits, so far as it has been proved by borings, represents but a moderate proportion of their entire thickness.

Beyond the alluvial plains or deltas, estuaries or bays are very generally formed, being the extensions or prolongations of depressed valleys, into which sea-water enters. Rivers bring down an amount of debris immensely greater than can he disposed of by their overflow during floods upon deltoid plains. The amount removed, as indicated by the spaces left between the flanks of valleys, and carried into the sea, would, if there were no subsidence, form very extensive plains where there is now sea, and would extend in some cases to hundreds, it may be even to thousands of miles beyond the present deltas; whereas, notwithstanding the great accumulations, deltas are by subsidence transformed into bays, and instead of shallow water the sea becomes, at a few miles from the mouth of the river, unfathomable by the ordinary deep-sea line. Lyell has directed attention to the rapid increase of depth, from shallow water at the mouth of the Mississippi, to 95 fathoms at a distance of 12 miles; 144 fathoms at 20 miles; and 452 fathoms at 52 miles.[1]

The inference to be drawn from the occurrence of subsidence near the mouths of great rivers appears to be, that where there is the greatest amount of accumulation, there subsidence has occurred to the greatest extent, progressing more rapidly than the filling up of the areas by sedimentary deposits.

It is a remarkable coincidence that subsidence of land, when covered with heavy accumulations of perennial snow, should be a phenomenon of general occurrence; it prevailed in the northern hemisphere during former periods over immense districts, but is restricted to a limited area (Greenland) at the present time. All writers on glacial geology recognize this progressive submersion of the land during what is called the 'Glacial Period,' when extensive districts both in Europe and North America, now fertile and luxuriant, were buried under a thick covering of snow; and the bays and seas in their vicinity were packed with icebergs and floating ice; also that a partial re-elevation occurred at its termination. This subsidence may be chiefly ascribed to the weight of the snow heaped upon the land, and in part to the clay which, in muddy streams, issued from beneath the glaciers, and was deposited in a sea covered with bergs and pack-ice bearing rock fragments, which they had carried from many distant localities. The melting of the floating ice caused these erratic pebbles, etc., to be dropped into this clay, and thus become an integral portion of the Boulder-clay. The combined pressure of the snow upon the ground, and the Boulder-clay upon the bed of the sea, weighed down the crust of the earth. It was again raised to a considerable extent upon the return of a more genial climate, which relieved the land of its load of ice and snow.[2]

[1] Principles, vol. i. chap. xix.

[2] President's Address, by Charles Ricketts, Proc. Liverpool Geol. Soc. Session 1871-72; also an abstract of the same, Geol. Mag. Vol. IX. 1872, p. 119.

It appears that Mr. T. F. Jamieson, in 1865, was the first who attributed this depression in different countries during the Glacial period "to the enormous weight of ice thrown upon the land; and considered that the melting of the ice would account for the rising of the land which seems to have followed the decrease of the glaciers."[1]

Professor Shaler, of Harvard College, U. S. A., in 1874, also appears to have arrived independently at the same conclusions respecting the cause of subsidence during the Glacial period; he considers that "we may more reasonably look to the weight of ice accumulated on the continents for the depression of the land areas it occupied than to any other cause."[2]

Similar explanations, in which Mr. Fisher coincides, may account for the subsidence recently occurring in Greenland simultaneously with a rapid increase of accumulated snow; and also for the gradual rise of Scandinavia as a natural result of the recession of glaciers.

In all the older rocks the same fact is evident:—wherever any large amount of strata has been laid down, there has likewise been a persistent depression, which progressed in at least an equal degree with the accumulation. In each individual formation, throughout the whole series, from the Laurentian rocks of Canada, or the Longmynd rocks of Shropshire, up to those now in process of deposition, the record in the one is the record in them all,—*it was formed during a period of subsidence.*

Though there has thus occurred a simultaneous and progressive depression during the deposition of the accumulations constituting stratified rocks, it might be argued that the subsidence has taken place to the same extent over the whole area, and that the strata are thicker in one place than in another simply because their bases have been deposited on surfaces of unequal elevation, that is, on areas consisting of submerged valleys and hills. It requires a certain stratum, forming as it were a base-area, traceable over extensive districts, and situated, when formed at or about the same level, before the relative amount of subsequent deposition and subsidence can be calculated in different portions of the district in question. The Carboniferous formation affords most satisfactory examples for determining the problem.

(*To be continued in our next Number.*)

V.—On the Brecciated Bed in the Dimetian at St. Davids.

By Thos. M'Kenny Hughes, M.A.,

Woodwardian Professor of Geology, Cambridge.

In recent discussions upon the classification of the Archæan, great importance has naturally been attached to the occurrence of beds of fragmental origin. In the distinctly volcanic beds these are numerous; in the older or more highly metamorphosed portion of

[1] History of the last Geological changes in Scotland, by Thomas F. Jamieson, F.G.S., Quart. Journ. Geol. Soc. vol. xxi. p. 178.

[2] Recent Changes on the Coast of Maine, by N. S. Shaler, Memoirs Boston Soc. Nat. Hist. vol. ii.

[3] Cause of the Glacial Period, by Charles Ricketts, Geol. Mag. Dec. II. Vol. II. 1875, p. 573; Rev. O. Fisher, *op. cit.* pp. 223 and 224.

the group they are less frequent and their character and origin are more obscure.

The beds in question sometimes appear to be made up of pebbles, but more often of pieces such as are commonly described as sub-angular, that is to say, pieces from which the corners have been removed while portions of the flat bounding surfaces remain, indicating their original form. Sometimes they are all distinctly angular.

When the fragments are derived from various rocks of different lithological character, or when fragments of one kind of rock only are imbedded in a matrix of a totally different character from the included fragments, it is obvious that the rock is composed of transported fragmental material.

But occasionally the constituent pieces are all of the same kind of rock, and even the matrix appears to be composed of the same material. It is then often difficult to discover the origin of the mass, and to make out whether we have a rock made up of worn and transported fragments or only a mass brecciated in place.

There are, however, some tests which may be applied with confidence even in these most difficult cases.

In mapping any district where exposures of rock are few and far between, it is often very important to determine whether a large mass of rock is in place or only the projecting portion of a boulder or tumbler. Now if the rock be cleaved, it is often sufficient to observe the direction of the cleavage planes; for, if the cleavage, which as a rule is much more constant than bedding, does not coincide with the general direction of the cleavage in the surrounding district, we may fairly suspect that the mass is not in place.

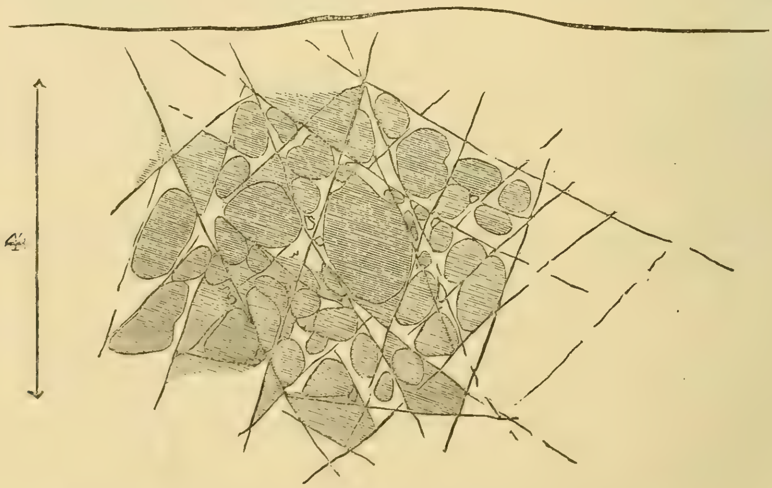
So in the case where a conglomeratic or brecciated mass is composed of pieces of rock of one kind only imbedded in a matrix of the same; if the fragments are derived from a cleaved or foliated or schistose rock, then, as the pieces in the conglomerate or breccia are irregularly thrown together, the divisional planes are seen in it at all angles to one another and not approximately parallel, as in the parent rock.

It is necessary to observe this point in drawing, for instance, the lower boundary of the Carboniferous beds in the Alais Coal-field in the South of France, where the basement bed is made up entirely of fragments of the underlying schist compacted into a tough mass, which it would be difficult to distinguish from the underlying solid rock, except by the application of the test above described.

There still remain the difficult cases of certain breccias and brecciated conglomerates in homogeneous rocks. It is well known that we have numerous cases of brecciation-in-place in chalk, especially in the Chalk Rock. In chalk the continuity of a layer of tuberous flints will sometimes tell us that we have brecciation in place, while in an adjoining section a few scattered ferruginous flints in the re-compacted chalk tell of old gravel beds from which they were derived, and prove that the chalk also must have suffered erosion and transport.

In the older formations also we have examples of the breaking up and recementing of rock masses in place. In some the infiltering water hardens the rock along the joints so that during subsequent weathering the unaltered rock perishes more rapidly than that part which has been affected by infiltration, and projecting ridges mark the lines of joint, as good mortar and the contiguous lime-strengthened part of the stone often stands out when the central portions of inferior building stones have crumbled away. In other cases the rock perishes most along the joints, so that the solid pieces between the divisional planes are more and more reduced in size, the corners are rounded off and at last they appear as subangular or rounded nuclei in a rotten matrix of somewhat similar material. Not exactly similar—for the process of decomposition does not often leave the rock as it was. A removal of some of the alkalines along the joints could probably in the case of granite be detected, and the chemist and mineralogist would report that the included fragments were imbedded in a matrix of different composition.

Even in this case it may be possible to determine whether the rock is made up of transported material or only brecciated in place. For it is extremely improbable that under any combination of circumstances fragments could be arranged by nature in such a manner that the flat bounding surfaces of consecutive pieces should over and over again touch the same plane, not being the plane of bedding; and if a sufficient surface is exposed to enable us to make out that the planes, which so limit the apparently included fragments, coincide with the joints which affect the whole rock, then the conclusion is inevitable that we have in such a case only the chemical destruction of the rock along the joints which have allowed a freer percolation of the surface water.



Brecciated Granitoid Rock, near Brynygarn, St. Davids.

Now there is a face of granitoid rock exposed on the east side of the Alan valley, S.S.W. of Brynygarn near St. Davids, which forms so marked a feature in that mass, that it has been taken as an horizon useful for reference when describing the exact position in that section where the Dimetian ends; though of course, if it be not a true breccia, it has no more value than any other mere geographical feature. The apparently included masses are of various sizes from a foot in diameter down to bits an inch across. They are subangular and stand out by weathering as if they were composed of harder material than the matrix in which they are imbedded. But when we apply the above-mentioned test, we find that this must be referred to one of the masses brecciated in place. As shown in the accompanying sketch, the larger and smaller fragments are packed in between the joints in such a manner as to prove conclusively that they are not the tumultuous accumulation of a shore deposit; for the flat sides of the pieces are commonly continuous in the same direction and agree with observed joints by which their limits and position are obviously determined. A close examination soon shows that kind of weathering along the joint planes which we see in the striped Silurian rock known as the Moughton Whetstone, found near Austwich in the Craven district, or in some of the banded flints so common over the south of England, where the rounding off of the corners is seen to be due to the mode of weathering. I take it therefore that the brecciated bed in the Dimetian of Brynygarn is not of transport origin, but represents brecciation in place and subsequent weathering along the joint planes.

VI.—Examination of a Calculation of the Age of the Earth based upon the Hypothesis of the Permanence of Oceans and Continents.

By T. Mellard Reade, F.G.S.

SOME views in theoretical geology are held so vaguely that when one attempts to grasp them it is like clutching at shadows. To any one who will put his ideas into figures our thanks are therefore due.

Mr. Wallace, in "Island Life,"[1] has treated us to a calculation of the Age of the Earth based upon the hypothesis now becoming fashionable of the "Permanence of Oceans and Continents." It is my intention now to examine into the validity of the figures he gives and the light they throw upon the idea he so strenuously maintains.

The nature of the calculation is this:—He accepts Prof. Haughton's estimate of the maximum thickness of the sedimentary rocks at 177,200 feet, assumes that all the denuded matter from the land area of the world, taken at 57 million square miles, is laid down upon a coast-line 100,000 miles long and 30 miles wide, and infers that as the area of deposit to that of denudation is in that case as 1 to 19, that the vertical accumulation of sediment will be nineteen times as rapid as its removal from the land. The denudation he takes at the

[1] Island Life, pp. 214—216. He says: "If therefore we take a width of thirty miles along the whole coast-line of the globe as representing the area over which deposits are forming, corresponding to the maximum thickness as measured by geologists, we shall certainly over—rather than under—estimate the possible rate of deposit. Now a coast-line of 100,000 miles with a width of 30 gives an area of 3,000,000 square miles on which the denuded matter of the whole land-area of 57,000,000 square miles is deposited. As these two areas are as 1 to 19, it follows that deposition, as measured by maximum thickness, goes on at least nineteen times as fast as denudation—probably very much faster. But the mean rate of denudation over the whole earth is about one foot in three thousand years; therefore the rate of maximum deposition will be at least 19 feet in the same time; and as the total maximum thickness of all the stratified rocks of the globe is, according to Professor Haughton, 177,200 feet, the time required to produce this thickness of rock, at the present rate of denudation and deposition, is only 28,000,000 years."

rate of 1 foot in 3,000 years. He finally concludes that the time required to produce this thickness of rock, at the present rate of denudation and deposition, is only 28 million years.

That there is a considerable amount of confusion of ideas pervading this estimate, I think is pretty plain; but let us try and see by reversing his calculation in what conclusions we are landed.

It is evident, if the figures mean anything at all, that 3 millions of square miles 177,200 feet thick represent the whole of the rock removed by denudation in all forms since the geological history of the Earth began. Spread this over 57 million square miles of land, and we get a deposit 9,326 feet thick, deposited in all geological time. But we must not lose sight of the fact that these hypothetic sediments represent rocks made and destroyed over and over again, how often it would be difficult to determine; but taking the proportion of igneous rocks exposed on the surface at $\frac{2}{25}$ of the total area of land,[1] we may safely put it down as at least 12 times; that is, each particle of rock on the average has been denuded and laid down at least 12 times. From this it follows that the *actual* thickness of the sedimentary crust of the earth, if there were no sedimentary rocks except on site of the present land areas, would be $\frac{9326}{12} = 777$ feet. But even Mr. Wallace has to provide for fluctuations of his continents in some degree, and I believe he will admit that a considerable additional area has been alternately land and sea. If he will reason it out, mark its boundaries and estimate its area, I think he will find it cannot even on his own hypothesis be less than double the present land surface of the globe. The average thickness over this increased area would therefore be but 388 feet. If Mr. Wallace can prove that the average thickness of the sedimentary crust of the globe is no more than this, we shall be a long way on the road towards accepting both his hypothesis and his ideas of the Earth's age.[2]

It so happens that I have but just read "Island Life," and I find my views on the subject of Oceans and Continents characterized as "hasty and superficial." Perhaps they are, and if Mr. Wallace will but just put me right in my analysis of his own calculation, I may be rapidly converted to profounder geological ideas.

NOTICES OF MEMOIRS.

I.—The Decay of Rocks Geologically Considered. By T. Sterry Hunt, LL.D., F.R.S.[3]

The author, in this paper, presented in a connected form the principal facts in the history of the decay both of crystalline silicated rocks, and of limestones or carbonated rocks, by atmo-

[1] See Chemical Denudation in Relation to Geological Times, p. 57.

[2] Dana, who, it seems (see Continents always Continents, "Nature," March, 1881, p. 410), preceded Mr. Wallace in many of the views expressed in "Island Life," estimates the average thickness of the sedimentary rocks in continental areas at 5 miles = 26,400 feet.

[3] Abstract of a paper read by T. Sterry Hunt, LL.D., F.R.S., before the National Academy of Science, at its meeting in Washington, April 17, 1883.

spheric agencies. Having first discussed the chemistry of the process, he noticed the production of spheroidal masses, or so-called boulders of decomposition, by the decay and exfoliation of massive rocks. He then proceeded to show that the process of decay is not, as some have supposed, a rapid or a local one, dependent on modern conditions of climate, but that, on the contrary, it is universal, and of great antiquity, going back into very early geological periods. These conclusions were supported by details of many observations among Palæozoic stratified and eruptive rocks in the St. Lawrence valley, as well as among Eozoic rocks in the Atlantic belt, as seen in Hoosac Mountain, in the South Mountain, and in the Blue Ridge. In connection with the latter he described the decay, not only of the crystalline strata, but of their enclosed masses of pyritous ores, and the attendant phenomena. The decay of the primal and auroral strata of the Appalachian valley, and the formation therein of clays and of iron and manganese oxides, was also discussed. The pre-Cambrian antiquity of the process of decay in the Eozoic rocks of the Mississippi valley, as shown by Pumpelly and by Irving, as well as similar evidence from Europe, was noted, while the more recent decomposition seen in the auriferous gravels of California was described and explained.

The final removal of the covering of decayed rock from many northern regions during the drift period was then considered; and the thesis advanced by the speaker in 1873, that the decay of rocks "is an indispensable preliminary to glacial and erosive action, which removed previously softened materials," was discussed in its relations to boulders, glacial drift, and the contour of glaciated regions. Pumpelly's development and extension of this doctrine to wind-erosion was noticed, and also the recent comparative studies of Reusch in Norway and in Corsica, in which similar views are enforced.

The principal points in the paper, as viewed at its close, are as follows:—

1. The evidence afforded by recent geological studies in America, and elsewhere, of the universality and the antiquity of the subaerial decay, both of crystalline silicated rocks and of calcareous rocks, and of its great extent in pre-Cambrian times.

2. The fact that the materials resulting from such decay are preserved *in situ*, in regions where they have been protected from denudation by overlying strata, alike of Cambrian and of more recent periods; or, in the absence of these, by the position of the decayed rock with reference to denuding agents, as in driftless regions, or in places sheltered from erosion, as within the St. Lawrence and Appalachian valleys.

3. That this process of decay, though continuous through later geological ages, has, under ordinary conditions, been insignificant in amount since the Glacial period, for the reason that the time which has since elapsed is small when compared with previous periods; and also, probably, on account of changed atmospheric conditions in the later time.

4. That this process of decay has furnished the material, not only for the clays, sands, and iron-oxides from the beginning of Palæozoic time to the present, but also for the corresponding rocks of Eozoic time, which have been formed from the older rocks by the more or less complete loss of protoxide bases. The bases thus separated from crystalline silicated rocks have been the source, directly or indirectly, of all limestones and carbonated rocks, and have, moreover, caused profound secular changes in the composition of the ocean's waters. The decomposition of sulphuretted ores in the Eozoic rocks has given rise to oxidized iron-ores *in situ*, and to rich copper-deposits in various geological periods.

5. That the rounded masses of crystalline rocks, left in the process of decay, constitute not only the boulders of the drift, but, judging from analogy, the similar masses in conglomerates of various ages, going back to Eozoic times; and that not only the forms of such detached masses, but the surface-outlines of eroded regions of crystalline rocks, were determined by the preceding process of subaerial decay of these rocks.

II.—Notes sur la Flore Houllière des Asturies. Par M. R. Zeiller. Mémoires de la Société Géologique du Nord. Tome Premier. Lille, 1882.

THIS memoir comprises a critical examination by M. R. Zeiller of about fifty species of fossil plants, chiefly Ferns and Sigillaria, collected by Dr. C. Barrois from the Coal-measures of Asturias. M. Zeiller has compared all the specimens with similar or allied forms from the Coal-measures of France, England, and America, and has identified all of them with previously known forms.

The Coal-measures of Asturias are referred to three basins, the central, northern and western, but the plants occur at different horizons.

According to M. Zeiller, the plants received from Dr. C. Barrois indicate two great stages in the Coal-formation of the Asturias, and in this respect he is corroborated by M. Grand' Eury, who has also seen the specimens. The upper stage is represented at Tineo, Lomes, Arnao, and Ferroñes, the deposits of Tineo and Lomes belong to the sub-superior, at least those of Tineo to the upper part; those of Arnao and Ferroñes occupy a position perhaps a little higher, that is to say, at the top of the series. The middle coal division is represented throughout the central basin and at Santo-Firme, the beds at Mieres, Sama, Ciano, etc. (central basin) belong to the upper part of the middle stage, and those of Santo-Firme to the middle, if not to the lower middle stage. The lower coal division is seen in the Cordal de Lena to the west of Pola de Leña. As to the small basins of Quiros and Onis, the specimens did not permit the age to be fixed, from their small numbers and the absence of any characteristic species. This memoir was intended to form part of the "Recherches sur les Terrains Anciens des Asturies," etc. (see Preface, p. 7), in which work, pp. 551–570, Dr. Barrois has fully described the characters and position of the Coal-fields of Asturias. J. M.

REVIEWS.

I.—Sketch of the Work of the Geological Survey in Southern India. By R. Bruce Foote, F.G.S., Deputy Superintendent, Geological Survey of India. Journal of the Madras Literary Society, 1882.

ALTHOUGH there is still a vast field for geological investigation in India, much has already been done by the energetic labours of the members of the staff, considering the dangers, discomforts, and many disadvantages to which they are exposed, the results of which are embodied in the numerous records and memoirs published. The above paper is by the author of the excellent notice of the 'Manual of the Geology of India' which our readers may remember appeared in this Magazine (1880, Vol. VII. pp. 79 and 127).

Mr. Foote has given a brief sketch of the work done by the members of the Geological Survey in Southern India, and draws attention to the more important points of interest, whether practical or purely scientific, concerning the several geological formations met with. In this respect his long experience and personal knowledge of many points, and the full justice he has done to the excellent work of his colleagues, renders this notice extremely valuable as far as the South of India is concerned; and this is no contemptible work, for it appears that the area mapped, which lies chiefly on the eastern side of the Peninsula, amounts as nearly as possible to 100,000 square miles.

The Cretaceous are by far the most interesting group in the country, with their great wealth of organic remains and the correlation with their presumed representatives in Europe, of which a table is given. The coast alluvium of the Madras district and the evidences of considerable elevation of land in recent times is an interesting feature. The gneiss country offers some points of interest, specially the presence of many beds of magnetic iron, and also the building stones. These latter rocks have furnished the bulk of the stone used in building all the greatest temples in South India. The position of the "Diamond Sandstones" in the Kadapa and Karnul districts and the labours of Messrs. Oldham and King are noticed. The stratigraphy of this great series of sub-metamorphic or transition rocks, which contain the Diamond sandstone, had not been fully established until Mr. W. King, who worked out the greater part of these areas, recognized two distinct groups, an important advance in South Indian geology; the two groups to which he gave the names Karnul and Kadapa are unconformable to each other, the basal conglomerate of the former containing the Diamond sandstone. Besides the Diamond rocks, useful limestones occur largely throughout the Karnul group; some of them have been utilized; others, as the Pālnād limestones, have of late been neglected, though many beds would furnish marbles of various colours and of great beauty. Their eminent suitability for decorative purposes had been fully appreciated by the old Buddhists, who built the exquisite carved railings and gateways to the great "Tope" at Amarāvati. Very interesting geological facts were gathered in the Madras region with reference to the gneissic rocks and their net-work of trap-dykes,—the plant-bearing Upper Gondwana beds, the lateritic formations and the alluvial valleys of the Palār and Nagari rivers.

The researches of the author on the Geology of the Eastern Coast, those of Mr. King in the southern parts of the Nizam's territory, and of Messrs. Blanford and King in the Godaveri valley, and their important and practical bearings, are fully noticed. Altogether, this clear and concise summary of this portion of the Indian geological survey is extremely useful, to which is appended a table of the several systems and groups of rocks of South India. J. M.

II.—Die Spongien, Radiolarien und Foraminiferen der unterliassischen Schichten vom Schafberg bei Salzburg. Von Dr. Emil V. Dunikowski. Mit 6 Tafeln. Besonders abgedruckt aus dem XLV. Bande der Denkschriften der Mat. Natur. Classe der Kais. Akad. der Wissenschaften. (Wien, 1882.)

The Sponges, Radiolarians, and Foraminifera from the Lower Lias Strata of Schafberg near Salzburg (Austrian Tyrol). By Dr. E. Dunikowski. 4to., pp. 34, with 6 Plates.

THIS memoir contains the results of a careful investigation of the minute organisms met with in certain beds of dark, siliceous, compact limestone of Lower Lias age, which were discovered by Prof. Zittel. Some portions of this limestone, on treatment with acid, proved to be mainly composed of fragmentary sponge spicules (with a few other siliceous organisms), mingled together in myriads, so that the deposits might fairly be termed sponge beds. The author has described and figured the various forms of spicules which he has been enabled to separate from the heterogeneous mass, and finds representatives of each of the four orders of fossil siliceous sponges. The *Monactinellidæ* are represented by numerous spicules, characteristic of the genera *Opetionella*, *Reniera* or *Suberites*, *Scolioraphis* and *Esperia*. To the *Tetractinellidæ* belong various spicules of the *Pachastrella* type, as well as examples of *Stelletta*, *Tisiphonia* and *Geodia*. The author failed to recognize more than two dubious spicules of *Lithistid* sponges, but we think it very probable that some of the smaller trifid spicules with horizontally expanded head rays, delineated on Taf. 2, belong rather to the dermal layer of *Lithistid* sponges, than to the *Tetractinellid* genus *Stelletta*. Spicules of the *Hexactinellidæ* are very abundant, and belong to the Lyssakine genera *Stauractinella* and *Hyalostelia*, as well as to the *Dictyonine* *Tremadictyon*, and *Craticularia*.

The Radiolarians are brought under ten genera with eighteen new species; they are mostly included in Haeckel's families of the *Sphærida* and *Discida*. These minute organisms are fairly well preserved, though oftentimes infilled with the siliceous matrix. The majority of the forms possess a porous sponge-like test; but a few exhibit a regular lattice-like shell.

The Foraminifera are only in the condition of siliceous casts, and mostly belong to the *Lagenidæ* family.

The importance of this memoir rests on the recognition of an abundant Sponge and Radiolarian fauna in a geological horizon where these organisms were previously unknown. The Sponges constitute distinct beds very similar to those which occur in the Lower and Upper Greensands and most of the spicules are closely allied to those present in these newer deposits. The Radiolarians, if we except a few forms described by Pantanelli from the Upper Lias strata of Tuscany, have been scarcely recognized below the Chalk, and yet they appear in these Lower Lias deposits, in great variety of form, and can nearly all be included in those family divisions which Haeckel has constituted for the existing members of the class.

The descriptions, measurements, and figures of these microscopic organisms are given in great detail, and we are enabled to add, from a comparison with specimens which have been kindly presented to us by Prof. Zittel, with faithful accuracy. G. J. H.

III.—Die siluerischen Etagen 2 und 3 im Kristiania gebiet und auf Eker, ihre Gliederung, Fossilien, Schichtenstörungen und Contactmetamorphosen. Von W. C. Brögger. Universitäts programm für 2 Sem. 1882. (Christiania: A. W. Brögger, 1882.)

The Silurian stages 2 and 3 in the Christiania District, and on the Eker; their Structure, Fossils, disturbed Slate-rocks and Contact-metamorphism. By W. C. Brögger.

The geologist, like other living beings, is affected by his environment,—under unfavourable conditions, like those occurring in Holland, he is almost extinguished, and in other areas, there is a close connexion between the character of his work and the geological structure of his country. Our own island, with its numerous rock-systems, has given birth to men who have studied rocks of many ages, and originated bold generalizations, and at the same time, too often to men who are unwilling to spend very much of their time in observation of smaller details. The Scandinavian peninsula, on the other hand, possesses few rock-systems, and consequently the attention of its geologists has been greatly concentrated upon the Archæan and Lower Palæozoic rocks. This being so, it might be thought that little work would remain undone in that area, but the book before us very effectually banishes that idea. Professor Brögger, it is true, only describes a very small thickness of rock (less than 500 feet), but he has devoted a great amount of labour to the study of this, and the result is a very complete account of the stratigraphy, palæontology, physical geology, and geognosy of the two stages. The stages themselves may be of small interest to many English geologists, but it is hardly an exaggeration to say that students of any branch of geology whatever, will find in this work new facts bearing upon their labours. It is to be hoped that Professor Brögger's removal from Christiania to Stockholm will not prevent him from issuing works on other stages.

The author commences with an account of the subdivisions of stage 2 (the Olenus-schiefer), and stage 3 (the Asaphus-etage), giving a full description of their local development, variations in thickness, lithological characters, and lists of included fossils. The next section, of over 100 pages, is devoted to a description of the fossils. The Graptolites are for the most part merely mentioned,—the author leaving the description of these forms to Dr. Holm, of Upsala, who is at work upon them,—he however inserts some important observations upon *Dictyograptus* (*Dictyonema*) *flabelliformis*, Eichw., and *Bryograptus*. The former is described and figured as a free form, possessing a sicula, and is thus shown to resemble the other Graptolites. The Echinodermata and Mollusca are next described, but the larger part of this section of the work is occupied by a description of the Trilobites, of which several new forms are described and admirably figured.

The third section gives a comparison of the stages 1—3 with their foreign equivalents; and here we find much that is new. The following correlations with the beds of England and Wales are adopted by Professor Brögger :—

Stage 1	=	Menevian Series.
,, 2*a*	=	Maentwrog.
,, 2*b*	=	Lower Dolgelly.
,, 2*d*	=	Upper Dolgelly.
,, 2*e*	=	Dictyograptus Shales (of Malvern, etc.)
,, 3*a α* (beds with *Symphysurus incipiens* and 3*a β* Ceratopyge Shales)	=	Shineton Shales (approximately).
,, 3*a γ* (Ceratopyge Limestone)...	=	Part of Tremadoc.
,, 3*b* (Phyllograptus Shales)	=	Skiddaw Slates, etc.

The author, in making these correlations, pays great attention to identical or closely allied forms occurring in different countries, and whilst tacitly assuming the value of palæontological resemblances in comparing widely separated deposits, gives additional weight to it.

Especially interesting is the very full account of the relationships of the Ceratopyge beds, and Professor Brögger's analysis of the fauna of the Shineton Shales of Shropshire. This, as he points out in the appendix, was made before he knew of the existence of Linnarsson's notice in the Geological Magazine of April, 1878, and although he differs from Linnarsson in some points, their more important conclusions are the same. The following are some of his conclusions :—*Conocoryphe monile* is an *Euloma*, perhaps identical with *E. ornatum; Olenus triarthrus* perhaps belongs to his sub-genus *Parabolinella; Conophrys salopiensis* is identical with or nearly related to *C. pusilla; Agnostus dux* may be compared with the closely allied *A. Sidenbladhi; Asaphellus Homfrayi* may be most nearly allied to *Niobe*, and *Platypeltis Croftii* to *Symphysurus incipiens; Lichapyge cuspidata* seems very closely related to *Lichas parvulus*, Barr., from Hof; *Obolella sabrinæ* belongs to the same group with *O. sagittalis*, and *Lingulella Nicholsoni* is allied to the group of *L. lepis*. From this analysis the author considers that it almost undoubtedly follows that the Shineton Shales correspond with a horizon between the Dictyograptus-schiefer 2*e*, and the Ceratopygekalk 3*a γ*, *i.e.* approximately to the deposits 3*a α* and 3*a β*. The latter, the Ceratopyge-schiefer, which certainly are above the Dictyograptus shales, contain the genus *Bryograptus* in Norway. Prof. Brögger supposes that these genera will be found to occupy similar positions in Britain also, and that they will each mark a distinct horizon, older than the Phyllograptus shales.

The author remarks that the Ceratopygekalk $3a\ \gamma$ has been previously correlated with the Tremadoc slates, and points out that a few Ceratopygekalk genera occur in the Welsh beds, as *Euloma*, *Niobe* and *Dikellocephalus.*

A careful analysis of the fossils of Hof in Bavaria is also made, and the comparisons are of interest to British geologists. Linnarsson's identification of some of M. Barrande's species of *Conocoryphe* with *Niobe* is mentioned; *Asaphus Wirthi* is also considered to be most nearly allied to *Niobe; Euloma* is perhaps represented by *Conocoryphe Geinitzi*, etc.; *Conocoryphe ? problematicus* may possibly be a *Symphysurus; Agnostus Bavaricus* represents *A. Sidenbladhi; Cheirurus gracilis* and *C. discretus* appear to be related to *C. foveolatus* and *Amphion primigenius*; *Bavarilla Hofensis* is possibly a *Neseuretus.* According to this analysis, the beds of Hof, containing this fauna, correspond with the lowest part of the Tremadoc slates, and approximately with the Norwegian Ceratopygeschiefer, in Prof. Brögger's opinion.

The importance of these comparisons should not be overlooked by English geologists. Both Linnarsson and Brögger consider the Hof beds to be more nearly allied to the second fauna of M. Barrande than to his primordial fauna, and this has also been pointed out by M. Barrande himself. Professor Brögger, in his book, gives strong reasons for bracketing the corresponding Ceratopyge beds with the Asaphus-etage (which contains also the Phyllograptus Schiefer, the representatives of the Arenig beds), rather than with the Olenus-etage (representing the Lingula Flags). Notwithstanding these affinities, many English geologists still insist upon drawing a hard and fast line between the Tremadoc slates and the Arenig beds, whereas if any line were to be drawn about this horizon (which appears unnecessary), it should be at the base of the Tremadoc slates.

The fourth section of the work is occupied with a discussion of the development of the fauna of stages 1—3. It is full of suggestive matter, and is accompanied by a table of the vertical distribution of the fossils. A very good illustration of the danger of basing conclusions upon negative evidence is given when considering M. Barrande's observations about the absence of Cephalopoda from the primordial fauna. Professor Brögger points out that no Cystideans have been found among the primordial fauna in Sweden, Norway, and Russia; from this, he says, we might conclude that there were no Cystideans at this time, and yet they are found in the primordial beds of England and Bohemia.

The fifth section is devoted to a description of the disturbances which have affected the strata, and the erosion of the beds. A number of very complex inversions are described and figured, many of which would be very difficult to detect, were it not for the comparatively easy identification of the affected beds. Some of the sections figured are of small horizontal extent (no visitor to Christiania should neglect to visit the one in the street below the Trefoldigsheds Kirche, in the heart of the city), whilst others extend over a considerable distance. It may be remarked that these foldings occur in an area not very far distant from the Highlands of Scotland, which are also composed of Lower Palæozoic beds folded amongst the Archæan rocks. Some of these foldings also may be very complex, for the structure of the two countries is very similar and points to movements of a similar character.

The last section of Professor Brögger's book treats of the contact metamorphism of the beds of stages 1—3 against the granite of Eker. The results he arrives at are of great interest, from their bearing upon the vexed question of regional metamorphism, but as this part of the work has been noticed very fully elsewhere (*Nature*, vol. xxvii. p. 121), it is unnecessary to comment upon it here.

The correlation of the beds around Christiania with those of Britain has been treated of somewhat fully above, because it seems especially important that the admirable discussion of the relationships of the Tremadoc Slates should be readily accessible to English readers; sufficient has, I hope, been said of the other parts of the book, to show the great value of the work to specialists in all branches of geology. J. E. M.

IV.—The Tertiary History of the Grand Cañon District, with Atlas. By Clarence E. Dutton, Captain of Ordnance, U.S.A. pp. 246, Plates 42, Atlas Sheets 23. (Washington, Government Printing Office, 1882.)

WHAT a Government Scientific Department of a great country may accomplish, when it has the requisite support, has long been apparent from the reports of the Geological Survey of the United States. Printed in quarto in a clear type upon the best of paper, and accompanied by coloured atlases in elephant folio, and also by a profusion of views and other illustrations along with the letterpress, they surpass all other publications of the kind with which we are acquainted. The monograph by Captain Dutton upon the Grand Cañon of the Colorado, on account of its subject, possibly surpasses its predecessors in interest.

Most geological students in this country have had their wonder excited by the frontispiece to Dr. Geikie's Text Book of Geology. It is reduced from one out of the twelve coloured views of a marvellous region given in the Atlas to this work. The original picture measures 29 inches by 18. Hence may be gained an idea of the illustrations of the atlas. Besides these views it contains twelve maps. The quarto volume is also profusely illustrated with a map, sections and views; and the frontispiece is a most delicate and artistic specimen of chromo-lithography. The tints of the rocks are like those of an exquisite silken fabric, and yet we are assured, by the author's descriptions of the scenery of that land of marvels, that they are true to nature. These illustrations are the work of Mr. Holmes.

The style of the book is almost as unique as the subject-matter. We seem rather to be reading the production of an enthusiastic artist skilled in geology, than of the emissary of a government office, commissioned with a toilsome and difficult survey. Nevertheless, nothing is left untold or undiscussed which comes within the compass of the task which he has undertaken. In some of the chapters he describes imaginary journeys; and it is at the moment of supreme interest during one of these, that he introduces his readers to the first sight of the Grand Cañon of the Colorado. "For eight miles from the Milk Spring we continue to cross hills and valleys, then follow a low swale shaded by giant pines with trunks three to four feet in thickness. The banks are a parterre of flowers. On yonder hill-side, beneath one of these kingly trees, is a spot which seems to glow with an unwonted wealth of floral beauty. It is scarcely a hundred yards distant; let us pluck a bouquet from it. We ride up the slope.

"The earth suddenly sinks at our feet to illimitable depths. In an instant, in the twinkling of an eye, the awful scene is before us. Wherever we search the Grand Cañon in the Kaibab, it bursts upon the vision in a moment."

The main purpose of the work is to describe the region on the northern side of that part of the Cañon which is called "the Grand Cañon," and to give its geological structure and history. There is nothing of petrology or palæontology in the book. It is chiefly concerned with the stratigraphy of the district, and with the mode of evolution of the peculiar contours of the surface, as affected by the stratification and the climate, under the action of forces of erosion. There are, besides, extremely interesting discussions on the volcanic phenomena, which appear to have been continuous during late geological periods, and have apparently lasted into recent times over certain areas within the district. The relation of these outbursts to the movements of faulting, plication, and change of level, are peculiarly interesting.

The geological map included in the volume is the central portion cut out from the general map of the western part of the Plateau Province contained in the atlas. It comprises about two and a half degrees of latitude, from 29½° to 32° N., and four of longitude, from 110° to 114° W. The structure of the region is simple, while the scale of the phenomena is immense. We find a series of formations, from the Tertiary to the Carboniferous inclusive, nearly conformable with one another, and dipping at a slight angle towards the north-east. The successive escarpments of these formations form ranges of cliffs. Some of them exceed 2000 feet in height, a height which we, who have not seen them, can scarcely realize. But the rocky cliff on which the Gemmi Pass is cut, is about 2000 feet above the village of Loesh, so that if we could conceive that cliff extending in perspective until it was lost in the distance, those who know it might form a notion of the scale of the scenery. The country being nearly bare of verdure, denudation progresses chiefly by the recession of the cliffs. It is Captain Dutton's belief that the whole thickness denuded off the district during Tertiary time was on an average 9000 feet.

It does not strike us that the amount of denudation here is more surprising than in many other regions. It is the abnormal forms which it has impressed upon the surface, and the strange scenery that results, which renders this country so peculiar. These forms the author attributes to the nearly level position of the beds, their great homogeneity in horizontal, and heterogeneity in vertical extension; and these acted on by the meteorological influences of an arid climate. Dr. Geikie attributes much of the denudation to wind, and the descriptions certainly favour that view.

Along a narrow strip at the bottom of the gorge the river has cut into a series of rocks older than the Carboniferous, and unconformable to it. These are believed to be Silurian and Archæan.

A system of great faults maintaining an average direction at right angles to the dip traverses the region. A further peculiarity of this peculiar country is that these faults give rise to more cliffs. The altitude of the ground on the upthrow side exceeds that on the downthrow by the amount of throw of the fault. Commonly we may stand over a fault of thousands of feet without any surface indications of its presence. Here, however, the faults have formed lofty cliffs, which have, comparatively, not receded very far since they were uplifted. The obvious conclusion is that the country has never been submerged since the disturbances took place.

As an effect of these faults, and of a great roll, or monocline, which is evidently a modification of the same kind of action, the country, through which the Colorado has dug its cañon, is divided into subordinate plateaux of different altitudes. These have each their special features. The first and second from the west, the Sheavwits and Uinkaret, are marked by their basaltic outflows; those of the latter being much more recent than of the former. The third is the Kanab, a desert region. The fourth is the Kaibab, the most lofty of all, elevated into the clouds, and watered by their kindly distillations. This is the paradise of the province, and the subject of enthusiastic encomiums with the author.

Captain Dutton has bestowed a great deal of pains, and of logical reasoning, upon the drainage problems. He has succeeded in showing how the present rivers, fed as they are from a distance, have held the same courses from the conclusion of Eocene time. He shows when they worked rapidly, and when more slowly, in abrading their beds; and points out how the present colossal features of the Cañon were produced. He takes care to remove from the mind an impression, which certainly needed to be removed, that the Grand Cañon is a deep and dismal chasm, shut out from the shining of the sun. It is nothing of the sort. It consists first of a valley ten or more miles wide, with precipitous sides a mile deep, having its bottom trenched with an inner gorge 1000 feet deeper still, and perhaps twice that width. The sides of the upper valley are carved into immense amphitheatres, with outstanding remnants of the beds, of fantastic forms, yet perfectly intelligible upon considering the arrangement of the strata and the forces which have acted on them. It appears to us to be the appreciation of the fitness of means to the effect produced, that in natural objects conveys the idea of beauty: and it is because it takes some while before the mind can embrace the connection of cause and effect under new conditions, that the scene, which bursts upon the view in the Cañon, bewilders for a time, and then enchants with its beauty. In the view copied into Dr. Geikie's Text Book, the spectator stands on the edge of the floor of the upper valley, called "The Esplanade," and looks down into the inner chasm. To the right and left of the picture are seen the walls of the upper valley, not any of those cliffs which, as escarpments, terminate the various formations of the plateau country. All the rocks in this view belong to the Carboniferous.

The fifth chapter, on the Toroweap Valley, describes some extremely interesting facts about the vulcanism of the district. There is also, as one of the illustrations of this chapter, a charming heliotype of the inner gorge of the Colorado at the lower end of that valley. But, above all, the section of basaltic dykes given in the diagram at p. 96 is to our mind one of the most valuable contributions to geological knowledge in the entire work. Here we have, seen in a section half a mile deep, four dykes of basalt. Three of them have had their upper parts and whatever they may have ended in, cut away by the corrosion of the river. But the northern one terminates in a cinder cone, standing now at an extreme corner of the edge of the "esplanade." It is partly dissected away by the recession of the cliff on which it stands, so that its structure is exposed to view. It is most interesting to see the connection here between most ordinary looking basaltic dykes and an actual cone of eruption.

It has just been announced that Captain Dutton has now undertaken the exploration of the great volcanic region of the Cascade Range. The work now before us gives assurance that the examination of this fresh district will be thorough, and the report upon it highly instructive. If, however, we may be allowed to make a suggestion, it would be, that the scientific matter should be thrown together into a separate part, somewhat after the manner of Part II. of Powell's "Exploration of the Colorado River." The geological reader of the present work feels somewhat oppressed with a little too much of what is no doubt very interesting and graphic, but yet not quite the strong meat in which he most delights. At the same time he does not dare to skip, for fear of missing some important fact or deduction, dropped by the way in the midst of somewhat effuse word painting. The book gives the impression of being written for two classes at once, and we cannot help thinking that it might have been arranged so that the perusal of some part of the descriptions of scenery might have been left optional to the scientific student, to whose eye the excellent illustrations at once convey nearly all the information of this kind which he requires. We may also remark that a few more names might with advantage have been placed upon the geological map. The names of the Vermilion Cliffs, for instance, and of House Rock Valley, important features often referred to, are not to be found. The map may be said in a certain sense to be "faultless," because the faults are omitted. They are, however, laid down in the atlas on a different map, on which the stratification is not marked, but are not inserted in that which gives it. This appears to be a sundering of matters that should be conjoined. We also desiderate a divided scale of miles.

Captain Dutton has worthily treated a noble subject. Every reader must feel his knowledge of the ways of nature largely increased by a careful study of this book. It conveys to us all a sometimes much needed warning, that there is a good deal to be known of which we know little. We look forward with the expectation of further instruction and delight, which we are sure will not be disappointed, from the results of his future explorations, in which we trust Mr. Holmes will accompany him. O. Fisher.

V.—Récherches sur la composition et la structure des Phyllades Ardennais, par A. Rénard. Extrait du Bulletin du Musée Royal d'Histoire naturelle de Belgique. (1882.)

THIS is a pamphlet of 35 pages, but though short it contains an immense amount of information, and that, too, on a most obscure and difficult subject, where the ill-defined minerals in the schistoid masses present a thick tissue of interlacing lamellæ, which almost defies the microscope. This portion is mainly chemical: the microscopic details are to follow.

The specimens have been mostly obtained from the "massif" of Rocroy in the French Ardennes. The author gives an outline of the history of the investigation previous to the well-known work of Sauvage, alluding to the idea of Omalius d'Halloy that these schists were steatitic.

Mons. Rénard concludes as the result of the combination of chemical analysis and microscopic research that the "phyllades" of the Ardennes are formed, in variable proportions, of three essential elements.

1. A micaceous substance which constitutes the base of these rocks, and is tolerably constant in amount. Its formula corresponds to that of *sericite*, $H_4 (K.Na)^2 (Al_2)^3 Si^6 O_{24}$.

2. A substance containing protoxide of iron and magnesia, and approaching *chloritoid*, whose formula may be stated as $H_2 R(Al^2) SiO_7$, where R is Fe and Mg. This occurs in greenish lamellæ and filaments, and is more variable in amount than the other substance.

3. Free silica, as *quartz* or *chalcedony*. The accessory minerals are magnetite, specular iron, pyrites, pyrrhotine, ottrelite, fibrolite (?), rutile, tourmaline, zircon, and garnet, along with carbonaceous matters.

The author states the rules by which he has been guided in estimating the quantities of these minerals, together with an explanation of certain anomalies, as, for instance, where the alumina in the sericite may be largely replaced by ferric oxide, and also where the same mineral may contain a portion of the magnesia assigned to the chloritoid. Traces of phosphoric acid, sulphuric acid, lime, and organic substance may be regarded as usually present.

Thirteen analyses are given of various examples of "phyllades," including one of the manganese garnet rock (*ceticule*) of Viel Salm, and the proportions of sericite, chloritoid, and free quartz are deduced from the per-centages found and tabulated in the ordinary way. The calculated amounts of these minerals are then exhibited in a second table for each analysis, and some brief microscopic notes are given for each specimen. In practice the sericite is credited with all the alkalies, and the corresponding atomic weights of silica, alumina, and water allotted to that mineral. In the same way the chloritoid is credited with all the magnesia and the ferrous oxide, and receives the rest of the alumina and of the water together with its proportion of silica, the balance of which is estimated as quartz.

Sericite, as before noted, is the most constant in quantity, and also the most abundant. It ranges from 56 to 23 per cent. Chloritoid, including, in one case, the variety ottrelite, ranges from 46 to about 10 per cent., and, roughly speaking, is about half as plentiful as sericite. The quartz ranges from 45 to 13 per cent.

Reverting to the analyses themselves, we may note that the *Silica* in these phyllades ranges from 65 to 45 per cent. It is highest in the green zones, and lowest in a pale grey phyllade in contact with a kind of diorite.

Titanic acid is a constant accompaniment, mostly ranging from $\frac{3}{4}$ to $1\frac{1}{2}$ per cent. It would seem to occur as rutile rather than as an ingredient of ilmenite.

Alumina is abundant, attaining to nearly one-third of the whole in the more basic specimens, but usually from 20 to 25 per cent. In most cases the *Ferric oxide* only amounts to 2 or 3 per cent., but in one case largely replaces alumina.

Magnetite.—Some specimens contain 3 or 4 per cent.

Ferrous oxide is not very abundant, ranging from less than 1 per cent. to about 3 per cent., though in one case it reaches as high as $5\frac{1}{2}$ per cent. *Lime* is very scarce, even in the basic specimen in contact with the diorite. The per-centage of *magnesia* is pretty steady at between 1 and 2 per cent.

The alkalies are also pretty constant in their amounts, potash being usually three and a half times more plentiful than soda. The general average of the two combined is from 4 to 5 per cent. In the most basic specimen the alkalies amount to over 6 per cent., potash being very nearly four times the amount of soda.

The water ranges from about 3 to 4 per cent. A synoptical table at p. 34 gives the aggregate results; and we are further promised a description, in the second part of the work, of the physical characters of each of the elements of the "phyllades" of the Ardennes.

The following extract from the work of Dr. Barrois, reviewed at p. 273, may serve to give some idea of what is meant by this term.

"The phyllades form beds of a schisto-compact texture, usually susceptible of yielding folia of a large size, and of thus dividing in a way almost indefinable into pieces of extreme tenuity. They are often more glossy than the ordinary schists, harder, offer more resistance to atmospheric influences, and eventually break up into an unctuous earth which does not make paste with water: their prevailing colours are bluish-grey, and greenish. In France the phyllade passes into slate." W. H. H.

VI.—The Coal and Iron Industries of the United Kingdom. By Richard Meade, Assistant Keeper of Mining Records. pp. xxi. and 876, with two maps. (London: Crosby Lockwood & Co., 1882.)

THIS is an important work, "comprising a description of the coal-fields, and of the principal seams of coal, with returns of their produce and its distribution, and analyses of special varieties: also an account of the occurrence of iron ores in veins or seams; analyses of each variety; and a history of the rise and progress of pig iron manufacture since the year 1740, exhibiting the economies introduced in the blast furnaces for its production and improvement." We have here noted the continuation of the title, which forms in itself a brief table of contents: the volume, as will be evident, attaining a portly size, equal in fact to that of Portlock's Geological Report on Londonderry, etc. Mr. Meade must have laboured long and most industriously at his task, while his many years' service in the Mining Record Office at Jermyn Street (now disestablished and merged with that at the Home Office) has given him exceptionally good opportunities of acquiring information on all matters relating to Mining; hence the work is one of great authority and merit.

The author plunges at once into his subject, not burdening his volume with any introductory matter on the origin and geological position of coal, or kindred topics, that are discussed in geological manuals. Chapter I. opens with an account of the Durham and Northumberland Coal-field. Its early history, and its extent, exposed and concealed, are first sketched out. And it is interesting to learn that as early as the year A.D. 852 there is a record of the Abbey of Peterboro' receiving twelve cart-loads of the pit coal. Details of the strata, descriptions of the various kinds of coal, and some analyses of them, are then given. The celebrated "Wallsend" coal (we are told) was for a long period of years produced from the High Main Coal of the Tyne, the colliery from which it was produced being at Wallsend, and hence the origin of this designation to distinguish the "Best Household Fire Coal," after the original Wallsend coal of the Tyne had been worked out. As might be expected, the volume is rich in statistics, and we learn that while in the year 1602 the vend of coal from Newcastle amounted to 190,000 tons; in 1880 the total return of coal raised for the year in the Durham and Northumberland Coal-field, amounted to 34,913,508 tons! The enormous increase is shown to follow the extension of the canal system, the introduction of gas, the application of steam, the demand for iron, and the development of our railway system: but for a long period coal was distributed through the country, either by ships or by means of pack-horses, mules, and asses. The household coal of this great northern Coal-field has ever had a high reputation in the London market, where it is known as "seaborne coal." The prices of coal and its cost of production, the population employed in the mines, and the resources and probable duration of the Coal-field, are likewise treated of.

This account may be taken as a type of those that follow. Chapter II. deals with the Yorkshire Coal-field, Chapter III. with the Cumberland and Westmoreland Coal-fields, and so on. Chapter XVII. gives an account of the Bovey Coal or Lignite, and of the Bideford Anthracite, in both cases perhaps some further details and references to authorities might have been given.

Accounts of the Coal-fields of Scotland and Ireland follow. The former country is fortunate in possessing the largest Coal-field in Great Britain, that of the Clyde Basin; whereas but little, as the author observes, can be said relative to the coal of Ireland. The time was when the sister island was two-thirds covered with coal-beds, now only a few patches or outliers are left. The total production of coal in Ireland in 1880 was but 133,702 tons, compared with 128,560,821 tons in England and Wales, and 18,274,886 tons in Scotland.

A general summary in reference to the Coal-fields of the United Kingdom furnishes us with many valuable statistics. It may be interesting to quote the following:—

Quantities of Coal Remaining and Available for Future Use from 1880:—

	TONS.
England and Wales	69,192,056,317
Scotland	9,669,172,642
Ireland	154,384,079
Total known Coal-fields	79,015,613,038
Concealed Coal-fields	56,273,000,000
Total coal available, 1880.	135,288,613,038

Mr. Meade tells us, that with these available resources, and an annual output of nearly 147 millions of tons, supplies are yet ensured for 920 years hence.

This brings us up to p. 315, and here endeth the account of the Coal-fields. Having thus indicated its contents, we may observe that, dealing as it does essentially with the economic science and statistics of our Coal-fields, it occupies a different position from that taken up by Professor Hull in his "Coal-fields of Great Britain," where the physical structure of each coal-field, its faults and other geological features, are so clearly illustrated; nor does Mr. Meade treat of the dangers attending the miner or of the cause of explosions, and but here and there of the methods of working, information on which will be found in the work of Prof. Smyth on "Coal and Coal Mining."

Passing on to the second part of the work before us, on the Iron

Industries, we have a capital though brief Introductory Chapter on the mineralogical characters of the principal iron ores, by Mr. Frank Rutley, Lecturer on Mineralogy at the Normal School of Science. Mr. Meade then proceeds to give an account of the Durham and Northumberland iron industries, noticing first the ironstone of the Coal-measures and giving analyses. He observes that the Coal-measures yield two kinds of ironstone, known as "Clay Band" and "Black Band," the former is an argillaceous carbonate of iron generally occurring in nodular masses; the latter term is applied to bands of carbonaceous matter, largely mixed with carbonate of iron. The iron ores of the Carboniferous Limestone are next described. Then there are notices of the persons employed in iron-mining, accounts of pig iron manufacture, malleable iron works, etc. Other districts are similarly treated. We may mention that the Cleveland, Northampton, and Lincolnshire iron industries are fully described, as well as those of Wiltshire, Dorsetshire, and other southern counties; but we miss any account of the early workings in the Wealden district. Probably the author disdained to notice these extinct iron-works, and full details may be found in Mr. Topley's Geological Survey Memoir on the district.

The iron industries of Scotland and Ireland are duly described, there is also a Chapter on the foreign iron ore imported, and two Chapters are devoted to fluxes (limestones) and to coal used in pig iron manufacture. There is also a table showing the geological distribution of British Iron Ores, by Mr. H. Bauerman, in which, by the way, the Wealden iron ore is just mentioned. Some statistical appendices, and a good index conclude the volume, which cannot fail to prove a most valuable work of reference to all interested in its subjects. We may add that a notice of this book would no doubt have appeared sooner had the publishers been generous enough to send us a copy: as it is, we have had to wait for an opportunity of seeing it.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 9, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Age of the newer Gneissic Rocks of the Northern Highlands." By C. Callaway, Esq., D.Sc., F.G.S. With Notes on the Lithology of the Specimens collected. By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

The object of the author was to prove that the eastern Gneiss of the Northern Highlands, usually regarded as of "Lower Silurian" age, was to be placed in the Archæan. While admitting that this gneiss frequently overlies the quartzo-dolomitic group of Erriboll and Assynt, he held that this relation was due to dislocation accompanied by powerful thrust from the east, which had squeezed both formations into a series of folds, thrown over towards the west, so as to cause a general easterly dip. As a preliminary to his demonstration, the author gave the following classification of the quartzo-dolomitic series, which, in the absence of clear proof of its age, he called the "Assynt Group," the subdivisions being taken in ascending order:—

C_1. Torridon Sandstone and Ben More Grit.
C_2. Quartzite.
C_2 l. Seamy. C_2 u. Annelidian.
C_3. Brown Flags.
C_4. Salterella Grit and Quartzite.
C_5. Dolomite.
C_5 l. Dark. C_5 u. White.

For the eastern gneiss the author proposed the term "Caledonian."

Taking the country examined from south to north, Loch Broom was first described. Here the author considered there was clear proof of dislocation. Between the Torridon and the Caledonian there were several subparallel faults, which increased in throw from west to east, Torridon Sandstone being first brought up through the quartzite, then further east through the dolomite, while still further east the Hebridean was thrown up, the Caledonian appearing east of the Hebridean. This Hebridean was the "porphyry" of Nicol.

In Assynt the "Upper Quartzite" was first discussed. The author described several sections which he considered to prove that this band was the ordinary quartzite repeated east of a great fault, which brought up the Hebridean; in one place, Glen Coul, the quartzite being conformably succeeded by the brown flags and dolomite.

The "igneous rocks" of Nicol ("Logan Rock" of Dr. Heddle) were regarded as the old gneiss brought up by a fault and thrown over on to the Assynt group to the maximum breadth of more than a mile.

The "Upper Limestone" of authors was described as either outliers of the dolomite or a part of the Caledonian series.

The Caledonian rocks were seen in Glen Coul to be immediately overlying the Hebridean, the Assynt group being caught in the angle between the two gneisses, and bent back in overthrown folds.

The mountain groups of Assynt were described as usually consisting of cores of Hebridean gneiss swathed in or capped by sheets of quartzite. In the former case the quartzite on the western slopes was contorted into overthrown folds by the thrust from the east.

In the Loch-Erriboll district, the "granulite" of Nicol was considered to be a lower division of the Caledonian gneiss, though bearing some resemblances to the Hebridean. In other respects, the views of Nicol were regarded as substantially correct. Along the entire length of Loch Erriboll, a distance of about twelve miles, the thrust from the east had bent back the Assynt group into overthrown folds, and pushed the Caledonian gneiss on to the top of the inverted quartzite. This had produced the appearance of an "upper" quartzite passing "conformably" below the eastern gneiss. The superior antiquity of the Caledonian was confirmed by the occurrence of outliers of quartzite upon the Arnaboll (Lower Caledonian) series, and by the fact that the granite, which sent numberless veins into the gneiss, never penetrated the quartzite and associated rocks.

2. "On a Group of Minerals from Lilleshall, Salop." By C. J. Woodward, Esq., B.Sc., F.G.S.

The minerals noticed in this paper occur in a bed of grey limestone in the Carboniferous Limestone at Lilleshall. They occur in vertical joints in the upper subdivisions of the bed. The following list gives them arranged in order of frequency, the least common being placed first:—quartz, bornite, towanite, iron-pyrites, hæmatite, barytes, calcite, dolomite (ankerite?). Of the first, the author has only met with a single minute crystal. Iron-pyrites is by no means common; hæmatite is more abundant. Of analyses of two specimens of the "dolomite," one agrees very nearly with ankerite, while another, identical in aspect, exhibits considerable differences, being only a ferriferous dolomite. The author suggests that it is doubtful whether ankerite should be retained as a mineral species.

3. "Fossil Chilostomatous Bryozoa from Muddy Creek, Victoria." By A. W. Waters, Esq., F.G.S.

In this paper the author described a collection of fossil Bryozoa, collected and sent over by Mr. J. Bracebridge Wilson, of Geelong. The collection is from Muddy Creek, Bird Rock, and Wauru Ponds, Victoria, and is of the so-called "Miocene" age. There are 64 species, of which 28 are known living, and 18 of these are now found fossil for the first time; but of the rest a large number have previously been found and described from Curdies Creek, Mount Gambier, and Bairnsdale. The author considered that 28 out of this number being known living is a large proportion, seeing that although our knowledge of the Australian recent fauna has been much increased during the last few years, it yet is very imperfect.

The collection furnished 13 species of *Catenicella*, of which 5 at least are known living; and the author indicated the great importance of a thorough study of the living species of that genus. A notch in the aperture simulating a sinus seems sometimes to be replaced by a suboral pore, and a plate on the front of the cell requires further investigation.

Three species are believed to be identical with fossils from the European chalk.

II.—May 23, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Basalt-glass (Tachylyte) of the Western Isles of Scotland." By Prof. J. W. Judd, F.R.S., Sec. G.S., and G. A. J. Cole, Esq., F.G.S.

Basalt-glass or tachylyte is a rare rock, although very widely distributed.

In the Western Isles of Scotland it has, by the authors of the paper, been detected in five localities only, namely, Lamlash (Holy Isle) near Arran, the Beal near Portree in Skye, Gribun and Sorne in Mull, and Screpidale in Raasay.

Basalt-glass is always found in the Hebrides as a selvage to dykes, though elsewhere it has been described as occurring under other conditions where rapid cooling of basaltic lava has taken place. Some of the varieties of basalt-glass in the Hebrides differ from any hitherto described by their high specific gravity (2·8 to 2·9) and by their low percentage of silica (45 to 50).

This basalt-glass is frequently traversed by numerous joints; it is occasionally finely columnar, and sometimes perlitic in structure.

From the acid glasses (obsidian) it is distinguished by its density, its opacity, its magnetic properties, and especially by its easy fusibility, from which the name of tachylyte is derived. By its greater hardness it is readily distinguished from its hydrated forms (palagonite, etc.).

In its microscopic characters basalt-glass is found to resemble other vitreous rocks; thus it exhibits the porphyritic, the banded and fluidal, the spherulitic, and the perlitic structures. In the gradual transition of this rock into basalt, all the stages of devitrification can be well studied.

The difference between these locally developed basalt-glasses and the similar materials forming whole lava-streams in the Sandwich Islands was pointed out in the paper, and the causes of this difference were discussed.

It was argued that the distinction between tachylyte and hyalomelane, founded on their respective behaviour when treated with acids, must be abandoned, and that these substances must be classed as rocks and not as mineral species; the name basalt-glass was adopted as best expressing their relations to ordinary basalt, the term tachylyte being applied to all glasses of basic composition and being used in contradistinction to obsidian.

2. "On a Section recently exposed in Baron Hill Park, near Beaumaris." By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

The author, about three years since, observed some imperfect exposures of a felsitic grit in the immediate vicinity of the normal schists of the district in a road which leads from Beaumaris cemetery to Llandegfan; but last summer had the opportunity, through the courtesy of Sir R. B. Williams, of examining the cuttings made in constructing a new drive, which runs through Baron Hill Park very near the above outcrops. After tracing the normal schists along the steep scarp of the hill, he came, after an interval of about 60 yards, covered by soil and vegetation, to a massive grey grit consisting of quartz, felspar, and minute fragments of compact felsite, which now and then attain a larger size, being an inch or so across. These grits, which pass occasionally into hard compact mudstones (probably more or less of volcanic origin), can be traced for some 350 yards to the neighbourhood of the above-mentioned road, which is crossed by a bridge; and a short distance on the other side of this is a considerable outcrop of the grit, which in places becomes coarsely conglomeratic, containing large fragments of the reddish quartz-felsite so common on the other side of the straits in the beds at or below the base of the Cambrian series. The schists appear to dip about 20° E.S.E., the grits about 25° E.

The author, after describing the microscopic structure of the various rocks noticed, pointed out that this section, though the junction of the two rocks is probably a faulted one, has an important bearing on the question of the age of the Anglesey schists, micaceous and chloritic. The Survey regards them as altered Cambrian; it has even been suggested that they may be of Bala age; others have regarded them as Pebidian. Now the felsitic grits and conglomerates cannot be newer than the Cambrian conglomerate of the mainland, regarded by Prof. Hughes as the base of the true Cambrian, and are probably older, corresponding with some part of the series between it and the great masses of quartz-felsite which are developed near Llyn Padarn and Port Dinorwig, which series lithologically and stratigraphically corresponds with the typical Pebidian of Pembrokeshire. Hence, as the Anglesey schists are in the full sense of the term metamorphic rocks, and the "Pebidian" but slightly altered, this section shows that the former must be much older than the latter, and so be distinctly Archæan.

3. "On the Rocks between the Quartz-felsite and the Cambrian Series in the Neighbourhood of Bangor." By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

This district has already been the subject of papers by the author (Q. J. G. S. vol. xxxiv. p. 137) and by Prof. Hughes (vol. xxxv. p. 682), who differs from him in restricting the series between the quartz-felsite and Cambrian conglomerate to little more than the bastard slates and green breccias of Bangor mountain. The author has traced on the S.E. side of the Bangor-Caernarvon road a well-marked breccia containing fragments of purple slate mixed with volcanic materials below the above-named Bangor series for more than a mile. At a lower level he has traced another well-marked breccia, chiefly of volcanic materials, for half a mile; and, lastly, a grit and conglomerate, apparently resting on the quartz-felsite named above, composed of materials derived from it. This has been traced on both sides of the road mentioned above for nearly two miles. For these and for other reasons given in the paper, the author is of opinion that, as he formerly maintained, there is a continuous upward succession on the S.E. side of the road, from the quartz-felsite at Brithdir to the Cambrian conglomerate on Bangor mountain. The district on the N.W. side of the road is so faulted that he can come to no satisfactory conclusions. The author is in favour of incorporating the above-named quartz-felsites with the overlying beds as one series, corresponding generally with the Pebidian of South Wales; older than the Cambrian, though probably not separated from it by an immense interval of time. An analysis of the Brithdir quartz-felsite by Mr. J. J. Teall was given, from which it appeared that the rock corresponds very closely with the "devitrified pitchstone" of Lea rock in the Wrekin district, described by Mr. Allport, but differs considerably in composition from those in the Ordovician rocks of North Wales.

CORRESPONDENCE.

PROF. GEIKIE'S PAPER ON THE ST. DAVIDS ROCKS.

Sir,—As my views on the St. Davids rocks are very freely criticized in the abstracts published of the paper read by Prof. Geikie at the Geological Society, on March 21st and April 11th, I trust I may be allowed to state that during the discussions which followed the reading of the paper, I emphatically denied that the evidence submitted by Prof. Geikie could in the least degree affect the conclusions I had arrived at. I stated also at the meeting on April 11th that since the previous meeting I had re-examined the district with Prof. Hughes and several other excellent observers, and that I had obtained such further evidence in confirmation of my views as will completely dispose of the most important of the arguments relied upon by Prof. Geikie.

When the paper is published, I shall be prepared to reply more fully to the author's statements.

Henry Hicks.

Hendon, N.W.

P.S. (June 11th)—I should like to mention that the above letter is in substance identical with one sent to "Nature" on May 6th, which, however, has not appeared in that Journal, yet the abstract of Prof. Geikie's paper was printed there with exceptional prominence. The readers of the Geological Magazine can draw their own conclusions. H. H.

THE PRE-GLACIAL AGE OF THE MAMMOTH.

Sir,—In the last of Mr. Howorth's series of essays on the Traces of a Great Post-Glacial Flood, entitled Flora and Fauna of the Loess, my evidence as to the age of the Mammoth quoted by my fellow-worker, Dr. Nehring, is dealt with as follows:—

"Let me quote another sentence from Dr. Nehring's paper. He says, 'The Mammoth is, as Prof. Boyd Dawkins has already pointed out, Pre-Glacial, Glacial, and Post-Glacial; his remains occur not only in the Loess, but in the most varied deposits of Europe, as in the Forest-bed, in Glacial gravel layers, in clay and loam, in Tuff deposits.' Dr. Nehring is surely not aware of the very thin ice upon which he is skating in this passage. Whether the Mammoth is found in the Forest-bed or not is assuredly one of the most disputed points in English geology. The evidence seems to point most certainly to its not occurring in the Forest-bed *in situ* at all, and that I believe to be the matured opinion of those geologists who have the best right to decide such a point. In regard to the Mammoth being Pre-Glacial, I altogether dispute it according to our present lights. The evidence is of the most fragile and unsatisfactory kind, so fragile that it is not surprising my gifted friend Professor Dawkins, who is quoted by Dr. Nehring, has published more than one opinion on the subject. As to the Mammoth being Inter-Glacial, I shall have a good deal to say, if my friend Dr. Woodward will permit me to continue the series of papers I have been writing in the Geological Magazine. At present, I can only say that I believe the Mammoth and the *Rhinoceros tichorhinus* to have been, at all events in Europe, so far as we at present know, entirely Post-Glacial, and I maintain that they are the characteristic quadruqeds of the Post-Glacial Ante-Neolithic deposits."—Geol. Mag. Dec. II. Vol. X. p. 278.

Any one reading the above passage would carry away the idea that I am doubtful as to the Pre-Glacial age of the Mammoth, and that Dr. Nehring is in ignorance of the fact that the best judges in this country had decided against it. What are the facts? To pass over the Scotch caves, Dr. Falconer identified the Mammoth as a mammal of the Pre-Glacial Forest-bed more than 20 years ago. This conclusion seemed to me open to doubt in 1868, but subsequent discoveries compelled me fully to accept it in 1878 (Q. J. G. S. vol. xxxv. p. 138). Since that time repeated discoveries leave no room for doubt about the matter. It is accepted by the late Professor Leith Adams, in his work on the Mammoth (Pal. Soc.), as well as by Mr. E. T. Newton in his valuable memoir on "The Vertebrata of the Forest Bed of Norfolk and Suffolk" (Geol. Survey, 1882), who may be supposed to have 'matured opinions,' and a right, if not "the best right to decide such a point." Its Pre-Glacial age is further confirmed by the discovery of one of its teeth in the gravel beneath the boulder clay of Northwich, Cheshire, as I pointed out in 1878 (Q. J. G. S. vol. xxxv. p. 141). Surely the view which I retracted against the Pre-Glacial Age of the Mammoth, although it be supported by Dr. James Geikie, cannot be said to balance the testimony of these independent witnesses which Mr. Howorth either does not know, or thinks fit to ignore. Whether or no my opinion is sufficiently 'matured' by the 25 years during which I have been working at the Pleistocene Mammals, to count in the controversy, may be left to those interested in such questions.

Mr. Howorth's method of disposing of evidence against his views may perhaps be allowable to an advocate fighting a case in the law courts, but it is not likely to advance the knowledge of the facts. We are not in a court of law, but in a court of science, where the wig and the bands of the special pleader appear to me to be out of place. Into the controversy as to the Glacial Period, or into the last revival of the old diluvial doctrine given up some fifty years ago by its great preacher in this country, Dr. Buckland, I must decline to enter, believing that the only satisfactory method of dealing with such matters is not merely to compile opinions at home, but to test them by years of patient work in the field, after the fashion of our great leaders, Lyell, Evans, and Prestwich.

W. Boyd Dawkins.

OVERLAP AND OVERSTEP.

Sir,—Mr. Goodchild's article on "Overlap and its related Phenomena," contains a useful suggestion, though I think the ambiguity arising from the use of the term overlap in a twofold sense and the desirability of limiting its application may be stated without importing further confusion into the subject or wrapping it up in the elaborate phraseology which Mr. Goodchild has employed.

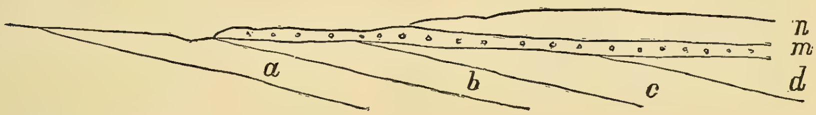
In the first place I never myself met with a person who applied the term overlap to a case of thinning out, whereby the higher member of a conformable series comes to rest upon a lower member of the same series in consequence of the alternation of an intervening stratum. If the term has ever been used to express such a relation, I think the precedent may safely be disregarded, since it is obviously unnecessary to confuse such a simple matter as the thinning out of a bed with the more complicated phenomena of overlap.

Secondly, I fail to see in what particular Mr. Goodchild's definition of overlap (p. 226) differs from that ordinarily given (see Jukes'

Student's Manual and Green's Physical Geology), except that he omits all mention of its necessary connection with unconformity and even appears to suppose that overlap may take place without any concomitant unconformity. I would ask Mr. Goodchild whether he could draw a case of overlap (in his sense) without an unconformity existing at the base of the series in which the overlap occurs; the case drawn in his figure (p. 227) is an ordinary one with an unconformity. So far it seems to me that he has only introduced more confusion into the subject than there was before.

His final suggestion is, however, much more to the purpose, and we now come to the point where a confusion does really exist in the minds of geologists. I think it is ordinarily supposed that transgressive and overlapping are convertible terms, but are they? and are not Mr. Goodchild's remarks really directed against the confusion which has arisen, from the want of a proper distinction between them?

If overlap be correctly defined as a relation between two conformable groups of strata, and as consisting in the extension of the higher group beyond the limits of the lower group so as to rest upon some member of an older series, as shown in Mr. Goodchild's diagram; then it is clear that the same term should not be applied to a relation between unconformable strata, such as the transgression of a single stratum across the edges of groups belonging to an older series. This relation is indicated in the accompanying diagram, but



would be better shown in a plan, in which the outcrops of the groups *d*, *c*, *b*, are gradually and successively hidden by the transgression of the group *m* across the edges of their component beds. This is a very different phenomenon from true overlap, and yet the so-called overlap of the Chalk in Yorkshire is exactly a case of this kind; the Red Chalk there is continuous and is not *overlapped* by anything, but is itself *transgressive* across the different members of the Jurassic series.

The difference in the nature of these two relations has, I suppose, been partly perceived by those who would speak of a *conformable* as opposed to an *unconformable* overlap, but such a distinction does not avoid confusion, while it introduces a cumbrous terminology, and I quite agree with Mr. Goodchild that, since the two things are essentially different, it only perpetuates confusion if we apply the same name to both. The only question is whether there is any necessity to invent a new term and whether that already in use, viz. transgression, is not sufficient for the purpose, so long as authors are careful to make the necessary distinction between overlap and transgression. The latter term has, however, acquired another meaning in our language, and I am therefore inclined to think that its correlative *overstep* will be likely to meet with favour, and its adoption would certainly emphasize the distinction to which Mr. Goodchild has called attention.

It must be remembered, however, that both cases involve an unconformity, and that the difference between them is really this: in overlap the basement member of the upper series has a limited extension, while in overstep the basement bed has a continuous extension. It is also worthy of remark that the unconformity between the two series will generally be much greater in the case of overlap than in the case of overstep, for in the latter the beds all dip in the same direction, and the existence of an unconformity is usually only made patent by the fact of overstep. The real want of the term overstep is not in fact brought out by the diagram drawn by Mr. Goodchild, since the unconformity there shown is so marked that the relation of the upper series to any single member of the lower series is not likely to be made a matter of discussion. It is only where both series dip evenly in the same direction that a term is required to express the relation of the upper to the members of the lower series.

May 18*th*, 1883. A. J. Jukes Browne.

CHALK-MASSES IN THE CROMER DRIFT.

Sir,—Mr. T. M. Reade is mistaken in supposing that I am alone in regarding all the larger masses in the "Cromer Drift" as reconstructed Chalk. In reference to this, and to his enquiry whether the Old Hythe pinnacle of Chalk figured by Sir Charles Lyell was of this reconstructed character, I refer him (and others) to page 150 of the Geological Magazine for 1864, where, in a footnote, Prof. H. G. Seeley observes as follows:—"The figures given in Sir C. Lyell's Elements, p. 129, are not included pinnacles of Chalk, but only reconstructed chalky drift full of all sorts of rocks."

It was the perusal of this note which first called my attention to the subject, and Mr. Harmer and I found Mr. Seeley's statement as to the masses being of reconstructed material correct, examining as we did the numerous masses worked for marl-pits and lime-kilns over the country inland occupied by the Contorted Drift, though in most of them fragments of material foreign to the Chalk, save galls of sand and clay, and were not common. The *sheets interstratified* in the lower part of the Cromer cliff section, such as that near 150 yards long at Runton (where this part, heretofore called the Till, is represented in Mr. C. Reid's memoir as the "Contorted Drift"), are of Chalk *not* reconstructed, and were brought from Chalk shores, and dropped on the bottom, as I have pointed out; and, as the submergence had then only begun, may very likely have come from some part of Norfolk, but when the masses of reconstructed Chalk were brought, and sunk deep into the substance of the sea-bed, the *whole of this county* was submerged, the highest points in it being formed of this sea-bed. For many years before Mr. T. M. Reade's paper on this subject, I have repeatedly referred the transport and introduction of these masses to floating ice grounding on the sea-bottom, as he does, but neither in respect to them, or to very much more of the facts connected with the North Norfolk Cliff (inclusive of the *true* Forest-bed), can I admit Mr. C. Reid's memoir to be any authority whatever, regarding it, as I do, as greatly at variance with the real state of the case.

As to tracing the masses in the Contorted Drift in a train up to Lincolnshire, which Mr. Reade challenges me to do, the formation containing them has been destroyed over West and North-west Norfolk, and over the area between there and the Lincolnshire Wold, by the subsequent advance of the Land-ice giving rise to the Chalky clay, as delineated in the maps to my late memoir on the Newer Pliocene period in England, but as far as the Contorted Drift can be distinguished in that direction they occur.

June 16th, 1883. SEARLES V. WOOD.

WEST GALWAY ROCKS.

SIR,—These rocks are referred to at page 657 of the "Text Book of Geology," by Dr. A. Geikie, and it is stated that my classification suggests that the Upper Cambrians pass unconformably into the Llandeilo formation without the occurrence of the thick Arenig rocks of Wales. I presume that my opinions have not been made sufficiently plain, as this eminent geologist has evidently misunderstood my writings on the subject. In the "Geology of Ireland" the classification of Lyell, and which also appeared to be the opinion of Sir A. C. Ramsay, was followed,—the representatives of the Arenig rocks of Wales being included in the Cambrian group, among the Upper Cambrians. But as some of my reviewers suggested that I had ignored the Arenig series, in subsequent writings more details were entered into; as, for instance, in the papers on *Irish Palæozoic Rocks,* Manchester Geol. Soc. April, 1879; *Supposed Upper Cambrian Rocks, Counties Tyrone and Mayo,* Royal Irish Academy, December, 1879; *On the Thickness of the Irish Bedded Rocks,* Royal Dublin Society and Royal Geol. Soc. Ireland, November, 1880, etc., etc. In these and other papers published about that time, the supposed equivalents of the Welsh Arenig rocks are specially mentioned, and the reasons given for supposing them to be equivalents.

How the rocks in the south portion of West Galway can be older than those in the north portion, it is hard to conceive when we know that the former are in part made up of fragments of the latter; that is, the rocks which are said to be oldest are made up of the *débris* of the younger rocks. Furthermore, on account of the remarkable similarity in the rocks and groups of strata that margin on the north-east and south, the rocks of the Bennabeola group of hills, also for other cognizable reasons, I am compelled to believe with Griffith and all the geologists who have examined the country that the rocks of the Bennabeola group of hills must be older than those in the country to the south-east and north of them.

In this south-west Connaught tract of Metamorphic rocks, which includes portions of N.W. Galway and S.W. Mayo, there were two periods of intense metamorphic action;—one before and the other after the accumulation of the Upper Silurian strata, as has been stated in the Memoirs of the Geological Survey, and in the "Geology of Ireland." Mr. Symes was the first to suggest that these metamorphic rocks belonged to two distinct geological formations; which was subsequently satisfactorily proved, because at the junction of his and my work, his younger metamorphic rocks graduated into unmetamorphosed rocks in which occur numerous fossils principally of Wenlock types. G. Henry Kinahan.

IRISH DRIFTS.

Sir,—In the April Number of the Geol. Mag., Mr. Swanston in reference to a former paper of mine on the Irish Drifts (Geol. Mag. Vol. X. 1873, p. 447) says, that if Mr. Howorth had relied "more on the work of Portlock" "and less on" myself, certain inaccuracies would have been avoided.

The mis-spelling of a name by the substitution of the letter *r* for the letter *v* (an error due to my caligraphy I presume), was hardly worth cavilling about, and the height of the glacial bed at Bovevagh was correctly given in my paper.

Referring to Portlock, I find at p. 157, *Turritella*, *Cyprina*, and *Nucula* (*Leda oblonga*) all referred to in the same sentence, the first species being confined to the bed near Bovevagh Old Church, the next reference, p. 159, says the bed is full of *Turritella* and contains only *fragments* of any other shell, yet at p. 737 *Astarte multicostata* (*A. compressa*) is recorded. Will Mr. Swanston kindly say what species are represented by these fragments?

After carefully reading Portlock's chapters, I cannot come to any other conclusion than that he found them all associated together. His special reference to *Turritella* being on account of its abundance at this place and not elsewhere.

I acknowledge that I have not personally examined the beds concerning which I wrote; but inasmuch as no two Irish geologists were in accord upon these beds, and having had the advantage of inspecting collections of species from most of the localities I have referred to, besides an intimate acquaintance with nearly, if not quite all the papers that have treated upon the subject, and the use of communications, lists of species, and parcels of unsorted stuff sent by various geological friends, I wrote with a view to bring together all that had been done up to that time. If Mr. Swanston will point out my inaccuracies, being on the spot, he can easily do so, and the cause of geology will be served.

Should Mr. Swanston be desirous of publishing a list of Irish Post-Tertiary fossils, a work much needed, I shall be very happy to assist him. Alfred Bell.

With the deepest regret we have to announce the death of the President of the Royal Society—Mr. W. Spottiswoode, LL.D., F.R.S., on the 27th of June, 1883, aged 58 years. The death is also announced of the former President, General Sir Edward Sabine, aged 95 years.

a. b. c. Types of Inverted Folds (Heim, Mechanismus der Gebirgsbildung.)

Fig.1. Symmetrical Fold.

Fig 2. Overfold, Type a.

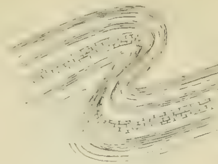


Fig 3. Overfold Type b

Fig 4 Overfold, Type c

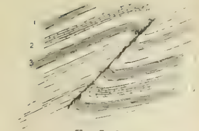
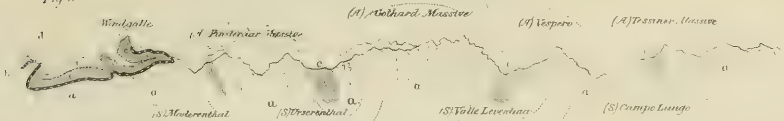


Fig.5. Overfault.

Type of Denuded Mountain System.

Section through North portion of Central Alps
Heim, Mechanismus der Gebirgsbildung Taf XIII fig 13

Fig 6



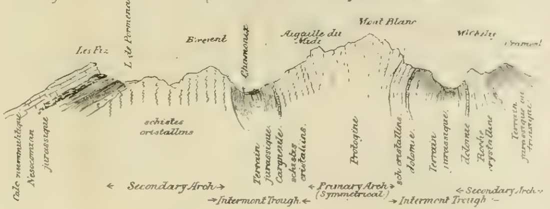
A Anticlinal Forms Denuded Anticlinal Ridges, or Mountain Arches
S Synclinal Forms Synclinal Troughs, or Intermont Depressions

Ref { (a) Gneiss & Krystall. Schiefer, Anthraatschiefer, &c
(b) Trias, Lias and Brown Jura
(c) Upper Jura & undetermined sediments between the Central Massives
(d) Cretaceous (e) Eocene

Type of Symmetrical Mountain Ridge, &c

(Geological Section of the Mont Blanc Range.)
(A. Favre, Recherches Géologiques, 1867, Pl. XIII Fig 1.)

Fig. 7



Geological Section from the Baumgarden Alp to the Fucka horn (Heim op cit Taf VII Prof XII)
Shewing deceptive arrangement of Strata in the flank of a denuded Mountain Range

Fig 8

Eroded & Compressed Intermont Trough
Strata on both sides inverted.
(Favre Recherches Géologiques, Plate V. fig 27)

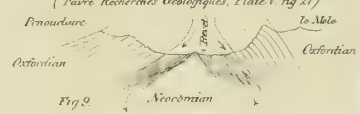


Fig 9.

Reference to Fig 10

Development of planes of dislocation in a stratum subjected to lateral pressure.

(a) Direction of lateral pressure.
(b) Direction of local yielding of laminae.
(c) Confluent lines of dislocation.

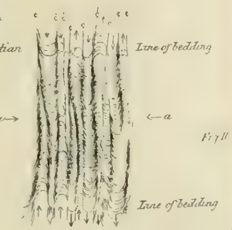


Fig 11

Ausweichungsclivage. (Heim, op cit Taf IV Fig)

THE

GEOLOGICAL MAGAZINE.

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No. VIII.—AUGUST, 1883.

ORIGINAL ARTICLES.

I.—The Secret of the Highlands.

By Prof. Charles Lapworth, F.G.S.

(PLATE VIII.)

(*Continued from p.* 199.)

(b). Special Principles of Mountain Structure, etc.

Heim's theory of inclined folds (overfolds).

THE theory of the gradual formation of overfolds and overfaults in a stratified system is thus developed by Professor Heim:[1]—

Wherever a stratified rock series is subjected to the lateral horizontal thrust of the earth's crust, a *fold* is originated. This fold consists of two opposed and symmetrical members, with more or less remote axes, viz. (Plate VIII. Fig. 1)

(1) An upward bend, or *arch;* and

(2) A similar downward bend, or *trough*, parallel to the former.

Connecting this arch and this trough lies a zone forming a *common* or *middle limb*.

(*a*) As the crushing continues, the arch *rises*, the trough *sinks*, and the middle limb *revolves* as a relatively neutral intermediate portion, and gradually attains a perpendicular attitude. As the pressure still increases, the middle limb is even forced somewhat beyond the vertical, and becomes inverted in position. In this way the trough-curve is brought *below* the arch-curve, and there originates first an *overhanging*, and finally an inclined fold (Plate VIII. Fig. 2).

During this process the lateral pressure has squeezed thinner those strata of different materials which are inclosed together in the central parts of the fold, while those in the main curves have been rendered somewhat thicker; but all three limbs of the fold have experienced the effects of the pressure in a similar measure.

If the compressing force has been neutralized at this stage, we obtain in this way an inclined fold, whose arch, middle limb, and trough limb are formed of about equal strength.

(*b*) In the case (*a*) described above, if the middle limb is very short, so that its double breadth has become wholly insufficient to withstand the amount of the compressing force—that is to say, if the pressure is more than sufficient to overturn the middle limb, the mechanical arrangement becomes considerably altered.

[1] Heim, Mechanismus der Gebirgsbildung, Band I. pp. 220–223.

The arch-limb, which has given way in an upward direction to the lateral pressure upon the strata, now overlaps *above*, while the trough-limb thrusts itself *downwards* below in the diametrically opposite direction. Both arch-limb and trough-limb suffer from the general horizontal side-thrust of the earth-crust *only;* but the intermediate middle limb lies wedged in between two masses of strata moving in opposite directions, at the same time that it is enormously burdened by the weight of the superimposed arch-limb and arch-core, while, in addition, it is squeezed by a component of the general side-thrust. As a natural result, the middle limb suffers a mechanical action, which may most fitly be termed a *mangling* or *rolling-out-action*, and must thereby become *longer*.

As the strata enveloped in the fold gradually give way to the lateral compressing forces, the beds forming the arch-limb can only move forward at the crest of the fold (which has a sharp curvature), by rolling themselves over in a downward direction towards the squeezed middle limb. There constantly takes place, therefore, an over-rolling movement at the *crest*, as the folding goes on. Having, in this manner, arrived in the region of the middle limb, the various strata formerly belonging to the arch-limb are there crushed and rolled out.

A corresponding and symmetrical movement takes place in the *trough-curve*. The end of the trough-curve is dragged upward in a rolling movement towards the middle limb, where its strata are crushed, flattened out, and extended.

On the *convex* or outside parts of the arch and trough-curves there is a continual tendency of the particles to the constantly lengthening middle-limb: on the *concave* or inside parts of these curves there is a corresponding movement from the centre of the middle limb towards the apices of the curves. The geologically *younger beds* of the folding system (*i.e.* the parts within the arch and trough-axes) move *downwards below* the under side of the middle limb; the geologically *older beds* glide *upwards* above the upper side of the middle limb. But these changes of position of the particles can never proceed, however, so quickly as the advancing movement of the over-riding and underthrust masses, for they have merely been rolled and dragged along by the latter.

Through the rolling-out process described above, the mass of strata dragged over the arch-bend grows thinner and thinner the greater its distance becomes from the overturning brow of the arch. In the same way, the lower portion of the middle limb, which feeds itself from the trough-limb by dragging particles upwards, rolls out thinner and thinner the farther it becomes removed from the trough-bend. Between both these regions the precise spot where the middle limb is at its weakest marks the special point where, in the original formation of the inclined fold, the curve between arch and trough originally changed direction, and which has therefore experienced for the longest time the rolling and dragging-out action in both directions.

(As a general rule the middle limb is rolled out uniformly, but this is not invariably the case. It is sometimes torn into individual shreds, between which the strata of the arch-core and those belonging to the trough-core touch each other.)

Whilst in the first type (*a*) of inclined fold described, a piece of strata corresponding with the width between the trough-limb and the arch-limb, is predestined from the very beginning to be the later middle-limb of the inclined fold; in this second type (*b*), the middle limb originates in great measure by the gradual curving round and rolling out of pieces of the two side-limbs. During the infancy of the fold (*b*), the particles eventually composing the middle limb were mostly portions of the lateral limbs, and underwent a mechanical transformation in their gradual transition into the middle-limb. It is evident that the zones of strata which were thus *dragged* by the two side-limbs into the central limb have, when combined, a collective breadth necessarily much inferior to that of the middle limb which has been *rolled out* of this material.

In the first case (*a*) the original breadth of the compressed zone of earth-crust enveloped in the final fold corresponded to the sum total of the *three* limbs; but in the second case (*b*), it only corresponds to the sum of the *two* side-limbs, plus a fraction of the middle limb.

(Although the process described above may be regarded as the normal mode of origin of the second type of inclined fold, it may nevertheless be developed very naturally out of the fold of the first type, if the compressing force be more than sufficient for the formation of (*a*).)

(*c*) As a third member in the series, there is the case when the middle limb is no longer sufficiently fed by the lateral limbs, or when the folding and rolling out go too far, or are continued to such an extent that the movements taking place in opposite directions on both sides of the middle limb, as well as the opposite movements of arch portion (limb and core), and trough portion (limb and core), are of necessity compelled to concentrate themselves upon an intermediate layer of middle-limb of ever-diminishing thickness. Finally, they come of necessity into immediate contact, and when this takes place, the arch-portion and trough-portion of the overfold are *completely sheared off from each other.* Instead of the middle limb we have now a surface of dislocation; and *the arch portion of the fold thrusts itself over the trough portion in the form of a more or less rigid mass.*

In many cases this overthrusting effect is due to the relief of downward pressure caused by the erosion of the brow of the arch. As a general rule, the trough bend is much longer able to furnish fresh material to the central limb than the arch bend, so that we find many inclined folds, which in their trough portions are of the type (*b*), and in their arch portions of the type (*c*). In these folds, a central limb is still recognizable in the vicinity of the trough bend, but, in the vicinity of the overlapping crest, they have become a rigid overthrust mass, without a trace of central limb.

We find consequently among inclined or reflexed folds a connected series of forms, each successive member of which may arise naturally from the preceding merely by an increase in the force of compression. These overfolds may be thus distinguished :—

(*a*) An overfold, originating by the overthrow of a central limb previously limited by two differently directed curves has three limbs of about equal strength.

(*b*) An overfold with gradual development of a middle limb, which has originated in the over-rolling of the beds at the apices of the curves, has a greatly reduced middle limb.

(*c*) The overfold which has originated by the shearing off of the arch portion from the trough portion, and upthrust of the former over the latter, has either (c^1) a middle limb squeezed very thin or else (c^2) no middle limb at all. We find in this last type the two following cases :—

(c^3.) The arch portion of the middle limb is missing, but the trough portion is still present.

(c^4) The entire middle limb is wanting.

The arch limb and trough limb of an overfold merely undergo side-thrust ; the middle limb suffers *stretching, rolling out, and squeezing.* The deeper they lie below the surface the greater is the ductility of the strata. In overfolds of vast extent the arch limb being nearer the surface is more rigid, the trough limb, being buried under more than double the burden, is more ductile. It often breaks up therefore under compression into a complete series of secondary folds. The position of these minor folds is prescribed to them by the limits of the primary trough of the overfold, for the whole space is filled up, and yielding is only possible in those directions in which the whole mass gives way. From this results the frequent harmonic folding of the trough limb.

Such is the theory of the gradual development of reflexed folds as laid down by Heim in his great work; and no one who has carefully studied in detail the appearances of the strata enveloped in the numberless overfolds in convoluted rocks, can possibly doubt its general correctness. Accepting, therefore, this fundamental theory as it stands, we obtain the following additional principles of mountain structure :—

11. In the process of the folding of the beds in an overfold (Plate VIII. Figs. 1—5), while the particles in the roof and floor of the overfold become crushed more closely together, those in the middle limb are subjected to gradually increasing extension. This gives in orderly sequence the successive formation of

(1) An overfold composed of three nearly equal limbs.
(2) An overfold with insignificant middle limb.
(3) An overfold with local relics of a middle limb.
(4) An overfold with a plane of dislocation in lieu of the middle limb (*fold-fault*).
(5) As the pressure increases, the strata shear along the plane of dislocation ; the axial plane of the fold (plexal axis) becomes the plane of an inverted fault, and the arch portion of the fold slides upwards over the trough portion until equilibrium is restored (*upthrust*).

In all the last three cases the final results are almost identical. The roof and floor of the overfold (arch-limb and trough-limb) repose at once upon each other apparently in regular and conformable succession.

12. By a series of repeated folds and faults of this nature, a rock formation of no great actual thickness lying upon the flanks of an ancient mountain range may be made to crop out over an enormous area, presenting the fallacious appearance of a massive formation of immense thickness, but of a most monotonous petrological character, being apparently formed of alternations of similar strata, which follow each other in parallel and unbroken order. Or, on the other hand, if the strata in this position include those of several distinct but conformable geological formations, these same physical accidents will necessarily give to the whole mass the fallacious appearance of a single and consecutive rock-series, whose strata all agree generally in dip, strike, and amount of convolution (Plate VIII. Fg. 8).

13. As a final result, however, in a theoretically symmetrical mountain range, if all disturbing elements are eliminated, broad parallel zones of such strata should flank the mountain range on both sides, as we approach the mountain axis. The corresponding zones on opposite flanks should be formed of identical strata, and answer precisely to each other in amount of convolution and average inclination. The crest of the range being longest exposed to denudation should show an axial zone of the oldest rocks, the youngest should occur in the plains at the foot. In other words, the folding, the faulting, and the geological age of the strata should all decrease in exact proportion as we pass outward from the vertical strata along the mountain axis through the plagioclinic rocks of its flanks, to the orthoclinic beds of the fringing plains.

The foregoing are perhaps the main principles which bear upon the appearances presented by comparatively homogeneous strata looped up by opposed parallel pressures into symmetrical folds of infinite length, perpendicular to the plane of curvature. But in actual mountain regions, none of these conditions obtain over a large area. The rock-formations implicated are very different in lithological characters, and vary greatly in their relative resistance to deformation under pressure. The tangential thrust differs much in local intensity, while the major loops are in truth long and irregular domes. Hence within a convoluted region all these phenomena must vary locally both in form and degree, and may be arrested at any stage, or, in the process of time (by the development of new and differently applied pressures), may be supposed to be extended indefinitely.

But before treating of the special modifications of the foregoing results which take place in nature, there are two additional conclusions which appear to flow so naturally from the application of the foregoing principles that they must be noticed in this connection.

Deformation of Individual Strata.

14. In all those cases hitherto considered, the masses of strata

undergoing deformation lie near the surface, and, owing to the absence of overlying rocks, they have comparative freedom of movement in a vertical direction. They consequently yield to the tangential crust stress by looping themselves up in *broad masses* into vast arches, the crests of which are directed obliquely outwards perpendicularly to the direction of local thrust; and the phenomena we have described affect the *entire mass of strata* enveloped in each fold, *considered as a whole.*

But at great depths beneath the surface, where the strata are overburdened by masses of superimposed rocks (and also in the cores and curves of the larger arches and folds themselves, where they are surrounded by enveloping rock-masses), the deforming strata have no longer the same freedom of vertical movement. Hence we may infer as a natural result, that the amplitude of the rock folds grows less and less in proportion as the weight of overlying material increases. The various stages of rock deformation under lateral pressure (folds, overfolds, overfaults, and overthrusts), under these new conditions are theoretically of the same *kind* as before, and take place in the same *sequence*, but are of rapidly diminishing *degree.*

As a typical term in the descending series, we select that theoretical case in which we shall suppose that the tangential thrust acts upon one stratum only.

As the general rock-mass in which it is imbedded gives way as a whole to the grand horizontal stress, the stratum is wrinkled up into a series of corrugations, the magnitude of which depend upon (*a*) the weight of the overlying rocks, (*b*) the thickness of the stratum itself, and (*c*) its comparative hardness and density.

As the overlying mass gives way and rises above each individual bed becomes in this way crumpled inwards upon itself into a set of minute and more or less symmetrical folds, each of which consists as before of an upward curve or arch, and a downward curve or trough, and an intermediate neutral wall or common limb, the axial planes of all three being approximately parallel, and inclined in that special direction in which the general mass of strata is giving way. As the process goes on, each bed may retain its individuality, but must of necessity become greatly increased in apparent thickness, viz. to an extent which is measured by the amplitude of its folds.

As the pressure increases, the several stages of rock-deformation already described here follow each other in their natural sequence. The miniature normal folds pass into overfolds with attenuated middle limb; next into overfolds with insignificant or fragmentary common wall, till finally the latter may become obliterated altogether and become replaced by a plane of dislocation, the roof and floor of each miniature overfold resting at once upon each other in regular and conformable sequence.

During this process those parts of the stratum forming the two side limbs have undergone compression and condensation: those in the neighbourhood of the common wall have been submitted to twisting and elongation. In all the later stages of its deformation, therefore, the bed is made up of wedges of strengthened material, whose thickened extremities are turned in opposite directions, and these wedges are separated from each other by planes of weakness, or of actual dislocation.

It is needless perhaps to follow this process farther. It is clear that in all its later stages the bed will be found to have undergone a peculiar change in its dimensions, having been greatly compressed in one direction, and elongated in another. It has given way under the lateral thrust by wrinkling itself up into folds whose axes are perpendicular to the direction of local pressure; and the entire mass is finally traversed by a series of planes of structural weakness (fold-faults) coincident with the axes of these contortions. In other words, we have before us simply the gradual development of that special type of schistosity, which is correctly identified by Sorby in his classical paper [1] with true slaty cleavage.

From the conditions of the case all the phenomena of corrugation must be attended with great local irregularities, and may be more or less incapable of being referred to their proper type. But the various stages of the process of deformation ought fairly to be identified by the gradual disappearance of the miniature arch and trough-curves, and the final obliteration of the middle wall, *and its replacement by a plane of cleavage.* Some of the stages appear to be illustrated in the published figures indicated below.[2] In the earlier stages the corrugation is easily recognizable as such. In the intermediate stages we seem to have that interesting appearance which has been interpreted as false contorted bedding. In some of the later stages we find the thickened stratum traversed by those oblique laminations, which are usually regarded as affording unequivocal evidences of the false-bedded nature of the metamorphic schists.

Deformation of mountain folds.

If the causes and results of overfolding of rocks under tangential thrust are correctly laid down in the preceding paragraphs, in so far as they affect the groups of strata involved in the *minor folds* upon the flanks of mountain chains, they must, theoretically, be equally true of the grander masses of strata enveloped in the *regional earth-waves*, each of which gives origin to a single chain in a mountain system (Plate VIII., Fig. 7). When these mighty arches and troughs are brought closer together by the great crust-creep, the arches must

[1] On the Origin of Slaty Cleavage, by H. C. Sorby, F.G.S., etc., Edinburgh New Philosophical Journal, July, 1853.

[2] Compare:—

(*a*) Corrugations only—rugæ continuous.
Ramsay, Geol. N. Wales, 1881, p. 239, fig. 96.
Geikie, Handbook Geology, 1882, p. 520, fig. 245.

(*b*) Corrugation with diminished middle wall.
Ramsay, *Ibid.* p. 231, figs. 78 and 79.
Geikie, *Ibid.* 120, fig. 19.

(*c*) Corrugation with dislocation planes ("contorted false bedding").
Geikie, *Ibid.* p. 479, fig. 189.
Lyell's Students' Elements, ed. 1871, fig. 628.

(*d*) *Overfolding and faulting* of rugæ.

(*e*) *Overthrust,* Bonney, Quart. Journ. Geol. Soc. 1883, pl. 39, fig. 2.

rise and the intermediate troughs must sink.[1] The great monoclinal folds defining the several mountain-flanks must gradually develope into magnificent overfolds, and these again in the process of time into overfaults, having the appearance of normal dislocations with tremendous vertical downthrow. Only, however, in ranges geologically new, or composed of rock-formations of immense thickness, can these features be expected to be typically developed. The reader may collect abundant illustrations of this structure from the magnificent maps and sections of the Uinta and Wasatch areas in Western America, where both these conditions appear to obtain; and may observe how this theory brings into harmony many of the known facts of the interrelations of the folding, faulting, and remarkable physical geography of that wonderful region, and reconciles at the same time some of the apparently diverse interpretations of its geological development put forward by its enthusiastic describers.

In more easily convoluted regions, or in mountain chains of much higher antiquity, this inevitable relation of sunken trough to mountain arch is necessarily less conspicuous, and long eludes detection owing to the bewildering complexities of the strata involved. But it is by no means impossible that the long straight (longitudinal or strike valleys) and so-called *anticlinal* valleys of the Scottish Highlands, such as those of the Great Glen and Loch Tay, walled in by steep hill-slopes and occupied by lakes of profound depth, are nothing more than greatly depressed intermont *synclinal troughs* owing their origin to the same causes which bring about the slow secular elevation and approximation of their flanking ranges.

II.—On Hypersthene Andesite.

By J. J. Harris Teall, M.A., F.G.S.

At the conclusion of my last paper on the Cheviot andesites and porphyrites (Geol. Mag. Vol. X. p. 262), I called attention to the close resemblance between the Cheviot hypersthene andesite (or porphyrite) and a rock from Steinerne Mann, Nahe, which has been called a proterobase.[2] Both rocks are black in colour and consist

[1] To this relation of sunken trough and mountain arch, there can, indeed, be no exception. The grand arch constituting a mountain chain is most properly regarded as an elevated anticlinal limited exteriorly by two depressed synclinals. Hence the paragraph ix. (*a*) 4 (p. 198) is mechanically incorrect as it stands, and should read:—

(IX. 4.) At the foot of either bounding synclinal of a mountain range the thrust is wholly horizontal; the twisting or shearing force is zero or very small, and the resulting folds are normal (symmetrical) and regular. But as we proceed towards the centre of the anticlinal of the range, this horizontal thrust is combined with a vertical component due to the weight of the mass above; the total thrust therefore becomes greater, and, moreover, its direction is more or less oblique to the transverse section of the rock, *i.e.* the twisting or shearing force becomes greater also. (The maximum of these latter effects occurs somewhere near the junction of the syncline and the anticline.) As a natural consequence the axes of the folds no longer remain vertical, but slope obliquely outwards, in the manner of inclined or reflexed folds.

[2] The term proterobase was introduced by Gümbel (Die paläolithischen Eruptivgesteine des Fichtelgebirges, München, 1874) for certain rocks occurring in the

macroscopically of glassy felspars (Mikrolin) imbedded in a ground-mass which has a resinous or semi-resinous lustre. Microscopically they consist of two generations of felspar, pyroxene mostly rhombic, magnetite, and a glassy base with various devitrification products. The principal microscopic differences lie in the minute constituents of the ground. Thus the ground-mass of the Cheviot rock abounds in very small hexagonal plates of a mineral, presumably hematite, whilst that of the Steinerne Mann rock contains small well-formed octahedra of magnetite and minute crystalline grains of pyroxene in a globulitic base. In both cases the ultimate base is a true isotropic glass.

The following are bulk-analyses of these two rocks which have been previously published in this Magazine.

	I.	II.
SiO_2	63·0	56·90
Al_2O_3	14·9	17·44
Fe_2O_3	4·7	6·50
MnO	—	trace
CaO	4·8	7·82
MgO	2·8	3·76
Na_2O	4·0	3·80
K_2O	1·9	1·98
Loss	4·0	2·76
	100·1	100·93

I. Cheviot rock. Sp. Gr. 2·54. Analysis by T. Waller.
II. Steinerne Mann rock. Sp. Gr. 2·69. Analysis by myself.

I now propose to give an account of some further researches into the characters of these rocks, which were carried out by myself in the Laboratory of the Royal School of Mines under the guidance of Dr. Hodgkinson.

For the purpose of isolating the porphyritic felspars and the pyroxenes, the rocks were broken up in an iron mortar and the fragments passed through a series of sieves. The grains finally selected for treatment were those which had passed through a sieve having 50 meshes to the inch, and had been retained by one having 100. The felspar was first obtained by taking up all the iron-bearing grains by means of a powerful electro-magnet, which was excited by five Grone's cells; and the pyroxene was then isolated from the powder thus taken up by means of hydrofluoric acid in the manner recommended by Messrs. Levy and Fouqué.[1]

Fichtelgebirge. It is defined by Rosenbusch (Massige Gesteine, p. 346) as a hornblende-bearing diabase. As the Steinerne Mann rock does not appear to contain hornblende, the term seems inappropriate.

[1] If I were repeating this isolation, I should use the solution of bi-iodide of mercury and potassium. The following directions for preparing this solution may be of interest to readers of the Geological Magazine. Mix together in a mortar carefully weighed portions of the two salts, bi-iodide of mercury and iodide of potassium in the proportion of 124 grammes of the former to 100 of the latter. Add the mixed salts gradually to a small quantity of water (500 grammes of the mixed salts will dissolve in 80 c.c. of water) in the cold. Then place the vessel containing the solution on a water bath and evaporate till a film begins to form on the surface of the solution. Allow to cool, and filter. The most convenient way of

Some little difficulty was at first experienced in stopping the action of the acid at the right moment, but at last this was overcome and the mineral obtained in a really surprising state of purity and freshness. The felspar and pyroxene were then examined under the microscope and carefully picked over.

	I.*	II.
SiO_2	55·06	52·03
Al_2O_3	27·37	30·00
Fe_2O_3	trace	trace
CaO	8·92	13·51
MgO	not estim.	·65
Na_2O	4·99	3·24
K_2O	1·30	·41
	97·64	99·84

I. Porphyritic felspar. Cheviot Rock.
II. ,, ,, Steinerne Mann Rock.

* I regret that want of material makes it impossible for me to repeat this analysis.

The composition of labradorite, according to Roth (Allgemeine und Chemische Geologie, p. 15), lies between the following limits:—

SiO_2	55·43	49·15
Al_2O_3	28·49	32·74
CaO	10·35	15·29
Na_2O	5·73	2·82

It thus appears that the felspars are both labradorite, but that they differ in composition in the same way as the rocks themselves differ. There appears, therefore, as we should expect, a definite connexion between the composition of the rock and the composition of the porphyritic crystals.

In the following analyses of the pyroxenes the material was taken air-dry, and the loss on ignition was not determined. The iron was estimated as Fe_2O_3, and is reckoned as FeO. MnO was not determined.

	I.	II.
SiO_2	53·06	49·21
Al_2O_3	4·90	4·76
FeO	16·62	15·58
CaO	4·09	13·25
MgO	19·64	15·79
	98·31	98·59

I. Cheviot pyroxene.
II. Steinerne Mann pyroxene.

filtering is to place a little asbestos at the bottom of an ordinary glass filter, as the dense liquid passes very slowly through ordinary filter-paper. The clear solution thus obtained will support fluor spar. My own stock solution has a specific gravity of 3·161. The above instructions are taken from a paper by V. Goldschmidt in the Neues Jahrbuch, I. Beilage Band, p. 179. The maximum density obtained by Herr Goldschmidt in the winter was 3·196. Any lower specific gravity may of course be obtained by dilution, and the original density may be again reached by evaporation over the water bath.

I quote the following analyses for comparison with the above:—

	I.	II.	III.
SiO_2	51·36	50·043	50·12
Al_2O_3	0·37	2·906	2·12
Fe_2O_3	—	—	1·60
FeO	21·27	17·812	23·59
MnO	1·32	0·120	—
CaO	3·09	6·696	10·49
MgO	21·31	21·744	11·05
Na_2O	—	·274	0·67
	98·72	99·595	99·64

I. Hypersthene, St. Paul's (Damour). Quoted from Dana's Mineralogy, 1868, p. 210.

II. Hypersthene from the hypersthene andesite of Buffalo Peaks (Hillebrand). Bulletin of the U.S. Geological Survey, No. 1, p. 29.

III. Hypersthene from Santorin lava of 1866 (Fouqué). Quoted from the above-mentioned Bulletin.

The predominating Cheviot pyroxene is therefore without doubt hypersthene.

The analysis of the Steinerne Mann pyroxene is chiefly remarkable on account of the large per-centage of lime, but it is worthy of note that in this respect it does not differ markedly from the Santorin hypersthene of M. Fouqué. From the microscopic examination of thin slices of the rocks, and also of the material isolated by hydrofluoric acid, I cannot think that this high percentage of lime is to be accounted for by supposing an admixture of hypersthene and augite in the material submitted to analysis. I incline, therefore, to the view that lime enters more largely into the composition of some of these rocks forming hypersthenes, than the older analyses of this mineral would lead one to expect. This, after all, need not occasion surprise when we consider the intimate relations subsisting between CaO, MgO, and FeO.

I take the opportunity which this paper affords of calling attention to several other rocks in which I have observed the rhombic pyroxene.

(1). A black rock labelled Propylite, Kremnitz, by Herr Stürtz, of Bonn. Macroscopically and microscopically this rock resembles very closely the two rocks to which special attention has been called in this paper. Glassy felspars (Mikrolin) and some small pyroxenes lie scattered throughout a compact ground-mass.

(2). A purplish-grey rock composed of white felspars in a compact matrix, labelled Pyroxen-andesit, Doluy Turcek, Kremnitz, by Herr Stürtz.

(3). A rock similar to the above, labelled Pyroxene andesite, Lokajen Berg, Ungarn, by Herr Stürtz.

These last two rocks have a ground-mass full of colourless felspar microlites, and therefore remind one very much of some of the less-altered Cheviot porphyrites. The rhombic pyroxene occurs also in slides of the following Hungarian rocks supplied by Messrs. Voigt and Hochgesang:—(1) Grey trachyte (Richthofen), Gönezerthal, Gönez, S. Ujvàs, Albanier Com. (2) Grey trachyte, Ober Kemenecze, Albanier Com. (3) Grey trachyte, Magos Tér, S. Telki Banya, E.S.E.

Gönez, Albanier Com. (4) Greenstone-trachyte (Richthofen), Unter Fernezely, N.E. Nagy Banya, Szathmarer Com. (5) Greenstone trachyte, Trapategy, S.W. Bereghsasz, Beregher Com. I may say that in no single instance have I observed the characteristic pleochroism of the hypersthene in any monoclinic augite. I would therefore ask, with Mr. Whitman Cross, whether it is not possible that the strongly-pleochroic "augite" extracted by Herr Oebbeke [1] from an andesite from the Sierra de Mariveles, Luxon, may not be hypersthene, and whether this pleochroic mineral may not occur in association with a non-pleochroic or differently pleochroic augite.

III.—On Accumulation and Denudation, and their Influence in Causing Oscillation of the Earth's Crust.

By Charles Ricketts, M.D., F.G.S.

(*Continued from* p. 306.)

The Carboniferous Limestone of the north-west of England was formed in a bay separated from another marine area farther south by a narrow isthmus [2] and promontory never submerged, extending, as Professor Jukes pointed out, in "a band of country running east and west across England from Leicestershire, through Warwickshire, South Staffordshire, North Shropshire into Montgomeryshire," [3] and to the mountainous district of North Wales.

The limestone is situated in and fills up valleys formed in Silurian and other rocks, and there has evidently been a progressive depression during the whole period of its formation; from the time when conglomerates and sandstones derived from the neighbourhood were distributed over the bottoms of these valleys,[4] forming the so-called "Upper Old Red Sandstone" of the Survey Maps, though considered by the Members of the Geological staff as forming in such cases the base of the Carboniferous series; [5] and this progressed whilst the flanks of these valleys were being gradually submerged, the basement beds of the limestone being very frequently composed to a great extent of fragments of Silurian rock in a matrix of limestone. This subsidence continued during the whole period in which the strictly marine series, represented by the Carboniferous Limestone, was being deposited; until and beyond the time when that

[1] Oebbeke, Beiträge zur Petrographie der Philipinen und der Palan-Inseln, Neues Jahrbuch, I. Beilage Band, p. 451.

[2] That portion of this isthmus, situated between Coalbrookdale and the Clee Hills, was sixteen miles wide at the termination of the deposition of the Carboniferous Limestone, and was reduced to twelve miles during that of the Millstone Grit.

[3] Memoirs of the Geological Survey, The South Staffordshire Coal-field; by J. Beete Jukes, F.R.S., p. xii. See also Jukes's Manual of Geology, second edition, p. 518.

[4] Professor J. Phillips recognized that "they were confined to *valleys* in the slate formation, and never follow that rock to its escarpments on high ground."—Geology of Yorkshire, part ii., p. 13.

[5] Mem. Geol. Survey, Geology of Kendal, etc., W. T. Aveline, F.G.S., p. 14; [Prof.] T. McK. Hughes, F.S.A., p. 15; of Kirkby Lonsdale [Prof.] Hughes, p. 16. On the Carboniferous Conglomerates of the Basin of the Eden, by J. G. Goodchild, Quart. Journ. Geol. Soc. vol. xxx. p. 396.

great change occurred, whereby waters, bringing down soluble silicate, mud, sand, and pebbles, were diverted into this area; the distribution of which produced, according to the conditions prevailing in different periods and localities, in the first place siliceous and carbonaceous materials characterizing the Upper Limestone, afterwards the varieties of strata characterizing the Yoredales and Millstone Grit, and at a later period the Coal-measures.

A modern event which must produce effects comparable with,—at least causing as great a contrast as the changes which occurred in the Carboniferous strata above the Limestone,—took place about 1852, when the muddy waters of the Whang-Ho were diverted from the Yellow Sea into the land-locked Gulf of Pe-Che-Lee, the present outlet being removed a distance of not less than 640 miles along the coast-line, around the rocky promontory of Shan-tung (East Mountain).[1]

A very great variation in the *thickness* of the Carboniferous Limestone occurs in different places, and often within very short distances. In the Coalbrookdale district the southern boundary of this formation extends no farther than Little Wenlock, near which village, at Oldfield Quarry, it is 25 feet thick; and a little further northward, at Steeraway, it is 40 feet,[2] but does not exceed 100 feet. It is evident the Carboniferous Sea did not extend over the Silurian rocks to the south, or over those of the Longmynd towards the west; for any strata resting upon them and belonging to that era are referred to the Coal-measure series.

At Llanymynech, 25 miles north-west of Coalbrookdale, the nearest locality where the Carboniferous Limestone now exists, the precipitous escarpment of Llanymynech Hill rises from a basement of Wenlock shale. Mr. G. H. Morton estimates the thickness of this mass of limestone at 450 feet.[3] This gets thinner towards the north, and at Grug-fryn, nine miles distant, it exists along such a narrow space, resting on Wenlock shale and having sandstone above, that the limestone seems to be not more than 100 feet, or perhaps only 50 feet in thickness.[4]

Near Llangollen, where it overlies beds of sandstone and conglomerate, the Carboniferous basement beds previously alluded to, the limestone forms the magnificent escarpment of the Eglwyseg ridge, and is exposed throughout its whole extent. Its entire thickness according to Mr. Morton, is 1200 feet. This forms a remarkable contrast to the exposure on the opposite bank of the River Dee. Within a distance of four miles, at Fron-y-Cysyllte, where the limestone rests on Wenlock shale, there are wanting no less than 873 feet of the lower strata as developed in the Eglwyseg ridge.[5]

In North Derbyshire near Buxton the thickness of the Carbon-

[1] The Double Delta of the Whang-Ho, by Samuel Mossman, Geographical Magazine, vol. v. p. 92.

[2] Geological Survey, Vertical Sections, No. 23.

[3] The Carboniferous Limestone and Cefn-y-fedw Sandstone between Llanymynech and Minera, by G. H. Morton, F.G.S., p. 122.

[4] Morton *op. cit.*, p. 81. [5] Morton, *op. cit.* pp. 39 and 75.

iferous Limestone has been ascertained to the amount of 1580 feet;[1] but it may be considerably more, for the base can nowhere be determined. Its thickness diminishes towards the north. From nine to twelve miles north-east of Settle, "in the vicinity of Arncliffe and Kettlewell, it is probably not less than 1000 feet thick." To the west of Arncliffe six and twelve miles respectively, "under Penigent and Ingleborough it is from 400 to 600 feet thick, and along the Pennine chain from Kirkby Stephen northward a less thickness may be assigned to it."[2]

Judging from such facts as these, there can be no question that the Carboniferous Limestone has been deposited on surfaces of unequal elevation, in valleys and gorges excavated in the older rocks, and that it has been almost throughout its whole extent precipitated slowly and equally, or been otherwise derived from the waters of the sea. The variation in thickness in different localities is very greatly owing to its having been deposited in the vacant spaces which formed these pre-Carboniferous valleys; at all events the evidence by itself is not sufficiently conclusive to decide that, though the accumulation has been greater in one place than in another, therefore the subsidence has been caused by this increase of pressure.

Though the subsidence has been almost entirely continuous during the whole period of the deposition of the limestone, the sea-bed formed was at no time situated at any great depth, for the valves of Mollusks are frequently separated, and the stems and joints of Encrinites have been washed from each other, as by the action of waves or currents. The water therefore having been shallow, a sufficiently correct base-line is afforded to determine the effects produced by the inundation of this submarine plain by large accumulations (derived from distant sources) which constitute the later Carboniferous rocks, whether a greater or less amount of subsidence occurred locally according to the amount deposited.

In the Coalbrookdale district the thickness of the Millstone Grit, where it lies upon the Limestone at Steeraway, is 80 feet;[3] a little beyond it rests upon Upper Silurian strata; whilst six miles further towards the south none has ever existed, the Coal-measures lying immediately upon Silurian rocks. At Llangollen according to Mr. Morton it increases in thickness to 723 feet.[4] Including with it the Yoredales, it extends in North Derbyshire to more than 3000 feet, with a greatly varying thickness, being of that amount near Sheffield, but it is only 1500 feet near Belper, a distance of less than 30 miles.[5] Beds of Coal occasionally recurring in these strata indicate low-lying land surfaces, posterior to the formation of which there has occurred subsidence with the accumulation many times greater in extent than its whole thickness near the southern margin.

[1] Mem. Geol. Survey, North Derbyshire, p. 18.
[2] Geology of Yorkshire, by John Phillips, F.R.S., part ii. p. 176.
[3] Geological Survey, Vertical Sections, No. 23.
[4] Under the local definition of Cefn-y-Fedw Sandstone, *op. cit.* p. 51.
[5] Fig. 37, Comparative Sections of the Millstone Grit and Yoredale Rocks, Mem. Geol. Survey, North Derbyshire, p. 139.

Similar variation in the thickness of deposits occurs also in the Coal formation. Coalbrookdale again affords an example where the accumulations and the changes of level are small compared with other districts; probably because it was situated at a distance from the sources from which the detritus was conveyed, and therefore could not receive the same amount of deposit. The strata in which the profitable beds of coal are situated range from "Little Flint Coal," situated immediately above the "Farewell Rock" (Millstone Grit) to the "Top Coal," and amount to only 180 feet; the gross average thickness of the beds of coal being about 40 feet,[1] that of the beds of workable coal according to Professor Hull 27 feet; the entire thickness of the Coal-measures amounts to 1200 feet.[2] In Denbighshire the Middle Coal-measures, the only ones worked, have a thickness of 800 feet, with from 27 to 30 feet of workable coal. The Lower Measures amount to 1000 feet, with several coal-seams varying from two to three feet. The aggregate thickness of these Coal-measures is about 3000 feet.[3] Again a very great increase is observed in the Coal-measures of the Lancashire district, where, including the Gannister beds, they attain a maximum thickness of 7300 feet.[4]

Taking Leicestershire as a starting-point, the different series of Upper Carboniferous strata attain a very moderate thickness; but a great and progressive increase occurs when passing thence in a north-westerly direction to North Lancashire. Professor Hull has demonstrated this in the following Table of

"Comparative Vertical Sections of the Carboniferous Strata from North Lancashire to Leicestershihe.

N.N.W.	Burnley district.	Mottram district.	North Staffordshire.	S.S.E. Leicestershire.
Coal-measures	8460	7635	6000	3000
Millstone Grit	5500	2500	500	50
Yoredales	4675	2000	2300	50
	18,635	12,135	8800	3100."

Commenting on the above sections, Professor Hull remarks, that "it will be observed the beds which attained so prodigious a development in North Lancashire dwindled down to one-sixth of their volume in Liecestershire."[5] The Coal series varies considerably in limited areas in different localities, and there is in Lancashire a general increase of thickness of the sedimentary materials, such as sandstones and shales, towards the N.N.W. Thus the *same* coal-seams are farther apart at St. Helens than at Prescot, and at Wigan than at St. Helens.[6] This difference in the thickness of the Coal-measures occurring within restricted areas has been confirmed by Messrs. De Rance and Strahan, who prove the amount

[1] Geological Survey, Vertical Sections, No. 23.
[2] The Coalfields of Great Britain, by Edward Hull, F.G.S., second edition, p. 96.
[3] Hull, *op. cit.* p. 99.
[4] Hull, *op. cit.* p. 123.
[5] Quart. Journ. Geol. Soc. vol. xxiv. p. 322.
[6] Hull, Coal-fields of Great Britain, p. 123.

between certain identical beds of coal to be one-third greater at Standish, near Wigan, than at Prescot, an interval of 13 miles.[1]

A most remarkable example of increase in the sedimentary strata occurs in the "Thick" or "Ten Yard" coal of Dudley, which in the southern portion is thirty feet thick, having only two to four feet of partings;—that is, during the whole period of its formation it remained constantly or nearly at the same level, being that of the great Carboniferous plain or delta. Professor Jukes proved that this thick bed of coal at a distance of five miles from Bilston in a northerly direction, in the neighbourhood of Bentley, is divided into ten or twelve separate beds, whose gross thickness is the same, but including the intermediate measures has increased to not less than 406 feet.[2]

Diagram of the Divisions near Bentley of the "Thick Coal" of Dudley and Bilston.

a. Thick Coal at Bilston, 30 feet.
b. Divisions of same at Bentley, 406 feet.
c. Heathen Coal.
Length of Section 5 miles. *Altered from Prof. Jukes.*

Conclusion.—From all these facts it may safely be inferred, wherever there has been a great accumulation, there also has supervened a great amount of depression. Such is the record of the present and every geological era. There must needs be a cause for the simultaneous occurrence of these phenomena being thus universal, inseparable, and in about the same relative proportion. As depression could only permit and by no possibility cause accumulation, the only reasonable explanation is that accumulation over considerable areas is, through the pressure exerted by its weight, the true cause of subsidence. This presupposes a comparatively thin crust to the earth resting upon a fluid or semifluid substratum.

If subsidence occurs in one place, there must, to maintain the equilibrium, be elevation in another. Some examples might be adduced, both in former geological periods and also at present, where elevation has ensued without any reasonable evidence that there has been a local withdrawal of pressure. Elevation would more certainly supervene upon the removal of pressure, and probably occur to a greater extent in the locality whence the detritus has been removed the transfer of which has caused subsidence.

Reference has already been made to the results subsequent to the

[1] Geological Survey, Vertical Sections, No. 61.
[2] Memoirs of the Geological Survey, The South Staffordshire Coal-field, by J. Beete Jukes, F.R.S., p. 25, etc.

dissolution of the snow which, during the Glacial period, enveloped the British Isles, Northern Europe, and North America. The re-elevation of the land to a certain height was ascribed to the removal of the pressure by the melting of this load of ice and snow; but in consequence of the accumulation of Boulder-clay which remained, it was not raised to so great an extent as before the submergence. The present gradual rise of the land in Norway and Spitzbergen may also be attributed to the partial removal of once greatly augmented snow-fields.

The immense amount of material removed, and the depth and width of valleys formed, indicate, not only the erosion to which strata have been subjected, but likewise that there has been a rising of the land to expose it to the action of subaerial agencies. If the land sinks as a consequence of the deposition of strata, there will be little difficulty in attributing upheaval to the effects of denudation, when the many thousands of feet of strata which have been removed are taken into consideration. The enormous amount of denudation to which Palæozoic strata in South and North Wales have been subjected was made apparent in the well-known sections by (Sir) A. C. Ramsay, in which the mass of material displaced has been illustrated by contour lines,[1] and may be recognized as having taken place to a greater or less extent in all the older rocks.

Captain C. E. Dutton states that "those areas in the Colorado district which have been uplifted most have been most denuded; he thinks we ought to turn the statement round and say that those regions which have suffered the greatest amount of denudation have been elevated the most; thereby assuming the removal of the strata as the cause and the uplifting as the effect."[2]

An examination of hilly districts demonstrates that Captain Dutton's remarks have a general application in different areas in our own country. Where denudation has been greatest, elevation prevails to the greatest extent, and the oldest deposits not unfrequently form the highest ground; or hills, sculptured during a previous geological era, and subsequently depressed beneath accumulated strata, have again risen as these deposits have been removed, and the former crest stands conspicuous as the summit of a mountain.

In North Derbyshire, near Buxton, the highest portion of the Carboniferous Limestone, forming the "water parting" between the east and west of England, is 1500 feet above the sea-level, and is surmounted in the neighbourhood by ridges only, composed of Millstone Grit, some of which run up to 1800 or even to 2000 feet.[3] The whole thickness of later Carboniferous strata,—the Yoredales, Millstone Grit and Coal-measures, amounting to more than 5000 feet,—has been removed by denudation; but on every side such strata dip away from the dome-shaped mass to lesser elevations.

In the district of Craven in Yorkshire the Carboniferous Limestone

[1] Memoirs of the Geological Survey, vol. i. plates 4 and 5, vol. iii. plate 28. Referred to by Fisher, *op. cit.* p. 222.

[2] The Geological History of the Colorado River, Nature, vol. xix. 1879, p. 251.

[3] Memoirs of the Geological Survey, North Derbyshire, p. 2.

rests horizontally on eroded edges of greatly contorted Silurian strata which, at the commencement of its formation, were situated at the then sea-level, their fragments, consisting of large blocks (some being 3 or even 5 feet in their longest diameter, with pebbles and smaller particles entering largely into the composition of the lower beds of limestone.[1]

The curvatures in the Silurian rocks having been formed previous to the commencement of the deposition of the limestone, it is evident the agency which caused them has had no influence in producing the present elevation of the land. The limestone, which is 600 feet thick, continued to subside under the accumulation of later Carboniferous strata, of the Yoredales, Millstone Grit, and Coal-measures, which has been estimated to reach a depth of at least 3500 feet. North of the Great Craven fault, not only have all these strata been removed by denudation, but the Carboniferous Limestone forms a plateau, now raised to about 1400 feet above the sea-level; the elevated ridges resting conformably upon it; such as Penigent (2273 feet), Ingleborough (2375 feet), and Whernside (2414 feet), being mere remnants of strata, formed subsequently to the limestone, which have resisted destruction.

Another illustration may be given of subsidence occurring whilst deposition was in progress, and of rising of the land during denudation. The metamorphic rocks which constitute the Malvern range were sculptured nearly to their present contour, but formed an island during the deposition of Upper Silurian strata; this was demonstrated by Miss A. Phillips, whose discovery proved that their base consisted of "a conglomerate full of Silurian shells, the pebbles being fragments of the rock-masses of the Malvern Hills."[2] Deposition progressed, and the land must have sunk to a great extent to permit the formation of the Upper Silurian and Old Red Sandstone strata, so greatly developed in the neighbourhood. But these, in a much contorted state, were again uplifted, and at the same time greatly denuded; but the elevation or formation of the hill is in nowise dependent on the foldings of these rocks, for the ridge again stood forth as an island from what may have been a near approach to the sea-level of the time, when, upon the upturned and eroded edges of these Silurian and other rocks, conglomeratic breccia,[3] and sandstones were deposited during the New Red Sandstone period, depression of the land occurring simultaneously. The land has since undergone a great amount of denudation, and the district has been raised to its present elevation. Such or similar methods of interpretation appear to be generally applicable in assigning a cause for the formation of mountains or other elevated ground.

The cause more generally assigned for subsidence of the crust of the earth is secular cooling of its mass. This cannot also account

[1] On a group of Slate Rocks, between the Rivers Lune and Wharfe, by John Phillips, F.G.S.; Trans. Geol. Soc. second series, vol. iii. pp. 10 and 13.

[2] Memoirs of the Geological Survey, The Malvern Hills, etc., by John Phillips, F.R.S., vol. ii. part 1, p. 66.

[3] Haffield Conglomerate of Phillips.

for the accumulations which so constantly accompany it, nor is it conceivable that the continuance of the same agency would occasion its re-elevation. If in any case depression has been due to such influence, it may be looked for in the extreme depths of the ocean, where the constant temperature nearly approaches the freezing-point; certainly not in the Arctic regions, where the mean annual temperature is very much lower; for though Greenland is sinking, Norway and Spitzbergen are rising; so also are extensive districts near to or within the Arctic circle—Labrador, Hudson's Bay, the Arctic Archipelago and the shores of Behring's Straits[1]—affording unmistakable testimony to elevation of the land within a recent period; in some cases affording evidence that such is now in progress. It has recently been estimated that the shores of Hudson's Bay have risen in places from five to ten feet within the century.[2]

Near the mouths of large rivers, in deltas and in bays, and during former geological periods, where strata have been deposited, depression has been persistent, even though such a thick covering has been overlaid as would retain the central heat and exclude the external cold.

Deposition and subsidence having been constant and contemporaneous during all geological periods, the phenomena can only be attributed to and associated together as cause and effect. Whether it be strata laid down in the sea, those forming deltas near the mouths of large rivers, or a thick covering of snow that has fallen on the land, the accumulated weight presses down the crust of the earth.

It is also nearly as certain that elevation of continents is to be attributed to denudation to which the land has been subjected, causing a relief of pressure, whether by the disintegration of the rocky mass or by dissolution of glaciers; in the former case it might be further assisted by the transfer of the molten substratum as a consequence of depression in another area.

In an address delivered at Sheffield more than three years ago, having reference to the Coal formation, it was remarked that "the more the subject is considered, the more astonishing does it become for the regularity of the subsidence; and its amount must have kept pace with the thickness of the accumulating deposits;"[3] but these concurrent phenomena demand more than wonder, they require serious and careful attention such as is yet to be bestowed upon them. This is the more necessary, as in them may be found the great motive power which not only produces changes of level in the earth's crust, but also permits and induces many other alterations in its physical condition.

Mr. H. B. Woodward, F.G.S., quite recently, in the Transactions

[1] Recent Elevation of the Earth's Surface in the Northern Circumpolar Region, by Henry H. Howorth, Arctic Manual, 1875, Reprinted from the Journal of the Royal Geographical Society, vol. xliii. 1873.

[2] The *Times*, Jan. 14, 1880.

[3] President's Address to Section C, at Sheffield, by Professor P. Martin Duncan, F.R.S., British Association Report, 1879, p. 330.

of the Norfolk and Norwich Naturalists' Society,[1] has specially alluded to my opinions respecting the dependence of upheaval and of subsidence upon the denudation and the deposition of materials; and has also re-directed attention to the subject in a favourable manner by a letter in the GEOLOGICAL MAGAZINE.[2] Having formerly (1873) criticized my views adversely, these recognitions of them must be considered to be greatly enhanced in value.

IV.—TRACES OF A GREAT POST-GLACIAL FLOOD.

PART 6. THE EVIDENCE OF THE ROLLED GRAVELS AND THE SANDS.

By HENRY H. HOWORTH, F.S.A.

IN a previous paper of this series I endeavoured to show that the so-called Marine Drifts found at high levels, on both sides of the Irish Sea and elsewhere, are proved by their testaceous contents to have had no connection with the Glacial Age; while the mode of their distribution shows that ice in no form can have distributed them as we find them, nor yet are they consistent with the submergence of the land for any considerable time beneath the sea; and I concluded that the only power known to us capable of distributing them is a wide-spread flood of water. I now propose to carry my argument considerably further, but before doing so, as it is so easy to be misunderstood, I must guard myself against the supposition that in what I have said or mean to say I am minimizing the Great Glacial Age.

Any one who will cursorily examine the present distribution of the Pliocene deposits, their disintegrated and broken character, the wide areas which are now entirely free from them, and yet the very specialized fauna and flora which characterize the broken fragments, will agree that a gigantic denuding agency has swept over the whole northern hemisphere, occupied by a continuous land surface in Pliocene times. This apart altogether from the more direct evidence of denuding forces we have in the products of the Glacial age. That Glacial age which intervenes between Pliocene and Post-Glacial times, and is such a marked and complete barrier between them, was no doubt the distinctive era when not only Pliocene but earlier Tertiary beds were scoured out and torn to mere shreds of their former extension. As we cannot suppose that the forces of Nature working on the same materials could have worked in a different fashion to that they work in now, we are driven, in view of the very greatness of the effects, to postulate that these forces, although precisely like those now current in form, were immensely different in degree. This is quite plain, whether we belong to the extreme school of Glacialists or no. It seems equally clear that a large portion of the work done was done by ice: we know of no other agency competent to do it. The smoothed and rounded rocks and other proofs of denudation that prevail so widely in the landscapes of the high latitudes of Europe and America are explainable

[1] The Scenery of Norfolk, vol. iii. p. 460. [2] Dec. II. Vol. X. p. 93, 1883.

by no other agency known to us than that of ice. Granting this to the full, however, my contention is that it does not necessitate our assigning to ice everything we meet with in recent geology. We cannot and must not assign to it work which ice is most clearly incompetent to accomplish, nor are we to import fresh transcendental laws into physics to supplement what empirical tests tell us are the controlling forces of matter, in order to support *à priori* theories and metaphysical dogmas about Uniformity.

This has been largely the burden of my previous communications. In the present paper I propose to carry my argument another step further. The superficial gravels may be divided into two well-marked series, according as their contained pebbles are rounded or have their angles more or less intact. The latter class are more limited in extent than the former. I have already treated of them and the lessons they furnish in the paper on the Angular Drift. Putting them aside, I now propose to consider the gravels containing rounded pebbles and the sand, which so generally accompany them, and which together form such a conspicuous feature in the Drift deposits of Northern Europe. Discarding for the present any considerations about the other contents of these gravels, let us limit our attention to the pebbles themselves. In the first place, then, these pebbles clearly did not originate in the action of ice in any form.

No observer known to me has argued seriously that the rolled pebbles which constitute the gravels in question, could have been rolled and rubbed into their present form by glacial action. They are, for the most part, unscratched, rounded, and water-worn, and quite out of the category of glacial products proper, and are to be correlated with the shingle beaches found by the sea, or the gravels continually being formed in rapid rivers. This is universally accepted even by ultra-glacialists.

But this by no means exhausts our problem. Much the larger portion of the rolled gravels which are so frequently met with in Northern Europe have no traces of marine or freshwater shells in them, and therefore according to the canons by which we have tested submarine and in fact subaqueous deposits, we cannot treat these gravels *as they are now found*, as long submerged marine beds, or as the immediate result of river action. On the other hand, the rolled and rounded character of the pebbles makes it clear that they must have been triturated and shaped under water. How, then, are we to reconcile the position? The reconciliation is by no means at once obvious, as may be judged by the various solutions of the difficulty that are current, most of them accepting the conditions that rolled gravels are as clearly the remains of sea-bottoms as shelly deposits. It seems to me the only real solution of the difficulty is to conclude that the shaping of the pebbles and their distribution as gravel are to be entirely separated: the two facts are not even to be taken as elements of one problem. So far as we can see, the pebbles are for the most part derivative. This has been long known in regard to some of them. For instance, in the gravels south of the Thames, where many of the pebbles are rounded, while others have their angles intact, the former have long been recognized as the débris of disintegrated Tertiary pebble beds. Searles V. Wood, Murchison, and others who have written so much on these beds are quite agreed about this.

The pebble beds of Budleigh Salterton have recently been shown to have been the matrix from which many of the pebbles of the gravels of Central England were derived.

Again, Mr. Mackintosh says, "South and South-east of the Wrekin and Ashley water-parting (as well as round the water-parting itself) there are extensive Triassic pebble beds which have been broken up and redistributed in a South and South-east direction, *probably for the most part by oceanic currents and waves*; for it would be unreasonable to suppose that all the great, and often continuous spreads of pebbles could have been uprooted and transported by floating ice" (Journ. Geol. Soc. vol. xxxvi. p. 182).

Mr. H. B. Woodward in a letter to Mr. Belt, in which he refers to the gravels on the Black Down Hills, says, "The occurrence of old pebbles in a clayey drift on the tops of the Greensand heights is the most important, because, on the Palæozoic rocks of Devonshire, it is often very difficult to decide between a drift gravel and the disintegrated conglomerates of the New Red Series" (Journ. Geol. Soc. vol. xxxii. p. 82).

If these conclusions be just, it enables us to reconcile the presence of great beds of water-worn pebbles with the complete absence of subaqueous débris, especially shells; for we can see at once that if the materials of these beds have been entirely re-sorted and are derivative, their more fragile contents have either been destroyed or sifted out in the process, and we have only the more resisting elements left, and we can most reasonably conclude that, except in the case of those beds bordering on the sea which contain marine shells in a broken condition, the rest of the gravels with rounded pebbles in all probability are the redistributed remains of gravels or pebble beds which previously existed on the land, and in their present position and distribution in no way evidence the recent position and distribution of the sea or of masses of freshwater. Having settled this, let us now consider more closely the mode in which these gravels are distributed. For this purpose we must enter somewhat more into detail.

It is the fashion to class most of the gravels and sands we are dealing with, with the Boulder-clay and other Glacial deposits. This view I cannot at all accept; but, on the contrary, I hold that they should be completely separated. When, in 1865, Mr. Hull published his paper on the arrangement of the Lancashire Drift deposits, in the Memoirs of the Lit. and Phil. Soc. of Manchester, separating them into three divisions, a lower Boulder-clay, surmounted by gravels and sands, and these again by a second Boulder-clay, he started a discussion which is still undecided. I venture to think that it will not be decided in favour of the propounder of the theory. That this tripartite classification holds good for certain very limited localities in Lancashire, Yorkshire, and for others in Wales, is true enough;

but when we attempt to deduce from these local instances anything like a general law, the evidence breaks down at once. Not only is it not applicable to the great continental areas occupied by drift at all, but it is not even applicable to a large portion of the United Kingdom, nor even to large portions of Lancashire and Wales. This seems most plain, and may be tested by a very superficial examination of the problem in many districts. This conclusion is by no means my own only, but it has the complete support of more than one experienced authority on the so-called Glacial beds.

Mr. Mellard Reade, who has studied these beds with such care, says, "From the time of Joshua Trimmer until now, attempts have been made to distinguish the various beds of clay, sand, and gravel, from each other. Trimmer divided them into 'Lower Erratics,' 'Boulder-clay,' and 'Upper Erratics' (sand and gravel). Professor Hull more lately into 'Lower Boulder-clay,' 'Middle Sands and Gravels,' and 'Upper Boulder-clay,' and this latter classification is the one now most generally adopted. My own investigations lead me to doubt the value of any of these classifications, and, what makes it more confusing, there is no real agreement among the supporters of this classification as to which division special beds belong. Thus Mr. De Rance considers all the shells of my list to be derived from the Lower Boulder-clay, while Mr. Mackintosh and Mr. Shore commit them to the 'Upper Boulder-clay.' As regards the fauna of the sand beds, I have shown that really no geological distinction can be based on these grounds, while, on the other hand, I have failed to trace out any stratigraphical connection that would support any of these theories of geological subdivision" (Transactions Geol. Soc. Glasgow, vol. vi. p. 265).

Apart from the coasts of North Wales, says Mr. Mackintosh (an observer of vast experience), "I have nowhere seen sand and gravel regularly and persistently interpolated between a lower and upper Boulder-clay" (Geological Magazine, Vol. IX. p. 21).

Ireland used to be quoted as a remarkable proof on a considerable scale of the reality of the tripartite division of the Glacial beds; but it will be exceedingly rash to quote Ireland, after the very suggestive and able papers by Mr. Kinahan in Vol. IX. 1st Series, and Vol. II. 2nd Series, of the Geological Magazine. In one of the latter papers he sums up the result of his admirable induction in the words: "There does not appear to be evidence in Ireland for two distinct ages of Glacial drift, separated by an interval represented by subaqueous accumulations (sand, gravel, marl, clay, etc.), and the reasons for this will be given in this paper" (*op. cit.* p. 111).

The fact is, like many other generalizations, the tripartite division of the loose surface beds is due to our mistaking a particular acre for the whole field, and when we base our theory upon an exceptional example,—when we poise our pyramid on its apex,—we naturally find it unstable. The superposition of the second Boulder-clay upon the gravels and sands in some very local deposits in Lancashire and North Wales is not a normal arrangement, but an abnormal one—an exception of great interest, as we shall endeavour to show in another paper, if we are permitted to print it; but still an exception.

For this reason we cannot accept Mr. Hull's tripartite classification, nor yet his name of Middle Gravels and Sands, for the superficial beds of sand and gravel covering the Boulder-clay in some places. The division in our view should not be tripartite, and strictly speaking not even duplex. It is quite true that in certain cases we find the Boulder-clay overlaid by gravels and sands, and these cases are more frequent than those in which there is a threefold arrangement, but even these are local and exceptional. Every tyro knows numerous cases of large areas where the clay occurs without any such covering, and where there is no reason to suspect any subsequent denudation; and these cases are matched by similar ones where the gravels and sands occur over similarly wide areas without the subjacent clays. The connection between the two is largely accidental. It is a great temptation, in mapping out these most eccentric and difficult beds, to form sequences out of them which we may delude ourselves into believing are realities, and not merely ingenious and unstable hypotheses; but such hypotheses are necessarily ephemeral.

If we are satisfied that the clays and gravels so often classed together are not to be symmetrically arranged either according to a duplex or triplex system, but must be treated as substantive integers standing apart from each other, and only occurring together by accident,—and if we are satisfied that, whatever may be the case with the Boulder-clay, the gravels are indisputably not the direct results of glacial action,—we may finally inquire as some have done whether these gravels are not the clays in another form—the pebbles constituting them being merely the triturated boulders washed out of the clay which preceded the gravels. This contention will not bear criticism and is inconsistent with experience. I must content myself with one carefully selected example as a test case. Mr. E. T. Hardman, in a paper published in the GEOLOGICAL MAGAZINE, Vol. II. 2nd Series, pp. 172–3, speaking of his experience on the geological survey in the North of Ireland, thus discriminates between the contents of the Boulder-clay and those of the gravels so often covering it. "The Till," he says, "contains invariably a very large per-centage of the local rock, whatever it may happen to be—Limestone when that rock prevails; Sandstone and shale near Coal-measure ground; and a plentiful supply of Basalt, both in large blocks and small pebbles, when over or within reasonable reach of it, together with igneous and metamorphic rocks from some distance; but in no case Chalk or Chalk-flints to the amount of more than about three or four per cent., even when in the Chalk country, unless where in very close proximity to unprotected Chalk exposures. On the other hand, the gravels, as a rule, contain perceptibly less of the local rock, plenty of travelled or foreign pebbles, and a great abundance of chalk and flints; of the last two so much that the ground is often white with them; and this often when at a distance of 100 feet from, or sometimes underlying them, is Boulder-clay, on which a considerable amount of time and trouble must be expended before anything from the Chalk would turn up. The district to which I refer is that comprising the south of Derry and Antrim, great part of Tyrone, and the northern part of Armagh. In those places I have examined many gravel-pits, and always noticed the distinction noticed above." Mr. Hardman then goes on to argue that if the contents of the gravels had been derived from the Till, "we should expect to find in the re-arranged part the same constituents as in the so-called Till; or, to put it more clearly, all the pebbles of the gravels must previously have existed in the moraine matter of the glacier, and would be found in all parts of the Drift in nearly the same relative proportions. Were the proportion of chalk, etc., in the Till very variable, it might be supposed that these gravels had their origin in some such chalky Drift. But this is not consistent with the facts. The Till is remarkably free from such pebbles, and in the extensive district I have examined hardly any difference in this respect could be observed."

This is assuredly very important evidence. It is more than confirmed when we turn from the pebbles to the sandy matrix in which they occur, and to the great beds of more or less clean sand that so often accompany the gravel, and are intercalated with it. The texture and composition of these sands are so entirely different to those of the clays, that it is impossible to assign them to the same origin. They are doubtless due to the trituration of entirely different rocks, the granular quartzose sands and the pulverulent argillaceous Till being obviously derived from a different matrix, and it being impossible to wash the one out of the other. Having decided this, we may next inquire whether the two sets of beds were distributed at virtually the same time and by the same forces, or whether there was a break and a hiatus between them. In studying the older rocks we should probably test such a question by the conformability or unconformability of the two. This is a very easy test in the case of rocks, but becomes difficult, and we have to rely on exceptional instances, in the case of the loose deposits, many of which are unstratified or stratified most irregularly. Although there is no unconformability between the Boulder-clay and the overlying gravel in the ordinary sense of the word, there is what is equivalent to it, a proof in some places that between the two there was no continuity. Thus, to quote Mr. Geikie, who is arguing for quite a different purpose: "At the top of the Cromer cliffs appear here and there considerable masses of sand and rolled gravel with marine shells. *Mr. Wood has pointed out that these deposits rest upon a highly eroded surface of the contorted drift, an appearance which was very noticeable when I visited the sections.*"—"Great Ice Age," p. 346. Again, speaking of the sand and rolled gravel, etc., he says, "As these deposits rest often in hollows eroded in the till and underlying beds, it follows that a period of considerable denudation must have preceded their deposition. It is quite possible that a land surface may have existed prior to the formation of the 'sand and rolled gravel,' and much of the sand and gravel, which is for the most part fossiliferous, may be of torrential or fluviatile origin" (*ib.* p. 391).

In describing the drift deposits near Thelwall, Mr. Atkinson, referring to a bed of fine white and yellow sand overlying the Boulder-clay, says, "Where the deposit of fine sand exists, it is found, on removing it, that a very large number of boulders lie under it, scattered over the surface of the clay or marl. *From this it seems probable that before the deposition of this layer of fine sand, the clay had undergone considerable denudation by the action of water on its surface; being floated away in the form of mud, while the pebbles which were contained in it were left behind. This supposition derives support from the fact that numerous depressions exist in the surface of the clay, and are filled up by the sand. These small accumulations of sand are locally termed sand-pots. They vary much in size, shape, and depth. When the soil and sand are removed from a moderately-sized area, as in a portion of a brickyard, the surface of the clay presents the appearance of having been scooped and channelled by the action of the water*" (Trans. Manch. Geol. Soc. vol. ii. p. 65).

In volume iii. of the same work, page 72, I find the following sentence from my late friend, who had a vast experience of the drift beds, Mr. Binney:—"A great deal of Till had been swept away by water before the deposition of the fine sand which often capped it." Another proof that the sand was deposited by a different movement and probably long subsequent to the Till is found in the remark of the same observer, that at the "junction of the sand and Till (where they follow one another horizontally), we sometimes find the sand intruded into the Till in the form of a long wedge" (*id.* pp. 358 and 359).

All this goes to show that a space intervened between the deposition of the Till and that of the gravel, and that their distribution was due to different circumstances.

The fact of the gravels and sands being in many places found superimposed upon the clays, does not connect them more closely than the superposition of the several sections of the Tertiary beds upon one another. It simply points to the gravels and sands being later in date, and in our view in many places considerably later in date.

This is a considerable step gained, and in what follows we must be considered as separating the gravels and sands entirely from the Boulder-clay in regard to their origin and the lessons they teach.

Now, while I propose thus to separate these gravels and sands from the clays with which they sometimes occur, I propose to argue, on the other hand, that they are to be correlated with other gravels and sands which superficially clothe the surface of the older deposits *where the Boulder-clay does not occur at all*, and which have been assigned to very different dates and origins, and to show that in all probability they are contemporaneous. That the fact of the gravels containing in some cases certain specific contents not present in others is perfectly explainable without disturbing this arrangement. Whether the gravels occur as they do at Macclesfield and in the so-called Middle Sands of Lancashire, with a number of fragments of marine shells,—whether as in Eastern England they occur with similar marine shells mixed with freshwater shells and ossiferous débris,—or whether they occur in vast barren sheets over Central and Southern England, with neither shells nor bones,—we propose to show that the great bulk of these surface gravels may be integrated into a continuous series, and owe their present distribution to one common overwhelming cause.

In regard to the High Level Marine Drift of which we wrote in the previous paper, it passes unmistakeably and insensibly into a similar drift without shells exactly like it in every respect save in the absence of these shells. For this drift also a marine origin has been generally adduced, and in fact every observer of any standing who has written about the beds, including notably Mr. Mackintosh, is agreed that the presence of the marine shells is an accident. The same transported boulders which have travelled from the same areas occur in both; the pebbles are similarly rounded and the sands are similarly laminated in places, while the beds are apparently horizontally continuous, nor is there any reason of any kind for doubting that they are contemporary.

"Near the summit level of the pass of Llanberis," says Mr. Mackintosh, "some years ago, I saw a striking section of obliquely laminated sand and fine gravel, probably about 1000 feet above the sea-level. The extent to which the stones were rounded, the arrangement of the laminæ and the position of the deposit (being away from any channel which could have conducted a fresh-water stream), all pointed to its being of marine origin, *though I did not see any shells*" (*id.* p. 357).

Most writers, as Mr. Mackintosh says, including Ramsay and Etheridge, have observed the resemblance these beds (without shells) bear to what may be seen on a sea-beach. The fact that *the rounded* pebbles found in the gravels of North Wales, which have come from Eskdale, in Cumberland, to North Wales, are found unrubbed at Eskdale itself, shows that the trituration took place *en route*, while the further fact that erratics have converged on this point both from Ireland and the Solway Firth, make it clear the transporting power was water, which could alone work along lines which are not parallel, in this way converging on one point. Again, Mr. Mackintosh remarks that the existence of the rounded gravel and sand deposits, with shells, at about the same level in different parts of North Wales, and likewise in England and Ireland, could scarcely have been the result of an accident (Journ. Geol. Soc. vol. xxxvii. p. 364). Quite so, but I would say further they could hardly be the result of icebergs or an ice-sheet, and can only be explained by a diluvial movement on a great scale. This is again testified by the fact that above the level of the shelly deposits rounded gravel and sand with shells would appear to be everywhere absent (*id.*). Finally, if we exclude ice, as we have assuredly given good reason for excluding it in a former paper, how else than by a violent movement of water, carrying with it great masses of *débris* and shingle, can we account for such a distribution of gravel as we find in Caernarvonshire? "From Clynnog to Penmanmawr," says Mr. Sharpe, "the whole western side of the Snowdon range is flanked by igneous rocks, forming either one broad belt or several narrower bands, broken by intervening beds of slate. This igneous zone is overlaid on the west by a thick bed of gravel, which for a space of about three miles broad and twenty-four miles long entirely conceals the beds lying next to the mountain chain. On the coast near Clynnog the gravel forms the entire cliffs, nearly 100 feet high; on the east of Caernarvon and Bangor it passes inland at some distance from the Menai Straits; it terminates northwards on the coast between Aber and Penmanmawr. It consists of rolled fragments of all sizes, from mere pebbles up to huge boulders, all apparently derived from the rocks of the Snowdon chain. The valley which contains this great drift deposit is the more remarkable when contrasted with the valleys on the east of the chain, which comparatively are free from gravel. There is, however, a similar accumulation of gravel in some of the lower parts of the south-west of Caernarvonshire." (Sharpe, Journ. Geol. Soc. vol. ii. pp. 305, 306.)

Let us again turn to those whom I have styled the Old Masters. This time we will appeal to Dr. Buckland, not Dr. Buckland at the time he published the Reliquiæ Diluvianiæ, but Dr. Buckland when he had turned his back on his old self and had become the friend and champion of Agassiz and his Glacial theories and the President of the Geological Society. After describing the Glacial striæ and rounded rocks in the valley of the Ogwyn, he adds, that he saw "no indications of undisturbed moraines in the valley of the Ogwyn, but that he was of opinion that they may have been *obliterated by the rush of water which transported the northern drift, and effected a lodgment of it on Moel Faban at the end of the Glacial period*" (Proceedings Geol. Soc. vol. iii. p. 581). Again, after showing in detail how in various places in North Wales traces of Glacial action are clearly discernible, he proceeded to consider *the remodification of Glacial detritus by violent inundations*, stating that the only two cases mentioned in his paper of deposits resembling moraines are both on the South-east side of the great mountain-chain, one at Pen Tre Voelas, high up in the valley of the Conway, the other in a high mountain valley near Llyn Ogwyn, showing that on that side of the chain there are no traces of those accumulations of far transported materials which occur on the North-west flank of Snowdonia and consist of pebbles of granite as well as other rocks derived from Anglesea, Cumberland, or Ireland, associated with fragments of existing species of marine shells and a tumultuous mass of other detritus. "These drifted materials," he says, "are found high up on the flanks of the mountains, namely, on Moel Tryfaen, at the height of 1392 feet, and at Moel Faban more than 1000 feet above the valley of the Ogwyn near Bethesda. From the former point they gradually descend to the plain which extends to the shore near Caernarvon, covering the whole of its surface," and he concludes that their position "*may be due to a great diluvial wave or marine current, advancing from the North and propelling before it the materials of which the drift is composed*" (*id.* pp. 583 and 584).

Dr. Buckland tells us further that Mr. W. E. Logan (now better known as Sir W. Logan) had called his attention to the occurrence of chalk flints in drifted gravel near Cardigan, over a space of 24 square miles. Some of the mounds of gravel being from 80 to 100 feet high. Mr. Logan attributed the origin of these chalk flints to a current from the north (Proceedings Geol. Soc. vol. iii. p. 584, note). It seems clear that the spreading of the mantle of gravel and sand over the slopes where it occurs is most manifestly the work of water, while the distant origin of much of the material and its confused arrangement point as unmistakeably to violent rushes of water. Let us pass on.

The high-level drifts either with shells or without, to which we have referred, are not covered by clay, but nevertheless they are unmistakeably the equivalents of the similar beds so covered in the plains of Lancashire and Cheshire and elsewhere, that is, of the so-called Middle Sands and Gravels. This is so obvious that it is not worth while enlarging upon it. Here, as on many other occasions, Mr. Mackintosh has done yeoman's service (see Geological Magazine, Vol. IX. pp. 189 and 190), but he is not alone. The so-called Middle Sands and Gravels are typically developed at Blackpool, in Lancashire; and, as Mr. Mellard Reade has shown, these shells are precisely those of the High Level Drifts; so are they in all other respects, and the same arguments as to their distribution apply to them. As in the case of the High Level Drifts, these lower gravels and sands of Lancashire pass, as we leave the sea-board, from a fossiliferous to an unfossiliferous condition, retaining their other characteristics intact. No one has ever doubted the precise equivalence of the two sets of beds. Mr. Binney, who knew these beds exceedingly well, wrote an interesting paper in the Memoirs of the Literary and Philosophical Society of Manchester (2nd series, vol. x. p. 121, etc.), in which he refers to some of the beds containing shells and others not, but it never enters his head to distinguish between their ages. Thus he says:—"The difference in the distribution of organic remains in the Drift is a subject well worthy of attention. It does not appear to be owing to the mechanical characters of the deposit; for while no shells have been met with in the sands and fine gravels of Kersal Moor, near Manchester, similar deposits at Bowdon afford them in considerable abundance. The Till of Manchester, so far as it has at present been examined, is also destitute of fossil shells, while the same deposit in most places west of a line drawn from Preston to Runcorn yields them more or less. We should scarcely expect to find delicate and fragile shells in a coarse gravel. If the mechanical characters of the deposit would account for the difference in preservation of the organic remains, the matter would be comparatively easy; but as we find that the sandy, gravelly and clayey strata of the deposits have little to do with the occurrence of the fossils, probably the beds on and near the flanks of the Pennine Chain may have been formed under conditions in some way less favourable to organic life, or else the shells of the mollusks of the then existing shells have been more frequently destroyed than those deposits more remote and lying near the present sea." The hypothetical inferences closing this extract are of course Mr. Binney's, and I do not accept them, but I gladly quote the passage as showing that a veteran authority on these beds deemed them all to be on one horizon whether containing shells or barren.

If we cross the Pennine Chain into Central England, we shall largely lose the great deposits of Boulder-clay that mark the maritime districts west of the mountains, but we do not lose the gravels. The sheets of widely-spread barren gravel are conspicuous enough and familiar enough. The fact that the Boulder-clay is not always found associated with these gravels does not affect their geological horizon. For, as we have said, we deem them, when found with the clays, to be of a different origin and a different date from the clays. Here I very gladly quote and endorse most completely Mr. J. Geikie's emphatic statement when he says, "In short, the flood-gravels of the Midland districts are precisely of the same origin as much of the gravelly drift that overlies the Upper (? Upper, H. H. H.) Boulder-clay in the low grounds of Scotland and other glaciated regions" (Great Ice Age, pp. 534-5).

The nature of these gravels has been well described by Mr. J. Geikie. He says: "They are not confined to valley slopes, but sweep up and over hill-tops, valley-partings, and water-sheds; extend across plateaux and platforms between separate valleys; and, in short, bear little or no relation to the present drainage-system of the country. It is not possible that these gravels could have been laid down by rivers in the process of deepening their valleys, their distribution and general appearance show that the surface had already received much of its present contour before the deposits were scattered broadcast over the country. I should mention that the deposits in question are frequently very coarse and rudely bedded. They often show a confused and tumbled appearance, consisting of sand, grit, angular *debris* and blocks, and well-rounded stones, promiscuously heaped and jumbled together, and, what is particularly noteworthy, many of the stones are often standing on end; and not lying in the position they might have been expected to assume had they been laid down by ordinary river action" (Prehistoric Europe, p. 140).

Again, speaking of this gravel, he says, "No one has succeeded in showing how it could have been formed by the action of ordinary rivers. It sweeps up and over considerable hills and occurs on the tops of plateaux, and on the dividing ridges of separate river basins. Mr. Lucy has met with 'Northern drift' at a height of upwards of 600 feet above the sea among the Cotteswolds. In fact, it is from the very circumstance that the gravels do occur in such anomalous positions that they received the name of hill gravels from Professor Phillips" (Great Ice Age, p. 364). The gravels we are talking of consist largely of foreign and transported elements. Professor Phillips more than 40 years ago wrote admirably about them, and it would have been well if the course of discussion upon them had followed the lines on which he worked, instead of these lines having been subject to almost complete denudation at the hands of the Ultra-Glacialists. In and under Bar Beacon, he describes a mighty mass of drifted quartz, gravel, and sand, with fragments of limestone, trap and coal-sandstone rocks as transported from Dudley, Rowley, etc. He traced the origin of the drifted gravels, coal, and sand, at Durham from the upper valleys of the Weir, and showed how in the Yorkshire vales, in Lancashire, Derbyshire, and Shropshire, we have gravels whose pebbles have in many instances come unmistakably from Cumberland. These transported gravels bear the same lessons on their face as those we have already read. The fact of their transportation involves an external impetus, and this could have been no other than water. "Before any particular masses of sand, gravel, or pebbly clays can be pronounced to be of *diluvial origin* (*says Phillips*), *and adduced in evidence as to the origin and operation of violent waters*, it is indispensably necessary to show that under the present configuration of the surface, with ordinary measures of local watery forces, the accumulation of such masses is impossible, This can be shown if the component pebbles of the presumed diluvium can be referred precisely to the situation whence they were dislodged, and these situations are separated by natural obstacles from any part of the drainage hollows connected with the locality where the gravel is found" (Phillips' Geology, vol. i. pp. 281 and 282). This is most judicious, and basing our induction upon it, we can hardly fail when we trace the course of the so-called Cumbrian drift and gravel, whose pebbles are clearly from Cumberland, and which have overspread large districts in Yorkshire, Lancashire, North Wales, Derbyshire, and Shropshire, in invoking for its distribution a flood of waters. As Phillips says, "It appears absolutely certain that none but oceanic currents are adequate to explain the extensive ravages of the solid land which produced and the violent currents which distributed the diluvium. Nor would the ordinary currents of the sea be adequate to the effect. It is requisite further to conceive that the sea was most violently disturbed, either over the points whence the detritus was brought (which supposes those points also to have been under the waves), or at some other situation. In the latter case, we may, perhaps, imagine so great a violence of water to be generated, as to permit the waves to be thrown to some height over the land; and it seems not impossible hereafter, when the geographical relations of the diluvium are well understood, to offer some reasonable explanation of the whole matter, on the principle now known to be true of great and sudden changes of relative level of land and sea, which, though limited in the area of the masses moved, might have very extended effects through the agency of water" (Phillips' Geology, vol. i. p. 298). This, which I had not seen when I wrote the paper on the Marine Drift, is assuredly a statement of the same arguments which I deem prove conclusively that that gravel which is continuous with the barren gravel now being discussed was distributed by precisely the same kind of great aqueous movement.

Mr. James Geikie, who is a distinguished champion of Ultra-Glacialism, virtually endorses the argument, although, as usual, he encumbers it with his great ice-sheet, which pervades his pages like a nightmare. He has no hesitation in assigning the tumultuous accumulations of shingle and boulders of Central England as proving the presence there of excessive floods and torrents. "Buckland, Conybeare, Sedgwick, Phillips, and the early observers," he says, "were much struck with the great quantities of shingle and the numerous erratics that strew the midland districts, and which occur even farther south, as in Cornwall and Devon, and they probably came very near the explanation of the facts when they attributed the transport of the materials to the action of great debacles" (Ice Age, p. 364).

All this is most probable. The point where we separate from Mr. Geikie is when he assigns a cause for these debacles and makes them local instead of continental. He is too experienced to explain the distribution of the gravel directly by his ice-sheet, but he connects it with the ice in another way by postulating that great and rapid floods were caused by the sudden melting of the ice-cap. In regard to this notion, I must be allowed to quote a very pertinent and sound argument of Mr. Smith, of Jordan Hill (Journ. Geol. Soc. vol. ii. p. 36). He says, "The melting of ice could never produce a debacle, in the rigid sense of the word. I mean such a debacle as would be produced by the bursting of a waterspout, or the head of a reservoir, or an earthquake-wave: the laws of matter prevent it. The conversion of sensible into latent heat is necessarily a work of time. Floods, possibly of great violence, might result from such a cause, capable of moving the greatest masses, but their action would be continuous, and they would necessarily separate the larger from the smaller fragments, and all of them from the clay in which they are imbedded. They would be arranged both according to their size and their gravity; but neither of these is the case, and I must conclude, with Sir James Hall, that such effects are 'inexplicable by any diurnal cause.' Again, as the same author says, floods caused by this means must run down-hill. If ice can move up mountains, which I, for one, beg to contest, until some proof is available, it is clear that water cannot, and therefore, water merely drawing from a rapidly-thawing ice-sheet could not distribute gravels over hill and dale irrespective of the drainage of the country, and which in many cases has evidently travelled up-hill." Mr. Smith, in view of these difficulties, postulates, as the only available cause, a rush of water such as is caused by earthquake-waves, and I do not see how he is to be gainsaid.

(To be continued.)

V.—On the Shell-Structure of *Chonetes Laguessiana*, De Kon.

By John Young, F.G.S.,

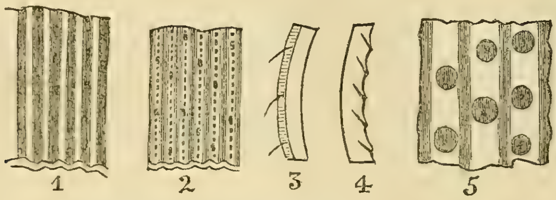
Of the Hunterian Museum in the University of Glasgow.

THE specimens selected for illustration of the shell-structure of this species of *Chonetes* were found in a bed of shale in the Lower Carboniferous Limestone series at Capelrig old quarry, in the parish of East Kilbride, Lanarkshire. The fossils in this shale have their structure generally well preserved, there being less change, through crystallization of the lime present in the shells of the various organisms, than is found in those obtained from most of the other fossiliferous localities in Western Scotland.

When we examine the outer surface of the shell of this *Chonetes* in well-preserved specimens, we find that the numerous ribs are comparatively smooth, and that in most specimens they are crossed by a few concentric lines of growth, which are generally placed near the outer margin of the valves. The ribs are also perforated to a certain depth, and at irregular intervals, by a slanting series of tubular openings, that were probably occupied by the bases of small spines. They are variable in number, on the average from 8 to 10 in the length of each rib. If the outer surface of such a specimen is slightly etched with weak acid, so as to remove a thin film of the shell, we then see that each rib is ornamented with a single row of very minute and closely-set tubercule-like pores, that descend vertically for a short distance into the substance of the shell, and then disappear as the surface is etched a little deeper. Whether these minute perforations ever opened at the surface of the shell as pores, it would now be very difficult to say, as the openings appear to have been too small, to admit any foreign mineral matter into the substance of the shell, by which such external openings could be readily recognized from the ordinary calcite of the shell.

When a specimen is examined with a pocket-lens, and is held so that the light shall pass through the ribs cross-wise in the direction of their length, the perforations are then seen to extend downwards into the substance of the shell through a layer representing about the thickness of the ribs. When looked at in a vertical direction under a low power of the microscope, they appear on the surface of the ribs as minute rows of tubercules slightly raised above the level of the shell. These tubercules are so close to one another, that their bases almost touch each other, and in the layer of the shell in which they have been formed, it is evident that the shell-structure, during its growth, has been modified to a certain extent, so as to allow of its arrangement around the perforations into the form of minute tubercules. This beautiful and interesting structure I have only found after etching some of my finest preserved specimens: it seems to be destroyed in those specimens where the shell is much crystallized.

In the larger, slanting, tubular openings found on the ribs, these, in etched specimens, are seen to be filled with mineral matter different from the calcite of the shell, and stand out on the surface as small, short spines. They do not pass through the thickness of the shell, but disappear, as the surface of either valve is etched, to near the middle layer. At this point a new series of perforations are seen in the shell-structure which do not reach the outer surface, but pass inwards, in an upward slanting direction, and open on the interior of the valves as numerous, raised, blunt tubercules, that give the inner surface quite a roughened appearance. This inner series of perforations are large and wide set, being most numerous around the outer margin of the valves, and are placed in single rows between each of the ribs, whereas the tubular openings, or bases of the spines, seen on the outer surface of the shell, are all planted on the ribs.



1. Inner perforations between the ribs.
2. Outer surface of shell when slightly etched.
3. Vertical section showing the minute perforations and spine-pores.
4. Vertical section showing the inner perforations between the ribs.
5. Inner surface of shell, etched to show the perforations.

All the sketches more or less magnified.

There can, I think, be little doubt about these inner perforations being tubular, as in some specimens they are found to be filled with a darker mineral matter than the substance of the shell, and in thin sections the shell-structure is seen to be arranged around the openings in minute waving or concentric lines of growth. This inner layer of shell, around the perforations, is dense in its structure, and is penetrated with no smaller series of pores than those seen between the ribs. In this it agrees in its inner shell-structure with several of the species of *Productus*, in which, also, as I have already shown, the inner series of perforations never did reach the outer shell-surface.[1]

The row of tubular spines along the cardinal edge of the ventral valve of this species of *Chonetes* reveals some interesting evidence as to their arrangement, which I do not think has been before recorded. These spines pass right through the thickness of the shell, as tubes, and open on the inner surface, the tubes being often filled with foreign mineral matter, which, being generally darker in colour than the substance of the shell, reveals the path of the tubes through the shell in the clearest manner. It is well known that the series of cardinal spines in *Chonetes* diverge from the beak on either side the valve, in a slanting manner, towards the outer extremity of the shell; but I do not think it is known that in their inner path through the shell, that the tubes slanted in the opposite direction, so as to point, or converge towards the beak.

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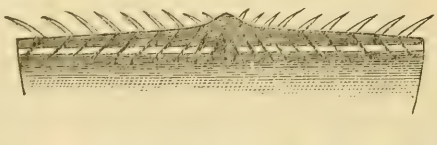


Specimen showing nine spines on either side the beak, enlarged one diameter.

This is beautifully shown in some of the etched specimens that I have prepared. In these it is seen that the spines nearest

[1] Davidson's Brachiopoda, part iv. pp. 296–301.

the beak slant inwards at the greatest angle, the inward convergence of the tubes decreasing on either side towards the outer edge of the shell. When the tubes, however, reached the cardinal edge of the shell, and were prolonged outwards in the form of spines, instead of continuing to converge towards the beak, they became suddenly bent in the opposite direction, so that they afterwards diverged from the beak in a slanting manner.

Chonetes Laguessiana, de Kon., is the only abundant Scottish Carboniferous species, that is of sufficient size, and thickness of shell, to allow of my examination, by means of etching with acid, of both its outer and inner surface. I find, however, evidence in other of our smaller *Chonetes*, of similar tubular openings on the outer surface, and raised tubercules on the inner surface of the shells, that agree with those seen in *C. Laguessiana*, and I have no doubt but that the whole genus was characterized by similar perforations, but modified in their arrangement in the several species.

In bringing this note to a close I have only to remark that the points of interest noted in my investigation of the shell structure of *C. Laguessiana* are four: these are, 1st, the occurrence on the ribs of both valves of a series of wide-set tubular openings or bases of spines, that do not pass inwards through the thickness of the shell; 2nd, a row of very minute close-set pores that are placed along the central line of each rib, but which descend only a very short distance into the shell substance, and then disappear; 3rd, a series of wide-set perforations, not visible at the surface, but which start near the middle layer of the shell, and are continued in single rows between each rib in an upward slanting direction through the shell, and appear upon the inner surface of the valves as numerous raised tubercules; 4th, a row of tubular spines in the cardinal edge of the ventral valve that open with round orifices on the inner surface of the shell, the tubes at first converging towards the beak, but on arriving at the outer edge being prolonged as spines and bending suddenly in the opposite direction. So many points of structure as are here noted cannot, I think, fail to make this species of *Chonetes* always an interesting object of investigation to the Conchologist. It would also be interesting to learn if similar structures and arrangement of the cardinal spines existed in other large and well-preserved species of the genus.

VI.—Note on *Chonetes Laguessiana*.

By Thomas Davidson, LL.D., F.R.S., F.G.S., etc.

At page 37 of his chapter "On the Minute Structure of the Shells of the Brachiopoda," and forming part of my work "On British Fossil Brachiopoda," Dr. Carpenter says:—"*Chonetes.*—Of this genus, also, I have examined two species, *armata* and *lata*, both of which are perforated,"—but Dr. Carpenter does not explain in what way they are perforated, viz. whether these perforations pass through the entire thickness of the valve, or are restricted to a small portion of its thickness as in *Productus.*

Mr. D. Oehlert, of Laval, having recently written me that he was describing some species of *Chonetes* from Mayenne, and could find in their shell not a vestige of perforations, I requested my valued friend Mr. Young to kindly examine well-preserved specimens of *Chonetes Laguessiana*, De Kon., in order to ascertain whether their shell was perforated and in what manner. Mr. Young has also examined the shell structure of the three species from Mayenne, viz. *C. plebeia*, *C. tenuicostata* and *C. sarcinulata*, and although the shell was much altered from mineralization, after having been etched with acid, he found perforations, but that they did not reach the outer surface, and slanted towards the beaks, as he has described to be the case in *C. Laguessiana*. At my request Mr. Young has likewise examined the shell structure of *Chonetes armata*, from the Devonian of Ferques, and found no traces of perforations on the outer surface of the valves, but having placed some of them in acid and watched them carefully as the etching went on, he found that the perforations in each case did not begin to show themselves until he had reached close to the inner layer of the valves where they appear in the shell structure as a series of little greyish-white tubes, slanting upwards towards the beaks of the shell as is seen in *Chonetes Laguessiana*. These punctures can be seen on the interior surface of the valves. None of the specimens, however, showed the least trace of that outer series of minute perforations so beautifully displayed on the ribs of well-preserved examples of *C. Laguessiana*.

In pages 295—302 of my Carboniferous Supplement, Mr. J. Young gives the results of his minute and lengthened examination of the shell structure in the genus *Productus*, and which satisfied him—First, that the perforations are seen only on the inner layers of the shell, and that, in no instance, except doubtfully in *Prod. mesolobus*, do they show themselves on the outer surface of the shell. Secondly, that the perforations enter from the interior surface of the valves and gradually get smaller as they pass outwards through the substance of the shell, and are lost before they reach the outer surface, so that it is only on the interior surface of the ventral and dorsal valves that these perforations are seen, or where the outer layers of the shell are decorticated or stripped off, as is often the case where the specimens have been extracted from hard limestone.

Thanks to Mr. Young, we now know the true nature of the perforations in the genera composing the family *Productidæ*, and he has ascertained at the same time that the shells of *Streptorhynchus* and *Strophomena*, are only perforated in the inner layers of the shell as in *Productus* and *Chonetes*.

REVIEWS.

The Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill. By Walter Keeping, M.A., F.G.S. pp. xi. 167. (Cambridge, 1883.)

THE work before us is the Sedgwick Prize Essay for the year 1879, and may be regarded as supplementary to the capital and concise Prize Essay for 1873, by Mr. J. J. Harris Teall, entitled

"The Potton and Wicken Phosphatic Deposits" (1875). Upware, we may mention, is a hamlet in the parish of Wicken; hence the two names, as Mr. Keeping points out, have been used synonymously in descriptions of the "Lower Greensand" (or Neocomian) coprolite beds, worked in the district. Upware is situated on the Cam between Ely and Cambridge, and being, as its Inn denotes, "Five miles from anywhere," is so far out of the beaten track, that only the great interest of its geology has brought it into notice. And here we venture to find fault with Mr. Keeping for using the name Upware instead of Wicken for these Neocomian deposits. The title on the cover is given thus, "The Fossils of Upware, etc.," whereas, as is well known, the terms "Upware beds," "Upware rock," and "Upware limestone," are commonly used for the Corallian beds so well represented at the same locality. Indeed these older beds form the main mass, for a distance of nearly three miles, of the low ridge or promontory that here rises out of the Fens. Little Brickhill, the other locality, whose Neocomian fossils are now particularly described by Mr. Keeping, is a village, about 2½ miles east of Bletchley Station, not far from Fenny Stratford, and in Buckinghamshire (not Bedfordshire as stated).

Mr. Keeping commences with a general account of the deposits, referring of course to the labours of Mr. J. F. Walker, who first described the Neocomian beds of Upware (Geological Magazine, Vol. IV. p. 309, 1867); and to those of his father, Mr. H. Keeping, to whom we were indebted for further important details, and whose original diagram (Geological Magazine, Vol. V. p. 273) is now reproduced with some alterations. Mr. H. Keeping then remarked on the unconformity of the Kimmeridge Clay to the "Coral Rag," observing that, "at the time of the deposition of the Kimmeridge Clay, a quantity of its broken and often rounded fragments became intermixed with it, so that in the vicinity of junction it actually presents the appearance of Boulder-drift." In the revised section now published, the unconformity of the Coral Rag and Kimmeridge Clay is not maintained, Mr. W. Keeping believing the beds to be conformable, and that "the destructive work of the removal of the Kimmeridge Clay went on during the earlier times of the formation of the Lower Greensand, and one of its results was the production of a curious deposit of irregular broken fragments," etc., in fact the bed previously mentioned. This is an important correction. The Neocomian beds of Brickhill were described by Mr. W. Keeping in the Geological Magazine for 1875, and although he has nothing to add to the stratigraphical details, our knowledge of the fauna has largely increased since then.

This Essay is mainly occupied with a detailed account of the organic remains—and the separation of the "indigenous" from the "derived" fauna. Belonging to the former 176 species are known, and among these certain Sponges, Brachiopoda, and Polyzoa are conspicuous. Perhaps the most interesting are the Brachiopods, upwards of 15,000 specimens of which have been accumulated in the Woodwardian Museum, from which have been selected a series arranged to show the relations of the species to one another by intermediate connecting forms. In this way the passage of *Terebratula Cantabrigiensis* through *T. depressa*, *T. Seeleyi*, and *T. prælonga* to *T. microtrema*, is said to be simple and clear. In the same way various species of *Waldheimia* and also of *Terebratella* have been shown to graduate one into the other. These are very important and interesting facts, and in reference to them the author says, "While thus pointing out the mutability of the forms of Brachiopoda, it is perhaps worth while observing that the value of the species is thereby in no way decreased, but on the other hand is, I believe, considerably increased both to the Naturalist and Stratigraphist. Whether we call our various forms *varieties*, *races*, *types*, or any other name, the facts of the great constancy of our recognized "specific" types, and their limited distribution in space and time still remain to us: our characteristic species are as useful as ever they were; while on the other hand we shall have added a most important help to the determination of the relations of rock beds to one another when we can recognize the true meaning of allied genera, species and varieties."

Turning to the account of the derived fossils, we learn that most of them are preserved in phosphate of lime, and that they belong to various ages ranging from the Neocomian to the Oxford Clay. The occurrence of the Neocomian species *Ammonites Deshayesii*, *Thetis minor*, *Terebratula ovoides*, etc., as derived specimens, is considered very remarkable. The bed from which these fossils were obtained seems to be represented in the East of England by large boulders of Neocomian grit, perhaps closely connected with the Lower Neocomian Sands of Lincolnshire.

There is an interesting chapter on the relations of the Upware and Brickhill deposits to other British formations, and a chapter on the Foreign relations of the Beds. These conclude the first part of the book: the second part is devoted to "special palæontology," or a description of the fossils, including many new species, and this portion of the work is illustrated by eight well-executed plates. The author is assuredly to be congratulated upon the success of his labours, resulting in the many new and interesting facts here brought together, which must have required much labour and patient investigation in their collection and solution. H.B.W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 6, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Estuaries of the Severn and its Tributaries, an inquiry into the Nature and Origin of their Tidal Sediment and Alluvial Flats." By Prof. W. J. Sollas, M.A., F.R.S.E., F.G.S.

Various sources have been ascribed to the mud which is so characteristic of the estuaries of the Severn and its tributaries, such as the rivers themselves, the waste of mud shoals, or of bordering cliffs, or the sea. The author considered the effect of these sources of supply, and showed that, although the first three are doubtless to a certain extent correct, they are inadequate to account for some very important phenomena. The tidal silt, on microscopic examination, is found to consist of both inorganic and organic materials, the former being argillaceous granules, grains of quartz, flint, etc.; the latter coccoliths, coccospheres, Foraminifera, occasional sclerites of Alcyonaria, fragments of Echinodermata, and triradiate spicules of Calcispongia, together with numerous spicules of siliceous sponges, a few Radiolaria, and a variable quantity of Diatoms. These organisms (described in detail by the author) are marine, and yet they occur on the banks of rivers at a great distance from a truly marine area. The author showed it to be improbable that they can have been derived, at any rate to a considerable extent, either from the older formations through which the Severn flows, or from the alluvial flats of its estuary; for although the latter do contain marine organisms of a generally like kind, the spicules, etc., indicate corrosion, and are generally not so well preserved as those which occur in the tidal silt. It seems, therefore, necessary to conclude that a considerable portion of the organisms now present in this have been brought from the sea; but sponges are not known to grow in any quantity nearer Bristol than the coasts of Devon and Pembrokeshire. It would therefore appear that these organisms, contrary to what might have been expected, have been drifted up into the tidal estuaries of the river for a very considerable distance. The author concluded by describing in detail the alluvial tracts of the Severn, which he considers to have been formed (with certain differences of level) much as tidal deposits are formed at the present day; and by pointing out the bearing of his investigations on the question of the probable results of the discharge of sewage into tidal rivers.

2. "Notes on a Collection of Fossils and Rock-specimens from West Australia, north of the Gascoyne River." By W. H. Hudleston, Esq., M.A., F.G.S.

This collection was forwarded to England by Mr. Forrest, who has been engaged for some time past in surveying the northern portion of the colony, and was accompanied by a map indicating the position whence the specimens were obtained. The author drew attention to a paper by Mr. Gregory, which appeared in the Quarterly Journal, many years ago, giving a brief description of the country as far as the Gascoyne river in lat. 25° S., together with some diagrammatic sections, which show a belt of sedimentary rocks between the sea and the crystalline plateau forming the interior of the country. This belt of sedimentary rocks widens materially towards the north, being about 90 miles across on the parallel of the Gascoyne river. Amongst the rock-specimens in the Forrest collection are crystalline schists, etc., in which white mica and quartz are the most prominent minerals; and it is evidently from the degradation of masses of this class that the arenaceous rocks containing the fossils were derived; no limestone has been sent, but where the grits are largely charged with fragments of Encrinites, Polyzoa, etc., there is a proportionate increase of calcareous matter. No specimens of coal or of recognizable plants were forwarded.

The fossils chiefly occur in "fossil range," which runs nearly N.N.W. for over 100 miles; they present a thoroughly Carboniferous (marine) facies, several of the species being identical with or closely allied to well-known Carboniferous Limestone forms. Out of more than 20 species there is only one (a *Pachypora*, allied to *P. cervicornis*) which could be regarded as Devonian. Corals, crinoidal stems, Polyzoa, Brachiopoda, and two large species of *Aviculopecten* make up the list. In the Appendix some of these were described. The corals are chiefly represented by *Amplexus* and *Stenopora*; whilst amongst the Polyzoa are two species of the very curious American genus *Evactinopora*, only known hitherto from the Lower Carboniferous Rocks of Illinois. The ubiquitous *Fenestella plebeia* is extremely abundant.

3. "Notes on the Geology of the Troad." By J. S. Diller, Esq. Communicated by W. Topley, Esq., F.G.S.

This paper gave a brief account of the results obtained by the author whilst attached to the United States Assos. Expedition. Together with a geological map (scale 1 : 100,000), this was sent to Mr. Topley for the service of the new Geological Map of Europe (and its borders), which is now being prepared by a Committee of the International Geological Congress.

The country described is that lying south and west of the river Menderé (Scamander). The sedimentary rocks may be divided into three great groups:—

(1) An old, possibly Archæan, highly crystalline series, forming the mountainous lands of the Ida range (5750 feet), but also appearing in smaller detached areas to the W. and N.W. Probably these have existed as islands from early time, and around these the later rocks have accumulated. Mt. Ida itself is almost a dome, the lowest rocks (talc schists) occupying the summit. On the northern slopes there is true gneiss. No igneous rocks enter into the structure of this mountain. At different horizons there are bands of coarsely crystalline limestone, and as far as can be seen this series is conformable throughout.

(2) Resting on these old rocks and in part made up of their remains is a series of partially crystalline rocks, chiefly limestone. It is probable that this series is in large part of Cretaceous age; but it contains rocks which are older, possibly Palæozoic. Eocene fossils have lately been discovered by Mr. Frank Calvert, which also may have come from this series. The rocks in the S. of the Troad, hitherto supposed to be Lower Tertiary, are now known to be of later date. Sharply marked off from these older rocks are the Upper Tertiaries; these are of two ages, occurring in two distinct areas.

(3) The *Upper Miocene*, which fringes the western shores of the Troad, and forms a broader band at the north-west corner in the lower course of the Menderé. Hissarlik is built on this. These beds are marine, and belong to the *Sarmatian Stage*. The Troad is the most south-westerly point at which the *Mactra-kalk* is yet known.

(4) Freshwater beds, which occur in force in the interior of the country, between the Menderé and the south coast, and in patches near the coast. These are *Upper Miocene* or *Lowest Pliocene*.

Later than these are the *Pliocene beds* of the great plain of Edsemet. The igneous rocks are of various ages, but most are of Tertiary date.

The oldest is a *granite* which intrudes through and alters the oldest (? Archæan) crystalline rocks. This is invaded by dykes of *Quartz-porphyry.*

Quartz-diorite invades and alters the group of partially crystalline rocks.

The oldest rocks in the newer series are the *Andesites* and *Liparites.* These, in part, are older than the Sarmatian stage, as the conglomerate at its base contains fragments of these rocks. But they are also in part of later date. Where they can be studied together, the Liparite is the later of the two, as it flows through and carries up fragments of the Andesite. The Andesite (unlike the Liparite) seems to have reached the surface, in some cases, through volcanic vents.

Basalts and Nepheline-basalts are of late Tertiary date; possibly they are the latest volcanic rocks of the district, but their relation to the other eruptive rocks of the Troad cannot be definitely determined.

The volcanic rocks in the isolated area between Alimadja and Lyalar are interesting because their relative ages are here well seen. The earliest was melaphyre, this was followed by mica-andesite, hornblende-andesite, augite-andesite, basalt, and late (if not last) by liparite.

Mr. Topley, who, in the absence of the author, read the paper, explained the objects of the Assos. Expedition and the geological results obtained by Mr. Diller. He gave a short account of previous literature, and mentioned some of the main points in which our knowledge of the Troad is now advanced. Mr. Topley briefly described the physical geography and general structure of the country, illustrating this by means of a section which he had prepared from Mr. Diller's map and paper.

II.—June 20, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Discovery of *Ovibos moschatus* in the Forest-bed, and its Range in Space and Time." By Prof. W. Boyd Dawkins, M.A.

The specimen described by the author formed part of the collection of the late Rev. F. Buxton, and was obtained by a fisherman from the forest-bed of Trimingham, four miles from Cromer. The edges are sharp, and the red matrix adhered in places, so that the author regards its geological position as satisfactorily established. It is the posterior half of the upper surface of the skull of an adult female *Ovibos moschatus.* The author describes the range in space and time of this animal, mentioning the different instances in which its remains have been found in Britain. These are, in some cases, undoubtedly Post-Glacial; but he inclines to consider the lower brick-earth of the Thames Valley, where the musk-sheep has been found at Crayford, as anterior to the Boulder-clay, which occupies the district to the north. This deposit at Trimingham, however, is certainly pre-Glacial, and so *Ovibos moschatus* belongs to a fauna which arrived in our country prior to the extreme refrigeration of climate which characterized the Glacial epoch, and afterwards retreated northwards to its present haunts, showing, with other evidence, that this epoch did not form a hard and fast barrier between two faunas.

2. "On the Relative Age of some Valleys in Lincolnshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

In a country which is traversed by a series of escarpments or hill-ranges, the valleys by which its drainage is effected are usually separable into two sets or systems, one parallel to the strike of the ridges, and the other more or less at right angles to the same. The origin of these longitudinal and transverse valleys has been explained by Mr. Jukes, who has shown that the course of a stream flowing in a transverse valley and crossing a longitudinal valley is not likely to be diverted, unless something happens to cut a deeper channel down the longitudinal valley to the sea. The possibility of this will depend upon the strike of the rocks and the trend of the sea-coast; where a longitudinal valley or the interspace between two escarpments abuts upon the coast, and is occupied by a stream running into the sea, the process of erosion may carry the sources of this stream back so far as to intercept the waters of a transverse river crossing a higher part of the same general depression or interspace. The author believes that this has happened in some instances, and notably in the case of two Lincolnshire valleys.

(1) *Valleys of the Steeping and Calceby Becks.*—These two streams have their sources near one another in the vicinity of Telford. The Calceby beck occupies a transverse valley, and flows north-east to the Saltfleet marshes; the Steeping flows in a longitudinal valley south-east to the fens by Wainfleet.

The disposition of the Boulder-clays (Hessle and purple) along the eastern border of the chalk wolds affords a criterion of the relative age of the valleys which open eastward, some being older and some newer than the formation of those clays. Glacial clays and gravels are found continuously along the Calceby valley, and occur also in the valleys of its tributaries; the same deposits sweep round the southern end of the Wold hills into the entrance of the Steeping valley, but do not run into it; hence it would appear that the Steeping valley is of later date than the Calceby valley.

Facts were given in support of the hypothesis that the Steeping valley has been rapidly developed and enlarged by the combined action of rain and springs, and that its backward extension has caused the interception of certain streams that originally flowed into the Calceby valley. As a matter of fact, the Steeping valley now extends behind the abrupt termination of a broad transverse valley, which is continuous with that of the Calceby beck, while the Telford beck, which appears to have originally been a tributary of the Calceby stream, now runs into the Steeping; and its peculiar course illustrates the manner in which this and other streams have been diverted from their original channels.

(2) *Valleys of the Trent and Witham.*—The Trent flows in a transverse valley as far as Newark, and is then suddenly deflected northward into a longitudinal valley. Proofs are given that its ancient course was eastward, by Lincoln to the Fens; and a remarkable series of old river-gravels are described, which mark out the former courses of the rivers Trent, Witham, and Devon.

The longitudinal valley along which the Trent now flows, from Newark to Gainsborough, may have been excavated in the first instance by a tributary of the Idle; the recession of this valley towards that of the Trent (assisted by other causes) probably led to the diversion of the latter river from its original transverse valley into that of the Humber.

The study of these changes in the river-courses of Lincolnshire leads to the conclusion that whenever a succession of ridges and depressions has been developed out of the surface of a country, a river crossing any one of the longitudinal valleys which happens to stretch to the sea-coast is liable to diversion by the backward extension of a stream draining directly into the sea from the termination of the longitudinal valley.

3. "On the Section at Hordwell Cliffs, from the top of the Lower Headon to the base of the Upper Bagshot Sands." By the late E. B. Tawney, Esq., M.A., F.G.S., and H. Keeping, Esq., of the Woodwardian Museum. Communicated by the Rev. O. Fisher, M.A., F.G.S.

The authors, after a brief sketch of the literature of the subject and of the method which they have adopted in measuring the beds in the Hordwell section, passed on to describe these, viz. the fresh-water Lower Headon series and the so-called Upper Bagshot Sands of the Geological Survey. They make the whole thickness of the former $83\frac{1}{2}$ feet. The bed numbered 32 in their section they identified with the Howledge Limestone on the other side of the Solent. It is almost the highest seen in the section, and underlies the true Middle Headon which is now no longer exposed. The authors pointed out that in their opinion the late Marchioness of Hastings and Dr. Wright have somewhat misapprehended the position of these several beds. Details were then given of the remainder of the section, and comparisons made with the details published by former authors; after which the authors described the underlying estuarine series, or Upper Bagshot Sands, which has a thickness of $17\frac{1}{2}$ feet.

4. "On some New or imperfectly-known Madreporaria from the Coral Rag and Portland Oolite of the Counties of Wilts, Oxford, Cambridge, and York." By R. F. Tomes, Esq., F.G.S.

The author, after pointing out the poverty of the British Corallian rocks in genera and species of corals as compared with the strata of equivalent age on the continent, proceeded to describe a section in the Middle Oolite at Highworth.

The author then described species of *Astrocœnia*, *Dimorpharæa*, and *Latimæandrina*, genera not hitherto recognized in the British Corallian; and for one of the forms he has discovered, he proposed a new genus to which he gives the name of *Crateroseris*. The paper concluded with some remarks on the well-known *Isastræa oblonga* of the Portland beds.

5. "The Geology of Monte Somma and Vesuvius, being a Study in Vulcanology." By H. J. Johnston-Lavis, Esq., F.G.S.

The author, after referring to the vast amount of literature which has appeared dealing with the same subject, stated that his object was to lay before the Society the results of his personal observations.

The external form and general features of Monte Somma having been described, the origin of the present condition of the volcano was discussed in some detail, and the geological structure of the mountain and of the surrounding plain, as revealed by well-sections, was carefully considered.

As the result of his observations, the author believes that he is able to define eight successive phases in the history of the volcano; and the events which took place during these several periods, with the products of the eruption during each, were discussed in detail.

The earliest certainly-recognized phase in the history of the mountain was distinguished by chronic activity, exhibited in outflows of lava and the ejection of scoria and ash. Possibly, however, a still earlier and paroxysmal stage is indicated by some of the phenomena described. Phase II. was a period of inactivity and denudation, which was brought to a close by the violent paroxysms of Phase III., followed by the chronic activity of Phase IV. Phase V. marks the return of a period of inactivity and denudation, which was again followed by the paroxysms of Phase VI. and the less violent outbursts of Phase VII., the last subsiding into the chronic activity which is the characteristic of Phase VIII., the modern period of the history of the volcano. The products of each of these periods of eruption were described in great detail. The eruptive phenomena which are illustrated by these studies of Somma and Vesuvius were then considered, together with the nature and result of the denudation which alternated with eruptive action in originating the present form of the mountain. The paper concluded with a statement of fifty propositions on the subject of vulcanology which appear to the author to be established by the studies detailed in the paper.

6. "Note on 'Cone-in-Cone' Structure." By J. Young, Esq., F.G.S.

This note was written with the object of calling the attention of the Geological Society to some very fine and remarkably interesting examples of the "Cone-in-Cone" structure.

The author, after referring to the views of previous authors on the origin of this structure, proceeded to describe the interesting examples of it which occur in the coalfields of Ayrshire and Renfrewshire. He pointed out that the structure is generally exhibited in bands overlying beds of fossils.

7. "A Geological Sketch of Quidong, Manaro, Australia." By Alfred Morris, Esq., C.E., F.G.S.

This district is situated about 250 miles S.S.E. from Sydney. The cliffs about the Bombala river are about 100 to 120 feet high, and formed of very dark limestone, crowded with fossils, chiefly *Pentamerus*. In the author's opinion there has been great disturbance in this region, resulting in a complete change in the course of the river Bombala and a displacement of the shale. A mass of ferruginous sandstone has also been upheaved. This, as well as the other rocks in the neighbourhood, contain Upper Silurian fossils. It appears to have been altered by heat. Pockets of galena and copper are occasionally found in the district, and there is a vein of hæmatite. Clay-slates occur as well as the above rocks, the cleavage being generally vertical or nearly so.

CORRESPONDENCE.

THE LOESS AND THE EPOCH OF THE MAMMOTH.

SIR,—*Non omnia possumus omnes* is an old adage especially to be remembered in complex inquiries. May I crave permission therefore, as I am honestly bound to do, to correct two errors of fact into which I have been led by the authorities I have followed. I followed Mr. James Geikie (Prehistoric Europe, p. 87) in naming the Lemming as found in Brixham Cavern. My friend Mr. Pengelly writes me that for Lemming ought to be writ *Lagomys.* This substitution does not of course affect the argument I used, except by strengthening it, since the Lagomys is more associated with grassy plains than the Lemming. Mr. Swanston in a courteous letter in the GEOL. MAG. for April corrects not so much me as Mr. Bell, whose paper I quoted. Here again, as he most fairly says, the correction does not in any way affect the induction I made. It is at the same time singular that the highest points at which marine shells have occurred in the surface-drifts of Britain should be on opposite sides of St. George's Channel nearly where it is narrowest, and where the water if rushing violently would be most throttled, and therefore rise to the greatest height.

I would next crave a small space in which to refer to a theory propounded by Mr. Searles Wood, F.G.S., in a recent Number of the GEOLOGICAL MAGAZINE, and repeated by him in a recent number of the Journal of the Geological Society, in which he claims to account for the Loess in a new way, namely, by lateral movements of the ground under conditions such as exist in the Siberian tundras. I confess that I have read over the passages in which this theory is maintained with surprise. Mr. Searles Wood is such an experienced field geologist that it would have been dangerous to suggest that he has never seen or handled Loess. He himself, however, makes this confession (GEOL. MAG. Vol. IX. Second Series, p. 339). Only in this way can I explain the conclusion he has formulated. In the first place, he treats the Loess as being a mere form of loam, and identifies it with the *Limon Hesbayen* of the Belgian geologists. No doubt the two deposits are more or less synchronous, but without doubt they are very different in composition and texture, and require an entirely different explanation if we are to account for their origin. The first and most important feature of the Loess, which discriminates it at once from the loamy deposits and which requires a special explanation, is its being saturated with carbonate of lime. How does Mr. Wood's theory meet this at all? The curious capillary structure of Loess is its second most remarkable feature. This is assuredly entirely at issue with lateral molecular movements such as Mr. Searles Wood suggests. The long fine tubes that permeate the Loess so thickly would be destroyed and its structure rendered completely homogeneous by the slightest movements such as he supposes. Again, such movements could only occur if at all in a pasty plastic mass, but the structure of Loess is the antithesis of such a plastic condition. As Baron Richthofen says, "water which forms pools on loam enters into Loess as into a sponge, and percolates it without in the least converting it into a pulp or mud."

This at once answers Mr. Wood's notion, that when the ground is frozen to great depths the surface layers of Loess, when melted by the summer sun, would be converted into sludge. And this is essential to his theory; for, as he says, where the material acted on is porous sand or gravel, the water arising from the summer melting of the surface layers would escape laterally without any displacement of the material itself. This is exactly the case with Loess, which is more porous than sand or gravel.

Again, how can Mr. Wood invoke the severely Arctic conditions his theory necessitates when he examines the Mammals, the Molluscs, and the Plants whose remains are found so widely distributed in the Loess? They bespeak comparatively temperate conditions when the Loess was deposited. Lastly, granting that these fundamental difficulties were overcome, it is assuredly unsafe to base such an induction as Mr. Wood makes upon a series of hypothetical data, as to the action of frost upon beds of soft material without, so far as I know, a single empirical test. We may as well claim the mirage for reality. Is not his method the very one he reprobates in the sentence about resorting to causes wholly supposititious, or only found to be in action to some very subordinate extent? It is in the domain of logic and *geological induction*, where we are equal, and not of *geological observation*, where we are not, that I claim to meet Mr. Wood, and to show that his arguments as applied to the real Loess, and not to some hypothetical Loess, are incomprehensible.

I must, in conclusion, reply to my old friend Professor Dawkins. I am not going to discuss with him whether there be a special logic for Lawyers, and another for Professors, nor whether in the terribly wide inductions that Science must make nowadays, if it is to compass all the facts, it is prudent or wise to base arguments on our own observations only, or on the observations of all good men. These are matters upon which your readers will, I am sure, not agree with Mr. Dawkins. Let us turn from such small issues to one of real importance, namely, the range in time of the Mammoth. Professor Dawkins admits that I was right in saying he had changed his view on this subject. He claims to have done so because of fresh evidence. First he cites the Scotch caves. This reference is a mystery to me. I know of no Scotch caves containing Mammoth remains, and I should be obliged by a reference to them. Secondly, he refers to Dr. Falconer's opinion, but Dr. Falconer's opinion was before him when in 1869 he wrote as follows of the Pre-Glacial Mammals: "To this list Dr. Falconer would add the Mammoth; but a careful investigation into the evidence which was supposed to establish its Pre-Glacial age has convinced me that the inference was faulty. The specimens reported to come from the 'Forest Bed' are in every case mere waifs and strays thrown up by the sea between high- and low-water mark, or very possibly derived from the sands above the Boulder-clay. The remains dredged up from the bed of the sea, in the collection of Mr. Owles, establish the fact that a Post-glacial deposit containing Reindeer, Tichorhine Rhinoceros, and Mammoth exists off Yarmouth, which very probably was the source whence some of the drifted remains were ultimately derived" (Proc. Geol. Soc. 1869, p. 210). This is not all. Dr. Falconer—great authority as he was on the fossil Elephants—could not claim the minute acquaintance with the "Forest Bed" possessed by Mr. Gunn, who was especially in my view when I referred to those best entitled to give an opinion on such a subject. Mr. Gunn persistently denied the presence of the Mammoth in the "Forest Bed," and Professor Adams, writing in 1872, says: "This view is still maintained by the Rev. J. Gunn, F.G.S., who has informed me that his latest experience gave him no cause to alter his views on that head" (British Fossil Elephants, p. 72). But Mr. Gunn is not alone. Mr. Clement Reid, who has worked so well in Eastern England, says, in "Nature," vol. xix.: "All the specimens said to come from the 'Forest Bed' have been dredged or picked up on the beach, and are of no value whatever. At Bacton, on the Norfolk coast, I dug out a jaw and three teeth of the Mammoth from a Post-Glacial deposit; if the denudation of the cliff had proceeded these teeth would have been found on the beach mixed with those of *E. meridionalis.* There appears to be one specimen, and only one, found *in situ* in the 'Forest Bed,' which can with any probability be referred to *E. primigenius;* this was found some years ago by Mr. Savin, of Cromer. *It has not yet been satisfactorily determined, but from its peculiarity and the difference of opinion about it, it appears certainly not to be the ordinary form.*"

Professor Dawkins says that "the fact of the Mammoth being Pre-Glacial was accepted by the late Professor Leith Adams in his work on the Mammoth" (Pal. Soc.). This is a most extraordinary statement. The following are Professor Adams's very words:—"The evidence of the Mammoth having lived during Pre-Glacial times has not been established by the specimens from the coast of Norfolk, at all events as far as the instances hitherto recorded are concerned" (British Fossil Elephants, Pal. Soc. pp. 72 and 73).

Mr. E. T. Newton, who is also quoted against me, says expressly that "the only reliable specimens from the Forest Bed of the *Elephas primigenius* are in Mr. Savin's collection, and were obtained near Cromer. *But it is important to observe that they differ from the typical E. primigenius*" (Mem. Geol. Surv. p. 106).

I confess to feeling very much embarrassed when I found Professor Dawkins quoting authorities in support of a theory which they repudiate so plainly. This is certainly not "Mr. Howorth's way of disposing of evidence."

Mr. Dawkins refers in a vague way to a number of instances which have occurred since 1868 which have established in his view the Pre-Glacial age of the Mammoth. May I ask for a reference to these cases. I have made diligent search for them, but hitherto have only found the famous Northwich instance, which had such an extraordinary effect on my impulsive friend the great Troglodyte. In regard to this tooth, Professor Adams, one of the witnesses cited by Mr. Dawkins himself, says, "The latter piece of evidence is, however, like the others faulty, from the absence of direct proofs as to, 1st, the exact stratigraphical horizon; 2nd, the age of the deposit; and, 3rd, the mode by which the information was obtained" (*op. cit.* p. 73). In addition, Mr. C. Reid (*loc. cit.*) and Mr. Horace B. Woodward (Geol. Mag. 1879, p. 235) both show very plainly that this Cheshire tooth is really valueless in the discussion. HENRY H. HOWORTH.

DERBY HOUSE, ECCLES,
July 5th, 1883.

CHALK MASSES IN THE CROMER DRIFT.

SIR,—Mr. Searles Wood gives Professor H. G. Seeley, writing in 1864, as an authority that the old Hythe Pinnacle of chalk figured by Sir Charles Lyell in his Elements, p. 129, is not chalk, "but only re-constructed chalky drift full of all sorts of rocks." As Lyell in a letter to Sir Charles Bunbury in 1864 states that it, "the grandest erratic in the world," had at that time "*totally disappeared*,"[1] it is difficult to understand how Prof. Seeley *in the same year* was justified in making such a statement. It is rather common now to assume that the late generation of geologists made incorrect observations, but I shall require better evidence before I can believe that Sir Charles could not, in common parlance, distinguish chalk from cheese—or say, "chalky drift full of all sorts of rocks."

But we will assume for the sake of argument that the pinnacle was of re-constructed chalk. What then becomes of Mr. Searles Wood's statement that "when the masses of re-constructed chalk were brought and sunk deep into the substance of the sea-bed, the whole of this county was submerged"?

Deep indeed they would have had to be sunk, as the pinnacle in question is shown reposing upon the "pan" immediately overlying the chalk, with its base imbedded in Till, and the whole upper part surrounded and covered with contorted drift. The boulder figured by me (p. 231, Q.J.G.S., 1882) is undoubtedly of real chalk, and it is not interstratified with the drift. It is also true that there are other included masses intermediate between chalk and chalky drift, but no hard and fast line in their mode of occurrence can be drawn between them. The phenomena are connected, as is well shown[2] by Mr. H. B. Woodward in his description of the "disturbed chalk at Trowse."

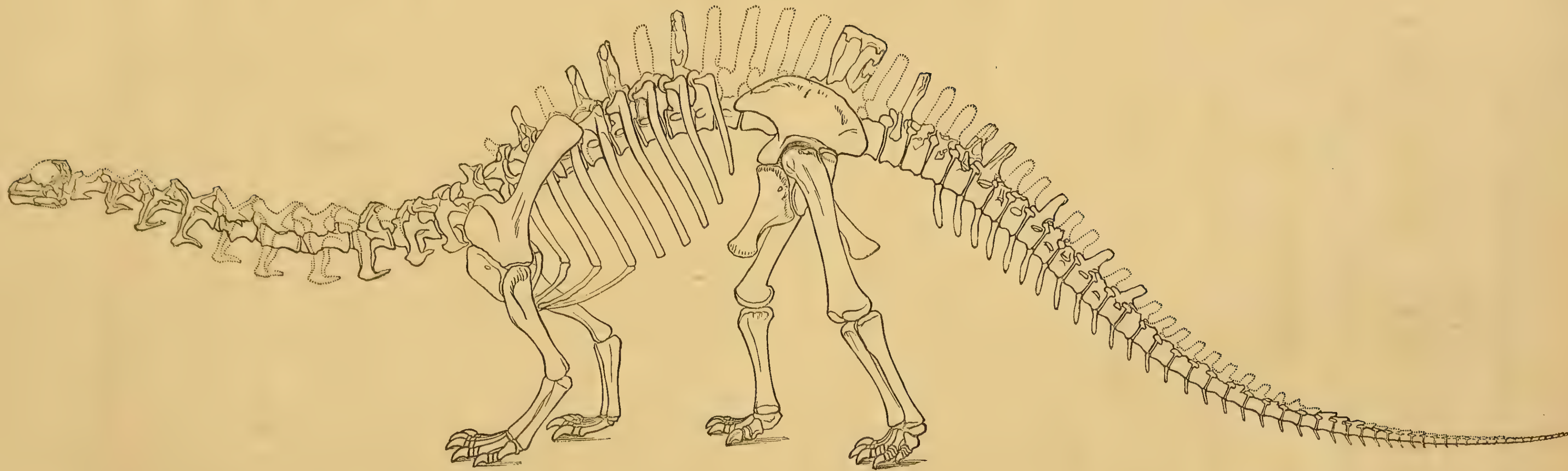
To conclude this correspondence, I cannot accept hypothetical ice-sheets as an explanation of the disappearance of what otherwise, by Mr. Searles Wood's theory, we ought to find, and I think I have a *right* to complain that he has a habit, unintentional no doubt, of putting among his facts what are in reality only opinions or inferences from his own theories. T. MELLARD READE.

July 5th, 1883.

[1] Life of Lyell, vol. ii. p. 441. Mr. Seeley speaks of pinnacles, whereas Sir Charles merely refers to one.

[2] Memoir of the Geology of the Country about Norwich.

ERRATUM.—GEOL. MAG. July, 1883, p. 332, line 7 from bottom of page for *alternation* read *attenuation*.



RESTORATION OF *BRONTOSAURUS EXCELSUS*, MARSH.

(REDUCED TO ONE-EIGHTIETH NATURAL SIZE.)

FROM THE JURASSIC FORMATION OF COLORADO.

THE

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ORIGINAL ARTICLES.

I.—American Jurassic Dinosaurs.—Restoration of Brontosaurus.[1]

By Professor O. C. Marsh, M.A., F.G.S.;
of Yale College, New Haven, Conn., U.S.A.

(PLATE IX.)

In previous articles the writer has given the more important characters of the order *Sauropoda*.[2] A volume on this group is now in preparation, and the illustrations (90 plates) are nearly completed. One of these is a restoration of *Brontosaurus*, which has so many points of interest that a reduced figure is here presented. Several new characters of this group are added, some of which will be of interest to comparative anatomists.

Restoration of Brontosaurus (Plate IX.).

Nearly all the bones here represented belonged to a single individual, which when alive was nearly or quite fifty feet in length. The position here given was mainly determined by a careful adjustment of these remains. That the animal at times assumed a more erect position than here represented is probable, but locomotion on the posterior limbs alone was hardly possible.

The head was remarkably small. The neck was long, and, considering its proportions, flexible, and was the lightest portion of the vertebral column. The body was quite short, and the adominal cavity of moderate size. The legs and feet were massive, and the bones all solid. The feet were plantigrade, and each foot-print must have been about a square yard in extent. The tail was large and nearly all the bones solid.

The diminutive head will first attract attention, as it is smaller in proportion to the body than in any vertebrate hitherto known. The entire skull is less in diameter or actual weight than the fourth or fifth cervical vertebra.

A careful estimate of the size of *Brontosaurus*, as here restored, shows that when living the animal must have weighed more than twenty tons. The very small head and brain, and slender neural

[1] From the American Journal of Science, vol. xxvi., August, 1883.
[2] See Silliman's Journal, vol. xvi. p. 411, Nov. 1878; vol. xvii. p. 86, Jan. 1879; vol. xxi. p. 417, May, 1881; and vol. xxiii. p. 81, Jan. 1882.

chord, indicate a stupid, slow-moving reptile. The beast was wholly without offensive or defensive weapons, or dermal armature.

In habits, Brontosaurus was more or less amphibious, and its food was probably aquatic plants or other succulent vegetation. The remains are usually found in localities where the animals had evidently become mired.

Among the new points in the skull of the *Sauropoda* recently determined are the following:—

Pituitary Fossa.—In *Morosaurus*, the pituitary fossa is comparatively shallow, much like that in the crocodile, and many birds, being connected with the under surface of the skull by the two usual divergent foramina for the passage of the internal carotid arteries. In *Apatosaurus*, however, it is remarkably different. Here the fossa becomes enlarged into a vertical canal, which, expanding below, communicates by a wide transverse orifice with the pharyngeal cavity. The arterial foramina are here canals thinly covered over with bone, and open just within the rim of the lower orifice. The pituitary cavity itself has a firm smooth wall throughout. The openings are both transverse, and oval in shape. The upper one is eighteen by six millimètres in its diameters; the lower opening thirty by twelve.

This remarkable connection of the cerebral cavity with the alimentary canal is an embryonic character, and corresponds to the condition observed in the chick at the fifth day of incubation. This peculiar feature appears to be a family character of the *Atlantosauridæ*.

Post-occipital Bones.—In two genera of the *Sauropoda* (*Morosaurus* and *Brontosaurus*), and probably in all members of this order, there is a pair of small bones connected with the skull which have not hitherto been observed in any vertebrates. These bones, which may be called the *post-occipital* bones, were found in position in one specimen, and with the skull in several others. When in place, they are attached to the occiput just above the foramen magnum, and extend backward and outward, overlapping the lateral pieces of the atlas, thus protecting the spinal cord at this point, which would otherwise be much exposed.

These bones are short, flattened, and slightly curved, resembling somewhat a riblet. The anterior end is thickened and rugose for attachment to a roughened surface on the exoccipital, just above and outside the foramen magnum. The shaft is flattened from above downward, and gradually converges to a thin posterior end. In *Morosaurus grandis*, these bones are about 65 mm. in length, and 30 along the surface which joins the occiput. They correspond in position to the muscle in mammals known as the *rectus capitis posticus minor*.

In the existing Cormorants (*Graculus*) a single slender bone is articulated to the occiput on the median line. This, however, does not correspond to the bones here described. To distinguish it from the post-occipitals, it may be called the *nuchal* bone.

Stapes wanting.—In the skull of *Morosaurus* in which the post-occipital bones were found in position and the other bones at the base of the skull were undisturbed, a careful search was made for the stapes, but no indication of it was found. Its absence in this specimen, so well preserved, would indicate that it was wanting in this genus, if not in the other Sauropoda.

Columella present.—In a skull of *Brontosaurus* in which the bones, although displaced, were in very perfect preservation, a pair of bones were found which apparently are the columellæ. They are elongated, flattened bones, with the shaft somewhat constricted in the middle, and twisted. Their length corresponds to the elevated posterior part of the skull in this genus.

Hyoid bones.—There are two pairs of hyoid bones in the Sauropoda. They are elongated, rodlike, and somewhat curved. In *Brontosaurus excelsus*, they are 210 and 130 mm. in length respectively.

Among the other points of interest in the skull of the *Sauropoda* are the following:—The parietal bones are very short, and form but a small portion of the brain case. They are composed chiefly of the flattened arched processes, which meet with the squamosals at their outer ends. There is no parietal foramen. The squamosals lie upon the par-occipital processes. They have a short deep groove for the reception of the post-frontal. On their lower part, which descends in front of the par-occipital process, they expand into a thin spoon-shaped form, which fits over the head of the quadrate. The quadrate has an oval rounded head, and slender shaft. Below, it is firmly united to the pterygoids. On the outer side, the quadrato-jugals are attached. These bones are elongate, and slightly sigmoid in shape. The lower end is rodlike, and curved forward, descending below the articular surface of the quadrate. The pterygoids are tri-radiate bones, with the posterior ends cup-shaped, resembling the partially closed human hand. This cavity, somewhat restricted by a thumb-like process, receives the basi-pterygoid process.

The Vertebræ.—There are twenty-seven precaudal vertebræ in *Brontosaurus*, of which the first twelve bear pleurapophyses, or hatchet bones, united to the centra, and may hence be called true cervicals. Of the remaining twelve which bear free ribs, the thirteenth, fourteenth, and fifteenth have the surface for the articulation of the head of the rib on the centrum, below the neural suture.

All the precaudal vertebræ have large cavities in the centrum, communicating exteriorly with the surface by means of large lateral foramina. This cavernous structure of the vertebræ gradually decreases posteriorly, until in the anterior caudal vertebræ it is confined to a small pocket above the transverse process. The neural arches of the presacral vertebræ contain numerous deep cavities. The pleurapophyses of the cervical vertebræ are also reticulate in their structure, and some of the anterior ribs have small but deep fossæ below the tubercle.

Post-metapophyses.—On the last two or three cervical vertebræ of *Brontosaurus*, there is a convoluted ridge of bone over the posterior zygapophyses. In the anterior dorsals, this ridge becomes stronger and more elongated, forming a distinct protuberance. These processes have not hitherto been described. As they are analogous to the processes in mammals known as metapophyses, they may bear the same general name, being distinguished as the post-metapophyses. The term pre-metapophyses should then be applied to the processes in mammals.

The post-metapophyses probably serve for the attachment of ligaments in the place of the neural spine, which is here wholly wanting. These processes, which are at first oblique in position, gradually become more vertical and stouter, and coalescing at their bases, finally become united throughout, and are thus converted into the neural spine.

Fœtal Dinosaurs.—Remains of a very small Dinosaur were found in immediate relation with the type specimen of *Morosaurus grandis.* These remains, which consist of a complete femur, the larger portion of both humeri, and several vertebræ, show no essential differences from the large specimens except in size, and indicate an animal of perhaps seven feet in length, and little more than two feet in height. The imperfect ossification of these bones indicates that the animal was very young, and it seems probable that it was fœtal. The only other similar case known in the *Dinosauria* is the apparent embryo observed by the writer in *Compsognathus.*[1]

Classification.—The various genera of the *Sauropoda,* and in fact of the *Dinosauria* in general, cannot at present be distinguished by the detached teeth. In one form, however, the teeth are quite peculiar, and the dentition appears to offer generic characters. The maxillary teeth of this form have been referred to *Stegosaurus* (Silliman's Journal, vol. xix. p. 255, pl. vi. figs. 4 and 5), as they were first found in connection with the remains of that genus. Later investigations indicate that they belong to the *Sauropoda,* and there is some evidence that they are the teeth of *Diplodocus.*

The main characters of the order *Sauropoda,* and of the two families now known to belong to it, are as follows:—

Order Sauropoda. Herbivorous.—Feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified. Pubes projecting in front, and united distally by cartilage; no post pubis. Fore and hind limbs nearly equal; limb bones solid. Sternal bones parial. Premaxillary bones with teeth. Precaudal vertebræ hollow. Each sacral vertebra supports its own transverse processes.

Family *Atlantosauridæ.* Anterior vertebræ opisthocœlian. Ischia directed downward, with extremities meeting on median line. Anterior caudals with lateral cavities. A pituitary canal.

Family *Morosauridæ.* Anterior vertebræ opisthocœlian. Ischia directed backward, with sides meeting on median line. Anterior caudals solid. Pituitary fossa only.

[1] See Silliman's Journal, vol. xxii. p. 340, November, 1881.

II.—Further Remarks on the Origin of the Loess.

By S. V. Wood, F.G.S.

In the August number of this Magazine, Mr. Howorth has challenged the view which I have advanced of the origin of the Loess (in common with the intrusive cave earth, the Warp of Trimmer, and the Trail of Fisher), from the slide of the upper and annually thawing layer of the permanently frozen soil, in the parts beyond the limit of the land-ice during the major and minor glaciations; or, as regards areas covered with sea during the major, from this process during the minor glaciation only.

It is not my intention to enter into any controversy on the subject of the Loess with Mr. Howorth, because, though far from dissenting from the occurrence of a great flood annually in the valleys of New England, when the land-ice which enveloped the New England mountains was melting during the wane of the major glaciation, as described by Prof. Dana, I am incapable of following Mr. Howorth's arguments in support of a general "Great Post-Glacial Flood." His challenge, however, induces me to lay before the readers of this Magazine some facts bearing upon the views broached by me, which had not come under my notice at the time of my previous paper on the subject, or at that of the publication of the second part of my memoir on the Newer Pliocene period in England, in the Quarterly Journal of the Geological Society for November, 1882.

The first of these is the remarkable ice formation of North Alaska. This formation is (in the Amer. Journ. of Science, for February, 1881,) thus described by W. H. Dall, the Assistant in charge of the schooner employed on the coast of Alaska, in his report to the Superintendent of the U.S. Coast and Geodetic Survey.

Landing on the 2nd September, at Elephant Point, on the Alaska shore of the Arctic Sea, some hundreds of miles north-east of Behring Strait, Mr. Dall found, as he proceeded along the beach, "the banks chiefly composed of volcanic breccia or a slaty gneissoid rock. These rose 15 to 50 feet in height above the sea, rising inland to hilly slopes, without peaks and probably not attaining more than 300 or 400 feet anywhere in the vicinity." Passing eastward along the beach these banks became lower and the rise inland less, and the rock changed to a greyish clay containing much vegetable matter (which in some places was "in strata in the clay, and in others indiscriminately mixed with it,") near the beginning of which was a layer of bog moss containing marl of freshwater shells, *Pisidium, Valvata*, etc., about six inches thick. A little beyond this a perpendicular surface of ice appeared in the face of the bank, solid and free from mixture of soil, *except on the outside.* This continued to increase slowly in height eastward. The ice was covered "with a coating of soil two or three feet thick, on which luxuriant vegetation was growing," and presented two faces to the beach, the lower and nearest rising to about 30 feet, and a higher and hinder to about 80 feet, each covered with a talus. "Thence the land rose gradually to a rounded ridge reaching the height of 300 or 400 feet only, at a distance of several miles from the sea," the northern end of which ridge abutted in the cliffs thus described on the shore of the bay. "There were no mountains or other high land about this ridge in any direction, all the surface around being lower than the ridge itself." About half a mile from the sea, and "perhaps 250 feet above high-water mark," at the depth of a foot, was a solidly frozen stratum of bog moss and vegetable mould, containing good-sized lumps of clear ice; and "there seemed no reason to doubt that an extension of the digging would have brought them to solid clear ice, such as was visible at the face of the bluff below." [This inference, I may remark, seems scarcely warranted; for nothing beyond lumps of ice *in* the moss and vegetable mould appeared to show that at this height, and still less at the higher parts of the ridge rising to 300 or 400 feet, there was not rock or other strata in the place of the ice, as had been observed to the west, where the breccia and rock appeared along the beach, and rose inland to hilly slopes of this elevation.] "There was much less clay over the top of the upper ice face than was visible over the lower one, or over the single face where there was but one and the land and bluff were low near the beach. There also seemed to be less vegetable matter. Near the beach six or eight feet of clay were observed in some places, without counting what might be considered as talus matter from further up the hill-side." In places the ice was penetrated with deep holes into which the clay and vegetable matter had been deposited *in layers*; and here the clay had a peculiar smell "as of rotting animal matter, burnt leather and stable manure combined," leading to the supposition "that these might be the soft parts of the Mammoth and other animals, whose bones are daily washed out by the sea from the clay talus." There was no high land from which a glacier might have been derived, and then covered with débris from their sides, and "the continuity of the mossy surface showed that *the ice* must be quite destitute of motion."

From this description, it seems to me that the coat of clay with mammalian remains over the ice can have arisen by no other process than that of slide from higher ground, where (this stationary ice giving place to soil and rock which was perennially frozen beneath the upper layer, which alone thawed,) the material originated; and that moving thus, it passed over the ice, where its motion continued in the same way, and from the same cause; the perennial ice taking the place of the perennially frozen ground. In no other way can I see how such clay could have overspread this ice, which Mr. Dall observes, "takes upon itself the functions of a regular stratified rock;" and it is to be observed that no ice was actually exposed above the elevation of about 80 feet, though the land behind it, as well as the land behind the banks of rock which skirted the shore before the ice bank was encountered, rose continuously to 300 or 400 feet. The *layers*, in which the clay had accumulated in holes in the ice, are worthy of notice in connection with the "bedding planes" said to occur often in the Loess.

How this ice, which Mr. Dall says "has a semistratified appearance as if it still retained the horizontal plane in which it originally congealed," originated he does not offer any suggestion. Neither do I, but substituting its perennially frozen state for the perennially frozen state of the ground beyond the limit of the land-ice during the glaciation, we have the conditions which then obtained, and gave rise to the material described by me under the letter γ; viz. the loam with angular fragments, land-shells, and mammalian remains; the intrusive cave earth; and the warp, trail, etc.; save that as the ice itself cannot generate the material, (as the frozen rock does, by the slide bringing layers of this successively within the thawing limit,) the material is but very thin over the ice except where it accumulates in hollows of this, and on the lowest part of the slope, all there is of it having slid from the nearest rock surface.

The other fact to which I invite attention, in this connexion, is that which forms the subject of a description by Prof. W. C. Kerr, in an article in the same American Journal for May, 1881, "On the Action of Frost in the Arrangement of Superficial Earthy Material." He describes, and illustrates by many cuts, the material which covers and hides the rock surface in North Carolina, and which he says is present generally over the Middle and South Atlantic States of the Union. This, which is derived from the rock it covers, varies in thickness "from a few inches to twenty, thirty, and even fifty feet." "It is found throughout the hill country and mountain section of the State (N. C.), passing eastwards into the Quaternary deposits." Fragments of quartz, usually small but sometimes a yard in diameter, and fragments large and small of gneiss, hornblende, slate, and other underlying rocks, occur distributed through the material, though sometimes accumulating towards the floor of the deposit, just as M. de Mercey describes in the case of the flint *éclats* of the Picardy loam. After describing the evidence of the slide in which these beds originated, and stating that they presented none of the features by which glacial deposits are usually recognized, Prof. Kerr offers the following view of their origin, viz.:

"As the earth is often frozen, in Canada and even Vermont, during severe winters to a depth of 8 or 10 feet, and as in Labrador and other subarctic regions the frost of the present winters penetrates to a much greater depth, so it is evident that during the prevalence of the great ice-sheet over the northern end of the Continent, as far down as Pennsylvania, and the prevalence of an Arctic climate in those middle latitudes, the earth was annually frozen to a depth equal to the maximum thickness of these deposits. The alternate freezing and thawing of the saturated mass of decayed rocks, constituting the Pre-Glacial surface, would of necessity produce just the movement and settling which are described above. That is, this freezing and thawing would give rise to precisely the same movements of the mass, and of the particles *inter se,* as are seen to occur in the true glacier, differing only in amount. In other words these masses were earth glaciers, and these deposits may be denominated frost drift, as distinguished from proper Glacial drift."

In my view of the case, this explanation of Prof. Kerr's requires the modification which is the essential part of the theory which I have formed of the beds described under the letter γ in my memoir on the Newer Pliocene period, viz. the permanently frozen condition of all but the upper part of the ground; for though in Canada and Vermont, however deeply the winter frost penetrates, it may all be dissolved by the warmth of summer, this is not so in Arctic regions, as we see by the case of the perennial ice of Alaska just described; though, from the much lower latitude of the regions where the phenomena in question took place during the Glacial period, the more vertical position of the sun may possibly, notwithstanding its generally diminished heat, have thawed the ground to a somewhat greater depth in summer in these latitudes, than now takes place in the case of land in the Arctic regions. That it did not thaw the whole depth in Europe, appears to me proved by the arrest in the formation of stalagmite during the accumulation of the cave earth; for this clearly shows that a stoppage of percolation then took place, which, so far as I can see, admits of no other explanation. Nor do I see (for the case has no analogy with the explanation which has been offered of glacier motion by the freezing of water penetrating the glacier fissures,) how motion would have been imparted to the mass by the mere freezing and thawing of the whole; as it is to the semifluid condition acquired by the upper portion, when saturated with water, without any downward escape for this water by reason of the permanently frozen condition of the deeper portion of the ground, that I attribute the sliding motion.

Although Professor Kerr makes no mention of land shells, or mammalian remains in this material, yet he speaks of peaty black gravelly soil with blackened stems and bark of trees, and fragments of wood, and grass blades, roots, and stems occurring in it, as Dall does of vegetable matter "in some places in strata in, and in others indiscriminately mixed with" the Alaska clay; and it seems to be identical in its character with the beds grouped under the letter γ in my memoir; but instead of representing, as those do, the action of the atmosphere on terrestrial surfaces beyond the limit of the land-ice during the minor glaciation only, it represents this during both glaciations.[1]

[1] Although the evidence of the minor glaciation in the Western States seems ample, yet Prof. Dana says that no sufficient evidence of it has yet been detected in the Atlantic States of the Union. It seems to me, however, that the "till-like deposit," *c g* of the section at p. 182 of his paper in the American Journal of Science for March, 1882, shown as wrapping unconformably the stratified sand which was deposited in the Connecticut Valley by the flood which resulted from the melting of the ice of the major glaciation, during the wane of that glaciation, affords such evidence. The Hessle clay of Yorkshire wraps thus unconformably the sand and gravel of the Cyrena formation; and its boulders are, like those of this bed *c g*, of the "Cobble-stone" character, and small in comparison with those of the clay of the major glaciation. As the less volume of the ice of the minor glaciation from which the Hessle clay originated, instead of so greatly overwhelming the valley partings as that of the major did, passed through the middle part of the Vale of York to the sea, so may the ice of the minor glaciation originating on the mountains of New England have been insufficient so to overwhelm the partings of the New England valleys, as that of the great glaciation did, but have escaped to the sea down those valleys, and there left its moraine on the sands which had previously been deposited there.

The Loess of the valleys of the Mississippi and its northern tributaries occupies a similar position, relatively to the area covered by the great ice-sheet from which the glaciation of the United States proceeded, that these beds of Prof. Kerr do; and there is, I think, a strong presumption of their identity. Although Pumpelly has advanced the dust theory for it, the opinion prevailing among American geologists has been that the Loess of America was of fluviatile, or lacustrine origin, during or subsequent to the Glacial period. As regards a river occupying these valleys up to the elevation to which the Loess extends (which is said to be 500 feet above the rivers), then, whether we imagine such to have arisen from the effluent water of the land-ice which overwhelmed the parting between the St. Lawrence and the Mississippi systems during the accretion of the ice, or whether we imagine it to have arisen from the annual flood during the dissolution of this ice, the objection presents itself that it would have been a permanent flood, during summer at least, and the area occupied by it could not have furnished vegetation for the land shells' subsistence. Further, as neither the floods during the wane of the ice-sheet, nor the effluent water from it during its accretion, have in New England, according to the opinion of American geologists (Dana and Upham) who have studied the question, produced anything but thick accumulations of sand and gravel, without any shells or other organic remains (save, perhaps, some of Reindeer) such as occur in the Loess, it is difficult to see how any similar action could have given rise to a formation so very distinct from this as is the Loess of the Mississippi drainage area. As regards its origin from a lake, then, irrespective of the physical difficulties besetting the existence of a lake maintained at the level up to which the Loess extends, while the lower part of the Mississippi Valley was depressed *relatively to the upper* as much as it is now (which Prof. Hilgard's description of the Port Hudson group, and late gravel beds, in the States of Mississippi, Louisiana, and Texas seems to show), an unstratified formation in which land shells for the most part only occur could hardly have resulted from it; for the shells of a lake would have been almost exclusively of fresh-water habit, and shells of the great American genera *Unio* and *Anodonta* would have abounded everywhere in it. Freshwater shells, such as *Limnæa*, do occur occasionally; and adjoining the rivers the unstratified Loess with land shells is said to overlie and pass down into stratified beds with freshwater mollusca. Sir C. Lyell (Antiquity of Man, p. 237) states that by his own observation he found this to be the case at Natchez, and that it occurs also in the valley of the Rhine. He, also, considered the Loess of the Mississippi Valley "from its homogeneous nature, the absence of stratification, and its terrestrial and amphibious shells, to have been formed by a great river which, like the Nile, inundated the wide plains bordering it on either side." The Nile flood does not, however, rise above the ordinary river stream to the tenth part of the height to which the Loess is said to rise above the streams of the northern affluents of the Mississippi; and if an unstratified loam with, for the most part land shells only, thus resulted, and was laid over stratified river beds with freshwater mollusca, it would not be in one continuous bed of unstratified loam 60 feet thick, as Sir Charles Lyell says he found it, but either films of this inundation mud with alternations of stratified beds with river shells would occur, or (and more likely) this mud would become mixed with the beds with river shells; for it is only beyond the area occupied by the permanent stream that the successive films of Nile inundation mud accumulate to form a continuous mass; and this, according to Lyell, proceeds at the rate of only $3\frac{1}{2}$ inches in a century. If the objection as to the height to which the Loess not thus underlain rises, be met by the answer that there was a cutting down of the valleys by the rivers during its accumulation, then the unstratified Loess with land shells ought to be found overlying stratified beds with river shells at all levels, instead of adjoining the rivers, as it is said to do, only. Lyell (Principles of Geology, vol. i. p. 461) mentions that the remains of three Mississippi Buffalo fish occurred at a depth of four feet from the surface of the Loess plateau above Vicksburg, and 200 feet above high-water mark. If the presence in it of fish-remains were one of the general features of the Loess, this would outweigh all objections to its fluviatile or lacustrine origin, but I do not find such alluded to as the case in any of the descriptions of the Loess by American geologists that I have met with; so that, considering the Mississippi Valley has been for ages, and probably during both glaciations, inhabited by races of men who have lived on fish obtained from the rivers, this isolated occurrence in unstratified material, only four feet from the surface, requires some collateral support to make it good evidence on the subject.

In his description of the Alaska Clay, Dall mentions a six-inch bed of marl of freshwater shells (*Pisidium*, *valvata*, etc.), of bog origin, as present at one spot in the clay; and it is obvious that if the Loess has originated in the sliding way that I suppose, such occasional patches of freshwater shells must have become incorporated with it. If from shrinkage in the river volume, or from a cutting down of its bed by the river, the ordinary deposit of the river became land along its edges, an atmospheric formation with only land shells, originating and sliding in the way I suppose, would be carried over it, and would thus give rise to that overlay of beds containing only river shells, by Loess with only land shells, which Lyell says occurs near the Mississippi.[1]

The descriptions of the Loess in different States of the Union by American geologists are too numerous for me to attempt to give an analysis of them; but though not altogether harmonious as to all

[1] In the section of the Trowbridge railway cutting at page 719 of the second part of my Newer Pliocene memoir (Quart. Journ. Geol. Soc. vol. xxxviii.) reproduced from a paper by Mr. Mantell, the loam (Drift) with Elephant teeth (γ of my memoir) which I refer to this sliding origin during the minor glaciation is shown as not only enveloping the Jurassic formations of the hill through which the cutting was made, but as spreading over the gravel of the river Biss.

its features, they are so that, with the exception of freshwater shells, such as *Limnæa*, occasionally, the mollusca in it are of terrestrial or amphibious habit. As regards the absence of stratification, and the general relation of the Loess to other formations, Hilgard says that, though unstratified, it often shows bedding planes, and that the Loess of the Lower Mississippi passes laterally and imperceptibly into a clayey loam, undistinguishable in its landward form from that which constitutes the general soil of the South-western States; and that "all observers testify to its dead uniformity over entire areas." These "bedding planes" often shown by the Loess seem to me to correspond to the "layers" in which, Dall says, the Alaska clay accumulates, where it occupies depressions in the ice mass it covers. General Warren says, "that in many places the Loess is nearly uniform in thickness, conforming with the previous irregularities of surface, as snow lies where it has not drifted." Also that it is "a fine material deposited over all other formations, including the Glacial deposits near the river, but not upon the river sand and gravel terraces." If this last be so, it seems only reconcileable with Lyell's statement, that the Loess overlies the river beds at Natchez, by this being a terrestrial formation synchronous with those terraces, and which slid but partially over their edges, as these became land before the formation ceased.

In his 6th Report of the Geological Survey of Minnesota, Winchell says that the Loess overlies "the boulders and gravelly clay of the real drift;" in respect of which I may observe that this does not make it later than the minor glaciation, the moraine of which may not have reached to where this occurs, and the Loess may here have been generated during this glaciation on the more advanced moraine of the major. It may, indeed, have been generated on this, here, during the latter part of the major also, as the ice receded; for Winchell adds that there is a gradual change from stony Boulder-clay to Loess *horizontally*. He also says that it is more sandy or clayey according to locality, but that while very thick in some confined valleys, it is thin or wholly absent on some rolling gravelly tracts. This latter agrees with what I have mentioned as to the action in which the material in question has I consider arisen, porous sand and gravel being adverse to it; the material where it covers beds of this kind, as, for instance, in the Somme valley, having slid from contiguous areas favourable to this action, just as the clay over the Alaska ice cannot have arisen from that ice, but must have slid from some contiguous rock area.

Although I am clear that the Picardy loam, the intrusive cave-earth, and the other formations described under the letter γ in my Newer Pliocene memoir, originated in the process I have described; and I think that the *Limon Hesbayen*, and the Rhenish and American Loess must have originated in a similar way, during both glaciations, yet I venture no opinion as to the extraordinary formation of North China, also called Loess. The accounts of its thickness are so staggering, and its origin in this amazing thickness (whether from dust or any other form of terrestrial accumulation, or from freshwater deposit), during the short time, geologically speaking, since the commencement of the Glacial Period (for the remains *said* to occur in it would show this limit in time), is so difficult of realization, that we may judiciously withhold all opinion about it until it has been examined more thoroughly than has hitherto been the case; but as regards the calcareous tubes with which it is said to be permeated,[1] and which are regarded by the supporters of the dust theory as evidence of the roots of vegetation, growing on the surface which was continually under accretion from supplies of dust, it would be well if they, and all who regard small calcareous and ferruginous tubes destitute of carbonaceous matter as indicative of roots, would weigh, and if possible clear up, the phenomena called by the late Charles Moore, in vol. xxxvii. of the Journ. of the Geol. Soc. pp. 71, 79, and 81, *Tubutella ambigua*, and found by him to occur in various formations (including modern brick-earths with freshwater shells); but which, though he thought they were of vegetable origin, occupied positions very difficult of reconciliation with it, as *e.g.* in the material filling deep fissures in the Carboniferous Limestone, and in what, to all appearance, was a mineral vein in the same limestone. These tubes he had submitted to friends, specially versed in various branches of science and natural history, with the result of obtaining from them the most conflicting opinions as to the organic or inorganic, animal or vegetable, origin of them.

In conclusion, I take this opportunity of mentioning that though M. de Mercey, whose minute description of the Picardy loam I condensed in first broaching my view of the origin of the Loess, speaks of this loam being formed of silex grains resulting from the continuous rupturing of the Chalk flints, and as free from any admixture of carbonate of lime, yet as Prof. Prestwich, writing (in the Phil. Trans. for 1860) of the loam (or loess) with angular flint fragments which overlies the gravel of the Somme valley, describes it, in one instance as "very," and in another as "slightly" calcareous, I take it that the escape of the water of the summer sludge laterally along the perennially frozen surface beneath did not altogether remove the calcareous matter by dissolution, leaving only the ruptured flint in grains of more or less minuteness, and in "*éclats*," behind, but that varying quantities of the macerated chalk itself were left to intermingle with the material which there resulted, as Loess, from the disintegration of the flint. As calcareous formations furnish the most favourable pabulum for the material described in my memoir, calcareous matter must often enter largely into the composition of that material.

It occurred to me after my Newer Pliocene memoir was published, that the view I take of the intrusive cave earth with angular fragments being the material thus arising from the annual thaw of the upper surface only of the perennially frozen ground, sliding over the land during the minor glaciation, and finding its way into the caves through fissures in the rock above, was open to the objection that when the material had once penetrated a fissure to a depth corre-

[1] These are said (by Todd and by Broadhead) to occur also in the American Loess, though (according to the former) restricted to the upper 30 or 40 feet.

sponding to that of the perennially frozen ground, it would be perennially frozen also, and its further progress through the fissure arrested; but reflection showed me that the warm air of the cave must have been continually rising through the fissures, and unless these were hermetically blocked must have kept their faces, and the material near thereto, unfrozen, and so allowed its entry to continue every summer.

III.—Joints.

By J. G. Goodchild, of the Geological Survey.

Of the various theories that have been advanced from time to time to account for the origin of jointed structure in rocks, the one that seems to find greatest favour amongst geologists of the present day is that put forth in M. Daubrée's *Études Synthétiques de Géologie Expérimental*, vol. i. p. 300, *et seq.*, wherein their formation is ascribed to the effects produced by torsion. No one can read the account of M. Daubrée's experiments without feeling convinced that the deductions he has drawn will enable us to account for the origin of many forms of joints in a manner that leaves little or nothing to be desired. The mere fact that some of the foremost leaders of geological science at the present day hold views on this subject practically identical with his, will, doubtless, be generally regarded as a sufficient reason for accepting M. Daubrée's theory as one that has supplied a definite and satisfactory answer to the much-vexed question of the origin of joints in general.

But in testing the validity of this theory by a large number of facts, one now and then comes across a case that does not seem to admit of such an explanation in a way that is altogether satisfactory. Such cases are, doubtless, rather to be regarded as exceptional, and as exceptions, they will perhaps be regarded as going to prove the rule itself. But they have to be accounted for somehow, whether they conform to a generally-accepted theory or not; and in attempting an explanation of these apparent exceptions we may chance to light upon some modification of the original view that may prove of sufficiently wide application to cover all the known facts relating to the subject under consideration.

In the present paper it is proposed, after detailing some facts relating to joints of the ordinary kind, to direct attention to a few instances of this exceptional kind, and then to offer for the consideration of the readers of the Geological Magazine one such modification of M. Daubrée's theory as appears in some respects to be more in accordance with the facts yet made known.

Joints vary so much in their mode of occurrence that it is difficult to formulate any definition that will apply to all cases and yet be exact; but the following may suffice for the purpose at present in view.

Joints may be defined as the divisional planes that cut in two or more directions approximately perpendicular to the outer bounding surface of consolidated strata in such a manner and at such distances apart as to divide what would otherwise have been a continuous mass of stone into separate blocks of an angular form. Four types of jointing may be recognized. 1. Prismatic jointing, such as gives rise to the divisional planes developed during the consolidation of certain rocks of metamorphic or of eruptive origin. Under this head is intended to be included the horizontal as well as the inclined joints observable in such rocks as granite, basalt, and others. 2. Shrinkage joints, such as are more obviously due to the contraction in bulk of the rock where they occur. The cracks developed in drying clay exemplify one extreme of this series; while the shattered and splintered character of certain dolomitized limestones, due to the change of dimensions of the rock in passing from simple carbonate of lime to dolomite, will serve as an example of the other. 3. Fault joints, or the prominent set of fissures commonly affecting rocks contiguous to great zones of dislocation. 4. Superinduced divisional planes of the kind ordinarily affecting consolidated rocks of sedimentary origin. For the present purpose these will be distinguished as Rift-joints, and it is their mode of occurrence and their probable origin that it is herein proposed to discuss.

The points of resemblance between joints and cleavage on the one hand and joints and faults on the other are often so numerous that it will be as well to state here some of their leading points of agreement and of difference in order to arrive at a clearer idea of the origin of the structure under consideration.

Taking the case of stratified rocks, in order to simplify the question, we find that as a rule the downward direction of joints bears a definite relation to the planes of bedding, whether the rock itself is inclined from its native position or not. Joints are therefore older than the disturbances that produced the inclination of the rock. Cleavage, on the other hand, bears no such definite relation to the bedding planes, but cuts downward through the rocks at an approximately uniform inclination, even where the rocks it affects happen to be flexed to every possible angle with the horizon. Cleavage is therefore posterior in date to the last great disturbance affecting the beds it traverses. Joints rarely, perhaps never, occur in less than two sets, whose orientation is such as to cause them to intersect each other at large angles. Cleavage, in all but very exceptional cases, is confined to one direction. Joints intersect the bedding at approximately equal distances apart, the distance varying according to the nature of the rock traversed; and the solid rock enclosed between the joint planes exhibits, at the most, only an imperfectly-developed tendency to fracture across the bedding more readily in certain directions than in others. These last planes of weaker cohesion northern masons term the "Bate," and they play a by no means unimportant part in the weathering of rocks, quite as much as in facilitating the work of the stonemason. Joints occur in stony rocks of all kinds, quite irrespective of their composition, their lie, their place in the geological series, or their position on the earth's surface. Cleavage produces a tendency to split in one direction only, and that to an almost indefinite extent, equally throughout rocks of particular constitution, and it does not affect the associated strata whose constitution happens to be different. In the British Islands it is confined, perhaps exclusively, to Older Palæozoic strata; and although jointing may be found all the world over, the geographical distribution of cleavage is irregular, and does not appear to be reducible to any law. Taking the case of the Older Palæozoic strata of the Basin of the Solway, for example; the rocks lying to the south of a line ranging approximately E. and W. through Cross Fell exhibit a tendency to cleavage increasing in degree up to a certain point as the rocks are traced southward; while to the north of that line cleavage gradually becomes less and less perfectly developed, until, as has long been known, it disappears almost entirely on the Scottish side. Yet the evidence of intense compression is much more marked where the cleavage is imperfectly developed than it is to the south of the zone referred to; even though the lithological character of the rocks affected may be identical in both cases. It is instructive to compare with this the uniform distribution of joints within the same area. It is likewise instructive to note, in such cases as that just referred to, that whereas the inclination of the cleavage planes varies to the extent of only a few degrees on either side of the vertical, save in exceptional cases, due to an easily explained cause, the joint planes are evidently as much affected by disturbances as are the planes of bedding themselves. On the other hand, joints are not more fully developed in the case of rocks that have undergone much plication or twisting than they are in rocks that show no evidence of having been disturbed at all. In other words, the extent or degree of jointing is not commensurate with the amount of disturbance the rock has undergone.

It would seem therefore that cleavage represents the effects of some special causes, which have affected particular areas only; while jointing results from some general causes, successively brought into action at every known period of the earth's history, and affecting all parts of the earth's crust alike.

The close relationship between joints and faults has frequently been the subject of previous remark; but as I propose to bring forward a few observations upon the origin of faults in a succeeding communication, I shall do no more than refer to it now.

That forces of a mechanical nature must have had an important share in the production of joints is rendered tolerably evident in many ways. One of the most striking of these is that of the clean cut fracture so often observed in cases where joints traverse compact breccias, or conglomerates, cutting slick through everything that comes in their way. It is common to find, amongst other constituents of such rocks, a big lump of quartz sheared in two by a joint without appearing to be in other respects in the least degree disturbed. The compact conglomerates of the Roman Fell Series, as well as the Brockram of Cumberland and Westmorland, the Hertfordshire Pudding-stones, and others, have long been known as presenting very remarkable instances of this kind.

Regarded as isolated cases, such joints as these would appear to admit of no possible explanation but that of actual shearing of the rock, caused by some kind of torsion similar in its action to that effected by M. Daubrée's experiments. M. Daubrée submitted plates of various substances to torsion, and succeeded in producing sets of cross fractures closely resembling joints in their mode of occurrence. As joints are present in every rock that will not readily change its lateral dimensions without fracture, no matter what the age of that rock, or in whatever part of the earth's surface it may occur, the acceptance of this view would, it seems to me, involve the assumption that every part of the earth's crust, through all geological time, has been uniformly acted upon by earth movements similar in their mode of action to the wrenching described in the account of the experiments above referred to. Whether the results of carefully-made observations upon the earth movements now going on lend any support to the view that such has been the case is a question I must leave for others to answer. But even if it were so, it appears, from the experiments themselves, that parallel sets of fissures could not very well be produced in this way; and even if they could be, it appears certain that, other things being equal, the greater the disturbance any given rock may have undergone, the more extensive should be its system of joints. Besides, every considerable change in the direction of the torsive force should result in the formation of a set of joints to correspond. So far from this being the case, the joints in some of the oldest, and, at the same time, some of the most highly-disturbed strata in the North-west of England, *e.g.* the Pre-Carboniferous rocks associated with the Pennine Faults, show systems of jointing certainly not a whit more complex or more fully developed than the joints occurring in the least disturbed parts of the Carboniferous rocks miles away from such zones of derangement.

Another fact having an important bearing upon the present question is afforded by the disposition of joints in the case of unconformable strata; especially of such unconformities as the field-geologist so commonly meets with in the course of his examination of the Palæozoic strata. Here we often find the newer of the two strata cleft by regular and well-defined systems of joints affecting them uniformly throughout a considerable thickness, and continued downward in many instances to the very base of the series. In such a case we might reasonably expect to find at least the immediately-subjacent strata affected in the same way, seeing that the torsive force must have been exerted through the lower set in giving rise to the joints that extend upwards with so much uniformity in the rocks above. Such community of jointing is, however, by no means of universal occurrence. Taking the case of the Carboniferous rocks of the northern part of England as an example, it is not at all uncommon to find the Carboniferous Limestone lying—over scores of square miles, almost as horizontally as it was originally deposited—upon a surface formed by the upturned ends of many thousands of feet of the Pre-Carboniferous rocks, so that the upper series, horizontal in its lie, oversteps a series of strata presenting a great range of variety in both their lithological character and their angle of inclination. The joints traversing the limestone extend downwards, as is almost invariably the case, at right angles to the planes of bedding, and the action of weathering has shown (as many a long day's work in connexion with them has given me very good reason to know) that the jointing has been developed in these rocks in a very perfect and regular form. There are many instances of fissures extending uninterruptedly downward through a distance of several hundred feet, where the downward flow of surface-water has fretted away the rock along the joint planes, which could hardly have been the case had not the jointing been, on the whole, directed vertically downwards with a certain amount of regularity. The joints traversing the older set, on the contrary, lie at every possible angle, according to the varied dip. That is to say, that in the overstepping series in the case of an unconformity, the joints have been formed quite independently of the joints in the rocks beneath, and nothing more than a local and clearly accidental connexion can be traced between the newer set above the unconformity and the older set below. As the rending of the higher sheet of stony matter must (if I understand the theory above referred to) have proceeded from below upwards, it is difficult to understand how it is that the forces that produced the upper set of joints have not affected the immediately subjacent rocks in the same way. To put the difficulty in another light, seeing that a series of well-developed planes of weak cohesion were already in existence before the joints above the plane of unconformity were formed, one is at a loss to understand how it is that these older joints have not guided the direction of the newer fractures in the same way as happens with faults under like circumstances. As it is, each set of joints seems perfectly independent of the other.

Another fact having some bearing upon the present question is that joints are as well developed in strata left undisturbed in their original position as in the same beds where they are bent into folds. Joints are stretched a little wider apart perhaps, under these last circumstances, but that is about all the difference.

The varied development of joints affecting any one group of strata whose several members differ much in structural or in lithological characteristics, is another point to be considered in connection with the origin of joints. A good instance is afforded by the Upper Yoredale strata in North-west Yorkshire, described by Phillips in his "Geology of Yorkshire," in the same connection. In these the calcareo-siliceous members locally characteristic of this part of the Yoredale series are traversed, in many instances, by a system of neat, fine, joints whose mode of occurrence causes the rock to be divided up into blocks of almost geometrical regularity of form. As the succession changes, something more than a mere difference in the degree of regularity of jointing may be observed. Joints of some kind or other traverse the limestone below, and others, less regular still in their mode of occurrence, affect the sandstone beneath that; but when we come to the shale bands or to any other rock whose constitution admits of the rock as a whole yielding with more or less facility under lateral tension, the joints are usually very imperfectly developed or are absent entirely.

The character of the bedding also affects the mode of occurrence of joints, for whereas in thickly bedded rocks of homogeneous and compact nature joints usually go clean down, without sensible deflection, from top to bottom of each post (or individual bed), in such rocks as present much variety in that respect, there is a very marked tendency towards an interrupted arrangement of the joint planes, giving rise to what masons term "bonding." In other words, instead of the joints extending uninterruptedly downwards through the strata, like the spaces do at the right or the left margin of these lines of print, the joints in one stratum will be found to underlie, or to overlie, an unjointed part of another bed of the rock, in the same way as the spaces between these words here and there underlie, or overlie, as the case may be, a continuous line of type.

The cleat of a coal-seam affords another instance of the same kind, which comes out with much prominence where the coal is devoid of partings and is at the same time associated with shales, or with fire-clay. In this, as in the other cases cited, the development of the divisional planes is directly proportionate to the degree of resistance that any given bed offers to lateral tension. Where the rocks give out readily sideways, the layers slide over each other when they are stretched; but where they are so constituted that they cannot readily change their dimensions in that manner, the rocks give way in other directions.

In speculating upon the causes that have led to the formation of joints then, it appears to me necessary to bear the following considerations in mind:—

(1) They affect every rock that has passed into the stony condition.

(2) Their date of formation in any given case is approximately coincident with that of the consolidation of the rock they affect.

(3) Their degree of development is inversely proportional to the lateral extensibility of the rock.

(4) Their mode of occurrence under given conditions is uniform over the whole of the earth's surface, and throughout rocks of every geological period.

(5) They occur rarely, perhaps never, in less than two sets, whose respective orientations are such as to cause them to intersect each other at angles approaching to right angles, while their downward traverse is approximately perpendicular to the planes of bedding and has affected each bed independently.

Taking these facts into consideration, it appears tolerably certain that while there can be no doubt about joints having been produced by disruption effected by mechanical means of some kind, simple torsion does not appear to be adequate to account for many of the facts in a manner that is altogether satisfactory. The subject needs complete reconsideration with a view to arriving at some explanation that shall be capable of application to all the phenomena yet known in connection with jointing.

One such explanation occurred to me in 1872 while mapping the highly-disturbed and complicated zone of Palæozoic strata associated with the Pennine Faults. After testing the validity of this explanation by the facts coming under my notice in the course of quite nine more years' work among rock of the same nature, and by the study of an extensive series of photographs illustrative of rock structure of other districts I have not been able to visit, I may now venture to offer those views for wider consideration as a contribution towards the discussion that will be needed before the question can be deemed to be finally settled.

The consolidation of rocks, as a rule, is largely dependent upon pressure induced by the accumulation of superincumbent strata: where there is reason for believing that no great thickness of overlying strata has been deposited, strata otherwise favourably constituted for consolidation remain very little more compacted than at the time of their deposition. The Chalk of the South-east of England may be compared with calcareous rocks elsewhere, as an illustration of this point. Or the Tertiary sands of the same area may be compared under the same aspect with beds of similar origin that can be shown to have been at some time or other carried down nearer to the centre of the earth. Any such depression of strata, whether beneath an accumulation of superincumbent sediment or beneath merely the waters of the sea, involves a certain amount of *lateral* compression resulting from the rock having to adapt its dimensions to the smaller space. In the cases where this sideway squeezing of the newly formed rocks takes place under conditions of pressure equal in amount to those caused by the weight above, so that the force of the thrust exerted upon the mass would be about equal in every direction, the rock would be merely reduced in bulk without being much affected in other ways. But where the depression of the strata represents a downward phase of a great undulatory movement of the earth's crust, uniformity of pressure in every direction must be the exception rather than the rule, and the mass would be compressed with greatest force in directions normal to the bounding lines of the area affected by depression during each downward phase of undulation.

Sediment consolidated under such condition could hardly escape being affected by a kind of inchoate cleavage or 'bate' varying in character with the nature of the sediment itself and with the extent and direction of the compressing forces.

In time, another phase of terrestrial undulation reaches the depressed area, and the downward movement by degrees gives place to a movement in the opposite direction. The former condition of things is then reversed. The rocks that had been squeezed into dimensions less than they originally occupied, and had been solidified within these smaller dimensions, are now, as they return towards the surface, subjected to lateral strain equal in intensity, and often also identical in direction with the thrust exerted upon them as they underwent depression. In other words, they were stretched out sideways as much on their way up as they were squeezed in sideways on their way down. Where the separate laminæ were so constituted as to slide easily over each other, they have altered their lateral dimensions in that way without any actual rupture. Where, on the other hand, the rocks were thickly bedded, or otherwise so constituted that they could not so readily adapt their dimensions to the larger space by lateral extension, they have given way at intervals; and they would give way more readily along the planes of weakened cohesion formed by the "bate" than elsewhere—more especially when, as must very frequently have been the case, elevation was only another phase of the same undulation that had formerly given rise at the same spot to depression, and the directions of strain were approximately coincident with the direction of thrust.

It is not meant to be suggested that the formation of joints has arisen through the action of a simple extensible force acting alone. Indeed, it is difficult to understand how any upheaval of the earth's crust could well take place except under the impulse of an upward thrust of some kind or other. And if this thrust acted in the form of a series of undulatory impulses propagated from below obliquely outwards, their effect upon sheets of stony matter subjected to great lateral tension could hardly fail to result in the spacing-out of the rock by a series of joints.

It may be objected to the view here set forth that a succession of earth-movements such as these must, in the end, inevitably result in joints of greater complexity in proportion to the number of times the rock has been affected; and that, as I have myself stated that no certain traces of such effects can be discerned amongst our older and more highly-disturbed strata, the explanation here given cannot well be the right one. The answer to this objection is that, in such cases, the subsequent tension is compensated by a further development of jointing, if one may so express it, in the form of faults, which have filled up the space by wedges of rock broken away from the parent mass along the pre-existing lines of weakness formed by the joints.

Joints in strata that have undergone metamorphism to such an extent that their older lines of weakness have been welded up, as well as the joints occurring in granite and rocks of similar mode of occurrence, present features different in some respects from ordinary rift-joints. But as these special peculiarities have been already, as I think, satisfactorily accounted for by other writers, and there is nothing in their mode of occurrence that militates against the view here suggested, I am content to leave that part of the subject without further mention, and to confine my attention for the present to the consideration of the special form of jointing whose origin it has generally been admitted is most difficult to account for.

IV.—On the Bagshot Sands as a Source of Water Supply.

By the Rev. A. Irving, B.A., B.Sc., F.G.S.;
Senior Science Master in Wellington College.

With the increase of population and the simultaneous pollution of rivers in this country, the question of water-supply for the purposes of human life becomes every year a more serious one.

Among the many schemes which have been advanced for the supply of London with water, it has been proposed by a high authority to bring the Bagshot Sands of the London Basin under requisition. These strata, covering, as they do, a considerable area at no great distance from the metropolis, and being for the most part of a porous character, would appear to form a convenient reservoir of water, since they contain stored up within them a large portion of the rain-water which falls on portions of Berkshire, Surrey, and Hants. The water obtained from these sands, either from surface-springs or deep wells, is free from calcareous hardness, but is highly charged with salts certain of iron, which, by oxidation on exposure to the air, yield an ochreous red precipitate, the nature of which seems generally to be but imperfectly understood. The inconvenience, however, which results, in the turbidity of the water after no great exposure to the air, and the rapid corrosion of iron pipes in which it is conveyed, are facts with which all inhabitants of the Bagshot country are only too familiar. The fact that this property of water drawn from the Bagshot Sands varies greatly according to the portions of those strata which furnish it, does not however appear to be so generally known. Recent difficulties in connection with the water-supply of our own particular district have forced the matter upon my attention; and as I have been able to arrive at some pretty definite results from the investigations in which I have been engaged for several months past, it has occurred to me that, as forming a subsidiary subject to geological science, they may be of interest to readers of the Geological Magazine.

It was from Prof. Geikie's Text-Book that I obtained the first clue, which has led me, I believe, to the true explanation of the green colour, which is so characteristic of a large portion of the sands of the Middle and Lower Bagshot series. The bearing of this upon the question of water-supply will appear as we proceed. My attention was specially drawn to this fact some months ago by the exposure of a section of light green sand (mixed with about 20 per cent. of fine clayey matter, which is easily separated from the sand itself by levigation in water), in the excavation of a small lake-basin in this neighbourhood. The sand in question is an accumulation of mere surface-drift, little more than mere rain-wash, at the head of one of the minor valleys of erosion, which are so common in the Upper Bagshot Sands as to give a distinct character to the country wherever these sandy strata constitute the higher parts of the *terrain.* These sands naturally are of a buff-yellow colour; and the problem was to account for their greenness, when found in such a position as I have just described. The case mentioned is by no means a solitary one: the occurrence of these light green sand deposits has been observed by me in several instances, in similar positions, during the last few years, but from one cause and another the examination of them has been put off till quite recently.

In a paper read during the early part of the summer before the Geologists' Association I gave an account of the causes of this peculiar greenness of sands occurring in such a position, together with the outline of the evidence which had been obtained, which goes to show that the green colour of these sands is due to *decomposed vegetable matter.* In these wild uncultivated tracts, given up to the growth of pine-woods, heather, heaths, ferns, and marsh-plants, the natural drainage is often impeded in those small valleys which I have described by a dense mass of rank vegetation, which has been growing there for ages. In many cases peat has formed in such spots, sometimes as much as three or four feet in thickness; and in every instance in which I have observed it, this green colour of the surface sands occurs below such peaty deposits. Further, this green colour is not destroyed by the action of either hydrochloric or nitric acid; so that it cannot be referred to any of the varieties of green minerals which may be included under such terms as viridite, glauconite, delessite, etc. Slow oxidation reduces the green colour to some extent, as is seen in the effect of the air upon the colour of the sands when they have been spread out upon the surface of the ground for several months; and a similar effect has been produced by drawing air through a small quantity of the sand suspended in water for five or six days and nights continuously. The colour also is partly removed by a powerful oxidizing agent, such as chlorate of potash dissolved in the strongest red fuming nitric acid. The colour is at once destroyed by boiling concentrated sulphuric acid, which, while it entirely removes the green colour, is itself blackened, in some instances becoming as black as ink, by the separation in the elementary state of amorphous carbon from the organic compounds to which the green colour is due. It was at this point that the remarks which are to be met with in Professor Geikie's book on the part played by humic, crenic, and apocrenic acids (products of vegetable decomposition), were found of service. The only information I have been able to obtain in the scientific literature of this country, on the nature of these organic acids, is found in Watts' *Dictionary of Chemistry*; but thanks to the kindness and courtesy of Professor Williamson of University College, who has furnished me with a copious list of references, I have been able to learn more about them from foreign sources, and in particular from that mine of information, Berzelius' *Jahresbericht.* Doubts have been expressed in some quarters as to the existence of these acids; but a perusal of the information given by Berzelius and others leaves no doubt in my own mind of their existence as veritable organic acids. Their actual chemical formulæ may not have been determined with any degree of certainty; but they form with bases well-recognized salts, the most important being those of iron and the alkali metals. Crenic salts are far more soluble in water than apocrenic salts, and as the former pass into the latter to a great extent by oxidation, and the basic iron becomes more highly oxidized, there remains no longer any difficulty in explaining why water charged with them in solution throws down a red ochreous precipitate of iron salts, on mere exposure to the air. Such a precipitate, when boiled in a solution of caustic potash or soda for some time, gives up the greater part of its crenic and apocrenic acids, which form corresponding soluble salts of the alkali-metals; and from these the acids are easily precipitated with acetate of copper, according to the method described in Watts' Dictionary. It may also be stated here that further evidence of their existence as definite acids is seen in the fact that the crenate of copper, which is precipitated, can be dissolved slowly in a hot solution of carbonate of soda or potash; the CO_2 goes off with effervescence, and from the alkaline solution thus obtained the crenic acid is again precipitated as a definite salt of copper in the same condition as that in which it existed before solution.

This replacement of CO_2 by these acids also goes to show that chemically they are more powerful than carbonic acid, and may be regarded therefore by the geologist as possessing even greater power than that well-known acid as a metamorphic agent, though their action must be obviously more limited in its range in this respect. Boutigny has shown that the medicinal waters of Forges-les-Eaux, which are derived partly from a peaty stratum, contain crenic and apocrenic acids as soluble salts, and, on this account, deposit an insoluble ferric compound on exposure to the air, just as the waters drawn from our middle and lower Bagshot Sands do.[1] I have heard it asserted by professional engineers, who have been much occupied with questions of water-supply, that the green colour of the middle and lower Bagshot Sands must contribute to the purity of the water which they furnish, on the supposition that this green matter was iron in a low state of oxidation. This however is a mistake; for (1) the green matter is the result of vegetable contamination, (2) iron in a 'low state of oxidation' is rather a reducing than oxidizing agent, and could hardly therefore act in the way which these gentlemen seemed to suppose.

There can be no doubt that the ordinary methods resorted to by professional analysts leave us still in the dark as to certain qualities of many waters which are pronounced wholesome and 'potable,'[2] though some advances have been made quite recently in these matters. It appears that the analyst considers it beyond his province to investigate the *nature* of the pollution by "vegetable matter" which is sometimes seen noted in analytic returns. It may be that in some of its forms such vegetable pollution of water does no great harm, yet no one would if he knew it drink water drained from a morass. On this point ordinary common sense leads the population of country districts to distinguish and avoid water thus contaminated. Nothing is more common, for example, in the experience of Alpine tourists, then to find themselves, when oppressed with thirst in the high Alps, warned against drinking from a spring of clear, and apparently pure, water. The natives know by experience its

[1] *Vide* Watts' *Dictionary of Chemistry*, 2nd Supplement. See also Julien (Journ. Am. Assoc. Sci. 1879, pp. 336, 337) for a long list of mineral springs in which these acids have been found.

[2] *Vide* paper by C. W. Folkard on "The Analysis of Potable Water," in the *Proc. Inst. Civil Engineers*, January 24, 1882.

unwholesome character. Such water can only be contaminated by vegetable matter; for, except in the immediate proximity of a collection of cattle-stalls, there is no chance of contamination of the water from animal sources. Such springs may be rendered impure either (1) from surface causes, where the water has drained wholly or partly from a morass, as often happens where moraine material or other forms of mountain-débris hold water, or (2) from lignite, peat, or vegetable matter in other stages of decomposition, which may have been imbedded in the strata from which the spring issues.

Just as ordinary human intelligence is to the Alpine peasant a guide in these matters, so it is to the peasantry of this district of Sandhurst. I have been at the pains to collect information on some 50 wells in the district, and have by this means arrived at some interesting results as bearing upon water-supply.

It is well known to geologists that the Bagshot strata admit of a triad division, as was shown some years ago by Prof. Prestwich; but the great difference between the actual character of the Upper Bagshot Sands and that of the Middle and Lower Bagshot Sands and Clays, is not so generally recognized. These differences are mainly: (*a*) the total absence of any continuous clay strata in the Upper Bagshot series, while the Middle and Lower series contain several persistent clay seams, which extend for miles through the country. (*b*) A bright buff-yellow colour is generally prevalent in the sands of the Upper series, the shade of colour generally approaching that of weathered limonite, except where, in parts subjacent to the portions of the surface of the country which have been the seat of the growth of marsh vegetation for ages, the colour is deepened into an ochreous red, which analysis shows to be due mainly to the presence of crenate and apocrenate of iron. The sands of the Upper series may therefore be considered as abounding in hydrated peroxide of iron, while from their distinctly *marine* origin[1] they are free from any admixture of vegetable matter. The iron is easily separated by solution in hot hydrochloric acid, from which it can be reprecipitated by soda.

The Middle and Lower Bagshot sands are of a less pure character. A bright ferruginous sand cannot be said to exist in either of these two divisions of the series. This statement is based mainly upon an examination of the specimens preserved some 20 years ago, when the deep well was sunk at Wellington College. This section I have more fully described in the paper to which reference was made above: it need not then detain us any longer, except to note that as soon as a well penetrates a certain clay-seam (9 feet thick in our well-section), no more bright ferruginous sands are reached; but in place of them we find a series of impure green sands, the green colour in some cases being of as dark a shade as that of green bottle-glass. Such green sands prevail for about 40 feet down. Then we have a series of clays, some of them "pipe-clays," for about 20 feet. Beneath these again the impure green

[1] *Vide* paper by H. D. Monckton, Esq., F.G.S., in Quart. Journ. Geol. Soc., No. 155, for a considerable list of marine forms preserved in the Upper Bagshots.

and greenish sands of the Lower Bagshot prevail for nearly 100 feet, when they give place to clays of the same character as those above. Roughly then say out of 200 feet of Middle and Lower Bagshot strata, there are nearly 140 feet of sands, stained of various shades of green. This green colour is, as I have shown, due to the products of the decomposition of vegetable matter; and it follows therefore that in so far as the presence of such vegetable pollution renders water unwholesome for drinking and culinary purposes, the Middle and Lower Bagshots must be abandoned as a source of water-supply. The light which is thus thrown upon the origin of these Middle and Lower Bagshot strata is also interesting. In the almost entire absence of fossils, we have now distinct evidence of the conditions under which they were for the most part deposited. Slow and probably intermittent as this process of deposition was, it is clear that dense swamps and marshes covered for ages many portions of what is now called the London Basin; since the strata themselves are evidently a series of marsh- shore- and lagoon-deposits. And I prefer to look upon the vegetable matter as originating in this way rather than from marine algæ, because, among other reasons, there is a remarkably low per-centage of chloride of sodium found in the waters which are derived from these strata. Taking the proportions of crenic and apocrenic acids as a general index of the extent to which the products of vegetable decomposition are present in these sands, I find from analyses of separate samples of the sandy strata which make up the series for the most part, that the proportion of vegetable matter present in the sands increases with the depth of the green colour, which characterizes the whole series more or less. These green sands, as well as the green sands of the valley-heads, which I have described above as occurring beneath modern peaty layers, turn black on heating, and give off water with in some cases a distinctly alkaline reaction to test-paper, with in some instances traces of ammonia; on heating more strongly in the air, they lose their organic matter entirely, and are converted into a bright red sand, by the complete oxidation of the iron which is present. The clays (of which there are three principal strata, each of them pretty persistent through the country) assume when dry various shades of black-brown; and these also, when calcined in the air, part with the whole of their carbonaceous matter and assume a light brick-red colour.

The bearing of all this upon water-supply is obvious. The clay-seams prevent the free passage downwards of the water which freely penetrates the Upper Bagshot Sands from the surface; so that a well, which passes through the uppermost or the middle clay-seam, must be supplied with water, which, though perhaps abundant, is necessarily impure, from the fact that it has travelled nearly horizontally, for a distance perhaps of several miles, from the outcrop of the sands to the well. Of course, where wells are dug for a few feet only into these Middle and Lower sands *at their outcrop*, the water may be pure enough; for their proximity to the surface has, through a long period of time, led to the destruction, by the action of free atmospheric oxygen held in solution in rain-water, of the noxious carbonaceous matter with which these sands abound wherever they are buried to to any great depth. All over the district the fact that good water cannot be got if a well penetrates the 'running blue sand,' as they call it, is familiar to every well-digger. In places in this district where denudation has removed all but a few feet of the upper bright ferruginous sands, shallow wells abound, and the water from them is pronounced wholesome as a rule. On the other hand, numerous cases have come to my knowledge, where wells have been sunk into the deeper sands, and these produce a water which, in its smell, its deposit of ochreous and organic matter on standing, and its general unwholesomeness as testified by the experience of the inhabitants, resembles water from a morass.

In one case the cottagers prefer to go nearly a quarter of a mile and dip their buckets in the nearest surface-stream rather than drink water from such a well close to their own doors. In another case, in the parish of Sandhurst, there are three wells on the same premises, the situation of the house being a few feet only above the 250-feet contour-line of the Military Ordnance Map, at about which level the uppermost clay-seam occurs throughout the district. One of these wells is only 10 feet deep, and yields good water; the other two are some 30 feet deep, and have long been disused on account of the unwholesome and objectionable character of the water which they draw from the sands beneath the clay. On the immediate confines of the Wellington College estate are two considerable villa-residences, the grounds of which are contiguous. A well at one of these only 8 or 10 feet deep furnishes good water, while at the adjoining house a deeper well, whose depth is such that it is supplied from the Middle Bagshot Sands, cannot, by all the means that have been tried, be made to furnish good water. But it is of no use to multiply instances, and I shall content myself therefore with citing one more, and that from the estate of Wellington College itself. A great part of this estate (some three-quarters of a mile in extent) is on the ferruginous sands (which, by the way, were included for very little reason by the Government Surveyors in the Middle Bagshot, and mapped accordingly). We have a surface-spring on the estate fed entirely from the ferruginous sands, and this yields, throughout the year, a plentiful supply of pure and wholesome water, which gives no deposit on standing. Analyses of the water from this spring, and from wells on the estate which occupy *the same geological horizon*, show only a mere trace of vegetable matter, not more than a small fraction of what is found in water drawn from the deeper Bagshot strata.

Without going more into details here, we may safely assert that *the whole of the well-water of the district which common human experience pronounces wholesome is drawn from the upper ferruginous sands.*

I have been informed by an eminent sanitary authority that the death-rate of the Sandhurst District is one of the lowest in England, and he used this fact as an argument against the notion of any deleteriousness attaching to vegetable contamination of water from the Bagshot strata, such as I have described. Of course that argument is completely met by the fact that throughout the district in question the water which is found to be wholesome, and is therefore generally used by the inhabitants, is obtained from the uncontaminated upper ferruginous sands, while that derived from the deeper sands is generally avoided. It may be useful here to give some details of the results of two analyses made by a responsible professional analyst (Dr. Shea, of Reading), of two samples of water, one from the upper ferruginous sands, the other from a deep well supplied mainly from the Middle and Lower Bagshot strata :—

	Surface Spring.	Deep Well.
	Water clear; no smell on boiling; no deposit after standing for 24 hours; no débris revealed by microscopic examination.	Turbid; faint smell on boiling; much 'iron' deposited in 24 hours; amorphous matter present (after settling).
	Grs. per gallon.	Grs. per gallon.
Total solids dissolved	13·00	15·75
Volatile on ignition	5·50	5·50
Chlorine	1·75	1·75
Nitrogen	0·12	0·70
Oxygen consumed in three hours	0·028	0·056
Free ammonia	0·015 parts in 1,000,000	0·02 in 1,000,000
Organic do.	0·060 ,, ,,	0·10 ,,

The rather marked amount of nitrogen in the well-water seems at first sight not easy to explain. Such nitrogen is present however only as nitrates. Dr. Shea suggests a distant source in space and time. A knowledge of the character of the deeper Bagshot strata reveals perhaps its real origin. Ammonia (which undergoes slow oxidation into nitrates) has been obtained by Fürst Salm-Horstmar[1] by dry distillation of peat with potash; and it has been pointed out above that the fresh green sands from beneath layers of peat give off in some cases water showing an alkaline reaction to test-papers, and capable of being recognized as distinctly ammoniacal. On the presence of nitrogen as nitrates, it is to be noted further that the great distance at which we are removed in this neighbourhood from all those sources of surface contamination which exist in towns precludes all possibility of these nitrates being accounted for from such causes; while any possible pollution from a grave-yard or cesspools in the adjoining parishes would appear in the water of the upper surface springs, and be effectually shut off from percolation downwards to the deeper strata for reasons before explained. As further evidence of the derivation of nitrogen from vegetation while undergoing decay, I may quote the results of analyses given by A. A. Julien[2] of peat at different depths from a peat-bog near Gutes Jessbach in Holstein, as follows :—

	Ash.	N.	C.	H.	O.
Brown peat from the surface	2·72	0·80	57·75	5·43	36·02
Nearly black peat at a depth of 7 feet.	7·42	2·10	62·02	5·21	30·67
Black peat at a depth of 14 feet	9·16	4·05	64·07	5·01	26·87

[1] Berzelius' *Jahresbericht*, 1842.
[2] Proc. Amer. Assos. Sci. 1879, p. 314.

Of the possible sources of nitrogen in peat and humus Julien[1] points out (1) the direct absorption of nitrogen from the atmosphere by humus during its oxidation, and of nitrous and nitric acids from atmospheric waters; (2) the exuviae and other remains of insects, crustaceans, worms, etc., which inhabit the swamps and morasses in which peat is formed; (3) the direct decomposition of the albuminoid substances found in plants. Each of these may well have played its part in the ancient swamps and morasses of Middle Eocene times, when these highly contaminated sands were deposited.

It has been pointed out above that chemical analysis shows that the sands which are coloured with the deepest shade of green contain the greatest amount of vegetable pollution. This is further borne out by examination of these sands under the *microscope*. The green, dark-green, and black grains are the same in all the sands, but the colouring matter exists only *as an incrustation upon the grains. I have not been able to find a single grain of any green mineral in any of them.* In the sand of the darkest shade of green every grain contributes to the colour of the sand: the lighter shades of green in the other sands depend simply upon the proportion of the green and blackish-green grains to the sand as a whole. These grains are coated, in some instances with colloid green matter, in others with a black opaque substance, the latter not spread uniformly over the surface of the grain, but adhering in numerous small particles to it. This is probably humic acid in combination with iron as a base. These materials form a tenacious glue, which not only adheres of itself to the larger grains, but cements smaller grains to them, giving them the appearance of a very rugged outline. For the most part decoction in caustic potash for several hours extracts the vegetal acids, so that when washed and dried the sand comes out as a very clean quartz-sand, the proportion of rounded grains to angular fragments (often of flint), varying very much in the different sands. Occasionally a hexagonal crystal of quartz, such as are to be seen often lining the hollows of flints, is met with, and in one instance two such crystals were seen attached to a rounded grain of amorphous silica.[2] As the cement is dissolved away in potash, the minute grains are detached from the larger ones, which in some specimens (those originally of the deepest green colour) come out as sharp clear angular fragments for the most part, while in other specimens, where more iron is present, that substance is found forming a thin film of peroxide on the surface of the grains, giving to the sand (originally of a dirty greenish tint) a light shade of red. The black colloid adherent matter of a few of the grains resists the action of the alkali for a long time, and these are seen, after decoction, still encrusted with it. Further chemical examination, details of which would take us beyond the scope of the present paper, has led me to regard this black material as humic acid in combination with iron and with silica, rather than as bituminous matter. Enough has

[1] *Ibid.* p. 317, and the authorities there cited.

[2] Cf. J. A. Phillips Esq., on "Grits and Sandstones," in Quart. Journ. Geol. Soc. No. 145.

been said, I venture to think, to reveal the true cause of the green colouration which is so prevalent in the Middle and Lower Bagshot Sands, and to show that a pure wholesome potable water is hardly obtainable from them without an extensive process of oxidation, which in time converts into water and carbonic acid all the soluble vegetable compounds, which are extracted from these sands by water.

V.—Traces of a Great Post-Glacial Flood.

Part 6. The Evidence of the Rolled Gravels and the Sands.

By Henry H. Howorth, F.S.A.

(*Continued from p.* 368.)

LET us move on again. The rolled gravels of Central and Southern England are divisible into two well-marked varieties, which were well discriminated, as Professor Phillips says, as long ago as 1815 by Dr. Kidd, and separated by him into a hill group and a valley group.

The former of these is the gravel we have just described, which has been largely transported, and contains a large number of foreign pebbles. The other gravel is of local origin and its materials, so far as we know, have not been derived or transported very far. The two gravels are otherwise distinguished in the main by another feature; while the former set are barren, the latter contain the débris of a land fauna in many places in large quantities, whence they have been called ossiferous gravels. Although these gravels are thus differenced, it seems most clear to me that their distribution as they are now found was contemporaneous, and that both were spread out, although not to the same extent, by the same potent cause. This seems to follow from two facts. In the first place they run into one another and dovetail together, passing in places from the one type to the other, as has been shown by Professor Phillips in the Thames Valley, and by others elsewhere; secondly, the same débris of a land fauna which characterize the local gravels are found also in certain localities where the two are in close contiguity in the transported gravels.

Phillips, who uses the term diluvium for the transported gravel, said long ago, "On the eastern side of the island, from the Tyne to the Humber, the gravelly deposits appear partly of local and partly of distant origin. On the Yorkshire coast, local gravel derived from the chalk wolds or oolitic moors, lies in very irregular beds, distinct altogether from the clays full of pebbles brought from the Cumbrian and Pennine mountains; at Bridlington local chalk and flint gravels lie over the other diluvium, and at Hessle, on the Humber, similar gravel lies under it. . . . . It is not solely, nor perhaps even principally, in this proper diluvium (*i.e.* the transported gravel) that the bones of elephants, hippopotami, horses, deer, etc., occur; they seem on the contrary to be rather more plentiful in the local gravel deposits. Cases, however, occur, as at Brandsburton, and at Middleton-on-the-Wolds, near Beverley, of elephantine and other remains in the midst of erratic gravel derived from great distances" (Phillips, Geology, vol. i. p. 279).

Again, he says, "Many parts of England are almost totally free from the accumulation of proper diluvium;—as the Yorkshire Coal-field, the Wealden denudation, large tracts in North Wales, the vicinity of Bath, etc. But these districts contain abundance of local gravel deposits, *which sometimes appear to be quite as ancient as the diluvium*" (*id.* p. 280). A very remarkable fact, to which attention has more than once been drawn, is the limited area in Britain in which the ossiferous gravels occur. Mr. Geikie condenses the facts from Mr. J. Evans most tersely. Speaking of the implement-bearing gravels, he says, "They occur in the valleys of the Ouse, the Waveney, the Thames, the Avon, and their numerous tributaries, and at various places along the Southern coast of England. North of the Ouse, and west of the valley of the Axe, no river gravels have yielded any palæolithic implements." The distribution of the implements is largely conterminous with that of the animals associated with the Mammoth, and beyond the district named they occur very sporadically. How is this?

"How," says Mr. Geikie, "are we to explain this anomalous distribution? It cannot be said that the mammalia may never have occupied the midland and northern districts. The fact that their bones occur frequently in caves that lie far north of the limits reached by the palæolithic beds, shows that the animals were by no means confined to a narrow area in the South-east of England, and the occurrence of the Hippopotamus near Leeds is further proof in the same direction. If the climate was suited to the mammals that swarmed in the South—to elephants, rhinoceroses, and hippopotami, to lions, hyænas, and tigers,—it surely could not have been other than genial in the North of England and Scotland. Yet in neither region do any of these animals occur in the superficial or unquestionable Post-Glacial river gravels." This is most true and very well put. Mr. Geikie goes on to answer his question by supposing that the line of demarcation marks the area submerged during his "great submergence" and thus explains how the ossiferous gravels have disappeared from the area outside the limits above mentioned. This is assuredly a very improbable suggestion. We have shown in the previous paper that not even the marine drifts of Wales supply any proofs of a prolonged submergence, *à fortiori* the barren gravels of Central and Northern England. Again, how can we postulate a submergence of North Wales to the extent of at least 2000 feet, which should be involving a subsidence contemporary with a quiescent condition in the valleys and uplands of South-eastern Britain. Such a contingency is surely most remote and would require very close proof, whereas there is no proof at all. The fact of shreds and sporadic pieces of the ossiferous gravels occurring in Yorkshire and elsewhere is tolerable proof that the mass of the deposit has been denuded; while the further fact that the palæolithic gravels of the south, as Mr. Geikie himself says, are remarkable for their great thickness and for being distributed independently of the present drainage systems, make it probable that since their formation the denuded gravels from the northern areas have been swept into and mixed with the gravels further south, and their place in the north has been occupied by the barren gravels which have come down from the mountain districts of Cumbria, and which were doubtless largely untenanted by the fauna which so abounded on the fertile plains.

Let us now inquire into the lessons furnished by the rolled gravels containing mammalian bones and palæolithic implements. In the first place the notion that they are fluviatile is based on a very small induction. Mr. Flower well says: "As long as it was believed that the implement-bearing gravels were never found except on or very near to the banks of rivers, it was reasonable to attribute to those rivers the transport of the gravel in which they were imbedded; but from more recent observations, both in England and France, it seems evident that the implement-bearing gravels, as well as others of the same character which are not yet known to contain implements, do occur in localities so far removed from existing rivers, and when found near rivers at such elevations as almost to preclude the belief that those rivers, however swollen by excessive rainfall or melting snow or otherwise, could have at all affected their condition" (Journ. Geol. Soc. vol. xxv. p. 458). Again he says: "I may notice that flint implement-bearing gravels have lately been observed in several other localities, on table-lands and hills far removed from any existing river and destitute also of the slightest trace of any ancient river" (*id.* 459). Again, Mr. Flower, speaking of the implement deposit at Brandon, says, "It occurs at an elevation of from 80 to 90 feet above that at Broomhill, which is two miles higher up the stream, and about the same above Shrubhill, which is several miles lower down. Yet notwithstanding this great difference in the levels, we have strong if not unmistakable indications, derived in some measure from the implements themselves, that all these deposits were (geologically) contemporaneous. The implements in each are substantially of the same age and character; the *matrix* of red gravel in which they rest is of the same composition; the beds rest directly upon the eroded surface of the Chalk or the Gault, and are more or less overlain by sands of the same description. But it is incredible that such deposits (if of the same age) should owe their origin to one and the same river; for if so, in order to reach the higher level, it must have been swollen to the height of 100 feet above the level at Broomhill and Shrubhill, and extending three miles to the south. *This would require a volume of water of dimensions and power several thousandfold greater than those of the present river; and to supply such a stream, the basin from which the river is fed* (occupying as it does an area of not more than 300 square miles) is altogether insufficient; nor, indeed, would the present contour of the country allow such a river to flow in that direction."

Again, as he urges, if the fluviatile theory be correct, in order to account for the Brandon and Lakenheath deposits, "we must suppose that this river overflowed at a height of at least 100 feet above the present stream, and afterwards altered its course, and flowed several miles to the north. But this could never have been the case: for just as at Moulin Quignon and St. Acheul the gravel beds described by Mr. Prestwich are not commanded by any higher grounds, and are out of reach of all running water, and of any possible interference from agents in present action, so here they are found at an elevation of at least 80 feet above the source of the river, which is not more than twenty miles distant, and there is no highland in the neighbourhood from which a river capable of leaving such a deposit could possibly have been supplied. It is equally clear that if the waters had been supplied, it never could have reached to the summit of the hills. These immediately overlook or overhang the great level of the fens, which was formerly a considerable valley, much of it having been filled up by peat within a period comparatively recent. Before the river could have attained to a height sufficient to submerge the hills and cover them with its spoils, it must have fallen into the low grounds on either side, and filling up the valley have found its way to the sea, or if not, it would have formed an inland lake. In either case the transporting power of the water would have been lost long before it reached the required level" (Flower, *op. cit.* pp. 458–9).

Mr. Flower, in view of these facts, does not hesitate to invoke as the *vera causa* of the distribution of these gravels the diluvian theory of the French geologists in a passage which I quoted in an earlier paper. Agreeing completely with his reasoning on this subject, I think it well, nevertheless, to support it by opinions offered by others more committed to extreme glacial views than he was.

I cannot accept some of Mr. Skertchly's reasoning on other matters, but in regard to these gravels I fail to see how he can be answered. His testimony is at one with that of Mr. Flower. He says, "I must now turn to the palæozoic (palæolithic is of course meant) gravels and sands of Suffolk. They have been described by many previous writers as confined to the river valleys, and to be, consequently, river gravels. This is no otherwise true than that being (naturally) thicker in valleys than elsewhere, they are there worked and the implements brought to light. In point of fact, however, they spread all over the country quite irrespective of the drainage systems, crossing watersheds, occupying the highest ground, and running down to the lowest; and at points as widely distant as possible from any water-course I have found implements. These gravels and sands are for the most part quite unstratified, and only show signs of stratification in limited areas. They form wide sandy heaths, which are only useful for rabbit warrens. *Every phase in their character shows that they are the effect of great floods sweeping across the face of the country. They have naturally accumulated in greatest force in the valleys, and as it would be impossible but that streams were locally formed, so we find portions showing stratification and false bedding; but these appearances are by no means confined to the river channels.* They are older than much of the present river valley, for the river has cut through them, and the waste so derived has been re-arranged as true river gravel, and in both, palæolithic implements are found, although in the latter case they are often rolled. It seems clear to me that man could not possibly have lived at the time when these great floods swept across the country, but must have been a prior occupant, whose discarded relics were swept up with the other surface matter to form the sandy deposits" (The Great Ice Age, pp. 340–1). So far, I agree most completely with Mr. Skertchly's graphic presentation of the position. I naturally also agree with Mr. Geikie's acceptance of this position. Mr. Geikie speaks of the palæolithic and ossiferous gravels of Southern England as "yielding unmistakeable proof of having been finally subjected to disturbance and reconstruction, a disturbance and reconstruction which were certainly completed before the advent of Neolithic man in Britain. Thus we meet with gravels of the age in question scattered over the whole length and breadth of some districts resting alike on valley bottom, hill side, and hill top—in fact, wrapping the country in a more or less continuous mantle. No river action will account for these appearances. The gravels, no doubt, lie thickest in the valleys, but they sweep up the hill sides, and over the hill tops, into totally different drainage areas." He then goes on to say how he had examined the country round Brandon with Mr. Skertchly and continues, "After we had gone over a considerable area, and noted the wide distribution of the gravels and their anomalous positions, it became evident that, as my friend said, if the gravels owed their distribution to river-action, then the river which scattered them must have been broad enough to cover the whole country like a wide sea. Then, again, no mere river-action will account for the coarse and tumultuous aspect so often presented by the palæolithic gravels. One frequently sees sand, clay, grit, well-rounded stones, angular blocks and sharp-edged débris, all huddled together in the direst confusion—the larger stones often standing on end, and not lying in the position they must have assumed under ordinary river-action." He concludes by saying that he might have entered into further details for the purpose of showing that the ancient ossiferous river-gravels of Southern England have been subjected to some powerful disturbing force since the time of their formation. The explanation of this he remits to Mr. Skertchly, and we have already quoted it (*id.* pp. 505–6).

Again, in another place, after postulating great floods as having resulted from the melting of his ice-cap, Mr. Geikie goes on to say, "To this period must be attributed those tumultuous deposits with occasional palæolithic implements and mammalian remains which are scattered over hill and valley alike in the east midland districts especially. No mere river-action can possibly account for the appearance presented by these confused accumulations, or for the anomalous positions in which they so often occur. *They clearly indicate the flow of immense bodies of water.*" He then goes on to deduce this water from his ice-sheet, and concludes that the result would be "to inundate wide regions with torrential waters. Thus, not only would new accumulations of clay, silt, sand, gravel, and shingle be formed, but the ancient gravels of the last interglacial period (? interglacial, H. H. H.) would be much eroded and their materials reconstructed and huddled together, while whatever lay loose at the surface, whether on hill top, hill side, or valley bottom, would be swept on so as to mingle with the heterogeneous detritus carried forward by the floods" (*id.* p. 534).

Mr. Searles V. Wood, who has done so much work in the elucidation of the surface geology of Eastern England, is also constrained to invoke torrents of water to explain the distribution of the so-called Cannon Shot Gravel of East Anglia; "consisting for the most part of thick beds of flints rolled into the shape and dimensions of the now obsolete cannon shot of from 12 to 32 lbs. calibre." This he attributes to "some local modification of the chalky clay formation by powerful currents, for he says he sometimes found imbedded in the gravels heaps of sand formed almost wholly of chalk grains" (Journ. Geol. Soc. vol. xxxvi. p. 500). He adds as his view that "torrents of water by their torrential character washed out much of the chalky clay in the valley of the Wensum and rolled the great flints in it, into the cannon shot shape." This gravel gradually changes its character as we go eastwards and southwards, becomes finer, the great spherical flints become fewer, and in this finer form spreads widely over South-western Norfolk and North-west Suffolk," covering the palæolithic brick-earths at Hoxne, Brandon, and Mildenhall. From Hoxne the bed increases in thickness and often becomes a thick deposit of only sand which stretches northward and inosculates with the cannon shot form. Mr. Wood, speaking of the loose sheets of surface deposits in East Anglia, refers to "these volumes of water pouring over Norfolk." Again, "The gravel which it (*i.e.* the water) produced by washing out the moraine and the large flints which by its torrential force it rolled into the cannon shot form described, were thus left on the plateaux and brows of the valleys, the largest stones nearest the water source, and the smaller stones and sand carried furthest. . . . . This water denuded the Hoxne brick-earth, forming or enlarging in so doing the lateral valley of the Gold-brook; and as it sank away it left the thin wrapper formed of gravelly sand which it carried over the denuded surface of the brick-earth" (*id.* pp. 501 and 502). This seems to me most reasonable. What I object to is the theory which deduces these floods from the melting of the ice-sheet, which I have already criticized. So much for the lessons taught us by the ossiferous gravels.

Let us now pass on. We have traced a continuity from the marine drifts on the Welsh hills through the so-called middle sands and gravels and the barren inland gravels to the ossiferous deposits of Southern and Eastern England. This continuity is shown to be complete in every detail. When we turn to many of these latter beds in Yorkshire and East Anglia, we find them containing marine shells and debris of a similar facies, and therefore of the same geological horizon as those at Blackpool and Moel Tryfaen. This is familiar enough. This mixture is well exhibited in the well-known Hessle beds of the Yorkshire coast, and in the gravels of the Fen districts.

It is surely a most complete proof of the chain of inference we have moulded, connecting the marine gravels of Moel Tryfaen with the ossiferous beds, that the marine shells in these Hessle beds, which are dovetailed into the ossiferous and Cyrena-bearing gravels, should be of the same types as those found at Moel Tryfaen and Macclesfield, and like them contain no species "but such as now live in the sea surrounding the British Isles, or in that immediately north of the Shetlands." And it is no small support of such an induction to find Mr. Searles V. Wood saying expressly that "the Hessle sand and gravel is the equivalent of the Middle sands of Lancashire" (Journ. Geol. Soc. vol. xxxvi. p. 525). On this point we may refer to another veteran writer on these beds. Joshua Trimmer, speaking of the Boulder-clay and the associated gravels and sands, says: "Notwithstanding the distance which separates the Till of the coast of Norfolk from that of North Wales and Ireland, he recognized a common character pervading the whole, which he attributed to their having *had a common origin*, being derived from the north, and he considered that the cause of the deposit of this Boulder-clay covered with sands, loam, etc., of a yellow colour, *seemed to have acted but once*, the same appearances not recurring" (J. G. S. vol. i. p. 219).

If, instead of turning eastwards, we travel towards the south, we shall find the same continuity established there. It has ever been a mystery that the Thames Valley should be deemed a complete barrier between Glacial and non-Glacial beds. Neither its physical configuration nor its other features will enable us to conceive how it should have been so. We have treated it as such in these papers merely for convenience, but we hold to no such position as a fact. The Boulder-clay no doubt thins out as we go south and disappears; but the Boulder-clay is largely a characteristic of maritime districts, and does not occur in vast typically glaciated areas such as many parts of Northern Sweden. If we put it aside as a local phenomena, and if we consider that the grooved surfaces, etc., which are so characteristic of the crystalline hard rocks in the north could not exist in the soft beds of the south except under very favourable conditions, we shall cease to wonder that there are so few traces of actual Glacial action south of the Thames. This is parenthetical only however. What we are urging now is that the barren and ossiferous gravels of Central England which are marked by triturated pebbles pass more or less insensibly by a gradual introduction of subangular and angular pebbles into the Angular Drift of the English Channel, and thus into the diluvium of the French writers. This has been shown by many observers. In Cornwall and Devon and in Kent the transition may be studied most graphically.

The lessons to be learnt from these southern and transition gravels have been at least outlined by Mr. Belt. "The facts to be explained," he says, "not only in Devon and Cornwall, but over the whole of the South of England, are—1. Gravels containing travelled boulders on the sides and tops of the hills up to about 1200 feet above the sea; 2. Denudation of the surface gravels in an intervening tract between the Upland and Lowland deposits; 3. In the lowlands, especially in the valleys within 100 feet above the level of the sea, a wide spreading out of gravels *that show signs of sudden and tumultuous deposition.* Subaerial denudation could not produce the hill gravels containing rocks brought from a distance. Nor could the deposits lying on the sides of the valleys have been left there during their excavation; for, as we have seen, the configuration of the country dates back at least to early Tertiary times. Water must have been present to form the gravels of Dartmoor up to about 1200 feet above the sea, and also to allow ice to transport the erratic blocks (? about ice, H. H. H.). Was the water that of the ocean or of a great freshwater lake? With respect to the area in question there is this insuperable objection to the theory of marine submergence, that over the whole district no marine beach, and not a single marine organism, has been found, excepting within a few feet of the present sea-level. Nor can sea-shells have once existed in the deposits, and been destroyed; for mammalian remains and land and fresh-water shells are preserved; and any agency that would have obliterated the one, would not have spared the others" (Journ. Geol. Soc. vol. xxxii. pp. 83 and 84). Mr. Belt then proceeds to postulate his great European lake pounded back by an Atlantic glacier, which I have already examined in a former paper. The facts he condenses in the passage above quoted seem to me to be explainable only by the wide-spread flood I have so frequently invoked. To continue, however. If we follow up these southern and transitional rolled gravels, we shall find as we have said the rolled pebbles gradually giving place to angular and subangular ones and, eventually, on reaching the Channel, we find at some points, as at Selsea, and the mouth of the Somme, the same collocation of ossiferous débris with marine shells like those in the adjoining sea, that we have in Yorkshire, and pointing the same moral of continuity. Now these angular drifts of the English Channel we have already devoted a paper to, and claim to have shown that they unmistakably evidence a great diluvial movement.

We have thus glanced at the various deposits of rolled gravel found in England, and which bear superficially only a distant relationship to one another, and shown that they are continuous, and that they all bear consistent testimony to a great flood of water having distributed and arranged them as we now find them.

If we leave England and travel elsewhere, we shall find the position here maintained largely supported. Thus, Sweden is a notable area in which very large districts are occupied by sands and gravels which were doubtless synchronous with the so-called Middle Sands and Gravels already discussed, since in them in certain limited localities, as near Upsala, we find testaceous remains which resemble those still existing in the adjoining seas. Especially do these stretches of sand and gravel occur in the northern provinces of Sweden, those of Dalecarlia, Helsingland, and Jemtland. M. Durocher, a very competent observer, who had closely studied the problem on the spot, long ago said of these deposits, that they bear very evident traces of the action of water. "In many places, especially where the district is most level, there is a continuous stretch of pure sand, sometimes very fine, without gravel or pebbles, and identical with the sand which accumulates on the coasts of granitic regions. In these provinces as well as in Lapland, and on the borders of Norway, we may travel for many leagues over horizontal beds of fine sand, sometimes containing boulders and sometimes having them on their surface." In regard to this sand we can make a curious induction which it is not possible to make in many parts of Britain from the very broken and diverse character of the subjacent strata here. In England we cannot well ascertain the exact provenance of the sands, but in Northern Sweden we may be sure that it has been derived from the disintegration of the granite and gneiss which occupies so much of its surface. Now it is curious that this Swedish sand should, as M. Durocher says, be so singularly quartzose. It contains some grains of felspar and small bits of mica; but these latter are in very small quantities, relative to the quartz and much less abundant than in sands which have resulted simply from the disintegration of granite or gneiss, and which have not been sifted by water (Bull. Soc. Geol. de France, vol. iii. p. 81).

This is assuredly unmistakable proof that ice neither in the form of land-ice or icebergs had to do with the distributing of the sands of Northern Sweden. As M. Durocher says, the immense deposits of sand in Helsingland and Jemtland are unmistakably due to the action of water. Again, if this water had been the sea, and the cause of its presence there mere submergence, we should assuredly have found marine débris in them very largely, whereas they do not occur in the more northern of these districts, nor are these traces of marine débris found at a higher level than 200 mètres, their presence there being explained as we explained them in the previous paper; but the *barren* sands occur, says M. Durocher, at a height of 1000 mètres above the sea-level, and as he justly remarks it follows that if deposited by the sea, it could only have been by an abrupt movement of the strata up and down, which would be a *vera causa* for such a flood as we are arguing in favour of. These sands in Sweden, and also in Norway where they likewise occur, like similar sands in England, are closely connected with the more patent erratic deposits the transported gravels, etc. Sometimes, as here, they occur with intercalated beds of rolled gravel, the surfaces where they join being most irregular in their outline, and causing the beds to thin and thicken out, says our observer, "just like the bands of clay, gravel, and rolled pebbles of the Tertiary (? Post-Tertiary) deposits of the West of France, *which have also been formed by diluvial action.*" The fact of these alternate zones all containing similar erratic blocks proves indisputably their approximate contemporaneity. M. Durocher has no hesitation in assigning the beds he so well describes to the movement of water on a great scale, adding, "If the mind finds it difficult to realize the extraordinary effects which water in violent motion will produce, since we cannot compare its effects with what is now passing under our eyes, we must nevertheless accept the action of water in this phenomenon as a fundamental postulate, as a consequence rigorously deduced from observation. It is no longer an hypothesis, but the corollary of a theorem" (*id.*).

If we turn from Sweden and Norway to Denmark, we have great stretches of what Forchhammer called the Boulder-sand formation, and which answer exactly in their mode of distribution and in other respects, including that of containing, near the sea-board, marine shells like those still living in the adjacent seas. Forchhammer says of these beds that they are always stratified; "but the strata are generally highly inclined, much curved, sharply broken off, and in a word resemble those strata which the greatly disturbed waves now deposit on our coasts" (Journ. Geol. Soc. vol. i. p. 271). Denmark also presents us with evidence of the continuity of these sands and gravels with the loamy deposits of Central and Western Europe, in that they have furnished remains of the Mammoth which so clearly characterizes the horizon of the latter beds which do not occur in Denmark. M. Valdemar Schmidt exhibited at the Copenhagen Congress of Prehistoric Archæology a Mammoth's molar from the neighbourhood of Odense in Funen, and said that in the Museum of Zoology attached to the University were some other teeth of the same animal found in different parts of Denmark (Comptes rendus, p. 31).

After mentioning the existence of similar gravels in North Germany, Mr. J. Geikie has some remarks, all which, save what I have put in brackets, I willingly accept—"When we get beyond the southern limits reached by the Upper Boulder-clay," he says, "we enter a region which was swept by [the] floods and torrents [coming from the *mer de glace*], the turbulent waters sometimes keeping to the valleys, at other times, [when these were choked with snow], overflowing upon the intervening plateaux. In this region, therefore, we often encounter wide-spread sheets of torrential gravels and sands in which may occur bones of the Pleistocene mammals and flint implements of Palæolithic workmanship [the relics of the last inter-glacial epoch]. Occasionally the whole thickness of the superficial covering in these districts is composed entirely of such deposits, but now and again we find them overlying river accumulations of a more orderly nature, in which both Palæolithic relics and mammalian remains may occur in abundance" (Prehistoric Europe, p. 359).

If we go further west-south-west, we come to the vast stretches of gravel and sand in Holland and Belgium. Here we have precisely the same lessons. The rolled gravels contain the same zoological débris as the loamy deposits further south and in their borders the so-called Campinian sands merge and pass gradually into the loams and the so-called diluvium with partially rolled and angular stones.

The fact that the gravels and sands are sometimes found tumultuously massed, in others rudely and confusedly stratified, and in others again with a stratification more regular, is assuredly consistent only with their having been in the arms of a mighty flood of waters which gradually subsided, and thus left various traces of its action. In some places the rude results of rapid and energetic action, in others the traces of more peaceable subsidence. Whichever way we turn, we seem to be able to explain the facts in one way only, namely, by the violent action of water, which, when we consider the continental nature of the phenomena to be explained (proving continuous conditions over wide areas), must have been on an overwhelming scale. Wherever we turn over a vast continent, we find the evidence uniform. The ossiferous gravels of Germany and England, the sheets of sand in Scandinavia, the diluvium in France, the loess in Central Germany, differing in texture and in contents, all merge into one another, all have the same character of mantling the country with continuous deposits independent of the configuration of the surface and of the drainage, and, whether we test them individually or grouped together, point an unmistakable moral, namely, a wide-spread diluvial movement, and there seems to be no possible argument against it save a number of metaphysical phantasms about Uniformity, worthy only, may I say with all deference, of the period when the *à priori* problem of a chimæra disporting itself *in vacuo* was deemed a reasonable subject of Philosophical investigation.

NOTICES OF MEMOIRS.

The Rocks in the Neighbourhood of Plymouth and their Stratigraphical Relations. By Richard N. Worth, F.G.S.

MR. R. N. WORTH, F.G.S., read a paper on "The Rocks in the Neighbourhood of Plymouth and their Stratigraphical Relations," at the recent meeting of the Devonshire Association at Exmouth. Pointing out that there was now abundant evidence of the existence of granitoid rocks in the Channel area off the South Coast of Devon and Cornwall, with which the gneissic rocks of the Eddystone Reef were associated, Mr. Worth traced the influence of these rocks into Plymouth Sound. Portions of the Shovel Reef on which the Plymouth Breakwater was partly founded were asserted to be gneiss; and whether this was so or not, there was ample evidence of metamorphic action on the shore rocks of the Sound, especially on the east, in the immediate neighbourhood of the presumed gneiss; in addition to the evidence of the near presence of such an intrusive granitic boss as that which probably caused the metamorphosis of the Eddystone Reef, and the rocks of the Start Point, which was to be found in the extraordinary displacements and contortions of the Staddon and Bovisand rocks. There was more direct evidence also of the existence of granitoid rocks in the immediate Plymouth district, in a boss of rocks at St. Budeaux, of very limited area, which seemed to form a kind of connecting link between the granite of Gunnislake and that of the Channel, and apparently indicated the existence of a granitic spur from the main granitic axis of the western peninsula.

The confusion into which the rocks of South Devon had been thrown was largely caused by the upheaval of the Dartmoor granite, originating an enormous vertical and lateral displacement, the extreme thrust of which was taken by a rocky buttress occupying what is now the Channel area,—itself probably an active agent. Where these two forces more nearly approached each other, folding and repetition would be most marked; while the widening of the space between the moorland and Channel axes would be accompanied by an expansion of the folds, and lead after denudation to greater irregularity of stratigraphical relationship. It was in the Plymouth district that the Devonian rocks of South Devon were pinched to their narrowest limits; and he believed that they supplied the key to the area generally.

Dividing these rocks into three series—the slates, etc., underlying the limestones; the limestones; and the overlying slates and sandstones;—Mr. Worth again subdivided the lower group into—(*a*) slates with metalliferous veins and elvans; which he called, from the locality of their greatest development, the Buckland and Bickleigh beds; (*b*) slates with interbedded volcanic matter—the Weston and Compton beds; (*c*) purple and green slates—the Mutley beds. All these, with the overlying limestones, belonged to the Middle Devonian; and were to be correlated with the Ilfracombe group of North Devon. Except in the immediate vicinity of the limestone, none of these beds were fossiliferous.

The slates overlying the limestone on the east of the Sound (and practically on the west also) appeared to belong to the Morthoe group. The Staddon and Bovisand grits and associated beds seemed to be faulted down and in all probability represented the Pickwell Down sandstones. Associated with these, but the conditions of association not very clearly made out, were highly fossiliferous slates, in some respects strongly resembling those of South Petherwin.

Mr. Worth suggested that all these groups might be traced folding round the granite in South Devon and East Cornwall; and that detailed mapping would render the connection clear, while without it nothing could certainly be done. However scattered the South Devon limestones might appear, he believed they belonged essentially to one horizon.

Going westward from Plymouth, Mr. Worth believed that there was a well-marked descending series, and that the east of the county of Cornwall only could be treated as Devonian. The existence of Lower Silurian rocks on the South Coast of Cornwall was admitted on all hands; and Mr. J. H. Collins, F.G.S., had adduced what seemed conclusive evidence that Upper Silurians extended across the county, and that the rocks in the mining district of West Cornwall were Cambrian or at least pre-Silurian.

REVIEWS.

I.—Supplement to the Monograph of the Silurian Leperditiæ of Russia; and a Monograph of the Crustacean Fauna of the Eurypterus-beds of Rootziküll in the Island of Oesel in the Baltic. By Fr. Schmidt. In the Memoirs of the Imperial Academy of Sciences at St. Petersburg, 7th series, vol. xxxi. 4to. 1883.

THIS Supplement and the accompanying Monograph constitute the "Miscellanea Silurica," Part III., published by the St. Petersburg Academy, and are valuable additions to palæocarcinology. The author is working also on the Trilobites of the Baltic Provinces (for the first part of this work, see Mem. Acad. 7 ser. vol. xxx. 1882); but in the meanwhile produces the present papers:—1. To explain and illustrate his views of the alliances of the Russian and English *Leperditiæ,* which have been treated of by himself and Mr. T. R. Jones; see the Memoirs of the Academy, ser. vii. vol. xxi. 1873, for the Russian Silurian Leperditiæ; and the Annals Nat. Hist., November, 1881, and March, 1882, for notes on the British and other species; 2. to compare and illustrate his views of the structure and relationship of the *Hemiaspidæ* and *Eurypteridæ,* of which the Island of Oesel yields many specimens from the laminated, dolomitic, Upper-Silurian Limestones of the west coast, particularly in the parish of Kielkond, below Rootziküll. Here the chitinous shells of *Eurypterus* and *Pterygotus* are beautifully preserved; the tail-spines of a *Ceratiocaris,* the cephalaspid shields of *Thyestes verrucosus,* Eichw., and *Tremaspis Schrenckii,* Schmidt, and the shells of the little *Lingula nana,* Eichwald. Other fossils occur as casts only, as *Bunodes lunula,* Eichw., *B. rugosus,* Nieszk., *B. Schrenckii* (*Nieszk.*), *Pseudoniscus aculeatus, Nieszk.,* and *Orthoceras tenue,* Eichw. About 7 versts further to the west, in a ravine near the Gesind Wessiko Maddis, a limestone contains a few Eurypterid remains, and is covered by shales full of *Platyschisma helicites,* Sow., *Leperditia phaseolus,* His., and many minute fish-scales, especially *Cœlolepis Schmidti,* Pander. Elsewhere M. Schmidt has found crustacean fragments in the coral-limestone of his stage K, at Attel to the west, and eastwardly at Magnushof, Uddafer, and Ladjal. He particularly points out that the Eurypterids are not found here in the uppermost Silurian beds, but below others bearing corals, brachiopods, and fish-remains, as M. Schmidt found reason to believe to be the case also in Gothland, and in Podolia; in these localities, however, *Eurypterus Fischeri,* Eichw., is the only known species.

In his new notes on the Russian *Leperditiæ* M. Schmidt offers a revision of the species met with in the Baltic Provinces, with a sketch of their distinctive characters, and of their vertical range. He uses A to K for his new stratal divisions of the East-Baltic Silurian formation, as given in Prof. Grewingk's new geological map of Estland, Livland, and Kurland, and in the introduction to his Revision of the East-Baltic Trilobites. The species treated of are:—

1. *Leperditia grandis*, Schrenck, in K.
2. ,, *baltica* (Hisinger), in I.
3. ,, *phaseolus* (Hisinger), in K.
4. ,, *Eichwaldi*, Fr. Schmidt, in I.
5. ,, *Keyserlingi*, Fr. Schm., in G_3.
6. ,, *Hisingeri*, Fr. Schm., in G.
7. ,, ,, var. *abbreviata*, Fr. Schm., in H.

Excepting *L. grandis*, *phaseolus*, and *Keyserlingi*, these are illustrated anew in plate i.; and in the descriptions at pp. 8–18, the points as to which the author has modified his former views, and those in which he differs from Mr. Rupert Jones, are fully discussed.

At page 18 he redescribes *Leperditia marginata* (Keyserl.) from Petschoraland, and gives some new figures in pl. i. figs. 13–19. *Leperditia Wilniensis*, Fr. Schmidt, from "East Siberia," is newly described and figured, p. 21, pl. i. figs. 20–22; and *L. Barbotana*, Fr. Sch., from the South Ural, is noted from new localities, at p. 22; *L. Moelleri* (p. 23, pl. i. f. 23–25) is a new species, and *L. grandis*, var. *Uralensis*, is also new from the same region (p. 24, pl. i. f. 26–28). Further mention of the Ural species is given at pp. 87, 88, where also var. *lævigata* of *L. Moelleri* is noted. *Leperditia Lindstræmi* (pl. v.*a*, figs. 17–20), and its variety *mutica* (f. 21, 22), *L. Nordenskjoeldi*, n.sp. (pl. i. figs. 29-32), and *L. Waigatschensis* (pl. i. figs. 33*a*, *b*, *c*), are described (pp. 25, etc.) as occurring plentifully in Upper-Silurian Limestones from Waigatsch Island in the Arctic Sea.

The mode of occurrence of the Eurypterids at Oesel, and the history of their discovery and collection, are treated of at pp. 28–31. The *Hemiaspidæ*, represented by *Bunodes lunula*, Eichwald, and var. *Schrenckii* (Nieszk.), *B. rugosus*, Nieszk., and *Pseudoniscus aculeatus* (Nieszk.), are described and figured at pp. 34–46, pl. i. figs. 34–49, and pl. vii. figs. 1–6. In the classification (at pp. 43–46) of the allied groups, the Hemiaspids stand as follows:—

1. { *Palæadæ*, in Walcott's sense [?].
 { *Merostomata*, ,, ,,
2. { *Trilobitæ*.
 { *Hemiaspidæ*.
3. { *Eurypteridæ*.
 { *Limulidæ*.

At pages 46–64 the *Eurypteridæ* are discussed, and the detailed description of *E. Fischeri*, Eichw. (pls. ii. iii. iii.*a*, figs. 1 14, and pl. vi. fig. 7), and *E. laticeps* (pl. iii.*a*, fig. 16; pl. vi. fig. 6), are given in full; and, further, the important Eurypterid genus *Pterygotus*, with its local species *H. Osiliensis*, n.sp., is treated at large at pp. 64–83, pl. iv.; v.; v.*a*, figs. 1–16; vi. figs. 1–5; and vii. figs. 7–11; and some woodcuts.

Ceratiocaris Noetlingi, n.sp. (p. 84, pl. vi. figs. 8, 9, and pl. vii. fig. 12), also from Rootziküll, and mentioned with good reason as being a close ally of *C. leptodactylus*, M'Coy, is an interesting member of this local group of Upper-Silurian Crustacea.

The beautiful and evidently correct drawings in the numerous plates of this work have not been surpassed by any figures of similar fossils, and, with the careful work of Magister Fr. Schmidt, will go far to elucidate the nature, structure, and alliances of the Leperditian Ostracods, and the Pœcilopodous, low Crustaceans occurring in a fossil state, especially in the Upper-Silurian strata.

II.—Lake Agassiz: a Chapter in Glacial Geology. By Warren Upham. 8vo. pp. 26, and Map. (From *Bulletin Minn. Acad. Nat. Sci.*, vol. ii.; printed in advance from 11th Annual Report of the Geol. and Nat. Hist. Survey of Minnesota, under the direction of Prof. N. H. Winchell.)

THREE years ago[1] Mr. Upham announced the discovery of unmistakeable traces of a great Quaternary lake, in what is now the Red River Valley of Minnesota, Dakota, and contiguous British territory, and proposed for it the name of the chief founder of the glacial theory. The results of subsequent explorations, which have not only confirmed the suggestions of the preliminary reconnaissance, but developed many interesting subordinate features, are recorded in the present memoir.

The lowest point in the Mississippi-Red River divide occurs in the west line of Minnesota, in a steep-sided valley 1 to 2 miles wide, and 125 to 150 feet deep, occupied in part by Big Stone and Traverse Lakes. From this point three distinct beach-terraces, at heights above the valley-bottom of 5, 55, and 85 feet respectively, extend north-eastwardly, forming the eastern margin of the far-famed Red River Valley. These beaches have been thoroughly explored and mapped, and level-lines have been carried along their crests for 175 miles, where they enter the impenetrable swamp-forests of Northern Minnesota. Throughout this distance the beaches (particularly the highest) are quite conspicuous, and practically continuous and unbroken. When projected beyond the region thus explored, by means of known altitudes and recorded observations of analogous beaches at various points in British America, these lines are found to include an area of greater length and little less width than Lake Superior. While these terraces are as manifestly wave-built as are those about the lakes to-day, Mr. Upham's carefully measured level-lines have disclosed the significant fact that *the beaches are neither horizontal nor parallel:* all slope southward, and in a degree increasing from the lowest to the highest, and the inclination of all progressively increases from south to north; the absolute inclination of the uppermost in the 175 miles (or 142 miles measured on the meridian) being 125 feet, and its slope increasing from ·4 ft. per mile at the south to ·75, and finally 1·5 ft. per mile at its northern extremity. Medially, the Red River Valley deposits are fine, clayey silts, horizontally stratified; but peripherally these pass into unstratified Boulder-clay, wave-washed superficially, but otherwise identical with that without the shore-lines.

[1] See Geological Magazine, Dec. II. Vol. VIII. 1881, p. 280.

The formation of the beaches is referred to the waves of a lake confined on the south and on either hand by existing highlands and divides, and on the north by the retreating ice-sheet of North America; the deposition of the Red River silts is attributed to the mud-charged waters of the glacial lake; and the excavation of the Big Stone-Traverse gorge is ascribed to the corrosion of the effluent which conveyed its surplus waters toward the Gulf of Mexico—corrosion which was not uniform, and whose temporary cessations are recorded in two shore-lines, while its final termination is marked by the lowest of the beaches. The departure from horizontality of the terraces is referred to the gravitational attraction of the ice-sheet upon the waters of the lake. The late General Warren first observed that the Big Stone-Traverse Valley (with its extension through which the Minnesota River meanders) was manifestly excavated by a great river, and suggested that Lake Winnipeg formerly overflowed into the Gulf of Mexico through this channel; but Mr. Upham justly insists that the recent subsidence of the northern part of the continent assumed in this hypothesis is disproved by the southward inclination of the shore-lines.

The general hypothesis that the superficial stratified deposits of northwardly sloping glaciated regions were laid down and arranged in lakes confined between the ice-front and south-lying divides, was broached and prominently advocated a decade ago by Belt in Europe, and N. H. Winchell in America; and it is to the survivor of these geologists that we are now indebted for the inauguration of the detailed survey by which complete verification of the hypothesis, as applied to a particular region, was rendered possible.

W. J. McG.

CORRESPONDENCE.

SECTION AT HORDWELL CLIFFS.

Sir,—In the discussion upon the paper "On the Section at Hordwell Cliffs from the top of the Lower Headon to the base of the Upper Bagshot Sands," by the late Mr. E. B. Tawney and myself, which was read before the Geological Society, June 20th, 1883, Professor Judd is reported to have said,

"That the paper seemed to be a critical one, and the criticism was rather of the nature of a statement that the authors had not seen what several distinguished observers, such as Mr. F. Edwards, Mr. Searles Wood, Dr. Wright, and others stated they had distinctly seen. He himself had seen a portion of the bed in question. This bed, which had been seen *in situ* by so many observers, we were now asked to believe was only a squeezed-out mass. It was remarkable that one of the authors of this paper [meaning myself] had assisted most of the geologists mentioned above, when either he failed to persuade them that his present view was the right one, or his memory had failed him as to what he then thought on the subject."

Now I wish to assure Prof. Judd that my memory does not fail me, and that I have seen the fossiliferous patch of stuff in question many hundreds of times, just in the same position that Mr. S. Wood, Mr. Edwards, Dr. Wright, and the Marchioness of Hastings had seen it, and I always believed it to be nothing more than a slipped mass, which I subsequently obtained complete proof that it was.

The patch in question when described by Mr. S. Wood was only to be found close to the beach, just above high-water mark and only extending some 20 yards in length and 9 inches in thickness. It was a sandy layer rich in fossils, and naturally it soon became all worked out, and the greater part of it carried away by collectors. It was not until after this that I considered it worth my while to seek permission for opening a pit at the place. This having been obtained, I commenced the work, with some pecuniary assistance from the Marchioness of Hastings, and on the third day I succeeded in finding the bed, from which the fossils had come, *in situ,* just in the sequence as I had always expected to find it, namely, close under the gravel, with all the Lower Headon Freshwater beds below it, showing clearly that all the previous authors were wrong in putting these freshwater beds above it.

The reason why I was unable to convince the geologists named by Prof. Judd is simply this, that although I had stated the opinion I had always held to some of them, yet I had not, at that time, had any means of corroborating my view, inasmuch as I had not then seen the bed in its true position; and it was only by constantly visiting the locality and after much close observation, that I was able to find the proper spot to dig down upon it; but this I eventually did, and ask no credit for it.

I cannot help thinking that Prof. Judd's remarks were quite uncalled for, and I much regret that I was not there to reply, but I did not think it worth while to go to London for the reading of the paper, expecting that on account of the press of papers at the last meeting of the Session there would be no discussion upon it.

The Professor further stated that "the coast had receded greatly at this point." This statement I strenuously deny; and I will undertake to find the very excavation made there by myself more than twenty-seven years ago, which would clearly prove that the coast had not receded since that time. In fact, it is protected by the accumulation of the beach which terminates in the spit on which Hurst Castle stands.

I think it a pity that so much wordy discussion should be raised on a point which could easily be settled on the ground. I have already offered to meet Prof. Judd at Colwell Bay and Headon Hill, and I now again offer to meet him at the Hordwell Cliffs; and if he is as good a geologist as I give him credit for being, I will undertake to convince him of the true position of the bed in question in less than twenty minutes.

The bed in dispute I wish to be distinctly understood to maintain is the marine Middle Headon of the Geological Survey, and equivalent to the Middle Headon of Colwell Bay, Headon Hill, White Cliff Bay, and Brockenhurst in the New Forest. H. Keeping.

Woodwardian Museum, Cambridge.

THE MASSES IN THE CROMER DRIFT.

SIR,—Sir Charles Lyell was misinformed as to his pinnacle at Sherringham having disappeared in 1864, for my first visit to the Cromer coast was in August of that year, and I saw it and drew it in my note book. I also well recollect it.

The woodcut of it first appeared in a paper by Sir Charles in the Phil. Mag for May, 1840 (p. 367), where he says that chalk flints are *scattered somewhat irregularly through it.* This is not the character of the chalk itself, but is exactly that of the reconstructed chalk (moraine), which forms hills flanking the Lincolnshire Wold. Although this part of his description was omitted by Sir Charles in subsequent publications, his cut in all of them shows the pinnacle as having from base to summit on the left side, and part of the way up from the base on the right side, numerous angular stones—presumably these scattered flints—distributed through it.

I must leave Mr. T. M. Reade's other objections to be answered by the general case shown in the Memoir on the Newer Pliocene Period, which from my having pointed out therein the great error into which he had fallen as to the elevations in Norfolk, and the consequent failure of such inferences as he drew from it, gave rise to this correspondence. SEARLES V. WOOD.

14th August, 1883.

OBITUARY.

WILLIAM MOLYNEUX, F.G.S.,

BORN MAY 22nd, 1824; DIED OCTOBER 24th, 1882.

WILLIAM MOLYNEUX, the subject of our present Memoir, was born at Nuneham Courtenay, Oxfordshire, a village on the banks of the Isis, where he received his first instruction. At an early age he was taken into the establishment of His Grace the Archbishop of York, where his education was advanced by Miss Harcourt, a sister of the Archbishop. He developed a taste for poetry and in 1853 published a volume of poems and some other works of a similar nature. In 1855 Mr. Thomas Jackson (private secretary to the late Duchess) obtained him employment under the late Duke of Sutherland, at Trentham, Staffordshire, where he resided six years. He wrote a Guide to "Trentham and its Gardens" in 1857, and commenced with Mr. Garner, F.L.S., his geological studies, and with that gentleman and Dr. Barnard Davis, F.R.S., he assisted in the exploration of several Romano-British Barrows.

A paper was read before the North Staffordshire Field Club, in 1866, by Mr. Molyneux, "On the Gravel Beds of Trentham Park," with an account of the fossils collected by Mr. Molyneux, drawn up by the late Mr. J. W. Salter, A.L.S., F.G.S. In 1859, Messrs. Garner and Molyneux communicated a paper to the British Association for the Advancement of Science at Aberdeen, "On the Distribution of Organic Remains in the North Staffordshire Coal-field," which was highly commended by Sir Philip Grey-Egerton, Bart. In 1860 Mr. Molyneux, communicated a paper to the Meeting of the

British Association at Oxford, "On Fossil Fish from the North Staffordshire Coal-field."

In 1861 he left Trentham, having been appointed Secretary and Librarian to the Mechanics' Institution, Stafford; and his collection of Fossil Fishes was purchased for the Museum of Practical Geology, Jermyn Street, London.

In 1864 Mr. Molyneux was elected a Fellow of the Geological Society of London, and was entrusted with a grant from the British Association to draw up a "Report on the Distribution of the organic remains of the North Staffordshire Coal-field;" this Report extended over two years and appears in the 34th and 35th volumes of the Association for 1864–65. In this latter year he also became a member of the British Association, and regularly attended its annual gatherings as long as he remained in England.

In 1867 Mr. Molyneux communicated a short paper to the Geological Magazine, "On the Gravel Beds of Trentham Park," Vol. IV. p. 173. On leaving Stafford he next (through the kind assistance of Mr. Darling) was engaged as resident agent to the late Marquis of Anglesea, at Burton-on-Trent. In 1869 he published an important work on "Burton-upon-Trent; its History, its Waters, and its Breweries"[1] (the preparation of which had occupied his spare time for three years). The work gives the rise of Burton and the development of the brewing trade, together with the geology of the district and the origin of its water-supply, on which the staple article of its wealth depends. Mr. Molyneux also published a pamphlet on "The Old River Courses and the Recent Floods of the Trent Valley at Burton-on-Trent"; suggesting means for the prevention of these disastrous inundations. It was about this time that his attention was more particularly directed to the promotion of Coal-mining in connection with the opening up of the Cannock Chase Collieries, being successful in the promotion of two companies, to one of which he acted, *ad interim*, as Secretary. The unprecedented success of the coal and iron industries about this time and the enhanced value of mining stock gave him then a cheering prospect of worldly success and prosperity; but unfortunately he did not realize his shares, and later on their value became depreciated by heavy calls, which he was unable to meet, and his chance of good fortune seems never to have returned.

Early in 1880 he left England, to assist Mr. F. North, who had just been appointed by the Government of Natal to make a survey of the coal-fields of that Colony, but the engagement came prematurely to an end through some misunderstanding soon after they landed.

Fortunately at this juncture he was engaged by the Corporation of Durban to examine and report on the Durban Borough lands, and to ascertain their nature, extent and resources, and the geological deposits composing them. He also reported on the water supply of the Borough of Durban. He was subsequently engaged, through the influence of Sir Bartle Frere, Bart., G.C.B., F.R.S., by the Government of the Cape of Good Hope, to Survey and Report on

[1] London: Trübner & Co., 1869.

the geology of the Karoo and Stormberg. This Report was presented to the Cape Legislature in 1881, and forms a most important and valuable contribution to our knowledge of the geology of this interesting district.

When in Natal he made arrangements to purchase a farm, and in the autumn of 1881 he returned to England for his wife and family and sailed for Natal to take up his residence at Inchanga. But the farming proved too severe and laborious for his constitution, and not so profitable as he had been led to hope and expect. He therefore undertook an exploration in the Orange Free State and the Transvaal, to report on the mineral resources of those countries. On the return journey he made an examination of the Dundee Coal-field, which resulted in the formation of a company to work the coal and iron there. Returning to Durban, he took a severe cold, fever and dysentery ensued, and after three weeks' illness he died in his 59th year. His remains are placed near those of Thomas Baines, F.R.G.S., the African traveller, in Durban Church Cemetery.

He leaves a wife and eleven children, three of whom are still infants.

The following is a list of papers published by Mr. Wm. Molyneux, F.G.S., late of Inchanga, Durban, Natal, and formerly of Burton-upon-Trent.

On the Coal Strata of North Staffordshire, with reference particularly to their Organic Remains. British Assoc. Reports, 1859. (Joint paper with R. Garner.)

Remarks on Fossil Fish from the North Staffordshire Coal-Fields. Brit. Assoc. Reports, 1860.

Report on the Distribution of the Organic Remains of the North Staffordshire Coal-Field. Brit. Assoc. Reports, vol. xxxiv. 1864; and 1865, vol. xxxv.

On the Gravel Beds of Trentham Park. Geol. Mag. Vol. IV. 1867, pp. 173-174.

On the Occurrence of Copper and Lead-Ores in the Bunter Conglomerates of Cannock Chase. Brit. Assoc. Reports, vol. xlii. 1872. (Proc. Sects. pp. 116-117.)

On the Occurrence of *Aviculopecten* and other Marine Shells in deposits associated with Seams of Coal containing Salt-water in the Ashby Coal-Field. Brit. Assoc. Reports, 1877.

The Cheadle Coal-Field (History of Cheadle), 1881.

(*A*) Papers read before the North Staffordshire Naturalists' Field Club:—1. "On the Gravel Beds of Trentham Park" (1866). 2. "Notes on Connemara" (1868). 3. "The Geology of Lilleshall," etc. (1872). 4. "The Rhætic Beds of Needwood Forest" (1874). 5. "The Water Supply of Staffordshire" (1876). 6. Presidential Address (1879). 7. "The Pre-Norman History of Repton" (1877). 8. "The Geology of Dovedale" (1878). 9. "On the Bunter Conglomerate of Cannock Chase" (1878). 10. "Bosworth Field" (1880).

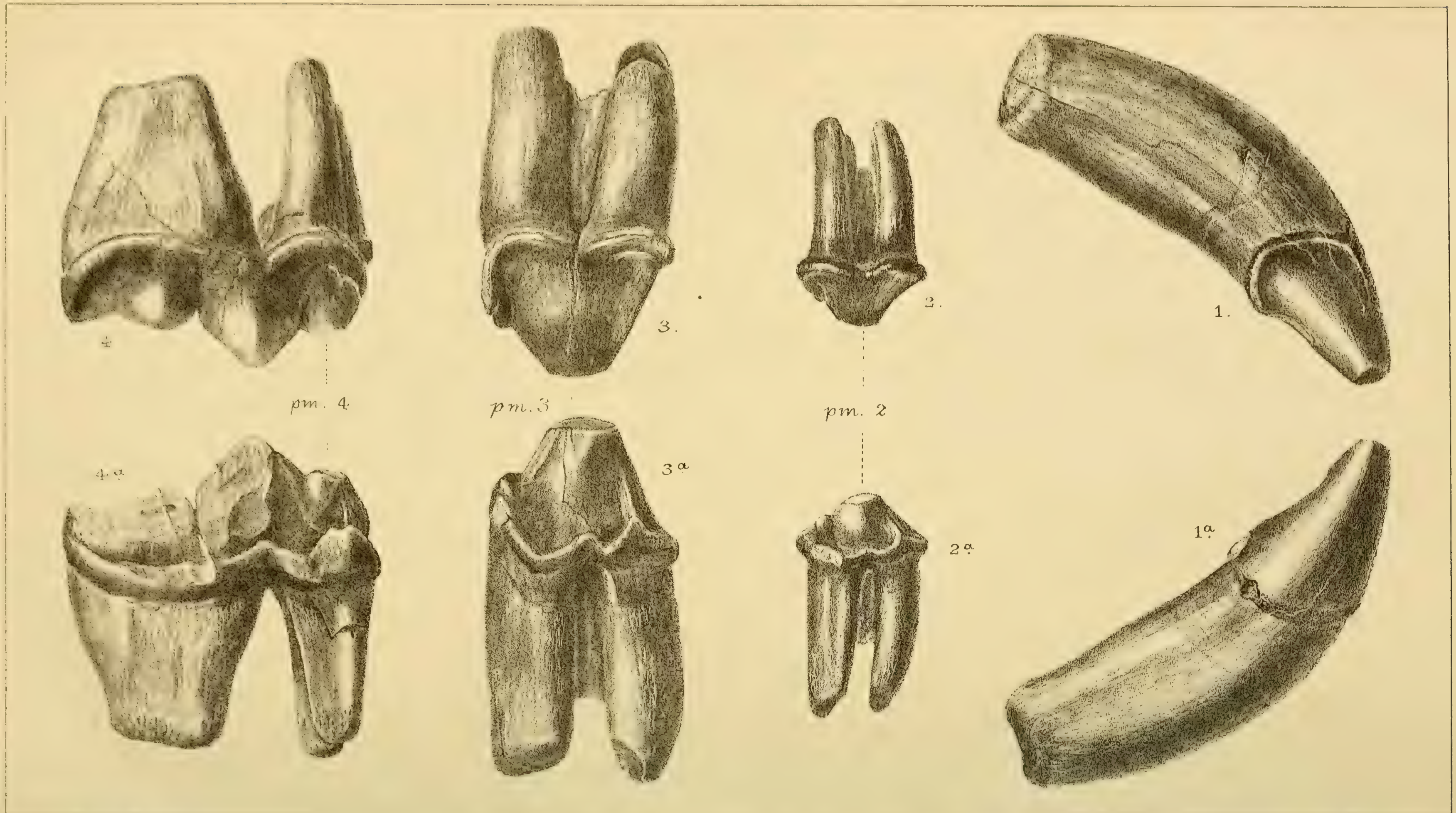
(*B*) Papers read before the Midland Scientific Association:—"On the Fossils of the Lower Coal-Measures of North Staffordshire." "On the Calcareous Hæmatite of the Churnet Valley." "Notes on the Fossils and Antiquities in the History of Burton-on-Trent."

Separate works:—

"Burton-on-Trent: its History, its Waters, and its Breweries." By William Molyneux, F.G.S. (London, 1869. 8vo. pp. 268. Trübner & Co.)

"Report on the Geology of the Karoo and Stormberg." By Wm. Molyneux, F.G.S. Presented to the Cape Legislature, and ordered to be printed. Cape Town, 1881.

A pamphlet on the "Conservancy of Rivers." (8vo. 1879, Bellamy: Burton-on-Trent.)



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HYÆNA CROCUTA, var. SPELÆA.

from the "Forest Bed" of Corton Cliff.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. X.

No. X.—OCTOBER, 1883.

ORIGINAL ARTICLES.

I.—On the Occurrence of the Cave Hyæna in the "Forest Bed" at Corton Cliff, Suffolk.

By E. T. Newton, F.G.S.,

of the Museum of Practical Geology.

(PLATE X.)

During some excavations which have lately been carried on by Mr. J. J. Colman, M.P., at Corton Cliff, Suffolk, a number of Mammalian teeth were dug out of the "Forest Bed," and these specimens, at the suggestion of Mr. James Reeve, of the Norwich Museum, Mr. Colman has very courteously allowed to be sent to me for examination and description.

A few teeth of *Rhinoceros Etruscus* and of *Cervus* accompanied the series of four upper teeth of *Hyæna* which form the subject of the present communication (see Plate X.).

Although the remains of Bears have been so frequently met with in the East Anglian "Forest Bed," yet indications of other large land-carnivora have only rarely occurred; and as far as I am aware, the following are all the specimens known from deposits of this age, namely,—the *Machairodus* tooth in Mr. Savin's collection; the distal end of a fibula closely resembling that of a Tiger, in the Jermyn Street Museum; the portion of a feline (?) humerus found by Miss Lucy Martineaux; the piece of a Glutton's jaw in Mr. R. Fitch's possession; a fragment of a Fox's jaw in the British Museum; a doubtful humerus of Wolf in the King collection, and a piece of a Marten's jaw in the Jermyn Street Museum. These being all the remains of carnivora known from the "Forest Bed," the series of teeth obtained by Mr. J. J. Colman are therefore a great acquisition, as they enable us to record the occurrence of another interesting genus and species in these deposits.

These teeth include a left upper canine, and the second, third and fourth upper premolars of the right side; they are of a very dark colour, the enamel being jet black and highly polished. The enamel of all the crowns, especially of premolar No. 3, shows vermiform granular wrinkles. The teeth are in a very perfect state of preservation, but the points of all the cusps have been worn down to flattened surfaces, as is usual with Hyæna's teeth that have been in use for some time. The greatest length of the canine is 61 millimètres. Seen from the front, the fang is straight; but the crown is curved inwards. A ridge of enamel runs up the hinder surface of the crown, and a second is seen at the front towards the inner side. A slight guard at the base connects these two ridges across the inner side (Fig. 1); while on the outer side no guard is to be seen (Fig. 1*a*).

The second premolar has a very obtusely conical crown, with a cingulum all round its base, except at the middle of the outer side (Fig. 2). The anterior ridge is well marked, but has no accessory cusp; but there is a distinct additional cusp on the posterior ridge.

The third premolar has a strong cingulum all round the crown, except at its outermost part, where it can only just be traced (Fig. 3). The anterior ridge is placed quite at the inner side of the crown, and at its base the cingulum rises up to form a distinct tubercle, which is separated from the ridge by a notch. The posterior ridge is short, because the hinder accessory cusp rises high towards the apex. A very decided groove marks off this cusp from the rest of the crown.

The fourth premolar has a strong cingulum on the inner side of the crown (Fig. 4*a*), and just an indication of it at the base of the anterior outer cusp, but there is no trace of it along the outer surface. The anterior tubercular cusp occupies the anterior fifth of the crown, the second cusp has nearly twice the height and twice the antero-posterior extent of the first; and occupies the second and third fifths of the crown; a deep cleft separates this from the hinder two fifths, which are occupied by a pair of confluent cusps.

Measurements of the teeth in millimètres, and decimals of an inch.

	Canine.		Premolar 2.		Premolar 3.		Premolar 4.	
	mm.	inches.	mm.	inches.	mm.	inches.	mm.	inches.
Length of crown from before backwards.	17·5	(·69)	17·0	(·67)	24·2	(·95)	40·	(1·57)
Width of crown...............	13·0	(·51)	13·0	(·51)	17·3	(·69)	22·	(·87)

A comparison of these teeth, with those of the Cave Hyæna, leaves no doubt as to their specific identity; but seeing that the recent *Hyæna crocuta* has teeth which, with the exception of being smaller, present the same characters, it becomes a question whether the *H. spelæa* is a distinct species or only a larger variety of *Hyæna crocuta*. Prof. W. Boyd Dawkins (Nat. Hist. Rev. vol. v. p. 80, 1865) discussed very fully the dental characters of the various species of *Hyæna*, both recent and fossil, and came to the conclusion that the *Hyæna crocuta* and *Hyæna spelæa* were only varieties of one species. The name of *H. spelæa* was, however, used for the fossil forms, as it was also in 1869 (Quart. Journ. Geol. Soc. vol. xxv. p. 192), but in 1880 (*Ibid.* vol. xxxvi. p. 398) this name is replaced by that of *H. crocuta*.

Professor Busk, in the Report on the Exploration of Brixham Cave (Phil. Trans. vol. clxiii. p. 581, 1873), expresses the opinion that the identity of the Cave Hyæna with *H. crocuta* "cannot as yet be said to have been absolutely proved." At the same time Prof. Busk fully appreciated the close resemblance between these two forms. Seeing then that the close relationship of the Cave and Spotted

Hyænas is generally acknowledged, and that no characters can be shown to exist by which they can be separated, excepting their size, it seems best to follow Prof. Boyd Dawkins, and to regard the Cave Hyæna as merely a large variety of the *H. crocuta*. Consequently, as the *Hyæna* teeth from the "Forest Bed" cannot be distinguished from those found in the Caves, they also are regarded as a variety of the *Hyæna crocuta.*

Fortunately there is no doubt in the present instance as to the horizon from which these teeth were obtained. The foreman of the works, Mr. W. Spurgeon, is positive as to the teeth having been dug out of the clay at Corton Cliff, and my colleague, Mr. J. H. Blake, who knows the beds of this locality so well, has no doubt as to the clay in question being the "Forest Bed," and the teeth themselves have the colour and mineral condition of fossils from this horizon.

EXPLANATION OF PLATE X.

Teeth of *Hyæna crocuta*, Zimm., var. *spelæa*, Goldf., from the "Forest Bed" of Corton. All figures natural size.

FIG. 1. Left upper canine seen from inner side.
,, 1*a*. ,, ,, ,, from outer side.
,, 2. Right upper premolar 2 from outer side.
,, 2*a*. ,, ,, ,, 2 ,, inner side.
,, 3. ,, ,, ,, 3 ,, outer side.
,, 3*a*. ,, ,, ,, 3 ,, inner side.
,, 4. ,, ,, ,, 4 ,, outer side.
,, 4*a*. ,, ,, ,, 4 ,, inner side.

II.—ON SOME BRECCIAS AND CRUSHED ROCKS.

By Prof. T. G. BONNEY, M.A., F.R.S.

PROFESSOR HUGHES in a brief but very valuable paper in the July Number of this MAGAZINE calls attention to a class of breccias of so much importance to the geologist that I am tempted to make a summary of notes that have been accumulating for some years and present it by way of a supplement. These breccias, produced *in situ* by mechanical forces, and subsequently modified by chemical, are very liable to mislead the student, and it is on this account (having myself been so misled in former, and often puzzled in recent years), that I call attention again to the subject—of what perhaps sufficient notice is not generally taken in text-books of geology.

"Fault rock," as it is sometimes called, is indeed mentioned, but these other breccias, though due to a somewhat similar cause, are rather slighted; yet the latter are of great importance because of their resemblance, macroscopic and microscopic, to rocks of a true fragmental origin. I have not had the opportunity of examining in the field the breccia which Prof. Hughes describes, but from specimens which I have seen and from the circumstances of the case have no doubt that he is quite right, and that this St. Davids breccia cannot be used as marking an horizon in the granitoid rock.

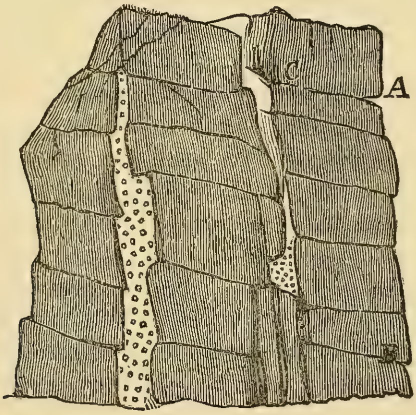
Breccias of this kind, to which we might give the names of "crush breccias" (remembering that occasionally they may be due rather to "strain"), are produced (like fault breccias) by mechanical forces, but differ from them in some respects. The latter occur in the immediate neighbourhood of an obvious dislocation of the rock-masses and cut more or less athwart the general lines of bedding (where these can be observed). The former, however, not seldom retain a general parallelism with the bedding, though of course there are cases in the more uniform massive rocks where it is exceedingly difficult to be sure as to the precise cause of the formation. A crush breccia in short occurs along a plane at right angles to the direction of maximum pressure, while obviously a fault breccia which does not begin to form until disruption has taken place under strain is more nearly in the direction of pressure. The circumstances of the case also will often cause greater displacements of the fragments and give it a closer resemblance to an ordinary breccia, from which however it is generally distinguished without much difficulty unless the fault happens to be small.

The "crush breccia" appears to be the result of some accidental local weakness in a rock generally uniform—a portion yields to the pressure, and the equilibrium being once destroyed a lenticular mass is crushed *in situ*—the fragments—and this is important to remember (for Professor Hughes' test cannot always be readily employed)—being sometimes turned about and relatively displaced. These breccias vary in size, but very commonly the fragments have diameters from an inch or two downwards. They may, however, be very small—say from a mustard seed to mere dust. In this latter case, of course they are most of all perplexing, but, commonly speaking, by patient work with the microscope the relations of the fragments and the true nature of the rock are to be discovered.[1] Some beds of schist apparently interstratified in more granitoid rocks, as I have already pointed out in more than one paper, are of this origin. In some cases, however, the crushing has taken place near a fault, and is in connexion with it; but still the rock resulting is of the type which I am describing. These crush breccias (including the minute forms) so far as my experience goes, are especially common in the oldest rocks, and in the more granitoid varieties of them. I have examined numerous specimens from the Scotch Highlands, collected by Drs. Callaway and Hicks, by Prof. Lapworth and myself. They occur in the massive gneisses of the Alps (I suspect very frequently the lenticular schist bands apparently interbedded are thus produced, but I have not yet had time to work out microscopically a considerable collection made both during the present summer and in previous journeys). This breccia in the St. Davids "Dimetian" (undoubtedly a very ancient rock, whatever its true nature may be) is another case. I once found a breccia near the top of the North Hill, Malvern, which I have now no doubt is another case, and it would be easy to increase the list. It must be remembered that very commonly micaceous, chloritic, and other minerals have been subsequently developed, which enhance the resemblance to an ordinary schist.

[1] Mr. Clough once sent me some remarkable instances from granites in the Cheviots.

Many of the serpentine breccias are thus formed. This rock is a brittle one, and seems to crush readily. Instances are frequent, but the most notable case has already been described by me in this MAGAZINE (Vol. VI. Dec. II. p. 365), at the quarries near Levanto. Here there could not be a doubt as to the nature of the breccia, although specimens might be selected here and there in which the fragments were in great confusion, and no one, who had not examined the rock *in situ*, could have determined its origin. I had no doubt that a breccia of lherzolite in a mass of that rock in the Ariège was of the same kind; and think it possible that the same origin may be assigned to a very singular breccia containing fragments of lherzolite and crystalline limestone which occurs in that neighbourhood. As however I could not in the time at my disposal find this *in situ*, I am unable to express a positive opinion.

"Crush breccias" also occur in sedimentary rocks. Some years since, I observed a very curious case in a slaty rock near the Pont Napoleon, St. Sauveur (Pyrenees). First, in a bedded slaty to arenaceous rock, occurred a number of narrow, nearly vertical, bands filled with a rather sandy-looking material, separated by wider bands—from $\frac{1}{2}''$ to $1''$ across and $6''$ to $8''$ long—of the normal dark calcareo-argillaceous rock. They closely resembled worm tubes—and at first I inclined to this opinion—but a little further down it became evident that they were only joints which had been made to gape, and then filled up by pulverized matrix and mineral infiltrations. A little lower



Incipient brecciation in slaty rocks near Pont Napoleon. The granulated portion consists of more arenaceous material in part squeezed up from below, but probably in part fragmental.

down occurred a further displacement, as in the diagram, where *A B* is the direction of the joints already mentioned, filled as above described —in part apparently, a squeezing up of a more sandy bed below, and a new set of separation planes were developed parallel to the line *A C*. These as a rule did not gape, but one fragment had often slipped over the other. Yet nearer the bridge "the joints were more irregular, not seldom those parallel to *A B* were curved in form, the fragments were more displaced, twisted and pulled about so as closely to resemble an ordinary breccia." From what I saw some years since, I now think it extremely probable that the noted brecciated limestone, uncovered since 1858 by the retreat of the Upper Grindelwald Glacier, is a crush breccia.

It may, however, be worth mentioning that another form of breccia is not uncommon to massive limestones, which we might call a "contraction breccia." Excellent examples of this will be seen in the Carboniferous Limestone of the Meuse, and in the polished slabs now so commonly imported from that region into this country. Here, though "crush" or "strain" breccias also occur, I have no doubt that many have been produced by contraction of the mass in drying, with subsequent recementation by infiltration. If a mass of wet rock be elevated and thus by natural drainage deprived of its contained water, very considerable loss of volume may be the result, which under certain circumstances may lead to the mass cracking and even breaking up *in situ*. Subsequent depression and percolation of water with mineral matter in solution would cement these fragments into a solid rock. The formation of a 'septaria stone' is an analogous case.

It is, however, needless to go on adding examples. Enough to say that 'crush breccias,' large and minute, are far from uncommon, especially among the most ancient crystalline rocks, and very puzzling, especially from their simulation of true bedding, whether of coarse fragmental material or fine streaky bands, more or less schistose, so that the student will do well to bear in mind Professor Hughes's cautions. It may, however, be added that in no case which I have examined is there the slightest trace, macroscopic or microscopic, of any melting of the rock. I have never been able to discover any fact in nature which gives the least support to the late Mr. Mallet's ingenious, but (as I hold it) erroneous hypothesis on the cause of volcanic action.

III.—On Eskers or Kames.[1]

By T. V. Holmes, F.G.S.

THE gravel mounds and ridges known as Eskers or Kames are, though conspicuous where they do occur from the variability of their outlines, very irregularly distributed in the districts in which they are found. Having been familiar with eskers in Cumberland, I was asked by Mr. H. B. Woodward to visit him at Fakenham this spring for the purpose of seeing whether certain ridges and mounds in the neighbourhood of Glandford and Blakeney were such as are called eskers in the north. And I found that Mr. Whitaker had also met with ridges of doubtful character a little west of Great Massingham. Having just had, accordingly, the advantage of visiting both the localities mentioned, in the company of Messrs. W. Whitaker, H. B. Woodward, and J. H. Blake, this seemed a good opportunity of introducing the subject of eskers to the Norwich Geological Society. The extreme irregularity of their distribution is well illustrated by the fact that not one of the gentlemen named had

[1] A paper read before the Norwich Geological Society, May 1st, 1883.

hitherto met with any esker-like ridges in East Anglia. As eskers are far more numerous and varied in Cumberland than in Norfolk, I will first give some description of those of Cumberland and afterwards refer to the ridges of Norfolk.

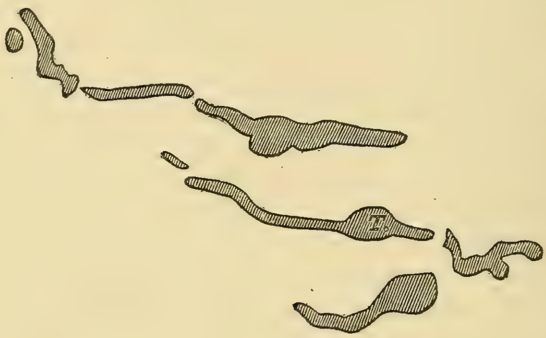
Eskers may be defined as ridges and mounds of gravel and sand which owe their existence and, in the main, their shape, to their having been heaved up by the action of water in the positions in which they are now seen. Of course they often owe something to circumdenudation, but a good section across an esker ridge contrasts in the most striking way with one across a mere gravel outlier. For whereas the latter would show nearly horizontal bedding, or a slight tendency to a basin shape, an esker has evidently been heaped up as a bar or sandbank is heaped up at the mouth of a river, the beds having a general dip from the centre towards the sides. A good illustration of an esker section is given in Prof. A. H. Green's "Geology for Students," 2nd edit. p. 472.

In Cumberland, north of the lake country, eskers are very common in particular spots, though many square miles of country are entirely devoid of them. Perhaps the most striking peculiarity of eskers is their irregular and unaccountable distribution. They may be seen in Cumberland at any height above the sea below 800 feet; possibly they may be found still higher. In one spot they may make the highest ground within a radius of two or three miles from their centre, in another, six or seven miles away, they are absent from the top of a plateau and present in the valleys around it. While in a third place, at no great distance, they may abound at much greater heights than exist in the other two areas, and be found indifferently on hill and in valley. In two places they are more especially concentrated, the neighbourhood of Brampton, and the country about midway between Abbey Town and Allonby. The first-named locality is from eight to ten miles eastward of Carlisle, the second about sixteen miles W.S.W. of that city. They abound on the Scottish side of the Solway about Cummertrees and north of the town of Dumfries. In Cumberland the eskers about Brampton and between Abbey Town and Allonby form compact areas of ground. Elsewhere there may be esker mounds and ridges, but each mound or ridge is an outlying patch. But in the two places mentioned a great number of these ridges and mounds are connected together by sand and gravel of similar character.

The Brampton esker tract is the higher and larger of the two, and lies mainly between 300 ft. and 700 ft. above the sea. Between How Mill and Brampton Stations the Newcastle and Carlisle Railway traverses this esker district, and so does the branch line to Brampton town. The Mote Hill is an esker, and eskers surround the little lake called Talkin Tarn. Peaty flats may be seen here and there enclosed by esker mounds. This esker tract dies away as a compact area about Naworth in the valley of the Irthing, on the north, and near Cumwhitton towards the Eden Valley, on the south. But isolated mounds may be seen here and there some miles above Naworth in the valley of the Irthing, and south of Cumwhitton in that of the Eden. And many others may be seen west of Brampton, towards Kirklinton and Irthington.

The Abbey Town and Allonby tract is at a much lower level than that of Brampton. Its base is from 30 to 50 feet above the sea, and the eskers rise to a height of 156 feet. And whereas the Brampton tract has higher ground on its eastern side and lower towards the Solway, that between Abbey Town and Allonby occupies the highest ground in its immediate neighbourhood, and descends both on the north-western and south-eastern sides to the level of the broad alluvial or peaty flats, which average about 30 feet above the sea. Many small peat mosses may be seen here and there in hollows in this as in the other esker tract, and where sections exist, the heaped-up formation of the ridges is more or less manifest.

North.



T = Torkin.

Fig. 1.—Esker Ridges near Crofton Hall, Cumberland (T. V. H.)

Scale—an Inch to a Mile.

Of the assemblages of isolated ridges and mounds, no better examples can be given than those on the east and north of Crofton Hall, six or seven miles S.W. of Carlisle. On the north side of Crofton Park one rather insignificant ridge suddenly swells out both in height and breadth and forms the well-known conical wooded hill called Torkin (see Fig. 1). On each side of Torkin the ridge rises perhaps 15 ft. to 20 ft. above the ground on each side of it, while Torkin reaches a height of about 70 ft. Sudden expansions of this kind are by no means uncommon among eskers. These eskers do not occupy the highest ground in their neighbourhood. Their bases average about 100 ft. above the sea, while much of the Lias plateau close to them on the north is more than 200 ft. But there are no eskers on the high land in this locality. In Cumberland the drift which covers almost all the surface forms ground with gentle, regular undulations and is not quite so flattened in contour, for the most part, as in East Anglia. But esker ridges are often as steep-sided as railway embankments, and the whole aspect of a district abounding in them contrasts very strongly with that of an eskerless region. As whole parishes are quite free from them, and they occupy but a very small proportion of the surface of North Cumberland, the appearance of a single esker mound in an otherwise eskerless district is apt to suggest to the antiquary the existence of a barrow rather than that of a natural eminence. But though the antiquary suffers an occasional disappointment from this resemblance, these ready-made barrows seem, on the other hand, to have occasionally been used as burial-places.

Previous to my recent visit to Mr. Woodward, the only hills I had ever seen in Norfolk at all resembling eskers were the Lighthouse Hills at Cromer, Beeston Hills, and some others between Cromer and Sherringham. A glance at Mr. Clement Reid's sheet of coast sections, however, shows most of these eminences to be simply hills of circumdenudation, not heaped-up esker mounds. But on the west side of the villages of Blakeney, Wiveton and Glandford, between Sherringham and Wells, Mr. Woodward showed me some ridges and mounds of the true esker type.

North.

Fig. 2.—Esker Ridges near Blakeney, Norfolk (H. B. W.)
Scale—an Inch to a Mile.

The most conspicuous of these ridges is that which appears to be called "The Downs," and extends for a distance of about two miles in a N.W. and S.E. direction (see Fig. 2). A section across this ridge, close to the spot at which it is crossed by the Blakeney road, showed the gravel of which it is mainly composed to be irregularly heaped up, and its whole aspect is that of a typical esker ridge. The other eskers are rather mounds than ridges of any length. Another section was pointed out by Mr. Woodward, about a mile south of the Downs, which showed the same irregularly heaped-up arrangement of gravel as the Downs section. Coarse gravel appeared to predominate in each case. The contrast between the contours of the esker and those of the eskerless country is almost as striking in this part of Norfolk as it is anywhere in Cumberland. Some very esker-like gravel and sand was pointed out to Mr. Woodward and myself by Mr. Whitaker, between Great Massingham and Roydon Row, the day after our visit to Glandford. The best example of an esker-like mound in this locality is on the north side of the road from Great Massingham to Roydon Row, and about half a mile eastward of Congham Common. The eskers hereabouts are found almost wholly in the valley near the road, the higher ground being almost free from them. Near Glandford, on the other hand, they stand high and usually cap the hills.

British eskers are most common in districts abounding with ordinary Glacial Drift, and appear to date from about the close of the Glacial Period. The evidence, as regards Cumberland at least, seems to me in favour of the supposition that at the close of that period the whole area was submerged, with the result of the conversion of much of the Till or Boulder-clay into gravel, usually more or less earthy. On the emergence of the district some of this earthy gravel was entirely removed, while the earthy matter was washed out of part of the rest, and the clean gravel and sand here and there heaped up into esker mounds and ridges; the positions of the latter at the time of their formation having been analogous to those of the various bars and sand banks now forming off our coasts. The distribution of eskers, and the presence of hollows without outlet in the midst of esker tracts, seem to me to be explainable only on the supposition that eskers result from the irregular heaping up of material in shallow seas or estuaries from the action of diverse currents. Both Profs. A. H. Green[1] and James Geikie[2] remark that these curious hollows cannot possibly be due to the action of rain and rivers, and the late Prof. Beete Jukes[3] states that the outlines of esker mounds and ridges "are not due to mere denudation, but, as shown by the external structure of the mounds, have usually been produced at the same time as the mass of the sand and gravel was deposited." Nevertheless an attempt was made by Mr. J. Durham (Geol. Mag. 1877, pp. 8–13) to show that though the materials of the Kames of Newport, Fife, are of marine origin, their shapes are due to rain and rivers, the sea having produced simply a plain of marine denudation. His explanation of the existence of the hollows without outlet in these Newport Kames is as follows:—"The pools are found in oval-shaped hollows, separated from each other, as well as from the drained areas, by comparatively trifling barriers; their oval hollows are the wider parts of the miniature valley of some vanished streamlet, while the barriers which block up their ends, and so form them into basins, are the narrower parts of the valley partially filled up by gravel washed down from its banks, the narrower parts being of course much more readily filled up than the wider." It seems to me that this view of the production of the contours of an esker tract by the agency of rain and rivers may rank with that once commonly held of the marine origin of escarpments, as an equally instructive example of what invincible determination on behalf of a favourite agency can effect where zeal is untempered by discretion. I think the best answer that can be given to the rain and rivers view is a brief account of the eskers of a region strikingly different from Great Britain in physical geography and climate—the coast of Peru and Bolivia.

For the following notes on the eskers of the western coast of South America I am indebted to my cousin Mr. J. J. Winder, who has resided many years in Peru and Bolivia, chiefly at Tupiza, in the

[1] Geology for Students, 2nd Edit. p. 472.
[2] Great Ice Age, p. 247.
[3] Manual of Geology, Jukes and Geikie, p. 710.

latter country. In addition to my trust in his statements as those of a good and careful observer, I have the more confidence that the ridges he has described to me are true eskers and not merely curious effects of circumdenudation, from the fact that his attention had been drawn to the subject just before visiting them by the perusal of a paper on eskers by the late Dr. Robert Chambers. The first esker district to be described is that between the port of Pisco and the town of Yca, in Peru. The eskers stand on a plain of marine denudation, which has a very gentle slope from the mountains to the sea, extends from the north of Peru to the borders of Chili, and is known as the desert of Atacama. They consist of high ridges and mounds of shingle mixed with sand. Mr. Winder remarks:—"That they are true eskers can hardly be doubted, as in some places where sections exist the shingle is clearly to be seen heaped up as though by the force of opposing currents." These ridges have a general east and west direction, and the roads or bridle paths to the interior usually run along their tops, crossing from one to another when necessary. As the ridges tend to converge towards the mountains and to diverge from each other towards the coast, the traveller towards the interior does not cross from one to another till he has arrived at a considerable distance from the shore. The reason for having the roads on the tops of the ridges is not merely the advantage of a better view, but the superior firmness of the ground. The district is almost perfectly rainless, and the only streams running through it result from a periodical melting of the snow on the mountains, and are dry most of the year. The only subaerial denuding power is that of the prevailing southerly winds which blow a considerable amount of sand from the esker ridges into the spaces between them. Consequently the ground between the ridges is so soft as to offer almost insurmountable obstacles to man and beast where more than a very short distance has to be traversed. These esker ridges sometimes rise to a height of more than 200 feet above the plain on which they lie.

Another district in which Mr. Winder has noted eskers is that between Cobija and Calama, a few miles south of the boundary between the coast of Peru and that of Bolivia. Here the shore is not low as about Pisco, but bold and rocky. The path from the coast-town of Cobija towards Calama is through a rocky gorge beginning about five miles from the port. After ascending this gorge about twelve miles, the traveller finds himself 2000 feet higher than he was at the other end of it, and emerges into open ground which has the appearance of a recently elevated sea-bottom. In two respects the eskers of this district differ from those of the other; they are much smaller, and their general direction is not east and west, but north and south. They are also much closer together. Travelling eastward is rendered much more laborious here than in the northern district through the unfavourable direction taken by the ridges. "It is very difficult," Mr. Winder remarks, "to give any general description of the district, as it is simply a desert in which there is often a distance taking two days' hard riding to traverse between places at which water may be obtained. Besides it is absolutely necessary to keep to the road or track, for if you leave it progression speedily becomes impossible. The undisturbed ground is covered by a dry salt scum, chiefly consisting of nitrate of sodium, which breaks with the weight of a mule and allows her to plunge almost up to her girths in soft sand and shingle." These eskers are visible a few miles from Miscanti, a post house on the river Loa, which turns to the north-west and forms the boundary between Peru and Bolivia. Near Miscanti the country becomes considerably changed, for though the desert of Atacama extends many leagues eastward, the road at Miscanti is on lava-covered ground, through which the river runs in a narrow trough with perpendicular banks. It is always full to the brim, and very deep and dangerous. A little vegetation may be seen on its banks, the result of the moisture arising from the evaporation of the water.

The long strip of country called the desert of Atacama is everywhere composed of sand and shingle with a crust of nitrate of sodium ($Na\ NO_3$) on the top. Much more nitrate of sodium—and in some places borax—is usually discovered on digging. The wonderful dryness of the air, and the entire absence of rain since the elevation of this tract of country above the level of the sea, could not be better attested than by the general diffusion of this substance, which is deliquescent in moist air and dissolves readily in water. There can thus be no doubt that these South American eskers owe their shape and distribution entirely to marine action, excepting only the slight modifications of form that have been caused by the southerly winds.

The similarity between the eskers of these rainy British Isles and those of the rainless coast of Peru, in almost every respect, clearly points out that the influence of rain and rivers has had nothing to do with the formation of either, and has modified their present shapes only in the slightest degree. Indeed, the chief difference between the British and Peruvian eskers appears to consist in the grassy covering given by our moist climate to ours, and its absence from those of Peru. It may possibly be thought by some persons that the evidence brought forward with regard to British eskers sufficiently testifies to their marine origin apart from the Peruvian testimony to the same effect. But the paper on the Kames of Newport from which I have quoted shows that geologists are by no means unanimous on this point. And it is worth notice that the only opposition to Mr. Durham's view, in the Geol. Mag., came from Mr. D. Mackintosh, whose remarks,[1] though sound and to the point, would be considered by many readers to come from a somewhat extreme believer in marine as compared with subaerial influences, and consequently not receive the attention they deserved. Most of us remember the time when our President, Mr. Whitaker, became one of the chief champions of the power of rain and rivers to form escarpments, against certain geologists of more or less eminence who believed, "not wisely but too well," in the denuding

[1] Geol. Mag. 1877, p. 94.

power of the sea and of little but the sea. And we all recognize in geology a tendency to the excessive invocation of an agency which like that of rain and rivers, or glacial action, has become potent to explain much that before its rise seemed almost beyond explanation. But this tendency, like all tendencies to excess, requires guarding against. The Peruvian testimony on the subject of eskers may therefore be valuable in other ways than that of showing conclusively the power of the sea alone to form these strange ridges, unaided by either rain or rivers. For it is possible that there may now be some danger of unjustly disparaging the powers of the sea, just as some years ago there was a tendency to a gross exaggeration of their influences.

IV.—Synopsis of the Genera and Species of Carboniferous Limestone Trilobites.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE XI.)

HAVING published in the Palæontographical Society's Volume for the current year the first part of my Monograph on the Trilobites of the Carboniferous Limestone, it occurred to me that a brief account of the species described might prove useful to some of the readers of the Geological Magazine.

I have prefixed a note on a pygidium of a new Trilobite which has since come under my notice, which I believe belongs to the genus *Proetus*. Should any of my readers possess new and undescribed forms of Carboniferous Trilobites, they will greatly oblige me by placing them in my hands to be figured and described in the second part of my Monograph.

I intend also to give a list of all the species of Carboniferous Trilobites hitherto described, both British and Foreign.

The Family *Proetidæ* was originally proposed by the late Mr. J. W. Salter (Pal. Soc. Mon. 1864, p. 2) to comprise the four genera *Proetus*, *Phillipsia*, *Griffithides* and *Brachymetopus*. The first-named genus had not until lately been recognized from the Carboniferous Limestone, but the three latter genera have only been found in that formation.

M. Barrande has suggested that Dr. Sandberger's genera *Trigonaspis* and *Cylindraspis*, from the Devonian of Nassau, also belong to the genus *Proetus*. Prof. Dr. Ferd. Roemer has also figured and described four species of *Proetus* from the Harz, and Messrs. Meek and Worthen have named a species of *Proetus* from the Lower Carboniferous series of Jersey Co., Illinois, so that *Proetus* seems to have a much wider range than the other genera, and serves to connect the otherwise detached group of Mountain Limestone forms with their relatives in the Devonian and Silurian formations.

I.—Proetus, Steininger, 1830.—The general form of the body is oval; the trilobation very distinct, through the entire length of body; the head is less than a third of the total length; the pygidium is rather longer than the head; the head-shield is always surrounded by a border consisting of an exterior raised rim and an inner groove or furrow; the border is sometimes prolonged into a spine at the angle of the free-cheeks. The posterior margin of the head is formed by the grooved and furrowed border of the free-cheeks on each side and by the two basal lobes, and the neck-lobe, which are separated from the glabella by a very distinct and deep furrow; the neck-lobe is broader than the free thoracic somites which follow it; the glabella is usually rounded and gibbous in front, but does not overhang its anterior border. (Barrande states that there are three pairs of short lateral grooves on its surface, although not always to be distinguished.) The axal furrows which surround the glabella are very distinct; the facial suture (which divides the fixed-cheeks from the free-cheeks) crosses the frontal border just in a line with the compound eye, above which it expands, forming a rounded palpebral lobe, then passing down close to the line of the axal furrow, it diverges outwards and crosses the posterior border obliquely behind the line of the orbit. The free-cheek is triangular, its surface is convex, and upon the highest point is placed the large compound reniform eye, which sometimes exhibits a faceted surface or is quite smooth according to the state of its conservation.

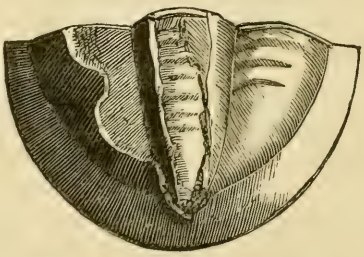
Free thoracic segments varying from 8 to 10 (*Proetus Barrandii*, Roemer, Devonian, Harz, has 8 somites; 9 and 10 is the common number for the Silurian species). The axis is always strongly arched, and does not exceed the pleuræ in breadth; the breadth of the axis diminishes very gradually to the posterior extremity; the pleuræ are more or less bent at the fulcral point, and have their extremities either pointed or rounded and their anterior margin faceted for rolling up.

The pygidium varies in its elevation, but the axis is always raised above the margin and diminishes to a blunt extremity, leaving a smooth border beyond; the number of coalesced segments in the tail-shield varies (Barrande says from 4 to 13 in species found in Bohemia); the pleuræ do not extend to the margin of the pygidium, which is often smooth.

The surface of the test is most frequently smooth or finely granulated; in a few species it is striated, and rarely it presents a combination of both kinds of ornamentation.

Proetus? levis, H. Woodw. sp. nov.

Phillipsia Brongniarti?, Baily, 1875. Mem. Geol. Surv. Ireland, Expl. Mem. Sheets 102 and 112, 2nd ed., p. 19.



Pygidium of *Proetus? levis*, H. Woodw.
Carboniferous Limestone, Moneenalion, Co. Dublin. Enlarged nearly twice natural size.

Cephalothorax unknown.

Pygidium:—22 mm. broad and 16 mm. long; smooth, semicircular, one-fourth broader than long, axis convex, 7 mm. wide, one-third the breadth of the pygidium at its anterior border, smooth, moderately elevated, axal furrows broad; where decorticated showing evidence of the coalescence of about 12 somites or rings, 12 mm. long, tapering to a blunt extremity, which does not reach to the posterior margin, but leaves a smooth border 4 mm. wide behind it; pleuræ slightly convex, very indistinctly furrowed, margin entire, smooth, broad; general surface smooth and destitute of ornamentation of any kind, save a simple rib-like furrow and ridge where the pygidium unites with the free thoracic segments.

Formation:—Carboniferous Limestone.

Locality:—Moneenalion Commons, Upper; Co. Dublin, From the Museum of the Geological Survey of Ireland, Dublin. Kindly lent by Prof. E. Hull, M.A., LL.D., F.R.S., Director.

The specimen here described is the same recorded by Mr. W. H. Baily, F.L.S., F.G.S., M.R.I.A., Acting Palæontologist to the Geological Survey of Ireland, in the Explanatory Memoir to Sheets 102 and 112 (p. 19), as "*Phillipsia Brongniarti*," and was obtained from the Upper Limestones on the south side of Dublin, at Moneenalion Commons Upper, about one mile S.E. of Castle Bagot (Sheet 111). In the Explanation to Sheet No. 111, Mr. G. V. Du Noyer wrote (p. 21), "The general aspect of the limestone varies between that of a palish and a dark-gray compact rock; it is usually very fetid, and contains layers of chert, while the shales are not so common as in the black beds at the bottom part of the group."

"Some beds are very fossiliferous, and the Trilobite (*Griffithides*) is not uncommon in them; others consist almost entirely of crinoid fragments, large *Productæ* occurring sometimes in layers."

The specimen under consideration is imbedded in dark (almost black) fetid crystalline limestone, full of crinoidal fragments and of Brachiopoda.

A careful comparison of this specimen with the pygidium described by Phillips (formerly called "*P. Brongniarti*," but now placed in the genus *Griffithides* under Phillips's original name of *obsoletus*) has satisfied me that they cannot possibly be placed together.

"*Ph. Brongniarti*" = *G. obsoletus* compared with *Proetus levis*.

(*a*) Axis of pygidium nearly equal to half the breadth.	(*a*) Axis less than one-third the entire breadth.
(*b*) Axis extremely gibbous.	(*b*) Axis but little elevated.
(*c*) Pleuræ very convex.	(*c*) Pleuræ almost flat.
(*d*) Axis and pleuræ very distinctly annulated.	(*d*) Axis and pleuræ very nearly smooth.
(*e*) Pygidium one-fourth broader than long.	(*e*) Pygidium one-third broader than long.

The fact of this abdominal shield from Co. Dublin being so unlike any one belonging to *Phillipsia* or *Griffithides*, led me to compare it with those of other genera, and I was at once struck with its resemblance to the pygidia of *Proetus*. Seeing that Messrs.

Meek and Worthen have applied this generic appellation to a Carboniferous Trilobite from America, there cannot, I think, be any very great objection to its use here.

The pygidium is certainly new, and agrees better with that of *Proetus* (e.g. *P. latifrons*) than with any other genus with which I am acquainted.

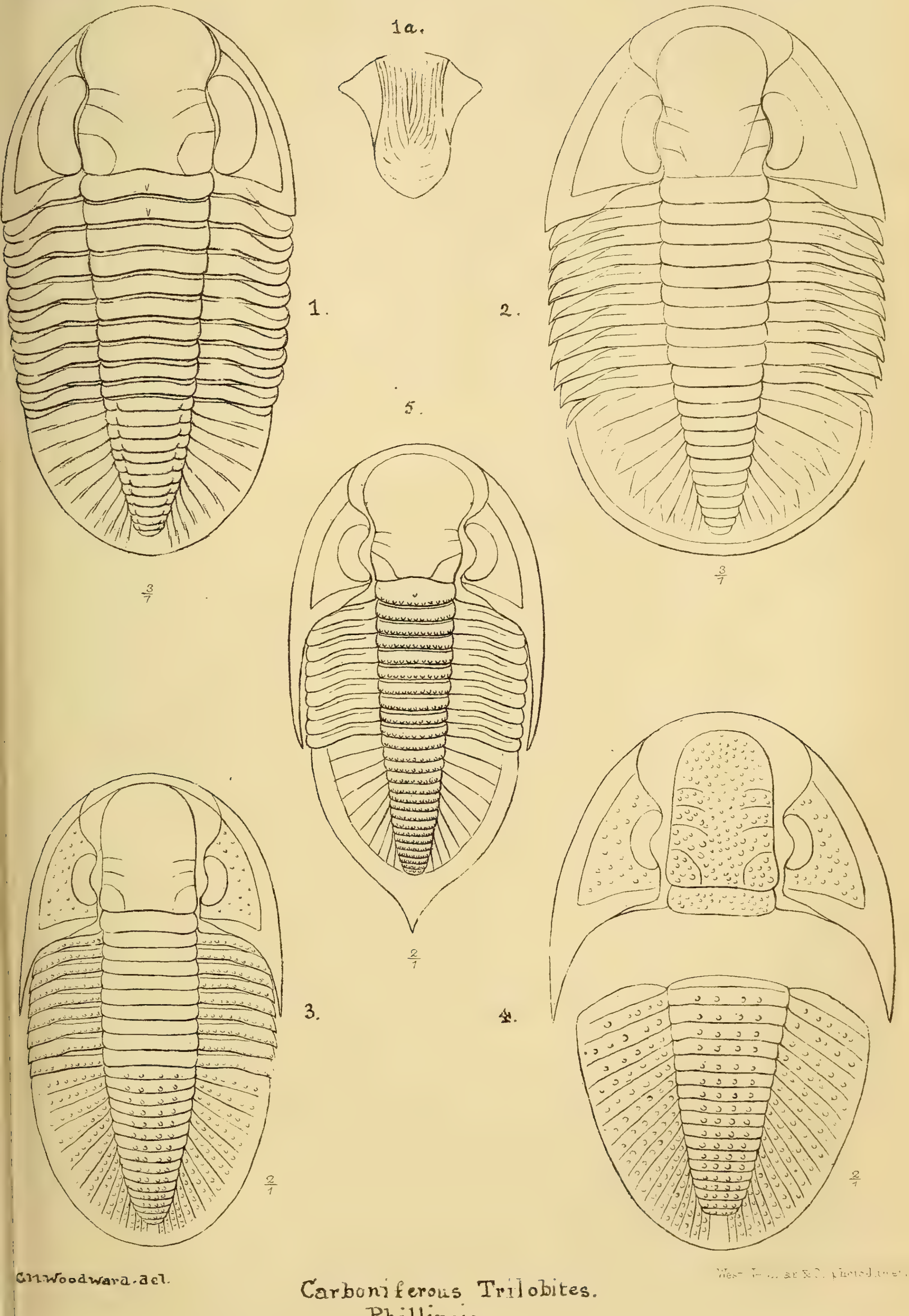
II.—Phillipsia, Portlock, 1843.—General form oval; glabella with nearly parallel sides, marked by either two or three short lateral furrows; the posterior angles, forming the basal lobes, always separated by a circular furrow from the rest of the glabella; eyes large, reniform, surface delicately faceted;[1] cervical furrow deep; free cheek separated from the glabella by the axal suture which forms an acute angle with the circular border of the cheek in front of the glabella; whilst the facial suture cuts obliquely across the posterior margin, just behind the eye, leaving a small pointed portion fixed to the glabella by the neck-lobe; angles of cheeks more or less produced, margin of head incurved, forming a striated and punctated rim. Thoracic segments nine in number, the axis distinctly marked from the side-lobes or pleuræ by the axal furrows; the tail, or pygidium, usually with a rounded border, the axis composed of from 12 to 18 coalesced segments.

Phillipsia Derbiensis, Martin, sp., 1809. Plate XI. Fig. 1.

Entomolithus (*Oniscites*) *Derbiensis*, Martin. 1809. Petrif. Derb. t. xlv. figs. 1 and 2.
Asaphus raniceps, Phillips. 1836. Geol. Yorks, vol. ii. t. xxii. figs. 14 and 15.
Phillipsia Derbiensis, De Koninck. 1842. Anim. Foss. t. liii. fig. 2.
——— *Jonesii*, var. *seminifera*, Portlock. 1843. Rep. Geol. Londonderry, etc. p. 308, t. xi. fig. 5.
——— *Derbiensis*, Morris. 1854. Cat. Brit. Foss. p. 114.
——— *Jonesii*, var. *seminifera*, M'Coy. 1855. Brit. Pal. Foss. p. 183.
——— *Derbiensis*, Salter and Woodw. 1865. Cat. and Chart. Foss. Crust. p. 16, fig. 111.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. Part i. p. 12, pl. i. figs. 1–9.

Glabella smooth, somewhat gibbous in front; sides nearly straight, with two short furrows near the front of the eye, and a circular furrow around the basal lobe at each posterior angle of the glabella; neck furrow deep, neck lobe rather broad, with one small tubercle on centre; fixed cheek very small; facial suture oblique, leaving a small angular portion attached to the neck lobe on either side. Eyes very large in proportion to head; reniform, smooth, but when well preserved showing a fine and minutely-faceted surface. Facial suture uniting with outer border of free cheek, and forming a very

[1] Messrs. Meek and Worthen, in their description of two Carboniferous Trilobites from Illinois and Indiana, remark, "eyes apparently smooth, but showing, when the outer crust is removed, numerous very minute lenses beneath," Geol. Surv. Illinois, vol. v., "Palæontology," 1873, 4to. pp. 528, 529. This observation may serve to explain the fact that many specimens do not show the faceted surface at all clearly; this is especially the case in the genus *Griffithides*. Emmrich believed it possible to use this character of the external surface of the eyes of Trilobites, as a means of classification, but I have not been able to accept his proposed arrangement based on this structure. (See Emmrich, *De Trilobitis;* Berlin, 8vo. 1839.)



C. H. Woodward. del.

Carboniferous Trilobites.
Phillipsia

acute angle, where it joins the glabella in front and a less acute angle behind the eye, where it unites with the posterior border. A broad groove or furrow surrounds the free cheek, running exactly parallel to its own outer border; the posterior angles of the head project slightly backwards, but are not produced into cheek-spines. The incurved under margin of the shield is finely striated as well as punctated. The hypostome (seen *in situ* in one of our specimens) is large, the mesial lobe is broad and spatulate, the surface being finely striated with wavy longitudinal lines; the lateral lobes or alæ are small, smooth, and pointed.

The thorax, which is roundly arched, consists of nine smooth and well-defined segments, the first only having a minute tubercle on the centre. The axis of the thorax, which next the head is considerably broader than its side lobes, diminishes gradually in breadth backwards to the pygidium, where it is only equal to its pleuræ in breadth; the pleuræ, which are smooth, are all faceted to enable the animal to roll itself up into a ball. The axis of the abdomen, or pygidium, shows it to be composed of thirteen coalesced segments, the pleuræ being united in a rounded shield, the border of which is smooth, as the ribs die out before they quite reach the margin. There is a faint tendency to ornamentation on the axis of the tail.

Formation.—In Carboniferous Limestone and in "Rotten-stone" band.

Localities.—Bolland and Settle, Yorkshire; Castleton, Derbyshire; "Rotten Stone," Matlock, Derbyshire; Longnor; Arnside; Blackrock and Little Island, Co. Cork; Middleton; Carnteel, Tyrone; Castlepollard, West Meath, and Limerick, West of Dromore Wood.

Specimens of *P. Derbiensis* have been examined from the National Collection, British Museum (Nat. Hist.), Cromwell Road; the Museum of Practical Geology, Jermyn Street; the Woodwardian Museum, Cambridge; the Museum of the Geol. Survey, Dublin; and from the collections of the Rev. E. O. de la Hey, M.A., Marple, Cheshire, and Joseph Wright, Esq., F.G.S., Belfast.

PHILLIPSIA COLEI, M'Coy, 1844. Plate XI. Fig. 2.

Phillipsia Colei, M'Coy. 1844. Synop. Carb. Foss. of Ireland, 4to. p. 161, tab. iv. fig. 6.
——— ——— Morris. 1854. Cat. Brit. Foss. 8vo. p. 114.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 16, pl. ii. figs. 1–10.

Head-shield broadly semicircular; glabella but slightly elevated, the central convexity not reaching to the front border, but separated by a broadly-expanded margin which makes the head one-third wider in front than at its posterior border; glabella marked by two short lateral furrows, and by a small basal lobe on each side, the neck-furrow is rather strongly marked, the neck-lobe is slightly broader than the first free segment; the posterior margin is divided obliquely by the facial suture, which runs in a very undulating line between the glabella and the free-cheek; eyes large, reniform, no facets visible; cheeks arched, somewhat produced at the posterior angles, surrounded by a furrow parallel to the border; free-segments nine; axis very slightly arched, equal to its pleura in breadth anteriorly, but diminishing slightly towards the pygidium; pleuræ faceted, extremities slightly produced and recurved; pygidium semicircular, axis slightly arched, and composed of twelve coalesced segments; pleuræ only faintly indicated, margin of pygidium smooth and slightly bevelled; surface of head and body generally (save the extremities of the pleuræ) finely granulated.

A detached hypostome found in the same deposit has been referred to this species. It is 7 mm. long, and 4 mm. broad. It is oblong in form; the alæ are very minute, the central lobe is gibbous and ornamented with fine raised concentric striæ or wrinkles, irregularly disposed.

This well-marked species was named by M'Coy after the present Earl of Enniskillen, and having only been found in Ireland, it has escaped the entanglements of palæontological literature, and is in consequence without synonyms. Although quite distinct from any other species of *Phillipsia,* it is marked by excellent generic characters.

In the peculiar broad, smooth, circular border to the front of the glabella this species approaches nearest to *Ph. truncatula* and *Ph. Eichwaldi.* It differs from *Ph. Derbiensis,* in which the glabella is very gibbous, and actually overhangs the front border. But in the broad, short, and flattened form of the pygidium we seem to lose the ordinary tail of the Carboniferous Trilobite, and to find a strong resemblance to the pygidium of *Asaphus* and *Ogygia* proper. This leads one to observe that the pygidium appears to be a less constant character and of less value for classification than the form of the cephalic shield.

Formation.—Carboniferous Limestone.

Localities.—Little Island, Cork; N. E. of Ballintra and Carrickbreeny, Donegal; Doohybeg, Co. Limerick, Ireland.

The specimens examined have been kindly lent by Prof. E. Hull, M.A., LL.D., F.R.S., from the Museum of the Geological Survey of Ireland, Dublin, and a single specimen is preserved in the National Collection.

PHILLIPSIA GEMMULIFERA, Phillips, sp. 1836. Plate XI. Fig. 3.

Asaphus, sp. indet., Brong. and Desmar. 1822. Hist. Nat. des Crust. Foss. p. 145, pl. iv. fig. 12.
———— "*Stokesii,*" Fischer. 1830–37. Oryct. du Gov. de Moscou (footnote, p. 121, *sine descriptione*).
———— *gemmuliferus*, Phill. 1836. Geol. Yorks, vol. ii. pl. xxii. fig. 11, p. 240.
———— ———— Buckland. 1836. Bridgw. Treat. vol. ii. p. 74, pl. 46, fig. 10.
Phillipsia pustulata, De Koninck. 1842–44. [*Sed non Trilob. pustulatus*, Schlot. 1823.] Desc. Anim. Foss. Terr. Carbonif. de Belg. p. 603, tab. liii. fig. 5.
———— *Kellii*, Portlock. 1843. Rep. Geol. Lond. p. 307, pl. xi. figs. 1, *a—c*.
———— *quadriserialis*, M'Coy. 1844. Synop. Carb. Foss. Ireland, pl. iv. fig. 8, p. 162.
———— *pustulata*, Morris. 1854. (In part only.) Cat. Brit. Foss. p. 114.
———— ———— Salter and H. Woodw. 1865. Cat. and Chart. Brit. Foss. Crust. p. 55, fig. 109.
———— ———— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
———— *gemmulifera*, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 17, pl. iii. figs. 1–8.

General form an elongated oval; head semicircular, glabella rounded anteriorly, the raised central portion marked by two short lateral furrows on each side, and by the usual rounded basal lobes, surrounded in front of the eyes by a rather broad, flat, circular border formed by the fixed cheek, which contracts behind the eyes, but extends obliquely outwards on each side from the neck-lobe, which is rather wider and more strongly marked than the succeeding free segments of the thorax.

Eyes moderately large, reniform, smooth, or when the faceted surface is visible, the lenses are very minute. Free cheeks forming an acute angle on the anterior border, and elongated posteriorly into spines which reach to the fifth thoracic somite. Raised portion of the cheek sparsely granulated, border smooth and broad, under margin striated. The nine free thoracic somites are nearly of equal size, the raised axis being slightly broader than its pleuræ; the axis smooth, pleura very minutely granulated and bluntly terminated.

Axis of pygidium composed of sixteen coalesced somites with four to five granules in a row on each axial somite, about thirteen lateral ridges to the pygidium with about six granules on each; margin narrow, smooth.

Formation.—Carboniferous Limestone.

Localities.—Bolland, Yorkshire; Clithero, Lancashire; Derbyshire; Kildare; St. Doolagh, Co. Dublin; Limerick, west of Dromore Wood; Hook Head, Wexford; and Little Island, Cork.

Many specimens of *Phillipsia gemmulifera* have been examined from the British Museum, the Museum of Practical Geology, the Museum of the Geological Survey of Ireland, the Woodwardian Museum, and a single specimen from the private collection of John Aitken, Esq., Sandfield, near Manchester, etc., and from the collection of Joseph Wright, Esq., F.G.S.

PHILLIPSIA TRUNCATULA, Phil., sp., 1836. Pl. XI. Fig. 4.

Asaphus truncatulus, Phillips. 1836. Geol. Yorks, vol. ii. pl. xxii. fig. 12, 13.
Phillipsia ornata, Portlock. 1843. Rep. Geol. Lond. p. 307, pl. xi. fig. 2*a*.
——— *truncatula*, M'Coy. 1844. Syn. Carb. Foss. Ireland, p. 163.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 21, pl. iii. figs. 9–14.

Head-shield broadly arched; glabella twice as long as broad, rounded in front, only slightly elevated; basal lobes rather produced, with three short lateral furrows on each side, two of which are anterior to the compound eyes; neck lobe distinctly marked, and like the surface of the glabella rather closely granulated; fixed cheek narrow behind, forming a small, rounded, palpebral lobe above each eye, and expanding into a wide flat circular border in front of the glabella; eyes reniform, smooth; raised portion of the free cheek sparsely granulated; border smooth and broad, terminating in a strong short cheek-spine which is striated beneath.

Thoracic rings wanting.

Pygidium.—Axis composed of eighteen coalesced somites, with six granulations on each axal segment; coalesced ribs of border also granulated; no distinct border to pygidium.

Formation.—Carboniferous Limestone.

Localities.—Bolland and Settle, Yorkshire; Castleton, Derbyshire; Monaster; Millicent; Limerick; Hook Head, and Malakeede, near Dublin, Ireland.

Specimens of *P. truncatula* have been examined from the collections in the Museum of the Geological Survey of Ireland, the Woodwardian Museum, the British Museum, and also from the collection of Joseph Wright, Esq., F.G.S., of Belfast.

Phillipsia Eichwaldi, Fischer, sp. 1825.

Asaphus Eichwaldi, Fischer. MS. 1825. Geognosticozool. per Ingriam Balt. Prov. Casan, p. 54, tab. iv. fig. 4. (Published by Eichwald.)
——— ——— Fischer de Waldheim. 1830–37. Oryctog. du Gouv. de Moscou, fol. p. 121, pl. xii. figs. 1 and 2.
Otarion Eichwaldi, Eichw. 1840. Bulletin Scient. de St. Petersbourg, p. 4, " Die Thier, etc., des Bergkalks im Nowogorod. Gouv., etc."
Phillipsia cœlata, M'Coy. 1844. Synop. Carb. Foss. Ireland, p. 161, tab. iv. fig. 4.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 114.
Griffithides meso-tuberculatus, M'Coy. 1855. Brit. Pal. Foss. Cambridge, 4to. p. 182, pl. 3D, figs. 10 and 11.
Phillipsia Eichwaldi, von Möller. 1867. Trilob. der Steinkohlen. des Ural. Bull. Soc. Imp. des Natur. de Moscou, part i. p. 121.
——— *cœlata*, H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
——— *Eichwaldi*, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 22, pl. iv. figs. 2, 4–11, 13, 14.

Head-shield circular, glabella slightly gibbous in front, but not overhanging the fixed border which surrounds its anterior margin, and also forms a rounded palpebral lobe over each eye. Basal lobes distinctly marked, rather triangular in form, with two short lateral furrows on each side of the glabella at the back of the eyes. The head is marked by two pores, one on either side of the raised glabella just in front of the eyes (I propose to discuss their nature later on); eyes rather large, and somewhat strongly faceted, the facets being larger than in *P. gemmulifera;* neck-lobe broad, marked by a single tubercle on centre, and by a row of fine granulations or minute tubercles along its posterior border, like those on the axis of the thorax, and separated on each side by a strong furrow; raised free cheek, small, but surrounded by a broad, flat margin, bevelled on the edge, striated on the under rim, and produced posteriorly into a long spine, which reaches even to the ninth thoracic somite; the entire head-shield, save the margin, is ornamented by very fine granulations; axis of thorax and abdomen very distinct, each ring being marked by a row of very minute, spine-like granulations along its posterior border; ends of pleuræ roundly terminated; *pygidium* composed of sixteen coalesced somites, central axis ornamented like thoracic axis; lateral lobes of pygidium about eleven in number; margin smooth; border rounded and striated with fine parallel lines.

Hypostome.—The hypostome, which is finely striated, has an oblong, median axis, slightly pointed at the extremity like a heraldic shield. The alæ are triangular in form.

Formation.—Carboniferous Limestone.

Localities.—Bolland, Yorkshire; Derbyshire; Tyrone, Ireland; Lennoxtown, Campsie; Newfield Quarry, High Blantyre, Lanarkshire; Gateside, Beith; Auchenskeith and Bowertrapping, near Dalry; Robroyston, near Glasgow; Auchenbeg, near Lesmahagow; Capelrig, E. Kilbride; Gair, Carluke; Boghead, near Hamilton, Scotland.

The specimens which have been examined are preserved in the British Museum, the Woodwardian Museum, the Museum of the Geological Survey of Ireland, and the following private collections, Messrs. John Young and James Thomson, of Glasgow; Mr. Robert Craig, Langside, Beith, Ayrshire, etc.

PHILLIPSIA EICHWALDI, var. *mucronata*, M'Coy. 1844. Pl. XI. Fig. 5.

Asaphus caudatus, Buckland. 1836. Bridg. Treat. vol. ii. p. 74, pl. 46, fig. 11.
Otarion Eichwaldi, Eichwald. 1840. Die Thier und Pflanzenreste des Gouvern. Novgorod, p. 4. (Bullet. Scientif. de St. Petersb. 1840.)
Phillipsia mucronata, M'Coy. 1844. Synop. Carb. Foss. Ireland, p. 162, tab. 4, fig. 5.
——— *Eichwaldi*, Verneuil. 1845. Geol. de Russie, vol. ii. p. 376, tab. xxvii. fig. 14.
Griffithides Farnensis, G. Tate. 1856. Proc. Berwick Nat. Club, p. 234.
——— *Eichwaldi*, Eichwald. 1860. Lethæa Rossica, Format. anc. p. 1435; Atlas, pl. liv. fig. 10
——— (or *Phillipsia*) *Eichwaldi*, Salter and Woodw. 1865. Cat. and Chart. Foss. Crust. p. 16, fig. 116.
Phillipsia mucronata, von Möller. 1867. Ueber die Trilob. der Steinkohl. des Ural, etc.; Bull. de la Soc. Imp. des Nat. de Moscou, No. 1, p. 121.
Griffithides mucronata, Traquair. 1869. Journ. Roy. Geol. Soc., Ireland, Dublin, pp. 213–218, and plate, figs. 1–7.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 37.
Phillipsia Eichwaldi, var. *mucronata*, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 23, pl. iv. figs. 1, 3, 12, and 15.

In this (var. *mucronata*) the only difference we have been able to detect is to be seen in the pygidium, in which the posterior border instead of being rounded is produced into a short blunt mucro.

Formation.—Carboniferous Limestone.

Localities.—Beadnell, Northumberland; Settle, Yorkshire; Wilkieston, Fife.

Phillipsia Eichwaldi, var. *mucronata*, has been examined from the National Collection, British Museum, the Woodwardian Museum, Cambridge; and from the private collections of Dr. R. H. Traquair, F.R.S.; Mr. John Young, Mr. James Thomson, and Mr. J. Smith.

PHILLIPSIA QUADRILIMBA, Phil. sp. 1836.

Asaphus quadrilimbus, Phillips. 1836. Geol. Yorks, vol. ii. p. 239, pl. xxii. figs. 1, 2.
Phillipsia quadrilimba, H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 56.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. pl. vii. fig. 1, p. 26.

Although I have been unable to trace the original specimen, which forms the basis of Prof. Phillips' figure and description of *Phillipsia quadrilimba*, I have allowed it to stand in case it may hereafter be found, and may prove to be a good and distinct species.

The following is Prof. Phillips' original description of *Asaphus quadrilimbus*, taken from the "Geology of Yorkshire," vol. ii. p. 239, pl. xxii. figs. 1, 2.

"Fig. 1.—The head. Margin quadrato-carinate, minutely striated; surface smooth; eyes very minutely reticulated. Fig. 2.—Abdomen."

Prof. Phillips figures a portion of a detached head and an imperfect tail, but they certainly do not appear to belong to the same individual, and probably not even to the same species.

Formation.—Top of Lower Scar (Carboniferous) Limestones.

Locality.—Bolland, Yorkshire.

PHILLIPSIA LATICAUDATA, H. Woodw. sp. nov.

Head imperfect, glabella tumid, rounded in front, with a narrow, smooth, raised marginal rim, general surface smooth, but finely punctated, under a lens; basal lobe separated by a deep semicircular furrow from the rest of the glabella, and with two short lateral furrows on each side. Neck-furrow deep; neck-lobe rounded, with one prominent tubercle on the centre, length of glabella 5 mm., breadth $3\frac{1}{2}$ mm., cheeks not preserved. Free thoracic segments unknown. Pygidium much broader than long, very strongly trilobed; axis elevated, consisting of twelve coalesced somites; each ring very strongly ridged, and each ridge ornamented with a line of minute tubercles; side pleuræ nine in number, rather broad for half their length, and minutely ornamented, but fainter for the latter half, and dying away near the margin, which is almost smooth. Length of pygidium 6 mm., of axis 5 mm., breadth of tail 9 mm., breadth of axis 4 mm.

Formation.—Carboniferous Limestone.

Locality.—Bolland, Yorkshire.

The four specimens of *P. laticaudata* are preserved in the British Museum, and once formed part of the "Gilbertson Collection."

EXPLANATION OF PLATE XI.

FIG. 1. Restored outline figure of *Phillipsia Derbiensis*, Martin, sp. Enlarged three times the nat. size.
,, 1*a*. Hypostome of same. Enlarged.
,, 2. Restored figure of *P. Colei*, M'Coy. Enlarged three times nat. size.
,, 3. ,, ,, of *P. gemmulifera*, Phill. sp. Enlarged twice nat. size.
,, 4. ,, ,, of *P. truncatula*, Phill., sp. Enlarged twice nat. size.
,, 5. ,, ,, *P. Eichwaldi*, var. *mucronata*, M'Coy. Enlarged twice nat. size.

(To be continued.)

V.—ON SOME FOSSILS SUPPOSED TO HAVE BEEN FOUND IN THE PLEISTOCENE GRAVELS OF BARNWELL, NEAR CAMBRIDGE.

By T. MCKENNY HUGHES, M.A., F.G.S.,
Woodwardian Professor of Geology, Cambridge.

IT frequently happens that in questioning the occurrence of remains in any deposit, we have to point out that they may have been derivative from older beds, or, on the other hand, may have been introduced at some later date into that in which they are actually found. In such cases various hypothetical explanations are offered with a view to proving that sources of error still remain, which must be investigated before the unexpected association of remains can be accepted as a fact. Such difficulties frequently meet us in investigating the contents of caves, beds of gravel and sand, etc., more frequently in connexion with the history of the newer formations, and especially in criticizing the evidence for the association of human relics with the remains of extinct forms of life. It becomes of importance therefore to place on record any well-authenticated case in which objects in the same deposit and in the same state of preservation can be shown to belong to totally different times.

The well-known deposit of Pleistocene gravels at Barnwell, near Cambridge, has long been worked, and its fossils are therefore pretty well known. The following is a list of the species preserved in the Woodwardian Museum.[1]

Elephas primigenius, Blum.
——— *antiquus*, Falc.
Hippopotamus major, Nesti.
Rhinoceros tichorhinus, Cuv.
Equus caballus, Linn.
Bos primigenius, Boj.
Cervus tarandus, Linn.
——— *elaphus*, Linn.
Megaceros Hibernicus, Owen.
Ursus spelæus, Blum.
Helix nemoralis, Müll.
——— ——— var. *hortensis*, List.
——— *cantiana ?*
——— *arbustorum*, Linn.
——— *ericetorum*, Müll.
——— *hispida*, Müll.
——— *rufescens*, Penn.
——— 2 or 3 other species.
Helicella, sp.
Valvata piscinalis, Müll.
Bithynia tentaculata, Linn. sp.
Succinea putris, Linn.
——— *elongata ?*
Planorbis marginatus, Drap.
——— *spirorbis*, Müll.
——— *vortex*, Müll.
Limnæa auricularia, Drap.
——— *palustris*, Drap.
Bulimus montanus, Drap. (=*Lackhamensis*, Mont.).
Clausilia biplicata, Mont. sp.
Zua lubrica, Müll.
Pupa muscorum, Linn. sp.
Ancylus fluviatilis, Müll.
——— *oblongus*.
——— sp.
Unio littoralis, Lam.
——— *limosus*, Nilss.
Pisidium amnicum, Müll.
——— *fontinale*, Drap.
Cyclas cornea, Linn. sp.
——— sp.
Corbicula fluminalis.
Chara (seeds of).
Leaves and stems of plants (undetermined).

Here, as elsewhere, we notice the curious association of northern and southern forms of life, the hairy Elephant and woolly Rhinoceros which seem to belong to the borders of the Arctic regions, and the Hippopotamus, which has travelled to the tropics, while the two common shells, *Unio littoralis* and *Corbicula fluminalis*, which lived in the same river with the Hippopotamus at Cambridge, are also now limited to more southern climes—the one shell not being found nearer than the Nile—the other having got as far as the rivers of France.

The interesting problems connected with the geographical dis-

[1] See also 1838, Brodie, Rev. P. B. Notice of the Occurrence of Land and Fresh-water Shells with Bones of some Extinct Animals in the Gravel near Cambridge, with Notes by the Rev. Prof. Sedgwick. Trans. Camb. Phil. Soc. vol. viii. 1844, p. 138. —Seeley, H. G. A Sketch of the Gravels and Drift of the Fenland. Quart. Journ. Geol. Soc. vol. xxii. p. 470.—Dewick, Ed. S. The Land and Freshwater Shells of Barnwell, from a list prepared by Mr. Dewick from the specimens in his own collection. Quart. Journ. Geol. Soc. vol. xxii. p. 477.

tribution of plants and animals suggested by this assemblage remain to be explained; but it seems well established that these forms of life belong to the Barnwell gravels, whatever age or ages they may represent. The Sheep is as yet unknown in this zone.

It was therefore with great surprise, that I found among the bones brought to me by workmen from the Barnwell gravel pits, with the remains of Ox, Deer? etc., the bones of a Sheep. They appeared to be in precisely the same state of preservation as the others obtained from the Barnwell beds. I therefore went immediately to the pits to examine the spot from which the bones were said to have been procured, and I ascertained that they were all found along a definite band coinciding with the bedding. It was not, however a bed, but a long cylindrical mass following a more sandy incoherent bed. I followed this a short distance, easily clearing out the contents of the hole, which was somewhat oval in section, and finding fragments of bone at the bottom; but what was more important, I discovered also on the sides of the hole the marks of the claws of the burrowing animal which had made it. It was therefore probably a badger earth, subsequently, as all huntsmen know is commonly the case, occupied by foxes. Where the hole was seen in section, it was entirely filled by sand and gravel which had worked down into it.

Here under the most favourable circumstances, it was not easy to detect that a portion of the gravel had been filled in at an entirely subsequent date to that of the main mass; while the state of the bones which had lain there so long under conditions similar to those affecting the rest of the gravel did not arouse any suspicion. It was only the close examination of the section immediately upon the finding of the bones of a species not expected to occur there, that led to the discovery of the true explanation. Another caution I would add. In such cases when burrowing animals come across obstructions such as long pieces of bone or stone, in their efforts to remove them they score them more or less deeply with their claws and teeth, producing cuts very much like those which would be made by primeval man with a blunt implement. I have seen numerous examples of this even in rabbit burrows.

VI.—Does *Elephas primigenius* occur in the Norfolk Forest Bed?

By John Gunn, M.A., F.G.S.

I HAVE been urged so strongly to state what is the result of my researches, with respect to the presence of *Elephas primigenius* in the Forest-bed series, that I am induced to offer the following remarks for insertion in the Geological Magazine.

During a search of upwards of 40 years, I have never met with a specimen of the tooth of an Elephant which could justly be considered to be more than a type leading to the *E. primigenius*, and certainly not with a specimen of the *Rhinoceros tichorhinus*, which is reputed to be the inseparable companion of that Elephant.

Mr. George Randall Johnson, who has many years searched the same ground, and who has distinguished himself by finding and also describing the *Cervus latifrons*, expresses himself very decidedly to the same effect in the Transactions of the Norwich Naturalists' Society.

It was with amazement that I read the following remarks by Dr. Falconer, Palæontographical Memoirs, vol. ii. p. 471:—"But our knowledge of the Mammalian species belonging to this extinct Fauna in the Forest-bed, regarded as a whole, is still in a very unsatisfactory state. The Proboscidea have yielded three well-marked species, with indications of probably a fourth: the former being *Elephas* (*Loxodon*) *meridionalis, E.* (*Euelephas*) *antiquus* and *E.* (*Euelephas*) *primigenius*. The genus *Rhinoceros* has yielded two well-marked species, namely, *Rh. Etruscus* and *Rh. leptorhinus* (*Rh. megarhinus* of Christol). It is worthy of remark, that although undoubted remains of *E. primigenius* have been yielded by the Forest-bed, its usual associate in the Quaternary valley gravels, *Rh. tichorhinus*, has not as yet, so far as I am aware, been established on reliable evidence."

Thus he states that undoubted remains of *Elephas primigenius* have been yielded by the Forest-bed, and that the presence of *Rh. tichorhinus* is not established upon reliable authority.

I can only say that in the descriptive Catalogue which Dr. Falconer made of my collection, the only specimen pointed out by him approaching to *E. primigenius* was No. 223, which he labelled "Old type of *E. primigenius*."

The same may be observed of the specimens in the Norwich Museum, and Miss Anna Gurney's collection, there is not one of *E. primigenius*, except such as have been dredged out at sea, or have fallen from more recent beds in the cliffs above; the same also may be said with reference to Mr. Rose's collection, now in the Norwich Museum, or Mr. Fitch's, or Mr. Johnson's collection, or the Rev. S. King's in the Jermyn Street Museum. I cannot imagine from what source these "undoubted remains of *E. primigenius* in the Forest-bed" are derived.

There is another point upon which Dr. Falconer was no less strongly assured, namely, that there are no intermediate forms between any of the four recognized European fossil species. He asks (Palæontological Memoirs, vol. ii. p. 253), "Do they show any signs in the successive deposits of a transition from one form to another? Here again," he adds, "the result of my observation, in so far as it has extended over the European area, is that the specific characters of the molars are constant in each," and further, *loc. cit.*, he proceeds to show that, "according to his numerical formula, there is no room for admission of any other forms."

The fact is, that Dr. Falconer, having taken a prominent part in establishing the recognized species, naturally regarded them with almost parental jealousy, and would not tolerate the introduction of any intermediate species, or variety. Every specimen found in the Forest-bed must be pressed into one or other of them.

Upon this point I joined issue with my esteemed friend, and I founded my opinion in favour of intermediate forms upon the discovery by Mr. Savin, sen., of the tooth of an Elephant described by Professor Leith Adams, Palæon. Monograph Fossil Elephants, part 3, plate xx. fig. 3, as *E. primigenius*? with a query. It was remarkable for the fineness and regularity of the enamel-plates and also their width. In these respects it corresponded with similar teeth found by Mr. Savin, jun., near the same spot at Overstrand, but at a higher level. It differs from them, however, in its excessive crimping, while the width of the tooth was such as to leave no room for the suggestion that the crimping was due to contraction; neither was it due to the worn-out condition of the tooth, because it had evidently pervaded the entire tooth in its primary and perfect state. This crimping removes it from the ordinary type of *E. primigenius*, and, as it differs essentially from all the other species or varieties of the Elephant, it appears to justify its claim to be considered at least an intermediate variety.

I have myself obtained several specimens which tend to establish an intermediate form. One resembled the several teeth found by Mr. Savin, jun., at Overstrand. It is an upper tooth with 8 plates remaining, much worn, letter *a*, tray 4, Norwich Museum. Another, not worn so low, with 14 plates remaining, is No. 223, above mentioned, which was labelled by Dr. Falconer "Old type of *Elephas primigenius*." To these may be added several more similar specimens.

Some, again remarkable for the like characteristics, are of much greater size. I may particularize a specimen (lower jaw) with 8 plates, remarkably straight and parallel, figured plate 1, letter I, new edition of Sketch of Geology of Norfolk, and especially a ramus with the penultimate molar perfect, plate iv. fig. 2 of the same edition. These were submitted to a meeting of the Geological Society at Somerset House, in 1867, under the names of *Leptodon minor* and *Leptodon giganteus*. I then stated that my object was not so much to establish a new species or variety, notwithstanding that *E.* (*Leptodon*) was as fully entitled to be considered such, as any of the recognized species, but merely to point out how slender was the partition which seemed to divide and separate them one from another, and that they were all so linked together, that it was difficult to say where one began and another ended.

Dr. Falconer, who was not present at the meeting, admitted that I ran him harder than anybody else, but stoutly defended the sacred precincts of his established species and subgenera.

In the year following he came to Irstead with M. E. Lartet, and we agreed to submit our differences of opinion to this distinguished Palæontologist. He looked carefully at the ramus No. 361, above mentioned, plate iv. fig. 2, and viewing it on every side, said, "It is not *E. meridionalis*, neither is it *E. antiquus*, nor *E. primigenius*," and he did me the honour to name it *E. Gunnii*. He also said the same of No. 306, a fragmentary jaw with a penultimate tooth. I do not mention this out of vanity, but simply in order that the truth may be known with respect to the variations of the supposed species of Elephant.

About this time M. Albert Gaudry also honoured me with a visit to Irstead; and in his splendid work on the "Animaux Fossiles de Pikermi," Paris, 1866, he remarks with reference to the *E.* (*Loxodon*) *meridionalis*, "This species presents a curious example of slow modification; for at its outset, that is to say, in the Crag, its molars have the digitations of enamel sufficiently massive and sufficiently distinct to warrant, according to Falconer (Mem. du 3 Juin, 1855, in the Proceedings of the Geol. Soc. for 1865), their being attributed to the Mastodon; when we follow it into the Forest-bed, we see that it gives occasion for that observation of the Reverend Gunn, 'There is a marked difference between the teeth found in the more ancient and those found in more recent beds. The mastodontic character of the ridges is diminished; the enamel more fine and less rugose' (Sketch of the Geology of Norfolk, 1864). Besides these variations, Mr. Gunn showed me in his fine collection at Irstead, near Norwich, a molar of the size of that of the *Elephas meridionalis* with the plates resembling the *Elephas antiquus*, and another molar in which the plates as thick as in the *Elephas meridionalis* are also *serrées* one against another as in the *Elephas primigenius*. *Reciproquement*, there is in the Museum of Norwich a molar which has its plates *minces* as in the *Elephas primigenius*, and nevertheless very *écartees* to one another."—Considerations générales sur les animaux fossiles de Pikermi, note, page 38.

Thus partial resemblances to the *E. primigenius* were noticed by M. Gaudry, both in the Norwich Museum, and my own collection, but no instance of that Elephant fully developed, and I may safely say, none could have escaped his penetration.

The Windham specimen in the Norwich Museum, a mandible with the penultimate molar on either side, suggests, in my humble opinion, the nearest approach, in the form of the jaw, to the *E. meridionalis*, figured plate III. No. 1 in my Sketch, and ascribed by Dr. Falconer, after much hesitation, to *E. antiquus*, and by Professor Leith Adams to the broad-toothed variety of that Elephant. This mandible has been described by Dr. Falconer in Pal. Mem. vol. ii. page 188, and by Professor Adams in the Palæon. Monograph, part 1, 'Fossil Elephants,' as *E. antiquus*, p. 39 and p. 53.

It was observed by Mr. Charlesworth in discussion at the meeting of the Geological Society in 1867, on the subject of the *Leptodon giganteus*, that too much reliance was placed upon the teeth, as if the dental formula of elephants were the sole criterion of species, and too little upon the bones and the anatomical structure.

The *E.* (*Leptodon*) *giganteus* offers, as a guide to specific determination, ampler means and larger portions of the skeleton than any other Proboscidean from the Forest-bed series. At the same spot at Mundesley, in a bed of sand immediately above the Elephant-bed where the ramus No. 361 was obtained, Mr. Dix has taken an immense os inomenatum, No. 225 in the Norwich Museum Catalogue, described fully by Dr. Falconer, Pal. Mem. vol. ii. p. 141. At the same place also, a humerus, No. 200, described by Dr. Falconer, *ibid.* p. 143. It exceeds in length, but not in massiveness, the grand humerus presented by Miss Gurney to the Norwich Museum from the Elephant-bed at Bacton. This Mundesley specimen is calculated by Dr. Falconer to have belonged to an animal that stood 17 feet, measured from the foot to the dorsal-vertebral spine. It is remarkable that the three several specimens, the ramus, the humerus and the os inomenatum, agreeing together in point of form, should have been derived from the same bed. What is still more extraordinary, there are in Mr. Randall Johnson's grand collection, two bones, a femur and a radius, taken from precisely the same spot, which exhibit the like peculiarity of structure, namely, excess of dimensions in comparison with substance.

Of the femur Professor A. Leith Adams writes, Pal. Soc. Mon. 'Fossil Elephants,' part iv. p. 222: "As compared with any femur at all referable to European extinct elephants, the specimen in the possession of Mr. Randall Johnson, late of Palling, far outstrips the largest in dimensions. It was discovered at Mundesley in the Forest-bed in conjunction with the humerus No. 200 of the Gunn collection (pl. xvi. fig. 2) and the huge radius also referred to page 217. Conjointly they represent a stupendous Elephant only second to the Dinotherium in size."

Thus it appears that these five specimens, which were found in the same bed, near the same place, remarkably correspond; so much so that it was the conviction of Mr. Johnson that they not only belonged to the same species of Elephant, but to the same individual. In this I should concur, if I had not found more than the component parts of one such Elephant. However, I look forward with pleasure to the time when Mr. Johnson's collection will, as he has promised, be placed in the Norwich Museum, and then his Elephantine bones will be laid by the side of mine, making together one unrivalled individual.

I trust I have said enough to prove that no more than a type of *E. primigenius* is to be seen in the several collections mentioned, of the preglacial period; and that intermediate forms of the Elephant do intervene between the species recognized by Dr. Falconer and others.

NOTICES OF MEMOIRS.

I.—Diamond Mining at Kimberley, South Africa.

FROM the Report of "The Central Diamond-mining Company (Kimberley Mine)," made at the third annual meeting, on the 28th May, 1883, at Kimberley, South Africa, we learn that the diamantiferous rock, known as "the blue," has been pierced for "about 530 feet at the south side of the mine," without any sign of its being penetrated, and with "eminently satisfactory" results as far as the Company is concerned. It is also stated that "about 250 feet down the walls of the reef[1] consisted of igneous rock," which

[1] The term "reef" is applied to any of the rocks, stratified or otherwise, bounding or interfering with the diamond-bearing magnesian breccia, which is called "the Yellow" at the top and "the Blue" below some 50 or 60 feet depth.

"was not vertical," but "coming in more or less" (whatever that may mean), and hence supposed to be safe from falling in.

From the "Summary of Transactions" of the Company, for the year ending 30th April, 1883, we gather the following interesting particulars:—

The quantity of diamond-bearing rock termed "the blue" that has been removed ("hauled")	344,205¼ loads
The quantity of "blue" that has been washed...	314,385¼ ,,
The "balance" ("blue" not used?)...	49,560 ,,
The quantity of diamonds found...	471,488 carats
,, ,, sold	434,890 ,,

Realized by the sale	£482,314	11	9
Cost (or value) of "plant" (Machinery, etc.) ...	£ 98,871	15	0
General expenses of working	£253,920	15	11

The quantity of "reef" (the bounding rock) hauled	285,468⅛ loads
The quantity of water used...	13,283,838 gallons

Amount received from the Kimberley Mining Board	£ 55,351	12	3
The Dividend declared	£100,951	0	0
Rates and Licenses paid	£147,709	4	3

—From the "Diamond-fields Advertiser," Kimberley, June, 1, 1883.

Diamond Fields, South Africa.

The De-Beer's Mining Company, in their Report of the Annual Meeting held on the 7th May, 1883, state that during the year ending 31st March, 1882, 96,439 loads (16 cubic feet) of "ground" washed yielded 76,859 carats of diamond, realizing £104,552 8*s.* 8*d.*; whilst during the year ending March 31, 1883, 166,136 loads washed yielded 149,396 carats, realizing £158,675 4*s.* 3½*d.* (£161,675 4*s.* 3*d.* according to one of the Tables), giving an average yield of 19*s.* 1¼*d.* a load, at a cost of 11*s.* 9¼*d.* a load, leaving a profit of 7*s.* 3¾*d.* a load. Average per carat 21*s.* 3*d.*

"Blue ground" already on the "floors" to March, 1882	3,000 loads
,, hauled and deposited on the floors to March 31, 1883	179,785 ,,
,, washed from March 1882 to April 1883, estimated at	166,136 ,,
,, left on the "floors"	16,649 ,,
,, "Floating reef" hauled	130,370 ,,

Besides this balance of "blue ground" the Company has 25,000 loads of "lumps" spread out on its "floors," representing a cost of £1250, and producing an average of ⅘ths of a carat a load, showing the "ground," after allowing a per-centage for "black reef" and "high ground," has averaged for the year at least a carat a load.

II.—Palæozoic Phyllopoda; As Reported on to the British Association, Southport, 1883, Section C. Geology.

PROF. T. RUPERT JONES, having especially devoted himself, in the past year, to a study of the fossil *Phyllopodous Crustacea*, finds that there are upwards of thirty recognized genera, of which seventeen occur in Britain.

After carefully collating original sketches and the tracings of all published figures, the following synopsis of the genera has been drawn up by him as a basis for a more complete study of this extensive group.

Geological Stage.	GENERA.	Special character.	No. of exposed abdominal segments.	No. of caudal spines. Styles and stylets of the telson.

I. CARAPACE UNIVALVE.

(I.) FLAT SHIELD.

1. *Neither sutured nor ridged along the back.*

(A). Posterior border entire. (Far behind.)

Silurian ..... ? = Raibl beds (Trias, Hallstadt)	*Discinocaris*, H. W., 1866	Angular notch*	4 ?	3 ?
	Aspidocaris, Reuss., 1867	Angular notch* * Round shield.		
Devonian.....	*Spathocaris*, Clarke, 1882	Angular notch.†		
Devonian.....	*Pholodocaris*, H. W., 1882	Sinuous notch.†		
Devonian.....	*Lisgocaris*, Clarke, 1882	Oblong notch.†		
Devonian.....	*Ellipsocaris*, H. W., 1882	Rounded notch.† †These shields differ in shape.		

(B.) Posterior border slightly notched.

Devonian.....	*Cardiocaris*, H. W., 1882	Front notch oblong.		

(C.) Posterior border deeply notched. (Open behind.)

Silurian	? *Pterocaris*, Barrande, 1882	Both notches angular (test radiately marked).		
Lower Silurian and Devonian	*Dipterocaris*, Clarke, 1883	Both notches angular.		

2. *Ridged along the back.* (*Like Apus.*)

Carbonif. & Devonian ? =	*Dithyrocaris*, Scouler, 1843 ..... (*Argas*, Scouler, 1835)	Ridged and sometimes prickled.	1, 4, or 6	3
Carboniferous	*Rachura*, Scudder, 1878	(Telson only known.)	—	3

3. *Sutured along the back.*

Silurian	A. *Aptychopsis*, Barrande (and H. W.), 1872	Angular notch.		
Lower Silurian	B. *Peltocaris*, Salter, 1863	Rounded notch	4 ?	4 ?
Lower Silurian	C. *Pinnocaris*, R. E., jun., 1878	Slight notch: striæ concentric far back.		
Silurian	D. ? *Crescentilla*, Barr., 1872	Notched before and behind.		

Geological Stage.	GENERA.	Special character.	No. of exposed abdominal segments.	No. of caudal spines. Styles and stylets of the telson.
(II.) FOLDED SHIELD, bent along the back (like *Nebalia*), so as to form two side-flaps or attached valves.				
Lingula-flags. 1.	*Hymenocaris*, Salter, 1853	Smooth	8 or 9	6
Silurian. 2.	*Dictyocaris*, Salter, 1860	Reticulate	6 ?	3 ?
Silurian. 3.	? ('*Cytheropsis testis*,') Barr., 1872			
Uppermost Devonian or Lowest Carboniferous. 4.	? *Protacaris*, Baily, 1872	(Not well known.)		
II. CARAPACE, BIVALVE; VALVES HINGED. (I.) POD-LIKE.				
Arenig and Lingula-flags.	1. *Caryocaris*, Salter, 1862	Pod-like, smooth	—	3?
Tremadoc, Silurian, and Devonian (America)	2. *Ceratiocaris*, M'Coy, 1849	Subovate, suboblong, etc.	5, 6, or 7	3
Silurian.	3. *Physocaris*, Salter, 1860	Round	5 or 6?	
Carboniferous.	4. *Colpocaris*, Meek, 1872	Subovate, strongly emarginate at one end (posterior).	—	3
Devonian.	5. *Echinocaris*, Whitfield, 1880	Leperditioid.	4 (spiny)	3
Silurian.	6. *Aristozoe*, Barrande, 1868	Leperditioid.		
Silurian.	7. *Orozoe*, Barr., 1872	Leperditioid.		
Silurian.	8. *Callizoe*, Barr., 1868	Leperditioid.		
(II.) CONCHIFEROIDAL; probably enclosing all the abdominal segments.				
Tremadoc.	1. *Lingulocaris*, Salter, 1866	Modioloid, and faintly ridged.		
Carboniferous.	2. *Solenocaris*, Meek, 1872	Long, and concentrically marked.		
Lower Silurian.	3. *Solenocaris*, Young, 1869	Oblong, and obliquely ridged, and concentrically marked.		
Silurian or Devonian?	4. *Myocaris*, Salter, 1864	Quadrangular, and strongly ridged obliquely.		
Carboniferous.	5. *Leaia*, Jones, 1862	Quadrangular, and strongly ribbed obliquely, and concentrically marked.		
Silurian? Devonian. Carboniferous. Triassic. Rhætic. Jurassic. Neocomian Tertiary? Recent.	6. *Estheria*, Rüppel, 1838	Like a bivalved mollusc, and concentrically marked.		

During the study of *Hymenocaris* it was found that "*H.? major*," Salter, comprises a *Ceratiocaris* possibly matching the Tremadoc specimens assigned to the genus by Mr. Salter; and it has therefore been put under the most authentic (*C. insperatus*) of the two Tremadoc species noticed by him.

The Australian *Hymenocaris Salteri*, M'Coy, having been assigned by Mr. Salter to *Caryocaris*, when he was studying that group in 1862, it has been regarded as a member of the latter genus.

With *Caryocaris Marrii*, Hicks, is a specimen associated under the same name in the Woodwardian Museum, that proves to be an *Entomidella;* as it differs somewhat from the known species of that genus, it is now named *E. Marrii.* Of the other specimens named *C. Marrii*, some do not differ from *C. Wrightii*, Salter; but one retains the specific name given by Dr. Hicks.

Besides the *Lingulocaris lingulæcomes*, Salter, some casts in the British Museum seem to warrant the adoption of a new name, *L. siliquiformis*, for a different but allied form.

III.—Examination of the Meteorite which fell on the 16th February, 1883, at Alfianello, in the District of Verolannova, in the Province of Brescia, Italy. By Walter Flight, D.Sc., F.G.S.[1]

I GATHER from a short preliminary notice, which has been sent by M. Denza to Professor Daubrée, and has been published in a recent number of the "Comptes Rendus," a few particulars respecting the fall of this stone, and its general appearance.

The fall took place, with a loud detonation, at 2·55 P.M. on the day above mentioned; it was heard in the neighbouring provinces of Cremona, Verona, Mantua, Piacenza, and Parma. In Alfianello it is described as "épouvantable."

It descended from N.N.E. to S.S.W. at a distance of about 150 mètres from a peasant, who fell fainting to the ground; telegraphic wires were set in motion, and the windows were shaken. It struck the ground about 300 mètres south-west of Alfianello, in a field on an estate called Frosera, penetrating the soil, in the same direction as it passed through the air, from east to west, to a depth of about 1 mètre, the path through the soil being about 1·50 mètre. When taken out of the ground, it was still a little warm. It fell complete, but was at once broken to pieces by the farmer of the estate.

The stone is oval in form, and somewhat flattened in the centre, the lower part being larger and convex, like a kettle, the upper part being truncated. The surface is covered with the usual black crust, and strewn with little cavities, now met with as individuals, now in groups, and in the eyes of some people bearing a resemblance to the impression of a hand or the foot of a she-goat. The stone weighs about 200 kilos.

In structure this meteorite belongs to the group Sporadosideres oligosideres, and resembles *Aumalite*, being almost identical with the meteorite of New Concord, Ohio.

[1] From the Proceedings of the Royal Society, No. 226, 1883.

The substance is finely granular, of ash-grey colour; a polished surface appears to be finely grained and breccia-form, with the elements offering different gradations of colour. Metallic grains are disseminated, and little nests are noticed, of iron with one of the compounds, of a yellowish-white or bronze. In one place where the metallic grains are numerous they appear to bear to the stony portion the ratio 68 : 1000. The density of the stone is 3·47 to 3·50.

The meteorite was dried at 120°, and treated with solution of mercury chloride, and thus there were dissolved the troilite and nickel-iron. The troilite constituted 6·919 per cent. of the meteorite, and the nickel-iron forms 2·108 of the stone, with the composition—

Nickel	71·205
Iron	28·795
	100·000

Here, again, as I have shown in earlier analyses, the percentage of nickel present in nickel-iron increases as the percentage of nickel-iron becomes less.

By long treatment with hydrogen chloride the silicates acted upon by that reagent and the silicates which resist the action were separated, and the stone appeared to possess the composition—

Troilite	6·919
Nickel-iron	2·108
Soluble silicate	50·857
Insoluble silicate	40·116
	100·000

The soluble silicate, which amounts to 50·857 per cent., and constitutes one-half the weight of the stone, consists of—

Silicic acid	35·12	18·73	
Iron protoxide	51·43	11·43	16·37
Alumina	1·518	0·707	
Lime	4·644	1·327	
Magnesia	7·269	2·904	
	99·98		

This olivine, which gives a green colour to a fragment of the rock that is at once recognized, is of unusual composition, containing as it does more than 50 per cent. of iron oxide. It agrees most closely with that which occurs in the meteorite of Ensisheim, the first recorded fall which has been preserved in any collection; it fell 17th November, 1492. The latest analysis of that stone is by Frank Crook, of Baltimore, made in Gottingen in 1868, and he found in the soluble portion of that stone 52·90 per cent. of iron oxide.

The insoluble portion, which forms 40·116 per cent. of the stone, has the composition—

Silicic acid	56·121	29·93	
Iron protoxide	13·397	2·97	11·05
Chromium oxide	8·281	...	
Lime	6·712	1·917	
Magnesia	17·263	7·065	
	102·174		

The bronzite, or rather augite, also agrees very well with that which forms the insoluble portion of the meteorite of Ensisheim. What was supposed to be alumina was further examined, and was found to be almost entirely chromium oxide, doubtless present in combination with some iron protoxide, alumina, and magnesia as chromite. And it appears not improbable that this part of the meteorite contains some tridymite, a few per cent., in fact.

IV.—PROFESSOR GOSSELET.—GEOLOGICAL SKETCH OF THE NORTH OF FRANCE.—ESQUISSE GÉOLOGIQUE DU NORD DE LA FRANCE. 3e Fascicule, Terrains Tertiaires. Texte et Planches par Prof. M. J. Gosselet. (Lille, 1883.)

WITH this Fasciculus the Tertiary series is commenced, and comprises descriptions of the Eocene, Oligocene and Néogène strata of the North of France and adjacent districts. After noticing the period of emersion between the deposition of the Chalk and that of the Tertiary strata, and the deposits referable to that age, the author describes the Lower Eocene, which comprehends the Montien, Landenien, Yprésien ; these are principally marine, with the exception of an estuarine fauna, which often intercalates the last two mentioned and may be contemporaneous with one or the other, and some very localized lacustrine beds containing *Physa*. The subdivisions and the variation in the lithological and fossil characters of the different localities are successively given. The succeeding Parisien, of which the beds at Cassel and Brussels represent the two principal types, is divided into five zones, characterized by (1) *Rostellaria ampla ;* (2) *Nummulites lævigata ;* (3) *Ditrupa strangulata ;* (4) *Num. variolaria;* (5) *Pecten corneus ;* their equivalents in other parts of France, in Belgium and England are pointed out. The Oligocene comprises the Tongrien and Rupelien, which are also divided into zones characterized by certain fossils. The Néogène is divided into Messinien (= Bolderien and Anversien of the Belgian geologists), Plaisancien (=Diestien) and Astien (=Scaldisien), their lithological, and fossil facies, and distribution being fully noticed.

Besides numerous references to previous works relating to the different geological divisions treated of in this part, there are five plates of Tertiary fossils, many sections, an orographic map at the beginning of the Tertiary period, and also four maps indicating the continental, estuarine and oceanic areas during the Landenien, Yprésien, Parisien and Diestien epochs. To the student of British Eocene and Oligocene strata, this contribution of Prof. Gosselet on the homotaxial (if not synchronous) deposits of the North of France will be highly instructive and useful, as representing the physical features, and associated faunas of that part of the area at the Lower Tertiary period.

The fourth and last fasciculus will appear in 1884, and will contain descriptions of the recent and diluvial strata, the physical movements since the secondary period, and the orography and geography of the region as deduced from its geological constitution.

J. M.

REVIEWS.

I.—MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA. Vol. xxii. The Geology of the Káshmír and Chamba Territories and the British District of Khágán. By RICHARD LYDEKKER, B.A. (Cantab.), F.G.S., F.Z.S., late Geological Survey of India. pp. 344, 4 Plates and 1 Map geologically coloured. (Calcutta, London, Trübner & Co., 1883.)

THE volume before us represents the combined results of the work of seven long seasons spent by Mr. Lydekker in the investigation of the geology of Káshmír and the neighbouring regions.

Several other geologists, notably the late Dr. A. M. Verchère, Lieut.-Col. H. H. Godwin-Austen, F.R.S., Col. C. A. McMahon, and the late Dr. Ferdinand Stoliczka, had worked largely at various parts of this district. Indeed, but for the death of that most excellent and able geologist, Stoliczka, on his return-journey from Yarkand, 19th June, 1874 (see Obituary, GEOL. MAG. 1874, Decade II. Vol. I. p. 382), it is probable that the task now performed by Mr. Lydekker with so much care, would have been completed by his predecessor, to whose loss he refers with profound regret.

It must not of course be supposed that this Memoir contains a complete and detailed account of the geology of the regions described. On the contrary, the author speaks of his own work with becoming modesty as a stepping-stone or foundation on which future work may be based. Owing to the arduous and inhospitable nature of the country, it was found impossible to study the geology of many of the more interesting districts with the precision and detail that might be wished. "To do this efficiently would occupy," says Mr. Lydekker, "not seven, but seventy summers"! This is the more readily understood when we learn that "The area described in the present memoir includes the whole of the dominions of the Maháràja of Káshmír and Jamu, the Karakoram range being taken as the boundary on the North-eastern frontier; the Chamba State, and a small angle of the British district of Láhol (Lahool); and on the extreme West, the British district of Khágán. The whole of this area may be roughly estimated at about 68,000 square miles"! (p. 4) or twice the area of the Kingdom of Portugal, and only one-third less than the area of Great Britain.

The south-westerly portion of the country defined above includes a small strip of the plain of the Punjab, beyond which the outermost ridges of the Himalaya commence.

This tract is taken to include all the area south of the Káshmír valley, which is coloured various shades of brown in the map, and is coincident with the Sub-Himalayan, or Tertiary, rock-series. It includes the districts of Púnch (Poonch), Naoshahra (Naoshera), and Jamu (Jumoo), in the last of which is situated the town of Jamu, the capital of the whole Káshmír territory. Through this tract the rivers Jhelam, Chínáb, and Rávi, make their way to the plains of the Punjab. Although the "Outer Hills" continue along the whole foot of the Himalaya, the river Rávi nearly forms the boundary of those coming within the area under consideration (p. 5).

And here it may be noted that the Map which accompanies this Memoir is a *geologically-coloured* reproduction of the very excellent geographical map, appended to Mr. F. Drew's account of the Jumoo and Kashmir Territories, published by E. Stanford, 1875.

By far the largest river-system of the whole area is that of the Indus, which leaves Káshmír territory in the district of Astor, where it receives the Astor river flowing from the Kishanganga watershed, and along the course of which the Astor and Gilgit road proceeds from Gurez. Above Bowanji (Boonji) the Indus receives the Gilgit river, flowing from the town and district of that name, which form the extreme north-western limit of Káshmír territory. The districts of Gilgit, Astor, Gurez, and Tilel, are collectively termed Dárdistán, from a peculiar Aryan race, the Dards, who inhabit them. Above Gilgit the Indus makes a sharp bend to the south-east and flows through Rondu from Skárdu, the capital of Baltistán, or Little Tibet. At this point it receives a large tributary flowing from the north and taking its origin in the mighty glaciers of the Mustágh or Kárákoram range north of Baltistán, known as the Shigar river (p. 8).

A few observations may be recorded on some of the features of the river-valleys. It has been observed by Mr. Drew that many of the great rivers after running for a long distance along *the normal strike of the rocks,* suddenly make a sharp bend to the south and flow more or less directly *across the strike* for the rest of their course; and in these cases a large tributary forms the upward continuation of the new course. This is exemplified in the bend of the Indus near the junction of the Gilgit river, and of the Chínáb at the junction of the Wardwan river above Kishtwár and again at the junction of the Ans river above Riási, in the Outer Hills, The bend of the Jhelam at its junction with the Kishanganga, at Muzafárábád, presents an analogous feature, but here the strike of the rocks changes at the same time as the course of the river, the former being probably the cause of the latter (p. 29).

By far the deepest of all the river-valleys is that of the Indus below Bowanji in Gilgit. Between that place and the Darel district, which has hitherto only been traversed by native explorers, Lt.-Col. H. C. B. Tanner, of the Survey of India, states that the river flows in a narrow gorge bordered by vast precipices ranging up to 20,000 ft. in height, at a level of a little over 3,000 ft.; thus making the river gorge *nearly* 17,000 ft. in depth. That a great part of this tremendous gorge has been cut by the river itself is proved by the occurrence of river gravels, and honey-combed rock-surfaces many hundreds of feet above the present river-level. The occurrence of Eocene strata in the upper Indus valley would seem to indicate that at all events part of that valley existed in Eocene times and that an arm of the sea then occupied part of Ladákh. There is, however, no absolute proof that the lower part of the valley then existed, as it is inferred that the drainage of the upper valley then flowed in the opposite direction to its present one (p. 30).

The present distribution of Glaciers in the Káshmír and Chamba territories is admirably displayed in the larger map accompanying Mr. Drew's work. It will be seen from that map that with the exception of a few small ones to the south of the Chínáb in Chamba, there are no glaciers south of the Zánskár range; where it becomes lower, glaciers are absent, reappearing again on the same line in the high regions about the peak of Nanga-Parbat. One of the glaciers at the foot of that mountain, near the village of Tarshing, descends to a level which is estimated at 9400 feet, the lowest level of any Himalayan glacier. To the north of the great Zánskár range, glaciers do not occur in any force till the Mustágh or Kárákoram range is reached, which forms the watershed between the Indus and the Turkestán river-systems. The most southern of this stupendous mountain barrier, which contains the second highest known peak in the world (28,000 feet), is covered with a complete network of glaciers, some of which (the Biafo and Bráldu glaciers) are only exceeded in size by the great Humboldt glacier of Greenland. The lowest limit to which these glaciers reach seems to be about 10,000 feet above the sea-level, and in contrast to other parts of Káshmír territory, they descend quite into the cultivated ground, their terminal moraines being frequently covered with a thick growth of cypress (p. 32).

There appears to be but little evidence of *recent* volcanic disturbance in this area.

The late Dr. Hugh Falconer mentions a very singular instance of a remnant of old volcanic energy still existing in Káshmír which he had examined. A tract of alluvium, with the strata elevated at a slight angle, and torrefied up to the surface to the condition of a well-burnt brick, there had been no outpouring of lava, and the tract was very circumscribed. In 1804 the ground was so hot that the Hindoos of Káshmír, simply by digging a few inches, were enabled to boil rice by the heat of the subsoil. There must have been a layer of incandescent matter beneath; but strange to say, it nowhere reached the surface. Mr. Lydekker believes, from the mention of inclined alluvial strata in the above record, that the locality alluded to must be somewhere along the fringe of the Pír-Panjál range, although he was unable to identify the exact spot (p. 45).

The older Mohammedan historians mention that Káshmír was formerly very frequently visited by severe earthquakes, the effect of which is abundantly manifest in the shattered condition of many of the old Buddhist temples, like that of Mártand, near Islámábád. Earthquakes appear to be much rarer at the present day, the writer never having felt or heard of one during the eight years in which he knew the country [1] (p. 45).

[1] Severe earthquakes are recorded in the years 1552, 1669, 1780, and 1828; by this last it is stated that about 1200 houses were thrown down and 1000 persons killed.

Twenty-two localities are recorded where hot springs occur, varying in temperature from 96° to 185° F.; some of these deposit travertine, or are rich in sulphur, iron, and carbonic-dioxide (pp. 42–44).

The formations observed in this vast area comprise low-level and high-level Alluvial deposits of Prehistoric and Pleistocene age; a Pliocene (Siwalik) series; Murree group of Miocene, and a Subáthu and Indus group of Eocene age. The Cretaceous or Chikkim series, the Jura-Trias, or Supra-Kuling series; the Carboniferous or Kuling series; all collectively called the "Zánskár system." These are preceded by Silurian and Cambrian rocks (not generally subdivided) known as the "Panjál system." Lastly, a Palæozoic and Archæan series comprising metamorphosed Panjáls and central gneiss, known as the "Metamorphic system" (p. 47).

The Alluvial deposits—as might be expected in such a region of high mountains and deep valleys watered by innumerable streams, many of which are ice-fed—are of vast and varied extent and composition. They form "Fans" and terraces and Alluvial plains and plateaux often of great extent and hundreds of feet in thickness. The town of Kishtwár, in the valley of the Chínáb, is built on one of these alluvial deposits, rising several hundred feet above the level of the river. Many of these plateaux, as Gurez itself, are several miles in length, and nearly half a mile in width (p. 64).

In the outer Hills they reach to 400 and 500 feet above the actual river-courses, and Mr. Medlicott concludes "that the existing rock-gorges have been to a great extent cut out before their accumulation, then filled by them, and subsequently cleared out again" (Records, vol. ix. p. 55).

Evidence is abundant of the former existence of numerous lakes, many of which were of vast extent. One in Rupshu, a Salt Lake now some five miles in length, formerly had an area between 60 and 70 square miles (p. 69).

The diminution in area of these lakes is not however due to the filling up by alluvial deposits alone, but to the fact that they formerly received a much more abundant supply of water than they do at the present day. There is good evidence also that the climate was less extreme, and that animal and vegetable life was once more abundant and existed at elevations where it is now scarcely known.

Many of the deposits in the existing river-valleys, consisting of a series of fine clayey and sandy layers often attaining to a height of 200 feet and more above the level of the valley and perfectly horizontal, conclusively point to the former existence of a dam lower down the valley by which the waters were ponded back. Mr. Drew has estimated that the great lake of Káshmír must have reached fully 2000 feet above the present level of the valley (p. 78).

Passing now from the latest Alluvial deposits to the Tertiaries, we find one great difficulty in determining the geological age of beds forming the solid geology of the area, namely, the very general absence of fossil remains.

In 1881, Mr. Lydekker was fortunate in finding at Chakoti, on the Jhelam, a palm-frond, referred by Dr. Feistmantel to *Sabal major* (a Lower and Middle Miocene form in Europe) (p. 89).

Nummulites (referred by Mr. W. T. Blanford, F.R.S., to *N. Beaumonti* and *N. granulosa*) were obtained near Murree from the Subáthu (Eocene) group (p. 94). Speaking of the Subáthu group between Khalsi and Nurla (Snurla) on the right bank of the Indus, Mr. Lydekker refers to the occurrence of numerous small disks supposed to be altered *Nummulites* or *Alveolinæ* (but obscure), also a species of *Turbo* obtained by the writer. Colonel Godwin-Austen obtained from the same shelly limestone what he believed to be *Hippurites* and *Hamites*. This is, to say the least, a remarkable assemblage, *Nummulites* and *Hippurites*, and we join the author in enjoining caution in their acceptance (p. 103). One solution offered is the persistence into Eocene times of certain Cretaceous types; but it seems to us more probable, as so often happens in collecting fossils in disturbed and very difficult areas, that the fossils of two or more distinct beds have become intermixed.

The following paragraph seems to suggest a probable solution.

"Along the southern border and to the eastward of the Zánskár river, the Tertiaries have been *much disturbed and not unfrequently inverted*, while their degree of alteration is frequently so great that, on the Gya river, they were at first mistaken by Dr. Stoliczka for Palæozoic rocks" (p. 113). And again, "It appears probable that the junction is really a normal one, the Tertiaries having been bent back under the inverted Palæozoics" (p. 95).

With regard to the age of the Himalayan Tertiaries, the occurrence of *Nummulites Raymondi* in the Ladákh Tertiaries and in the Khirtar group of Sind, identifies this higher zone as of Middle Eocene age, and as the equivalent in part of the Subáthu group of the Sub-Himalayas. The whole series may probably be roughly classed as of Eocene age. Possibly the higher beds may extend into the Miocene epoch, and partly represent the Murree group of the Sub-Himalaya. One point of extreme interest is the bearing of the Indus valley Tertiaries on the elevation of the Himalaya, and the enormous height to which the Tertiaries in the neighbourhood of Leh have been elevated, reaching in Kanri or Stok peak, nearly opposite Leh itself, to the height of 21,000 feet. We are thus led to conclude that the great period of crushing was subsequent to Eocene times, and this is further proved by the frequent inversion of the older rocks on the Tertiaries and the intimate blending of the Tertiary and Palæozoic rocks in the Drás valley. So that we must conclude that the Upper Indus valley must have been raised from the sea-level to its present enormous elevation entirely since the Eocene period, doubtless causing tremendous lateral pressure, which has inverted all the older rocks of the Outer Hills, causing a vast amount of contortion and crushing of the rocks which were raised by it (p. 121).

The next 87 pages (pp. 122—208) are devoted to an account of the Zánskár System, or the Mesozoic and Carboniferous rocks. The Palæozoic and Mesozoic rock-systems which overlie the great crystalline foundation of the north-western Himalaya occupy a series of more or less well-defined depressions or basins between the great crystalline areas. The best defined are the Zánskár basin, the Spiti basin, between the Zánskár and Ladákh ranges; the next is the Káshmír basin; a third may be called the Chamba basin.

No fewer than ten divisions have been noticed by the late Dr. Stoliczka, viz. Cretaceous, Upper and Middle Jura; Middle and Lower Lias; Rhætic and Trias; Carboniferous; and Upper and Lower Silurian. Each of these divisions has its local name (generally after a town or district); in this case all 10 names have been derived from the Spiti valley, where they all occur.

Owing to the general paucity of fossil-remains in the Mesozoic rocks in many districts of Káshmír, it has not generally been found practicable to recognize these minor groups, and since all the rocks from the Carboniferous to the Cretaceous appear as one homogeneous geological formation marked by the prevalence of dolomites and limestones, though the lower beds are generally more shaly, the whole of this enormous rock-system is termed the "Zánskár system."

On pp. 158–159, a list is given of all the fossils determined hitherto from the Zánskár rocks of the Káshmír Basin. The "Supra-Kuling" series, comprising 18 species consisting of Cephalopoda, Gasteropoda, Lamellibranchiata, Brachiopoda, Crinoidea, and Anthozoa, has a Triassic facies. (See plates ii. and iv. for figures of some of these fossils.)

The "Kuling series," from Káshmír Valley, numbering 43 species, comprising 31 Brachiopoda, 3 Lamellibranchiata, 1 Cephalopod, 7 Polyzoa, and 1 Trilobite, agree with the Lower Carboniferous of India.

Another series of fossils, obtained from Kato, in Ladákh, are probably of Jurassic age; they comprise 5 Cephalopoda, 4 Gasteropoda, 4 Lamellibranchiata, and 2 Brachiopoda.

In Chapter VIII. Mr. Lydekker discusses the "Panjál system," or older Palæozoic rocks (Silurian and Cambrian?), consisting of a great series of slaty and volcanic rocks, totally devoid of organic remains, save some obscure impressions from one locality which may possibly prove to be Graptolites.

Some interesting coloured sections are given on Plate III. which serve to show both the amount of contortion and of denudation which these squeezed and crumpled rocks have undergone.

Although palæontological evidence is wanting, the petrological characters and stratigraphical relations of the Panjál rocks leave no doubt that they correspond to rocks of undoubted older Palæozoic age in other areas, as the Blaini, infra-Blaini, and some of the underlying rocks of the Simla area. The great bulk is homotaxial with the Silurian of other parts of the world, although the higher beds may probably represent Lower Carboniferous, and the lowest may be part of the Cambrian.

Chapter IX. is devoted to the consideration of the crystalline and metamorphic system, or Hypogene intrusive, older Palæozoic and Archæan rocks. The newer of these rocks are the altered equivalents of rocks of the Panjál system, and sometimes even of higher rocks; while the older probably correspond with the Archæan (Huronian and Laurentian) systems of European geology.

Mr. Lydekker observes, "Most of the pink areas on the map contain representatives both of the Panjál (Older Palæozoic) and of the central (Archæan) gneiss; in most cases no boundary can be traced between them; but in certain cases there is clear evidence of the denudation of the latter before the deposition of the former; and it is consequently presumed that a similar unconformity, since obliterated by metamorphic action, must originally have existed in all cases between the two rock systems."

Chap. X. is devoted to the Economic Geology of the District.

We cannot help in conclusion giving one more extract from Mr. Lydekker's work descriptive of Lake Páng-Kong, which lies at an elevation of 13,936 ft. above the sea and is over 50 miles in length.

"It may not be out of place to mention incidentally the magnificence of the scenery on the shores of the Páng-Kong lake, which if it were but in any less inaccessible region would attract crowds of visitors, whereas it is only visited by a comparatively few hardy sportsmen and travellers.

The rock-scenery of parts of Ladákh for its striking contrasts of colour is probably unsurpassed in the world, but when to this is added the presence of a large sheet of water like the Páng-Kong lake, the whole effect is then inconceivably magnificent. Standing at the north-western end of the lake at Lukung, the traveller has for the foreground a smooth beach of dazzling white quartz sand, some two miles in length, beyond which lies the broad expanse of the clear blue water of the lake, sparkling in the brilliant sunlight, and blending softly in the far distance with the horizon; while on either side there rise up the picturesque and rugged cliffs of the brilliantly coloured slate rocks, bounded on the south-west by the more sombre gneissic crags of the higher range.

The contrast of the white beach, of the blue water, and of the many-coloured barren rocks around, seen under the dazzling light of a sub-tropical sun, forms an impression on the memory of the fortunate beholder, too deep to be expressed by words, and the recollection of which can never be totally effaced by any other scenes, be their beauty what it may" (p. 258).

We congratulate Mr. Medlicott, the Superintendent of the Indian Geological Survey, on this interesting and important volume now added to the list of Memoirs, and although it may be the last of Mr. Lydekker's Field-work for India, since we understand he will not return again to the scene of his eight years' labours, we believe he is still busy at home working out the grand series of the Sewalik Vertebrata to be figured and described in due course for the *Palæontologia Indica*, to which, as well as to these Memoirs, he has already so largely contributed.

II.—Life of Sir William E. Logan, Kt., LL.D., F.R.S., F.G.S., etc., First Director of the Geological Survey of Canada. By Bernard J. Harrington, B.A., Ph.D., Professor of Mining in M'Gill University. 8vo. pp. 432. With Portrait and 29 other Illustrations. (London: Sampson Low & Co., 1883.)

FEW men born at the dawn of the present century deserve a higher place in the annals of geology than the late Sir William Logan, the subject of this volume. His life extended over the most important period of the development and growth of Geology and he himself took by no means an insignificant part in securely laying down the grand foundation of facts on which that science now securely rests.

A Scotsman by parentage but born in Montreal in 1798, he completed his education at Edinburgh, and having early displayed a love for geological pursuits, he commenced (in 1831) in South Wales a study of the structure of the Coal-fields of that region. The detailed work which he then achieved during seven years was generously handed over by him to Sir H. T. de la Beche, and incorporated in the Maps of the Government Geological Survey of that area.

It was whilst mapping these South Wales Coal-beds that Logan made a most important observation on the origin of coal, then but little understood. He pointed out that each coal-seam rests on an "under-clay" or "fire-clay," in which rootlets of *Stigmaria* branch freely in all directions. This association of coal and *Stigmaria*-clay he found to be so constant that he was led to the conclusion that the clay represented the ancient soil or mud in which the *Stigmaria* grew, and that the coal was the result of the accumulated growth and decay of the matted vegetation which had once lived upon that soil. Looking back, after a lapse of forty years, we are astonished at the brilliance of Logan's early deduction, which served to throw so clear a light upon the nature and origin of coal, and entitles its author to our highest esteem as a most careful and accurate observer.

After protracted attempts to secure for Canada the benefit of a Geological Survey of its territory, the provincial legislature at length, in 1842, reluctantly voted the sum of £1500 for the purpose, and we are not surprised to find that De la Beche, Buckland, Sedgwick and Murchison were unanimous in recommending Logan for the post of Provincial Geologist.

From his appointment in 1842 to 1869 when he retired, Logan's entire time, bodily and mental energies, and not unfrequently his private resources also, were expended in carrying out the survey of his native country; a truly "Herculean task" as Sedgwick observed. He lived however to produce an admirable map of Canada geologically coloured, and based in great part upon sheets topographically surveyed by himself. He also had the laborious honour remitted to him of representing Canada as Special Commissioner at the 1st Great Exhibition in London in 1851, in Paris in 1855, and again in London in 1862.

During his long experience as a Geological Surveyor, Sir William Logan had frequently to perform the painful task of disabusing the public mind as to the supposed existence of coal and other mineral wealth in localities where they could not possibly occur. Here are two or three instances given by his Biographer.

"Some of the inhabitants of the vicinity of Baie St. Paul, below Quebec, announced the discovery of what they stated to be indications of the existence of coal in that region, and had even induced the member for Saguenay County to apply to the Legislature for means to carry on boring operations in search of the supposed coal seams. But the Government naturally objected to granting the money unless it could be shown that there was some ground for expecting useful results, and Logan was instructed to visit and examine the locality. The newest rocks in the region belong to the Trenton formation, and in neither these, nor those beneath them, was there the slightest probability of the existence of coal. But the professed discoverers of the substance had somehow got it into their heads that the presence of coal-seams in any region was usually indicated by fragments being carried to the surface by springs of water, and having carefully packed numbers of springs with pieces of imported coal, they easily convinced the more credulous inhabitants that untold wealth lay beneath them.

The fraud and absurdity of the whole thing must have been evident to Logan from the first, and he might have dismissed the matter as a farce. But to those ignorant of the principles of geology this would have seemed arbitrary dealing, and besides, he had been instructed by Government to report upon the locality. He accordingly reported, giving all the scientific reasons against the occurrence of coal, and finally stating plainly his belief that the fragments had been placed in the springs for a purpose."

This is not the only instance in which Logan had to expose these would-be discoverers of coal. In the very first year of the Survey an Act was passed establishing the Gaspé Coal and Fishing Company, based on the supposed existence of coal in Gaspé; but owing to the adverse opinions of Logan, the shareholders refused to pay up the coveted capital until coal was actually found.

Again it was announced that *a real practical miner* had discovered coal near Bowmanville in Upper Canada. Boring operations were undertaken to test the ground, and sections representing alternations of sandstone, shale and coal-seams were published in many of the newspapers. Great excitement was caused by the wonderful discovery and intense indignation expressed against the geologists, whose fine theories had all been upset "by a practical working man." Logan declared from the first there was no coal there, and refused even to visit the place. A great friend of Logan's, Sheriff W. B. J——, being on his way to Montreal, stopped at Bowmanville to see for himself how matters stood; he saw the bore-rod lowered and fragments of coal extracted from the hole. Reaching Montreal, he hastened to the Survey Museum, and placing the black fragment in Logan's hand, asked, "What do you call that?" "A good bit of Newcastle coal," was the reply; "I saw it taken out of the bore-hole at Bowmanville with my own eyes." "Ah," said Logan, "you should have been there sooner and looked more sharply and then you might have seen it put in." Not long afterwards, while some visitors were witnessing the extraction of coal from the same bore-hole, they observed that the coal was mixed with bread and cheese, which had accidentally got into the hole during the preliminary packing operation. This put an end to the Bowmanville excitement. Eventually it turned out that the bore-rod had never reached the solid rock at all, but had simply passed through a portion of the superficial deposits (pp. 262–265).

One of the great achievements of Logan during his long labours in Canada, was the establishment of the Laurentian System. Here is Prof. Harrington's history of its origin:—"For a long time great quantities of erratic masses of a rock composed largely of Labrador felspar were known to exist in the valley of the St. Lawrence; and in 1852 it was discovered *in situ* by Logan in the townships of Morin and Abercrombie, and described by Hunt in his official report for that year. Subsequently the rock was shown to belong to a great stratified series resting unconformably upon the Laurentian gneiss. It was hence called by Sir William the Upper Laurentian Series, and was believed by him to intervene between the Lower Laurentian and the Huronian, although nowhere found in juxtaposition with the latter. We have already seen that the Laurentian as originally described includes a lower group of gneisses without limestones, to which succeeds a group of gneisses and interstratified limestones. These two groups together constitute the Lower Laurentian of Logan; but inasmuch as the upper division might be confounded with the Upper Laurentian proper, it has been sometimes termed Middle Laurentian. Owing to the occurrence of the series in Labrador, and the predominance in it of Labrador felspar, the Upper Laurentian has sometimes been called the Labradorian series; and in 1870 Hunt suggested that it should be termed the Norian series, inasmuch as it is largely composed of rocks similar in character to the norites of Esmark found in Norway. The facts obtained with regard to the above-mentioned groups previously to 1863, by Logan, Hunt, and other members of the staff, were summed up in the 'Geology of Canada,' and the rocks there described may be tabulated as follows:—

		Feet.
1. Lower Laurentian or Ottawa Series.	Gneiss of Trembling Mountain, etc.	5,000 ?
2. Middle Laurentian or Grenville Series.	Trembling Lake Limestone	1,500
	2nd Orthoclase gneiss	4,000
	Green Lake Limestone bands of gneiss, etc.	2,500
	3rd Orthoclase gneiss	3,500
	Grenville Limestone, bands of gneiss, etc.	750
	4th Orthoclase gneiss, including a thin bed of limestone and a bed of quartzite	5,000
3. Upper Laurentian (Labradorian Norian).	Anorthosite rocks, limestone, and gneiss	10,000 ?
4. Huronian.	Conglomerates, chloritic and other schists, limestone, etc.	18,000

Sir William's more important work in the cause of science may be briefly summed up as follows:—(1.) Investigations with regard to the origin of coal, which resulted in a much clearer understanding of the subject than had been current before his time. (2.) The establishment of the Laurentian system as a great series of crystalline rocks, divided into several groups, and containing at certain horizons evidences of organic life. (3.) The proof of the existence of a second series of crystalline stratified rocks (the Huronian) resting unconformably upon the Laurentian. (4.) The identification of the various formations of Canada younger than the Huronian, and the establishment of the fact that the inferior rocks of the Palæozoic series rest unconformably upon the Laurentian and Huronian. (5.) The production of a number of admirable geological maps, giving not only the results of his own explorations and those of his staff in Canada, but including the work accomplished by various geologists in the other British Provinces and in parts of the United States.[1]

"Earnestness and singleness of purpose were amongst the most marked features of Sir William's character. From the time that he began the Geological Survey until the day of his death, the great aim which was perpetually before him was to thoroughly elucidate the geology of Canada, and to render the knowledge acquired subservient to the practical purposes of life and to the advancement of his native country."

We have to thank Professor Harrington for the interesting volume he has produced. If biographies were read more, but we fear that they are not frequently referred to, we would say that the perusal of the record of such a well-spent life ought to stimulate many to become desirous of emulating so noble a man. Of one thing we are sure, that out in the wilds, in many a distant and lonely spot, Logan's memory is still warmly cherished by hundreds of Canada's rough but warm-hearted children.

CORRESPONDENCE.

THE SCHISTS OF THE LIZARD DISTRICT.

Sir,—In Professor Lapworth's third part of "The Secret of the Highlands," he refers to an illustration in my paper on the Hornblendic and other Schists of the Lizard District (Quart Journ. Geol. Soc. 1883, pl. i. fig. 2,—the reference is incorrectly given by him) as evidencing a form of dislocation liable to be mistaken for false bedding. I feel bound, therefore (as it is implied that I have so mistaken it), to state that the specimen there figured (rather badly) was only a fragment broken off from a much larger surface of rock, and that I do not think it possible that the structure could be explained by any kind of corrugation or shifting whatever, but that it must be a record of original stratification. Corroborative instances could be found by the dozen in the Lizard district. I am perfectly well aware of the simulative structures referred to by Professor Lapworth, but can assure him, as the result of a rather extensive experience

[1] See obituary of Logan, Geological Magazine, 1875, Decade II. Vol. II. p. 382.

among metamorphic rocks, that various structures, which can only be due to the deposition of the original materials, are by no means unfrequent, especially among the higher groups. But while thus defending myself from an implied charge of error, I am glad to take the opportunity of expressing my full concurrence in the general conclusions of these valuable papers. They contain a very lucid exposition of the principles on which mountain chains have been produced, and I expect that in the main the 'Secret of the Highlands' has been discovered. The analogies between the Highlands and the Alps are in many respects close; but their 'mountain making' belongs to very different epochs of geological time, so that they are in very different stages of their history. In each we have a great nucleus of Archæan rocks containing more than one group. In the Alps the next great period of deposit on record (I do not forget the Carboniferous strata of the west) was throughout the Mesozoic, continuing to the earlier Kainozoic. In the Highlands the corresponding period was the earlier Palæozoic. As the Alps became a mountain-chain in Pre-Miocene days, so did the Highlands in Pre-Devonian. There is also a close analogy between the Old Red Sandstone of the latter and the Nagelflue and Molasse of the former. Possibly we may even extend our comparison to the marginal volcanic deposits of the two; but be this as it may, there is I think little doubt that to interpret the Highlands as a greatly denuded mountain-chain is the most hopeful way out of the puzzles which their rocks afford.

T. G. Bonney.

MR. WALLACE'S REPLY TO MR. T. MELLARD READE ON THE AGE OF THE EARTH.

Sir,—I have just received from Mr. T. Mellard Reade, F.G.S., a copy of his paper on the "Age of the Earth" (which appeared in your Magazine of July last), in which I am asked to put that gentleman right as regards what he calls his "analysis" of some figures and estimates given in my "Island Life"; and I gladly seize the first opportunity of doing so. To avoid the necessity of repeating my own statements as well as those of Mr. Reade, I must ask the reader who is interested in this matter to refer back to the above-mentioned article.

The first statement of Mr. Reade's which I have to "put right" is the following:—"It is evident, if the figures mean anything at all, that three millions of square miles 177,200 feet thick represent the whole of the rock removed by denudation in all forms since the geological history of the earth began. Spread this over 57 million square miles of land and we get a deposit 9326 feet thick deposited in all geological time." This is not quite an accurate representation of my statements. The figures quoted represent, not the whole matter denuded, but only that portion of which a record still exists in the rocks; and this matter has been deposited, not "in all geological time," but only in that portion of geological time indicated by the known series of stratified rocks; unconformities and other breaks representing unknown intervals of which we have no record. With these corrections the figures used by me do imply what Mr. Reade says they do; which is, in other words,—that the average thickness of that portion of the earth's crust formed by the known stratified rocks does not probably exceed nine or ten thousand feet.

Mr. Reade, however, without directly impugning these figures, attempts to show that they lead to absurd or incredible results, and he does this by manipulating them in a way which is altogether beyond my comprehension. He first says, that these rocks have been made and destroyed over and over again; and then argues that, *because* the exposed igneous rocks cover about $\frac{1}{12}$ of the land surface, *therefore* "each particle of rock, on the average, has been denuded and laid down at least twelve times." I have in vain tried to see any connection between these two statements, but what follows is still more unintelligible. Mr. Reade adds:—"From this it follows that the actual thickness of the sedimentary crust of the earth, if there were no sedimentary rocks except on the site of the present land areas, *would be* $\frac{12}{9326}$ = 777 feet." Correcting the clerical error of $\frac{12}{9326}$ instead of $\frac{9326}{12}$, this means that, because the stratified rocks have been successively formed from the denudation of older rocks (stratified and igneous), therefore their *actual* thickness would be many times less than by estimates founded on direct measurement it is known they *actually* are! It is, I think, evident that, from Mr. Reade's point of view, he should have here multiplied instead of divided by 12. For if the older rocks have been reduced in thickness by denudation, and their débris has gone to form newer rocks in each successive epoch, it is clear that when first deposited all the rocks *would have been* thicker than now, though there is no definite relation between the number of successive formations and their greater thickness, as Mr. Reade seems to suppose. For example, if half the original Palæozoic rocks have been denuded to form the Mesozoic and parts of the later rocks, and half of the original Mesozoic to form the Tertiary, and half these again to form glacial and recent deposits, each would have been at first about twice as thick as it is now,—not one-fourth the thickness, as Mr. Reade's mode of calculation would make them; and as the whole problem is one of the *time* taken to produce these various deposits, the greater original thickness would have to be used in the calculation.

But, even if Mr. Reade's figures are thus corrected, his whole criticism is radically unsound; for, as I have explained in my original discussion of the subject, denudation is so unequal in its action and occurs so generally on the edges of uplifted strata not over their surfaces of deposit, that it would be quite possible for $\frac{9}{10}$ or even $\frac{99}{100}$ of a formation to be destroyed by denudation, and yet for the remaining $\frac{1}{10}$ or $\frac{1}{100}$ to give a fairly accurate measure of the *average* thickness or even sometimes of a *maximum* thickness of the original deposit. Our measures of the thickness of the sedimentary rocks will, therefore, not be seriously affected by the fact that by far the larger portion of all of them have been destroyed by denudation, and again and again laid down to form newer rocks; and as I have used measures of the *maximum* thicknesses, I have considered that these would in all probability not differ much from the original *average* thicknesses of the same rocks before they had suffered denudation. No doubt some rocks may have been wholly destroyed by denudation, or are so covered up by later deposits as to be beyond our reach, and to allow for these I am willing to admit that my estimate of the whole thickness of the rocks, and therefore of the time taken to produce them, may have to be considerably increased; but this would bring my figures nearer to those usually arrived at, not enormously further from them as Mr. Reade endeavours to prove.

Yet again, Mr. Reade points out that continents have fluctuated, and have sometimes been larger than now. To allow for this he doubles the land surface and reduces the corresponding thickness of the strata to one-half! But, surely, if the continents have been sometimes larger, they have also been sometimes smaller, and I see no reason to think we can take any fairer *average* than that of the present area; and even if the average *had* been double, then the denudation and the deposit would presumably have been double also, not half as Mr. Reade suggests.

With regard to my fundamental position—that the areas of deposition are (and always have been) very much smaller than the areas of denudation, and that, in making any estimate of geological time founded on the thickness of the sedimentary rocks and the known rate of denudation, this fact must be taken account of, Mr. Reade makes no objection; and, whatever "confusion of ideas" may have pervaded my estimate, the subject has certainly not been rendered clearer by his criticism.

Finally, as regards the general theory of the "Permanence of Oceans and Continents" (or, more properly, of Oceanic and Continental areas), which Mr. Reade somewhat sneeringly remarks "is now becoming fashionable,"—it is time that its opponents should give up petty criticism of unimportant details or collateral issues, which have little bearing on the main question, and attempt to grapple with the whole body of facts and arguments adduced in its support by some of the first geologists of the day, and which I have endeavoured to set forth in a connected form in the pages of "Island Life." Any such general examination of the question from an adverse point of view, I have hitherto failed to meet with.

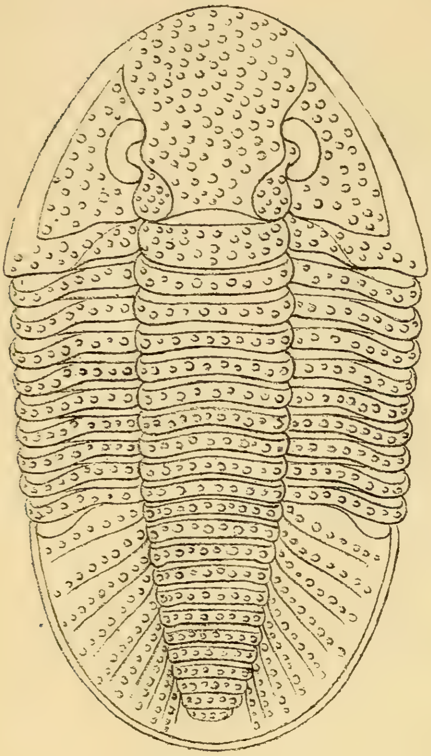
Alfred R. Wallace.

THE OLD HYTHE PINNACLE OF CHALK.

Sir,—On referring to the Life of Lyell, I find the letter relating to the disappearance of the Old Hythe Pinnacle of Chalk was written in 1869, not 1864. The evidence of Lyell does not therefore conflict with that of Prof. Seeley and Mr. Searles Wood, as I thought it did, but taken with theirs, rather points to the total destruction of the pinnacle between those dates. With this correction I must close the correspondence on this subject so far as I am concerned.

T. Mellard Reade.

Sept. 4, 1883.



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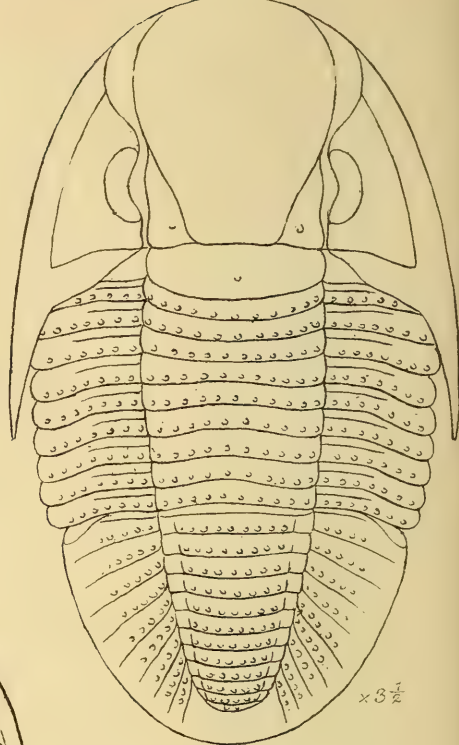

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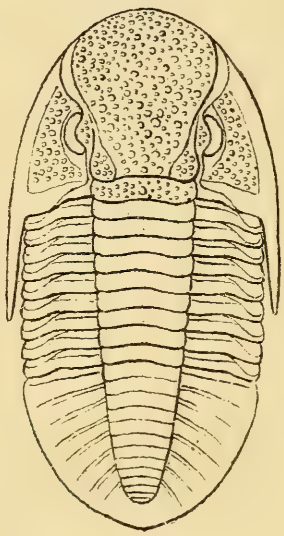

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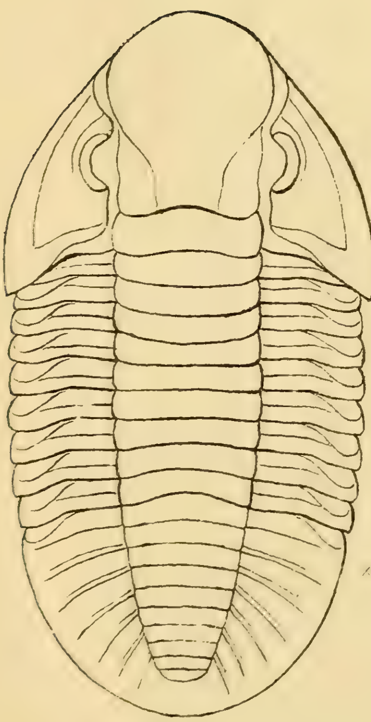

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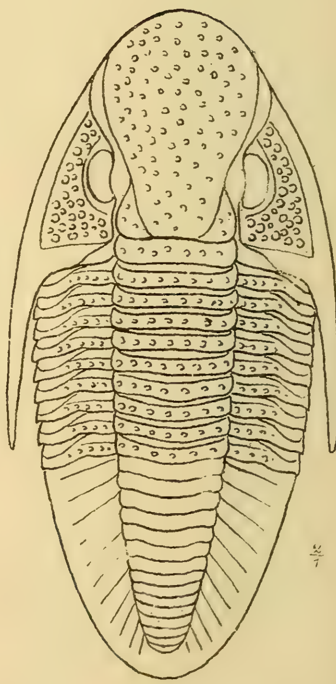

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G. M. Woodward del.

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Carboniferous Trilobites.
Griffithides.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. X.

No. XI.—NOVEMBER, 1883.

ORIGINAL ARTICLES.

I.—Synopsis of the Genera and Species of Carboniferous Limestone Trilobites.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE XII.)

(*Continued from p.* 454.)

III.—Griffithides, Portlock, 1883.—Outline oblong oval; glabella pyriform, gibbous in front, destitute of lateral furrows; basal lobes inflated; cervical lobe broad; eyes small, lunate, smooth; axial furrow clearly defined, outline of free cheek broadly triangular, outer posterior angle sometimes produced into a cheek spine. Thorax with nine segments; pygidium rounded, composed of from ten to thirteen coalesced somites.

There has been much confusion among writers upon the Carboniferous Limestone Trilobites, as to the generic characters which may be relied upon in separating *Phillipsia* from *Griffithides.* While fully admitting the difficulty which arises from having so frequently to determine the genus and species of these Carboniferous forms upon a pygidium alone, yet whenever the head is preserved, we venture to think there ought not to be any hesitation.

The following brief diagnosis of the characters may be found of use in separating the two genera most commonly met with:—

Phillipsia.	Griffithides.
1. Sides of glabella nearly parallel.	1. Glabella pyriform.
2. Marked by either two or three short lateral furrows.	2. No short lateral furrows on the glabella.
3. Basal lobes continuous with the glabella.	3. Basal lobes distinct from the glabella.
4. Eyes large, reniform.	4. Eyes small, suboval.

Griffithides seminiferus, Phillips, sp. 1836. Pl. XII. Fig. 1, and 1*a*.

Asaphus seminiferus, Phillips. 1836. Geol. Yorks, vol. ii. p. 240, pl. xxii. figs. 8, 9, 10.
Phillipsia gemmulifera, De Koninck. 1842. Animaux Foss. Terr. Carb. Belgique, p. 603, pl. liii. fig. 3 (non Phillips).
——— ——— M'Coy. 1844. Synopsis Carb. Foss. Ireland, p. 163.
——— *seminifera*, Morris. 1854. Cat. Brit. Foss. p. 114.
——— ——— Salter and H. Woodw. 1865. Cat. and Chart. Foss. Crust. p. 15, fig. 110.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
Griffithides seminiferus, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 28, pl. v. figs. 1–9.

General form ovate-oblong; head-shield arcuate, glabella large, gibbous, over-hanging the anterior border; basal lobe pyriform; neck-lobe broad, separated by a wide furrow above and below; eyes small, reniform, smooth; raised portion of free cheek, glabella, and neck-furrow coarsely and irregularly granulated, margin of free cheeks smooth, lateral angles not produced into cheek spines, thoracic segments nine, axis wider than pleuræ, only diminishing very slightly towards the pygidium; each segment ornamented by a single row of coarse granules (about eight on each side and ten on the axis); axal furrows strongly marked; segments arched, ends of pleuræ rounded, faceted portion smooth; pygidium composed of twelve coalesced somites, axis tapering gradually to an obtuse extremity; side ribs about nine, ornamented each by a single row of tubercles eight to ten on axis, about eight on each pleura; margin of pygidium narrow, edge bevelled.

Hypostome, Pl. XII. Fig. 1*a*, broad and short, wings not distinct from central lobe; obliquely striated, free extremity rounded and emarginated.

Formation.—"Rotten-stone Band," Carboniferous Limestone.

Localities.—Matlock, Derbyshire; Settle, Yorkshire; and Black-rock, near Dublin.

Specimens have been examined from the British Museum, the Woodwardian Museum, and the collection of Joseph Wright, Esq., F.G.S., of Belfast.

GRIFFITHIDES GLOBICEPS, Phillips, sp., 1836. Pl. XII. Fig. 2.

Asaphus globiceps, Phillips. 1836. Geol. Yorks, vol. ii. p. 240, pl. xxii. figs, 16–20.
Griffithides globiceps, Portlock. 1843. Rept. Geol. Londonderry, p. 311, t. xi. figs. 9*a*, *b*.
Phillipsia globiceps, De Koninck. 1844. Anim. Foss. Terr. Carb. Belgique, p. 599, tab. liii. fig. 1.
Griffithides globiceps, M'Coy. 1844. Synopsis Carb. Foss. Ireland, p. 160.
——— ——— Oldham. 1846. Journ. Geol. Soc. Dublin, vol. iii. pt. 3, p. 188, pl. 2.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 109.
——— ——— Salter and Woodw. 1865. Cat. and Chart. Foss. Crust. p. 16, fig. 117.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 37.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 29, pl. vi. figs. 1, 3, 4, 5, 6.

General form ovate-oblong, head elevated, glabella very gibbous, overhanging the anterior border of shield, contracting rapidly to about half the width behind, where it unites with the neck-lobe; basal lobes prominent, triangular, to which the eyes seem to be united without the intervention of any fixed cheek; but there is a very narrow border united to the glabella forming the palpebral lobes which join the lateral lobes, or nearly so; neck-lobe moderately broad, axis strongly arched: lateral portion crossed by cheek-suture obliquely; eyes very small but exceedingly prominent; cheeks very narrow and compressed, ending in short, blunt spines; margin of head striated longitudinally; eyes very minutely faceted; thoracic segments nine in number, strongly trilobed; axis wider than the pleuræ; the posterior portion of each segment strongly corrugated, and each pleura groove extending rather beyond the fulcral point; the extremity of each pleura is rounded and broadly faceted; pygidium rounded, consisting of eleven coalesced somites which in the axis continue the corrugated character of the thorax, but diminish to a blunt termination considerably within the border; the ribs of the pygidium are double and die out before reaching the edge of the tail-shield, leaving a somewhat wide smooth margin. Surface of head very finely punctate.

Formation.—Carboniferous Limestone.

Localities.—Bolland and Settle, Yorkshire; Forest of Wyre, Preston; Millicent, Clane, Kildare; Waterford, Clonea; Derryloran, Tyrone; Blackrock, Dublin; and Athlone, Ireland.

Specimens of *Griffithides globiceps* have been examined from the National Collection, the Museum of the Geological Survey of Ireland, from the Woodwardian Museum of Cambridge, and from Mr. Joseph Wright's Collection.

Griffithides acanthiceps, H. Woodw. 1883. Pl. XII. Fig. 4.

Griffithides acanthiceps, H. Woodw. sp. nov. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 32, pl. vi. figs. 2, 10, 11.

Head-shield semicircular, produced in front, glabella very gibbous, overhanging the anterior margin, twice as wide in front as at the nuchal furrow, the whole surface strongly granulated; basal lobes very small, rounded; neck-furrow deep; neck-lobe rounded; fixed cheeks exceedingly narrow, scarcely discernible, forming a rounded palpebral lobe (the surface of which is granulated) over each eye, and a narrow rim around the glabella; eyes small, finely faceted, inner raised portion of cheeks granulated, margin smooth, posterior angle produced into long cheek-spines equal to the glabella in length.

Thorax consisting of nine free segments, surface of thorax smooth without ornamentation; axis arched, rather wider than its pleura, broader next the head and diminishing very slowly to the pygidium; each of the pleuræ strongly grooved down the centre, posterior portion rounded and slightly raised, anterior portion slightly depressed; fulcral points distinctly marked, extremity of pleuræ faceted in front and rounded.

Abdomen or pygidium composed of about thirteen coalesced somites, border smooth, slightly channelled, ribs terminating close to border. Extremity of pygidium very slightly pointed.

Formation.—Carboniferous Limestone.

Localities.—Craco, near Grassington; Settle, Yorkshire; and Castleton, Derbyshire.

The only specimens of *G. acanthiceps* known to me are in the Woodwardian Museum, Cambridge, and in the cabinet of J. Aitken, Esq.

Griffithides longiceps, Portlock, 1843. Pl. XII. Fig. 3.

Griffithides longiceps, Portlock. 1843. Rep. Geol. Londonderry, p. 310, tab xi. figs. 7*a*, *b*.
——— ——— M'Coy. 1844. Synopsis Carb. Foss. Ireland, p. 160.
——— ——— Morris (*in part*). 1854. Cat. Brit. Foss. p. 109.
——— ——— H. Woodw. (*in part*) 1877. Cat. Brit. Foss. Crust. p. 37.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 33, pl. vi. figs. 7, 8, 9.

General form ovate-oblong; head-shield very large in proportion to the rest of the body, forming two-fifths of the entire length; glabella very gibbous, pyriform, basal lobes obtusely triangular, with a tubercle on the centre of each; fixed cheeks very narrow, but expanding rather at the sides of the glabella in front of the eyes; axal portion of the neck-lobe very broad, and separated by a strong furrow, and bearing one tubercle on its centre; eyes moderately large, reniform surface very finely faceted; raised inner portion of free cheek rather narrow, surface finely granulated, outer margin wide, posterior angles produced into broad and stout spines, reaching to the fifth segment of the thorax; thorax composed of nine free segments, the axis arched, equalling half the entire breadth of the thorax; each segment bordered by ten or eleven granules on its axis along the posterior border, and seven or eight on each pleura; pleuræ rounded at their extremities, pygidium composed of thirteen coalesced somites, ornamented in a similar manner to the free thoracic ones; axis tapering to a blunt extremity, and surrounded at its termination by the smooth border of the tail-shield; ribs nine in number, dying out near the margin.

Formation.—Carboniferous Limestone.

Localities.—Settle, Yorkshire; Cookstown, Tyrone; Creggane, Limerick; Brockley, near Lesmahagow.

Specimens have been examined from the Museum of Practical Geology, Jermyn Street; the Woodwardian Museum; the Museum of Geological Survey of Ireland, and from Mr. John Young's Collection.

Griffithides platyceps, Portlock, 1843.

Griffithides platyceps, Portlock. 1843. Rep. Geol. Lond. p. 311, pl. xi. fig. 8.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 109.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 37.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. part i. p. 34, pl. vi. fig. 13.

Only the glabella of this species is known, but as it presents some peculiarities, and General Portlock was always so careful an observer, we may safely quote his remarks in case other and more perfect remains should be discovered.

"This is," he remarks, "a larger individual of probably another species (distinct from *G. longiceps*), the surface is granular, and it is proportionately flatter. It may be called *Griffithides platyceps*" ("Report on the Geology of Londonderry and Tyrone," p. 311). From the Carboniferous Limestone of Derryloran, Tyrone, Ireland.

The one specimen examined is from the Museum of the Geological Survey of Ireland, Dublin, and is probably Portlock's original specimen; but his figure, if such is the case, does not assist us in recognizing it with absolute certainty.

GRIFFITHIDES OBSOLETUS, Phillips, sp., 1836.

Asaphus obsoletus, Phillips. 1836. Geol. Yorks, vol. ii. p. 239, pl. xxii. figs. 3-6.
——— *granuliferus*, Phillips. 1836. *op. cit.* fig. 7.
Phillipsia Brongniarti, De Koninck. 1842. Anim. Foss. t. liii. fig. 7.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 114.
——— ——— Salter and H. Woodw. 1865. Cat. and Chart. Foss. Crust. p. 16, fig. 113.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 55.
Griffithides obsoletus, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. Part i. p. 35, pl. vi. fig. 12.

This species is founded on a very broad and smooth pygidium, nearly one-fourth broader than long, composed of ten coalesced somites, the axis much broader than the pleural portion, each of the nine rib-like plicæ being marked by a furrow down the centre (as in the pygidium of *G. globiceps* already noticed), the margin of the tail-shield is smooth.

The glabellal portion of the head, most probably belonging to the same individual (being enclosed in the same piece of matrix), although mutilated, exhibits peculiar and delicate striations over its entire surface. The head (somewhat restored) is figured by Prof. Phillips with the pygidium. This specimen is the type of Phillips's figure in the Geol. of Yorkshire, and was at that time in the Gilbertson Collection, and now in the British Museum (Natural History).

Formation.—Carboniferous Limestone.

Locality.—Bolland, Yorkshire.

Specimens of *Griffithides obsoletus* have been examined in the National Collection and from the Woodwardian Museum, Cambridge.

GRIFFITHIDES LONGISPINUS, Portlock, 1843. Pl. XII. Fig. 5.

Griffithides longispinus, Portlock. 1843. Geol. Rept. Lond. p. 312, pl. xxiv. fig. 12.
——— ——— M'Coy. 1844. Carb. Foss. Irel. p. 161.
——— *longiceps*, Morris. 1854. Cat. Brit. Foss. p. 109.
——— ——— Salter and H. Woodw. 1865. Cat. and Chart. Brit. Foss. Crust. p. 16, fig. 115.
Phillipsia ——— V. von Möller. 1867. Trilob. der Steinkohl. pp. 19 and 73.
Griffithides ——— H. Woodw. 1877. Cat. Brit Foss. Crust. p. 37.
——— *longispinus*, H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. p. 36.

General form elongated-oval; head wider than long; glabella very gibbous in front, slightly overhanging the anterior border, much broader in front than behind the eyes, basal lobes small, rounded; neck-lobe strongly arched, narrow, divided from the glabella by a deep neck-furrow; fixed cheeks narrow where they pass from the posterior border and above the eyes, forming the small rounded palpebral lobes, after which they expand again slightly on each side of the glabella before the facial suture unites with the front border; surface of glabella thinly and irregularly tuberculated; free-cheeks small, elevated, channelled around the eye and the border, the small area so inclosed covered with numerous rather coarse and irregular bead-like ornamentations; eyes reniform, moderately small, smooth; margin of cheeks smooth, produced into rather long cheek-spines ("long flat striated spines," Portlock[1]); margin of head-shield incurved, finely striated; thoracic segments nine in number, axis strongly arched, each segment having a narrow elevated central rib ornamented with about twelve small tubercles or spines, with a smooth anterior articular portion and a less elevated posterior border; the pleuræ are strongly grooved and are bent down at the fulcral point, their extremities being faceted and obtusely pointed. Pygidium composed of from twelve to fifteen[2] coalesced segments; axis strongly arched and ribbed, like the thorax, but no ornamentation visible; side-lobes of pygidium also arched; the ribs running to the border; a wide striated margin is exposed where decorticated.

Formation.—Carboniferous Limestone.

Locality.—Carnteel, Tyrone, Ireland.

The specimen figured is preserved in the Museum of Practical Geology, Jermyn Street, and is unique.

GRIFFITHIDES CALCARATUS, M'Coy, sp., 1844.

Griffithides calcaratus, M'Coy. 1844. Synop. Carb. Foss. Ireland, p. 160, pl. iv. fig. 3.
——— *mucronatus*, H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 37.
——— *calcaratus*, V. von Möller. 1867. Trilob. der Steinkohl. p. 19.
——— ——— H. Woodw. 1883. Pal. Soc. Mon. Carb. Trilob. pt. i. p. 38.

This species was proposed by Prof. M'Coy in 1844, for a specimen from Ireland of which he figures the head only, but describes the head and tail also. We have not been so fortunate as to see the original of M'Coy's figure, but we give his own description as follows:—"Cephalo-thorax semioval; glabella smooth, ovate, most convex in the middle of its length; cheeks small, triangular, flat, smooth; wings strongly striated, broad, prominent, rounded, terminating posteriorly in long, flattened spines; eyes moderately lunate (smooth?), connected with the glabella by a nucleus on each side; pygidium with a smooth margin, each segment with a row of very minute granulations.

This beautiful species is most nearly allied to the *G. longispinus*, of Portlock, but is at once distinguished by its smooth cheeks; the eyes also, in the present species, are differently formed and placed, and the glabella is much smaller and less prominent in front. Length of glabella five lines, greatest width three lines; width at base one line, width of cephalo-thorax seven lines; length of eyes one and a half lines, width one line; length of posterior alar spine three lines. The pygidium has a broad, smooth margin or limb, in which it differs from that of *G. longispinus*, in which the segments are extended to the margin; there are a single row of very minute granules on each segment. Width of pygidium five lines" (*op. cit.* p. 160).

[1] There is reason to conclude that one of these spines existed when Portlock wrote his description, although it is only now indicated by a fragment and by the scar where it once rested.

[2] The extremity is injured, so that the exact number cannot now be ascertained.

Although I placed *G. calcaratus* in 1877 as a synonym under *G. mucronatus*, I find that neither the description nor figure admit of its being so disposed of, and I therefore give it on M'Coy's authority.

Valerian von Möller says of *Griffithides calcaratus*, "M'Coy only figures the cephalothorax, it is nearly related to *P. globiceps*, Phill., but is distinguished from this species by the very inferior size of the glabella, and by the long flattened cheek spines; from another Trilobite, *P. longiceps*, Portl. (= *G. longispinus*, Portl.), with which it is also nearly connected, but from which it differs in its very narrow glabella and the wide flattened border around the pygidium."

GRIFFITHIDES MORICEPS, H. Woodw. sp. nov.

Head-shield semicircular, 22 mm. long and 30 mm. broad; glabella elevated, very gibbous and obtuse in front, and twice as wide at the anterior border as at the neck furrow; basal lobe small, rounded; surface of glabella and free-cheeks thickly covered with large round granulations; facial suture running very close around the glabella; free-cheeks hatchet-shaped, central ornamented part raised and bearing the small smooth reniform eyes close to the basal lobe; border of cheeks deeply furrowed and smooth, with a raised margin having a rounded rim; neck-lobe narrow, smooth, flattened and separated by a rather strongly marked neck-furrow, which is continued and unites with the furrow surrounding the free-cheeks, forming somewhat blunt angles to the head-shield.

Formation.—Carboniferous Limestone,

Locality.—Settle, Yorkshire.

All the specimens of *G. moriceps* which I have seen are preserved in the Woodwardian Museum at Cambridge.

EXPLANATION OF PLATE XII.

FIG. 1. Restored outline figure of *Griffithides seminiferus*, Phil. sp., enlarged twice nat. size.

,, 1*a*. Hypostome of same.

,, 2. Restored outline figure of *Griffithides globiceps*, Phillips, sp. enlarged one and a half times nat size.

,, 3. Restored outline figure of *Griffithides longiceps*, Portl., enlarged three and a half times nat. size.

,, 4. Restored outline figure of *Griffithides acanthiceps*, enlarged one and a half times nat. size. H. Woodw.

,, 5. Restored outline figure of *Griffithides longispinus*, Portlock, enlarged twice nat. size.

(*To be continued.*)

II.—A FEW WORDS CONCERNING THE PERIODICAL MOVEMENT OF THE OCEAN.

By Dr. H. TRAUTSCHOLD,
of the Petrovsky Academy, Moscow, Russia.

SINCE geology entered the order of exact sciences, it has been acknowledged by all those, who thoroughly studied it, that the history of the earth is to be divided into three great periods, which have been called, after the faunas they contain, Palæozoic, Mesozoic and Cainozoic. Indeed it could not escape the eye of the palæontologist, that between the marine faunas of the Permian period and the Trias on one side, and the Chalk sea and the Eocene period on the other, there is a greater difference than between the animal world of any of the other periods. In the transition-period between Permian and Trias, Corals, Cephalopods, Reptiles, etc., underwent an astonishing change; thousands of forms seemed to have perished, thousands of new ones appeared; in the succeeding time, shortly after the commencement the fauna of the Mesozoic seas showed, on the whole, quite another stamp, than that of the Palæozoic seas. A quite undisturbed development seemed to have reigned from Silurian to Permian, and there seemed to have been a sudden interruption of that development during the Permian period. Again, there followed an era of the most quiet and peaceful evolution during the Triassic, Oolitic and Cretaceous periods, where the connection between the several marine faunas seems to have been an uninterrupted one; then, at the end of the Cretaceous period, the marine fauna underwent a new change. The dawn of a new time (Eocene) begins, thousands of forms again disappear to be replaced a second time by new ones, as had occurred during the Permian period. Again, the Cephalopods seem to have been the class against which a war of annihilation was directed, and in their place the Pelecypods and Gasteropods take the leadership in the new era. The Enaliosaurians having reached a high development die out entirely and the Crocodilians retire to the rivers. The Secondary fauna gives way to the Tertiary, bearing a thoroughly new stamp.

What was the cause of such an important change in the first as well as the second instance? Geology is by far too new a science to solve important questions like these. Notwithstanding the marvellous zeal with which the surface of the earth has been explored in our century, larger spaces of it can only be opened to our knowledge after the lapse of a great many years, and therefore it is quite impossible at once to draw general conclusions from the results of these investigations. But now, Europe having been explored in the most careful manner, as well as the structure of the North-American continent to a great extent, now that Russian naturalists and v. Richthofen have made us more familiar with the Asiatic continent, we may venture to open out more general views. Now we are able to answer the question with more assurance, what was the cause of the apparent interruption in the evolution of the maritime fauna at the end of the Permian and the beginning of the Tertiary periods in the northern hemisphere?

The cause of these phenomena was no other than the periodical movement of the ocean.

The most suitable areas for the clear demonstration of this movement are large plains, built up by horizontal strata, whose order has never been disturbed. A plain of this kind is to be found in European Russia. It leaves nothing to be desired as to the undisturbed horizontality of its strata, and the surface shows in the direction of its rivers only a slight inclination towards the south and south-east. A glance over the map of Murchison and Helmersen makes it evident that in the north of European Russia the Palæozoic formations unite with each other from west to east in rows like ribbons. The Silurian is in the western part, and its ocean-floor came to the surface before the other systems; here was the shallowest part of the Silurian sea, and its deepest in the northern half of Russia towards the Urals, where the bottom of the Permian sea was laid bare last. Here westward from the Urals, even in our days, the Rama and Viatka flow to the south into the Volga, which also follows this southern inclination. It is evident that the architecture of the Palæozoic strata in the northern part of European Russia is as follows:—In the west (Esthonia) on azoic foundation, Silurian; towards the south and east with continuation to the north, Devonian, with underlying Silurian; east from the Devonian and parallel to it, Mountain Limestone, covering Devonian and Silurian; finally Permian between Mountain Limestone and the Urals, covering the systems just mentioned. When in the northern part of Russia the bottom had been left by the Palæozoic sea, the southern part was perhaps still covered by a shallow sea with the exception of some islands, formed by Silurian, Devonian, and Mountain Limestone deposits, as well as by large plutonic masses rising above the water. So there were not only deposited the Palæozoic formations, but also a part of the lower Mesozoic as Trias, but probably only in thin layers, for the most part destroyed afterwards or covered by newer deposits. A small remainder of Trias is to be seen in the Caspian Steppe (Mount Bogdo) and the Lower Oolite comes to the surface in the Crimea and in the Caucasus, From the evidence of this lower series of the Mesozoic rocks we may therefore conclude that during the Triassic period the ocean receded from the Aralo-Caspian Plain, Western Siberia, the Kirghiz Steppes, as well as from the Steppes of South Russia, but washing still the crystalline base of the Caucasus. The ocean had withdrawn constantly and slowly from north to south as far as the basins of the Caspian and Black Sea, and this movement had probably begun at the commencement of the Silurian period.

But when this receding movement took place in the northern hemisphere, the water must flow off not only to the south, but wherever the passage to the ocean was open. So the water that had covered the Russian plain had to flow off to the Baltic Sea and to the Arctic Ocean. This is in perfect concordance with the occurrence of Muschelkalk near Berlin, Magdeburg, on the Olenek in Siberia, which shows that the deposits with *Ceratites* were accumulated at the same time, and that the sea-level during that period was almost the same over this area. The higher position of the Muschelkalk in middle and southern Germany and in the Alps is to be attributed to subsequent movements of the surface of the solid crust of the earth.

It seems, therefore, that towards the end of the Triassic period or at the beginning of the Oolitic, European Russia must have formed a similar continent with similar shore-lines as at the present day.

Only when the sea of that time was inhabited by the Bathonian and Kellovian faunas, the renewed rise of the ocean reached again the height of the Russian plain and again overflowed a large part of it. The rising waters found here indeed an almost thoroughly flat plain, the deposits of the former Palæozoic sea having filled up every depression of that part of the earth's crust. Only a comparatively narrow depression remained in the northern part of Russia, parallel with the Urals, and in their neighbourhood; Southern Russia being inclined to the south and separated.

If we take into consideration the low position of mount Bogdo of Triassic age, it is not probable that there are under the Cretaceous and Tertiary deposits in Southern Russia still sediments of Lias or Inferior Oolite; at least there is nothing visible, and what there is to be seen belongs to the Upper Oolitic strata, as *e.g.*, the Coral-rag of the Donetz (Isium) forming a kind of isle, partly covered with Cretaceous sediments. In middle and northern Russia only Upper Oolitic strata exist, the fauna of which is comparatively uniform, the typical forms being nearly the same at Sysnau, Moscow, Yaroslav, on the Petshora and on the isles of the Arctic Sea. This uniformity is explicable, because the rising waters must have spread with great tranquillity over the almost absolutely horizontal plain.

But these waters did not cover the Russian plain to any great height, and the sediments they deposited are to be estimated by hundreds, but not by thousands of feet; likewise these sediments evidently do not belong entirely to the sea-water of that epoch, neither were they brought by currents from far; but the advancing sea found them at the spot itself, stirred them up, mixed the diverse material, and deposited them again, burying at the same time in the mud the remains of the marine animals of the Bath, Kelloway, etc., periods.

The strata of the Moscow Oolitic system offer a good illustration of this process. As it is known, the plastic black Oolite clay (Kelloway and Oxford) rests in the government of Moscow immediately on the Upper Mountain Limestone. But here and there between the latter and the Oolitic clay, is intercalated a red or variegated clay, which has been deposited during the Permian period and is not fossiliferous. The rising waters of the ocean met with these clays, but at the same time also with the remainder of the vegetation of the Carboniferous and Permian systems, originated in the shallow basins of the Carboniferous Limestone. The depth of the new sea not being considerable, every storm must have stirred up the shallow water and caused the mixture of the Carboniferous substance with the underlying clay. In this manner a clayey sediment of the quality of the Moscow Oolite clays was produced, without the sea-water furnishing the material, which, considering the shallowness of the Russian sea of that time, was impossible. But not only was the clay coloured black, but also the glauconitic sand, of which the upper half of the Moscow Oolite beds consists, as the stratum with *Amm. virgatus*, and not unfrequently the stratum with *Amm. fulgens*. Even near Moscow in the stratum with *A. virgatus* are often to be found pieces of petrified wood of Coniferæ, which possibly can be explained by the formation of this layer after the water had risen above the region of the Stigmaria swamps up to that of fir trees. The reason that the older Mountain Limestone of the government of Toula and other places is not covered by Jurassic sediments is due to the fact of the more considerable height of those localities than that of the greater part of the government of Moscow and Riasan, where the newer Mountain Limestone is covered by Oolitic rocks. The circumstance, that the newer limestone of the Carboniferous system of Russia has been deposited in the lower part of the central marine basin, indicates by itself the receding movement of the Palæozoic sea. I have endeavoured long ago in several of my former papers to show, that the lower position of the newer sediments on undisturbed rocks affords one of the principal proofs of the general retreat of the ocean.

The process in the formation of the Jurassic or Oolitic sediments in Russia is therefore simply as follows: When the Russian plain was submerged, the waves of the shallow sea stirred the peat mud of the Stigmaria swamps, mixed it with the underlying Permian clay and formed a black mud, which we now call Moscow Oolite, because it contains Oolitic animal remains. When the sea of that time rose still more, it overflowed wood-covered spots of the former continent, which furnished to the *Ammonites virgatus* stratum the above-mentioned pieces of wood; at the same time the decomposition of amphibolic rocks gave the material for the formation of glauconite, which is the essential compound of the layers of the Upper Jura with *Amm. virgatus* and *Amm. fulgens*. Small prominences of syenitic rocks are found amidst the strata near Paulowsk in the government of Voronesh, where they are denuded by the river Don; it is more than probable, that these rocks, everywhere hidden by newer sediments, have there a great extension.

The sediments of the Cretaceous period have not the same extension in the northern part of European Russia nor those of the Jurassic period. The last indications of them do not go further to the north than the 58th degree of latitude. If we do not admit that the Cretaceous deposits everywhere towards the north are destroyed, we must acknowledge that a new receding movement of the ocean had begun at the end of the Cretaceous period in this part of the earth. But though the destruction after the retreat of the sea has been very considerable, and though a great part of the greensand of the Moscow Oolite and of the Cretaceous strata have been changed by prolonged trituration into alluvial sand, and the sediments of Gault, Upper Greensand, and Chalk Marl have undergone similar changes, we must still say, that in those places where these deposits have existed before, some remains of them have been conserved here and there, as sufficiently proved by the outliers of Gault, Upper Greensand, and Chalk Marl in the Government of Moscow, that have escaped the general destruction.

If the absence of several systems of marine sediments speaks in favour of the existence of a long continental period in Russia, in the Government of Moscow, from the end of the Carboniferous period to the half of the Oolitic period, so beside the Stigmaria swamps and the above-mentioned fragments of wood in the Virgatus stratum of the Moscow Jura, there are also several other positive witnesses proving the existence of a continental epoch. One of these witnesses is a piece of *Calamites arenaceus* from the red sands of the river Wytchegda, another witness is a tooth of *Ceratodus*, found in a marl of Wetluga by M. Nikitin. Furthermore, M. Krotof has discovered on the Volga near Tumki, in the sandstone, fragments of the stems of *Pinites biarmicus* and freshwater shells like *Unio umbonatus*, Fisch., and *U. castor*, Eichw. Luckenberg has also found that the variegated marls, lying immediately under the Jurassic strata near Simbirsk, contain the same shells, together with *Estheria minuta*. Among the best witnesses of the continental period between the Carboniferous and the Jurassic periods are not only the rich flora of the copper sandstone at the foot of the western Urals and the Steppe of Kargala, but also the gigantic Saurians and the fishes of the same sandstone, which enlivened the swamps and lakes and rivers of the Permian and Post-Permian period. And whilst this continental fauna and flora extended themselves over Russia, the shallow Permian sea contracted itself more and more, containing only a limited number of animals, which induced the French to give the name pénéen (πένης) to the Permian system, showing in the West of Europe the same poverty of species. A relative scarcity of species is also observable in the Russian Oolite, and this is not astonishing, if we take into consideration that owing to the shallowness of the narrow sea of that epoch a great number of pelagic animals must have been excluded.

Towards the end of the Cretaceous period a second retreat of the sea from European Russia took place. As the Russian sea of that time was in connexion with the ocean, the receding movement of the sea must have taken place as well to the north as to the south and west; it is therefore remarkable that in the northern part of Russia we find not a trace of Tertiary sediments. Are we entitled to think that the Russian sea at the Tertiary period was depressed only to the south?[1] But if that was the case, nevertheless, the whole ocean participated in the movement, and the Tertiary sea must have left its shells on the shores of Arctic Russia as well as the post-Tertiary ocean left its shells during its gradual retreat at the mouth of the valleys of the Dwina and Petchora. Moreover, during the Tertiary period there was no mountan chain that could prevent the flowing off of the sea-water.

It is remarkable also that the northern half of Russia, after having become for the second time a continent, only became habitable for lower and higher animals very late. I have already mentioned in my former papers that its eluvium and alluvium do not contain even traces of shells, and that the upper layers of dry land formation contain only remains of Mammoth, *Rhinoceros tichorhinus*, *Bos priscus*, *Cervus megaceros*, etc. Evidently during the whole Tertiary

[1] We find here in regular succession the Tertiary sediments one after the other, the older occupying the higher points of the plain, the younger the lowest near the shores of the Caspian and Black Sea, and between these basins.

period the land was deprived of vegetation till the Diluvial period, and still further to the north perhaps even still later, because neither Mammoth nor Rhinoceros were able to go over to the Scandinavian peninsula, where, as is generally known, remains of those Pachydermata do not occur. Shall we attribute this absence of vegetable and animal life to a great accumulation of ice in this part of the earth during the Tertiary period?

III.—On the Long Meadend Bed.

By Searles V. Wood, F.G.S.

In the September Number of this Magazine, Mr. H. Keeping impugns the accuracy of my father's view as to the shell-bed at Meadend, which it seems has now disappeared; and says that it was a slipped mass from a bed which, by digging, he found *in situ* higher up the cliff slope, "close under the gravel with all the Lower Headon Freshwater beds below it"; adding "that he wishes to be distinctly understood to maintain that it is the marine Middle Headon of the Geological Survey, and equivalent to the Middle Headon of Colwell bay, Headon hill, Whitecliff bay, and Brockenhurst in the New Forest." As I am the only survivor of those who in 1843 worked at this bed, and upon whose discoveries in it my father's description of it was based, I wish to put on record the facts at that time, and vindicate my father's accuracy.

My father, in Charlesworth's "London Geological Journal" for September, 1846, describes two distinct and widely separated beds with marine shells; viz. (at p. 2 and 3) one about 10 or 12 feet above high-water mark, close to the ravine about half a mile from the village of Milford, and another nearly a mile from this, which began at the edge of the beach about 300 yards west of Meadend, and is the bed in question.

From the first of these, which he termed the "Upper Marine," he gave a list of shells (with, in most instances, specific as well as generic names), "as the joint result of Mr. Edwards's researches and his own."[1] This list quite agrees, as far as it goes, with the list of Middle Headon shells given by Messrs. Keeping and Tawney in their paper in vol. xxxvii. of the Journal of the Geological Society, p. 115; and there is, I believe, no question raised by Mr. Keeping, or even Prof. Judd,[2] about the identity of this bed with the Middle Headon, the coincidence both in organic contents and stratigraphical position being in accordance with it. I did not work at *this* bed, but my father and Mr. Edwards only.

[1] To this list he, by a footnote at p. 117 of the continuation of his paper, adds two genera, viz. *Cardium* and *Gastrochæna*. By a clerical error he refers in this note to p. 4, instead of p. 3, of the first part of his paper.

[2] I take Prof. Judd to indicate this bed in his "New Forest" vertical section (Q. J. G. S. vol. xxxvi. p. 170) by the thin marine band, which he connects by dotted lines with the Brackish-water beds of his parallel vertical "West end of Isle of Wight" section; the Meadend bed not being indicated at all by him, but belonging to the upper portion of that division of his "New Forest" section which is marked "Sands."

The second bed which my father described he termed the "Lower Marine," and says that it began in the gorge called Beacon Bunny as a light-coloured sand under a bed of lignite, which he regards as the base of the Lower Freshwater, and might be traced to the eastward until lost below the freshwater beds at a point about 300 yards from Meadend, disappearing there beneath the shingle of the beach. This point of seeming disappearance was west of Meadend; and it was there that the bed yielded shells, and where Mr. F. E. Edwards, my father, and I (together with Mr. J. W. Flower, and the Rev. D. Laing, visitors for a few days to my father and Mr. Edwards respectively, and both now dead) worked at it; and it was from the result of our combined labour that the list of genera given by my father at p. 4 was made. The bed here was crowded with shells at one part (the part yielding them being of very small thickness), and showed itself under the mass of talus which masked the lower portion of the cliff; and as it was thus visible for only a few yards, it may, as Mr. Keeping says it had, have slipped from a higher place in the cliff above it; for this would agree with the position assigned to it by my father at Beacon Bunny, which is further west. Neither case, however, as explained in the sequel, by any means gives it the geological position on which Mr. Keeping insists.

The genera which my father gives from this "Lower Marine," or Meadend bed, are 16 in number, viz. *Oliva*, *Potamides*, *Ancilla* (*Ancillaria*), *Natica*, *Melania*, *Melanopsis*, *Pleurotoma*, *Bulla*, *Mactra*, *Cyrena*, *Corbula*, *Sanguinolaria*, *Venericardia* (*Cardita*), *Cytherea*, *Lucina*, and *Potamomya*. Of these 16, four, viz. *Oliva*, *Potamides*, *Sanguinolaria* and *Potamomya*, do not occur either in my father's list of shells from his "Upper Marine," which is the Middle Headon, or in Messrs. Keeping and Tawney's list of Middle Headon shells, which is made out by them from no less than seven distinct, and for the most part widely separated localities, which have for very many years past been assiduously searched by various collectors. Not only are these four thus absent, but only seven of the sixteen genera given by my father appear in that column of Messrs. Keeping and Tawney's list which is headed "Long Meadend."[1]

Of the four genera thus absent from every Middle Headon locality, two are freshwater, and have no significance beyond contributing, with the other freshwater genera mentioned by my father, to show the truly estuarine character which he assigned to this Long Meadend bed; but the other two are marine and Bartonian, and one of them, *Oliva*, is of the highest significance in this question. It comprised only one species, *Oliva Branderi*,[2] and I well recollect that it

[1] Their list does not appear to be intended as a complete one for Meadend, but only to show what Middle Headon shells occur at that place, for they mention species of two more of these genera, viz. *Cytherea* and *Corbula*, as occurring there, but explain that they are omitted from the column *because they are not Middle Headon species.* In that paper Messrs. Keeping and Tawney seem to take the correct view that the Meadend bed is Upper Bagshot, though Mr. Keeping now wishes to be understood to maintain that it is Middle Headon.

[2] This species is represented in the Edwards Collection, now in the British Museum (Natural History), Cromwell Road, and is marked by F. E. Edwards as from Meadend.—Edit. Geol. Mag.

was one of the commonest shells in the bed. My father has preserved eleven specimens of it, of various sizes, which are in my possession, and to which the locality "Meadend" is attached in his handwriting. These are easily distinguishable from the Barton specimens by the sand with which some are filled, and by a rough exterior, unlike the smooth, almost polished, exterior of the Barton specimens. Now this species so common in the Meadend bed, and at Barton, and also given by Deshayes from several localities in the "Sables Moyens," the recognized French equivalent of the Barton beds, is not only absent from the Middle Headon list of Messrs. Keeping and Tawney, but does not, so far as I can trace, occur any higher than the bed in question either in England or the continent; but occurring thus abundantly in this bed, it serves to confirm the position which my father assigned to it, viz. an estuarine transition from the Barton marine, to the Lower Freshwater (or Lower Headon) formation. Belonging thus to the top of the Upper Bagshot its importance becomes apparent, for it constitutes the transition bed from the Upper Eocene to the Lower Oligocene, though when my father described it the Barton clay and London clay were regarded as identical by geologists, the first of the papers in which the Eocene succession was worked out by Mr. Prestwich having appeared after the first part of my father's description was published.

So much for the Palæontological evidence, and now for the Stratigraphical.

The Lower Freshwater, partaking of the uniformly gentle eastern dip of all the beds in the cliff on the Hampshire side of the Solent in this part, extends from this Meadend or "Lower Marine" bed of my father, to his "Upper Marine," which was nearly a mile east of it, and near to Milford; and (with the Newer Pliocene gravel capping everything unconformably) has exclusive possession of this length of cliff, as far east as the part where the Middle Headon, or "Upper Marine" of my father, comes in by virtue of this dip, and which, though concealed by talus both in 1843 and 1845, must begin below the gravel some way to the west of the ravine where my father found it, and worked at it, low down in the cliff (10 to 12 feet above high-water mark), but still very far to the east of the Meadend bed, and separated from it by a series of freshwater sands, marls, and clays (the Lower Headon), which constitute the cliff in this part below the unconformable gravel cap and above the talus thus concealing its base. It was at a point about the central part of this long stretch of cliff both horizontally and vertically, that the collection of Mammalian, Reptilian, and Fish-remains was obtained by my father and self, with our unaided hands, during six weeks of the summer of 1843, and a similar period in 1845, which were partly figured in the London Geological Journal of 1846, and soon afterwards presented to the British Museum. The whole of these, with the exceptions mentioned in the foot-note,[1] were obtained from one place, not more

[1] Prof. Judd having in his vertical section (Q.J.G.S. vol. xxxvi. p. 170), representing his view of the beds on the Hampshire side of the Solent, marked one horizon as that from which the Reptilian, and another as that from which the Mammalian

than twenty yards in length, in the upper four or five feet of a fine white impalpable sand, so hard as to be cut into blocks, full of *Limnæa, Paludina,* and other freshwater shells, and of the remains of the American river fish *Lepidosteus,* which was overlain by a layer of pinkish stone (with freshwater shells) from 12 to 18 inches thick, blocks of which we had to detach to get at the sand beneath. The part of the cliff thus worked by us was clean scarped (a talus occupying the part below, and giving us access to it), and just about midway between the beach and the cliff top. It was about three furlongs east of Meadend. By the dip of the beds this sand rose westwards and ran out beneath the unconformable gravel and near the cliff top at or immediately west of Meadend, cut off there by the denudation which preceded the deposit of that gravel; while eastwards it was overlain and succeeded by beds of purely freshwater clay, marl, and sand, which yielded principally *Paludina* and *Unio* (*Solandri*), and which by the easterly dip disappeared beneath the talus as the place of the "Upper Marine" (or Middle Headon) was approached. This "Upper Marine" in its turn was from the same dip succeeded eastwards by freshwater beds (Upper Headon), until by the fall of the cliff top to the beach level, near Milford, everything disappeared.

I submit therefore that my father's assignment of this bed, as transitional from the Barton to the Lower Headon, is borne out to the full, both palæontologically and stratigraphically, though, as the sands with lignite, now I believe regarded as Upper Bagshot, which principally constitute the cliff between Meadend and the rise of the Barton beds as we go west, were, so far as we could detect, otherwise unfossiliferous, these may (though I think not) be freshwater, and so interrupt that transition; but the presence of the bed higher up in the cliff at the place where I and the others worked at it, as Mr. Keeping says he found it from digging to be, is quite inconsistent with its having "*all* the Lower Headon freshwater beds below it." Nothing but an intervening denudation which had, previous to the deposition of the bed here, removed the succession of clays, sands, and marls, with *Paludina* and *Unio Solandri,* just described, would be reconcileable with the geological position Mr. Keeping thus

remains of Hordwell were obtained, I desire to record that the whole of those which my father and I obtained (with the exception of a fragment of the jaw of *Palæotherium* with teeth, many plates of *Trionyx,* and some Crocodilian teeth, which were obtained from a layer of brown sand over the shelly seam in the Meadend bed itself,) were procured from the one place and horizon mentioned in the text, and comprised the remains of *Alligator* (Crocodile according to some palæontologists), *Emys, Palæotherium, Microchœrus,* and *Spalacodon,* figured in the London Geological Journal, as well as the cranium of a Rodent, still, I believe, unnamed, some small ophidian vertebræ, and part of a bird's bone, all of which have been these 35 years past in the British Museum. Mr. J. W. Flower obtained the larger of the two fragments of the jaw of *Spalacodon* figured, and a fragment of *Palæotherium* jaw with teeth, from a few feet lower in the same hard sand nearer to Meadend. I sent to Professor Judd a sketch that I made in 1843, and had preserved, of the cliff, showing all the parties at work at it in that year, and the positions they occupied. From what part Mr. Keeping procured the remains collected by him for the Marchioness of Hastings I know not; but this was not until after the conclusion of our labours in 1845.

claims for it; and this, in the face of the palæontological facts which I have pointed out, is the reverse of likely.

These were the facts in 1843 and 1845; since which time I have not visited the Barton-Hordwell Cliff, though I have (in 1856) the opposite one of the Isle of Wight; the drawings I then made of which, from Sconce Point to Alum Bay complete, lead me to regard the view of it taken by Messrs. Keeping and Tawney, in their paper of December, 1880, and by the Geological Survey, as correct.

IV.—On the Dissolution of Aragonite Shells in the Coralline Crag.

By Percy F. Kendall.

In 1879 Mr. Sorby in his Presidential Address to the Geological Society published the result of his investigations into the question of the extent to which the mineralogical constitution of shells, etc., influenced their preservation as fossils.

He pointed out that the two forms of carbonate of lime—calcite and aragonite—occur in the hard parts of various Invertebrates, and that aragonite, though harder and of higher specific gravity than calcite, is a less stable substance, and is much more easily acted upon by carbonated water. This would of course tend to the dissolution of aragonite structures under circumstances which might permit of the preservation of calcite, and he instanced the shells in a raised beach, in which he observed that those shells which were composed of an inner aragonite and an outer calcite layer had lost the inner layer altogether.

Mr. Sorby's classification is as follows:—

Calcite.	Aragonite.
Foraminifera.	Corals.
Annelids.	Cephalopoda.
Echinoderms.	Gasteropoda, except *Patella*, *Fusus*, *Littorina*, *Purpura*, and some others.
Polyzoa, containing also some aragonite.	Conchifera, except *Ostrea*, *Pecten*, and the outer layer of *Spondylus*, *Pinna*, and *Mytilus*.
Brachiopoda.	
Ostrea and *Pecten*.	
Cirripedia and all other Crustacea.	

During some recent work in the Crags of Essex and Suffolk I have observed a very remarkable confirmation of Mr. Sorby's conclusions.

The Upper beds of the Coralline Crag are in most places coherent enough to retain casts of organisms which may have been dissolved from them, and such casts have been noticed by geologists since the time of Dr. Mantell, whose collection in the Natural History Museum contains one from a pit at Aldeburgh. To this pit my remarks will chiefly apply. Here well-preserved shells and other remains are very abundant, indeed there is no place where such a profusion of beautiful and delicate Polyzoa can be obtained, but besides these there are many casts of shells to be seen in the matrix, the shells themselves having been completely dissolved away. Tabulating these as below, I find that with one exception the whole of the shells are referable to Mr. Sorby's calcite division, while the casts without any exception are of aragonite organisms.

Shells, etc.	Casts.
Truncatulina (?)	*Pectunculus glycimeris.*
Polymorphina.	*Cyprina Islandica.*
Serpula, sp.	*Cardium*, sp.
Polyzoa (about 80 sp.)	*Mactra* (*subtruncata* ?).
Terebratula grandis.	*Thracia* (?).
Lingula Dumortieri.	*Panopæa Faujasii.*
Anomia patelliformis.	*Tellina*, sp.
Ostrea edulis.	*Astarte Omalii.*
Pecten Gerardii.	,, sp.
,, *pusio.*	*Nucula nucleus.*
,, *maximus.*	*Venus imbricata.*
,, *opercularis.*	*Cytherea chione* (?).
,, *tigrinus.*	*Solen* (*ensis* ?).
Lima exilis.	*Teredo.*
,, *Loscombii.*	*Emarginula fissura.*
Pinna (fragments).	*Turritella incrassata.*
Scalaria subulata.	*Trochus*, sp.
Echinus (*Woodwardii* ?).	*Nassa* (*granulata* ?).
Temnechinus, sp.	,, sp.
Balanus, sp.	*Natica*, sp.
Crab claws.	*Buccinum Dalei.*
	Cassidaria bicatenata.
	Voluta Lambertii.
	Calyptræa chinensis.

Some of the casts are of a very remarkable character, the cavity being lined with delicate encrusting Polyzoa which had grown upon the shell. The backs of the cells would alone be seen of course. *Serpulæ* occur in a similar manner.

This case appears to confirm in a striking way Mr. Sorby's conclusions, for we see that intermingled with *casts* of the largest and most massive of the Crag shells (*Voluta*, *Cassidaria*, *Panopæa*, and *Cyprina*) are the most fragile tests (Foraminifera and Polyzoa) in an exquisite state of preservation.

The *Scalaria*, which constitutes the solitary *apparent* exception to the rule that only calcite organisms are preserved, is I believe really a calcite shell for the following reasons :—All the undoubted calcite shells of the Coralline Crag are characterized by a very compact texture and by being translucent, which characters are common to the genus *Scalaria*, while the aragonite shells have a chalky appearance and are opaque.

I believe that this will be found to be a character sufficiently constant to be of use in determining the zoological position of obscure forms, *e.g.* in the Red Crag of Walton Naze, certain tubular tests are found which might be referred either to one of the genera of tube-forming Annelids, or to such Gasteropodous genera as *Cæcum* or *Dentalium*. I have however, referred it to the *Annelida*, because its exture is that characterizing calcite shells.

Mr. Searles V. Wood, in his work on the Crag Mollusca, remarks in speaking of the genus *Vermetus*, "This approaches so near to the testaceous Annelides that it cannot be distinguished by the shell alone ;" but I conceive that in the Pliocene fossil examples at least there need be no difficulty if attention be paid to the point I have indicated.

Mr. Sorby mentions as examples of Gasteropods having a calcite layer, *Fusus*, *Purpura*, *Littorina*, and *Patella*; but he informs me that he has not tested *Scalaria*. This accords exactly with what I have observed in the Crag beds, but to the genera named above I would add *Tectura* and *Murex* (*M. tortuosum*). The *Fusi* are very interesting, the genus is not very clearly divided from *Trophon*, and hence errors may arise, but the species of *Fusus* occurring in the Crag which appear to have a calcite layer are *F. antiquus*, *F. scalariformis* and *F. Berniciensis*. *Fusus altus*, *F. costifer*, *F. muricatus*, *F. cordatus* and *F. gracilis*, have no calcite layer preserved, and I do not think that the first two ever possessed any, but *F. gracilis* in the fresh condition certainly looks like a calcite shell. It is a fact worthy of notice that in those *Fusi* which have a calcite layer the first two volutions are destitute of it. This suggests the question:—Is not this embryonic condition indicative of descent from an ancestor which was devoid of a calcite layer? All those Eocene species of *Fusus*, such as *F. longævus*, *bulbiformis*, and *pyrus*, which I have examined, appear to be entirely aragonite. Two species of *Littorina* occur in the Crag beds, viz. *L. littorea* and *L. suboperta*, the former has a thick calcite layer, but I have never seen a trace of one in *L. suboperta*. I cannot however say that it may not have had one, for the specimens are so much worn.

I have been somewhat surprised to note that among the hundreds of calcite shells which I have collected among the Crags, I have never come across any which were bored by Carnivorous Gasteropods, with the exception of *Purpura tetragona*—which by the way has an extremely thin calcite layer; there is, however, at Jermyn Street a bored specimen of the *Purpura lapillus*. The calcite shells seem to enjoy a like immunity from the operations of boring Annelids, but here again I have seen an exception in the case of a *Pecten* in which an abortive attempt had been made to excavate a crypt.

I understand that *Purpura lapillus* and *Murex erinaceus* do a great deal of damage to our Whitstable oyster beds by boring the young shells. The modern "Natives," however, have very thin shells as compared with the crag *O. edulis*.

Certain species of adnate Polyzoa (*e.g.* *Lepralia puncturata* and *Hippothoa abstersa*) frequently excavate a little hollow at the back of each cell when encrusting aragonite shells, but I have never seen a calcite shell similarly hollowed. *Cliona* borings are abundant in the Crag shells, whether of aragonite or calcite.

I may remark in conclusion that the consolidation of the Coralline Crag and the dissolution of the aragonite shells appears to have taken place previously to the deposition of the Red Crag, or at any rate of the Middle part of it, as I have found a fragment of Coralline Crag with shells and casts in the coprolite diggings at Boyton.

V.—Notes on Geological Sections, within Forty Miles Radius of Southport.[1]

By Charles E. De Rance, F.G.S., F.R.G.S., A.I.C.E.

STRIKING a radius of 40 miles from Southport, the line will be seen to intersect the sea-coast near the Silurian districts of Ulverstone in North Lancashire, and Colwyn Bay in North Wales. The succession in both cases is very similar, Denbighshire Grits and Flags of the one area corresponding in time to the Coniston Grits and Flags of the other; and just as the Silurians of the Lake District are overlaid by a fringe of Carboniferous Limestone, so the Silurians of Diganwy are overlaid by the Carboniferous Limestone of the Great and Little Ormes Head. Laid upon a floor of Silurian rocks, the Carboniferous Limestone may be regarded as extending continuously under the Irish Sea, and underlying the various Carboniferous and Triassic rocks now occupying Lancashire.[2]

The whole of the Carboniferous rocks have been folded, and contorted, and subsequently denuded before the deposition of the later rocks, which do not rest always upon the Coal-measures, which have been denuded over the whole of the Furness and Fylde districts, and also in the country between Southport and Ormskirk. The Carboniferous Limestone of North Wales has been made the subject of careful study by Mr. G. H. Morton, F.G.S., who has been able to trace successive horizons or beds in it; but it appears to be doubtful whether these can be traced in the Lancashire exposures—in which the upper part of the series is commencing to assume the type called the Yoredale series by Prof. Phillips, in which the limestones are intercalated with intervening beds of shale and sandstone, which gradually increase in importance in proceeding north, until the limestones form by far the smaller vertical thickness of the entire mass. Near Sedburgh good sections of the base of the Carboniferous Limestone are seen in the banks of the Hebblethwaite Beck, a tributary of the Rawthey, sometimes the Lower Limestone Shales are present, and in this case they rest on the so-called Old Red Conglomerate, which is directly overlaid by the Limestone when the shales are absent, the conglomerate forming simply the "local base" of the Carboniferous Limestone, as in North Wales, where Mr. Morton has clearly made out it forms the base of the Middle Limestone beds, when the Lower Limestones are absent.

Prof. Phillips, in a paper on the formation of valleys near Kirkby

[1] Read before Section C at the British Association, Southport Meeting, 1883.

[2] Detailed observations on the district will be found in the following Memoirs of the Geological Survey:—The Burnley Coal-field; The Country Around Wigan; The Country Around Bolton; Superficial Deposits of South-west Lancashire; The Country Between Liverpool and Southport; The Country Around Southport, Lytham, and Southshore; The Country Around Blackpool and Fleetwood; and in the Maps which these Memoirs illustrate.

Lonsdale in 1864 (Brit. Assoc. Report), describes the subterranean water-ways in the Carboniferous Limestone; these channels are locally called "greiks," and take the whole of the dry weather flow of the stream; in floods they have not sufficient diameter to take the flow off, which boils down the rocky bed of the stream. The caves in the "greik" become gradually enlarged, the roof falls in, and the chain of caverns become exposed to daylight and form a steep and narrow gorge, but as Prof. Phillips pointed out, the valley is not due to the breaking away of the caves; for the valley must have been first excavated in the overlying impermeable rocks, before the water could have free access to the limestone, and by acting mechanically and chemically upon it, have formed the caves. Prof. Hughes points out that the condition most favourable to the formation of "swallow-holes" and caves is when a deposit of clay, or shale, overlies the limestone, and allows the growth of peat, or the existence of decaying vegetable matter in a swamp, to furnish acid to the water in addition to the carbonic acid derived from the air; the limestone is always pitted all round the margin of the overlying impermeable material, the swallows are initiated at the junction of lines of joints, which as the clay is worn back, determine the existence of other sets of swallows. Each set as a rule drains into the same underground channel far below; so, though the ramifications of the feeders vary from time to time, according to the wearing back of the impermeable covering, and the opening out of new swallow-holes, the lines of underground drainage remain the same.

Lower Longridge Grit.—This deposit is the lowest sandstone in the Lancashire Carboniferous series; it is a somewhat inconstant horizon, and resembles in character the Gannister beds of the Coal-measures; it is seen in brook sections on the northern slopes of Longridge Fell. The Bowland shales of Professor Phillips overlie it, and may be well seen in Longridge Fell; and in Parlick Pike, near Chipping, these shales form an important part in the scenery of the Forest of Pendle, the steep slopes of which are all composed of the disintegrating shale of this age, reaching a maximum thickness of 700 feet. The occurrence of numerous fossils, and seams of ironstone nodules, give these shales the appearance of Coal-measures, which have led to many fruitless searches for coal.

Upper Longridge Grit.—This is largely worked as a building stone in numerous quarries in Longridge, where good sections may be seen; the grit is not less than 1000 or 1200 feet; it is the first important member of the wonderful development of Millstone Grit occurring around the Lancashire Coal-field, which reaches its maximum thickness in the neighbourhood of Bacup, and thins southward to the Biddulph no less than 2000 feet, or about 80 feet per mile. The Millstone Grit can be best studied in the Bacup district, and around Haslingden.

The *Kinderscout Grit* is well seen in the elevated moorland raised by faults between the Wigan and Burnley Coal-fields. Good sections both of the conglomerate, and of the fine hard beds quarried for "sets," may be well seen near Withnell Station; on the top of the Moor occur thin coal-seams, with a Gannister floor, with *Stigmariæ.*

Overlying the Kinderscout Grit are the Sabden shales, which attain a thickness of 2000 feet, on the county boundary; they are well seen near Preston, at Sales Wheel on the Ribble, where they are intercalated with thin limestones with *Encrinites,* and other fossils.

The *Third Grit* is generally a fine-grained massive rock; it is sometimes a conglomerate, as seen in the fine cliff known as the "Ratchers" at Belmont, near Bolton. Sometimes this bed is separated into two divisions by a bed of shale with marine shells. The shales overlying the Third Grit contain the Brooksbottom series of coals of the late Mr. Binney.

The Haslingden Flags, or Second Grits, occupy a large area in the Haslingden district, where they can be studied in the numerous quarries where they are worked for building purposes, for which they are of great value; they are generally traversed by a bed of shale; the lower flag-band is quarried at Haslingden, the upper bed at Entwistle and Edgworth. On the surface of the flags may be noticed numerous rain-prints, sun-cracks, and worm-tracks.

The highest grit below the Coal-measures is called the *Rough Rock,* or First Grit. It is a massive hard conglomerate, apparently made up of the waste of granitic rocks; near the base is a Coal-seam called the Feather Edge Coal, from the peculiar fracture it exhibits. In the neighbourhood of Accrington this Grit is soft and fine-grained, so much so indeed, that it is dug for sand, and the coal in it is called the "Sand Rock Coal." The Rough Rock is well seen in the picturesque escarpment at Houghton Towers, between Preston and Blackburn, where it reaches its maximum thickness of 450 feet.

The shale associated with the Feather Edge Coal at Rochdale yields 18 species of fossils, of which half occur in the overlying Lower Coal-measures. Of these 18 forms 13 are plants, and 3 shells of marine Mollusca; amongst the former are *Calamites Suckovii,* amongst the latter *Aviculopecten papyracea.* Indications of this fauna and flora, with a few additional forms, occur in the Millstone Grit series at *three* intervals below the horizon, viz. in a bed of shales in the Second Grit, in the bed of shale between the Second and Third Grit, and in the shale between the Third and Fourth Grit, pointing to a continuous land surface throughout the whole of the Millstone Grit period, and down into the Lower Coal-measures, from which surface the plants migrated, as from time to time the shallow sea-bottom, through the temporary stoppage of subsidence, and subsequent deposit of sand, became land, more or less covered with freshwater, at the bottom of which thin seams of coal from one inch to two feet in thickness, were formed.

The *Lower Coal-measures* overlying the Grit series are not separated by any physical break, nor do they differ from them biologically. The shale beds increase in thickness, and the sandstones become fine-grained, and the Coal-measures more numerous.

The following table gives the general thickness :—

Below the Arley Mine.

Billinge District.	Feet	in.		Horwich District.	Feet	in.
Black Shales	210	0		Sandy Flagstones ...	858	0
Lower Coal-measures (Upholland Flags and Shales) ...	850	0		Lower Coal-measures ...	852	0
Upper Mountain Mine[1]..	2	0		=40 *Yards Mine*	1	4
Fire Clay and Shales	10	0				
Fire Clay Coal		10		Measures	114	0
Shales and Bullion	245	0				
Bullion Coal		8		= *Upper Foot Mine.*		
Shales and Flags	46	1		Measures	36	0
Gannister Coal	1	4		= *Gannister Coal.*		
Measures	181	8		Measures	36	0
Fifth Coal	1	3½		= *Lower Foot Mine* ...	1	6
Measures	32	0				
Lower Mountain Mine ...	2	8	398	Measures	399	0
Lower Coal-measures...	336	4				
Rough Rock	100			Rough Rock	126	1

Between the Middle Coal-measure-black shale at Bury and the underlying Lower Coal-measure-flagstones occurs a physical break. There is little doubt that the Middle Coal-measures are everywhere unconformable, but it is difficult to make out the relation.

The Lancashire Coal-basin, by faulting and subsequent denudation, has become separated into four distinct districts; the largest and most important of them is the Wigan and Bolton field; to the north-east is the Burnley Coal-field; to the south-east is the Manchester Coal-field, which at present is confined to working Coals in the Upper Coal-Measures.

I have found it convenient to divide the Middle Coal-measures of the Wigan area into the following groups, for the purpose of comparing them with the adjacent areas, as follows, in descending order :—

Groups.	*From*	*To the*
F. The Ince.	the Ince Yard Coal.	Pemberton, 5 feet.
E. The Pemberton.	the Pemberton, 5 feet.	Wigan, 5 feet.
D. The Wigan.	W. 5 feet.	Wigan 9 feet.
C. The Cannel-King.	W. 9 feet.	Yard Coal.
B. The Bone.	Yard Coal.	Orrell 5 feet coal.
A. The Orrell.	Orrell 5 feet.	Orrell 5 feet, or Arley Mine.

Following these groups from Prescot to Wigan, the vertical thickness between the Arley mine and the Ince Yard mine is found to increase from 1400 feet to 2200 ft., the measure having thickened 50 feet per mile, for each of the 16 miles traversed, the rate of increase of the first 4 miles being at the rate of 82 feet per mile, the average being reduced by the last 6 miles increasing only at a rate of 20 feet per mile. On the eastern margin at Burnley, in which the attenuation of the thickness of the measures from the centre of the basin is still more marked, the vertical thickness here being

[1] The word "Mine" is used in parts of Lancashire, instead of "Coal," for certain seams.

only 850 feet, giving an average rate of thinning of 64 feet per mile for the 21 miles traversed. From these facts it would appear, that a special line of subsidence, or a contemporaneous synclinal axis, ranged through this district along a definite line, which gradually travelled to the north-east in time, from the neighbourhood of St. Helens to that of Wigan, the Wigan coal-basin being a synclinal of deposition, as well as one of flexure.

Permian.—The sections around Harcourt and Dalton in Furness are of very great interest, associated as they are with the occurrence of the valuable deposits of iron-ore found in the cracks and fissures of the Mountain Limestone beneath. These sandstones are largely developed at St. Bees, and are called the *St. Bees Sandstone;* there they rest upon the Coal-measures. A considerable area is occupied by Permian Sandstone in the Lancashire Fylde. Sections are to be seen in the railway cutting between Garstang Junction and Garstang.

Further south, a representative of the Magnesian Limestone, so largely developed on the eastern side of England, occurs at Skillaw Clough, near Burscough Bridge Station, east of Southport; this thin limestone and its associated sandstone rest upon the denuded and upturned edges of Millstone Grit. At Bedford Leigh, the limestones are thicker, and contain well-marked Permian fossils, as *Bakewellia* and *Schizodus.*

New Red Sandstone.—The Lower Mottled Sandstone is well seen at Eastham, on the Cheshire bank of the Mersey; it consists of fine rounded grains, which are generally segregated together by iron, but which occasionally run through the fingers like silver-sand, exhibiting what I have called the Millet-seed grains. A very hard compact form of this rock was penetrated in the Bootle boring of the Liverpool Corporation waterworks, and at the Warrington Waterworks Co.'s boring at Winwick, in which a fine running sand underlaid the compact bed.

The Pebble Beds.—These were proved by the Bootle boring and adjacent sections to be not less than 1200 feet; they consist of rather hard coarse-grained sandstone; they are well seen in the quarries round Liverpool and Birkenhead, and in the railway cuttings near Edge Hill and elsewhere east of Liverpool, and on the Parkgate and Hooton railway, especially about a mile east of Neston.

The Upper Mottled Sandstone.—The yellow beds are well seen at Scarisbrick quarry near Southport; the middle streaked beds are well exposed in the railway cuttings near Ormskirk, especially in the St. Helens railway close to the town, where the current planes are cut off, and the eroded surface overlaid by the Keuper basement beds. The lower red beds are seen at Bromborough Pool in Cheshire.

Keuper Basement Bed.—These are well seen near Southport at Halsall, and at Cleve Hill near Maghull, the building stones associated with them, and occurring at a somewhat higher horizon, may be seen at Storeton quarries, a few miles from Birkenhead; in this quarry occurs the celebrated footprint bed, from which were obtained the slabs now preserved in the William Brown Museum at Liverpool, and in that of the Royal Institution, Colquits Street.

Various outliers of Basement beds occur in the Ormskirk district resting on the eroded Bunter beds, and they are well seen in Wallasey, the north-eastern promontory of Wirral.

Keuper Frodsham Beds.—These soft current bedded Sandstones are well seen in the Orrell railway cutting, and in the Frodsham railway cutting, in which these beds are exceedingly well seen, as they are also in the St. James's Cemetery at Liverpool.

Keuper Waterstones.—The waterstones are largely exposed in the district lying between Irby and Heswell Hills, and the villages of Irby and Pensby are located on them. At Irby Hill these beds rest on the Basement beds, which are coarse, well-bedded, and contain a few pebbles.

The waterstones are seen at Liverpool, at the Toxteth Cemetery, where they were long ago described by Mr. G. H. Morton, under the name of the "Cemetery Shales." An outlier of this subdivision is preserved by a fault in the railway cutting at Orrell, east of Waterloo.

In this cutting an interesting section is still to be seen, first described by myself,[1] in which the waterstones rest on a conglomerate top of the Keuper Frodsham beds.

Keuper Marls.—These occupy a considerable area in the neighbourhood of Southport, where they were bored into to a depth of 189 yards at the Palace Hotel, and where they are well seen near Brown Edge. East of Fleetwood the Red Marls have been found in the thick deposits of rock-salt, as in the Cheshire district. In the latter area the best sections are visible in the banks of the River Weever, above and below Northwich.

Lias.—This formation has never been discovered in Lancashire, but there is some reason to believe a tract of this formation may occur in a synclinal in the Keuper Marls, under the estuary of the Ribble. The evidence on which this assumption rests is the fact that fragments of some pyrites, evidently derived from the Lower Lias, are to be found washed up on the shore, in the neighbourhood of Hesketh Bank.

Glacial Drift.—Nowhere in England does the Drift perhaps more completely obscure the solid geology than in the greater part of West Lancashire. The valley of the Ribble at Preston is entirely excavated in Glacial Drift, which attains a thickness of about 200 feet, and consists of an upper clay separated from a lower, by a bed of sand and gravel; very good sections were exhibited in the same beds, in the construction of the new railway station, and were long ago described by Sir Roderick Murchison, in the construction of the original station. Sections can still be seen in the Sand Pits, near Deepdale Station, on the Longridge railway; exceedingly good sections can also be seen in the cliff overhanging the Ribble at Red Scar, east of Preston, the triplex arrangement there can be well studied.

The dome-shaped arrangement of the Lower Boulder-clay can be well seen in the fine cliffs extending from Blackpool to Norbreck,

[1] Mem. Geol. Surv. Expl. of Sheet 90, § 9.

which have been carefully described by Mr. Binney, Mr. Mackintosh, and by myself, and recently by Mr. Mellard Reade. The lower clay is more closely packed with stones than the upper, and no signs of stratification are seen, which are always to be found in the Upper Boulder-clay on close examination.

On the Cheshire coast good sections of the Drift are to be seen in the banks of the Mersey at Egremont, and between Eastham and Hooton Park, and on the banks of the Dee between Parkgate and West Kirby.

The Upper Boulder-clay is sometimes very finely laminated, this is particularly the case in the brick-pits near Wigan. This clay is locally called "buck-leaf marl," probably meaning "book-leaf."

Alluvium.—In the valley of the Ribble the Glacial deposits are often masked, near Preston, by old river terraces, marking successive stages in the process of denudation of the valley since the Glacial episode.

This is also the case in the valley of the Irwell, in which well-marked river-terraces extend for miles, and have suburbs of Manchester built upon them.

The alluvial floor of the river Ribble consists of fine loamy material resting on peat with trunks of trees, lying upon rough river gravel—followed towards the estuary of the river, the peaty bed gains in importance, and is continuously connected, with the thick peat mosses occupying so much of West Lancashire, which in the lowland plain reach a thickness of 20 to 30 feet.

The peat beds are well seen at Blowick near Southport, and at Rossal and Pilling, near Fleetwood. At Blowick and from there down to Hightown they rest on grey clays of estuarine origin; these are well seen at the mouth of the River Alt at Hightown, where the clay is overlaid by peat, tree trunks and roots, which are covered at high tide.

The *Presall Shingle* underlies the peat in the district lying between the Wyre and the sea, it is an old beach a little older than the Grey clays, near Southport, the latter is underlaid by the *Shirdley Hill Sand* which is partly marine, and partly blown; at Shirdley Hill it rises into a range of ancient Sand Dunes. At Fleetwood estuarine clays overlie the peat, and in the clay have been discovered Roman coins.

Blown Sand.—The prevalent wind on the coast blows from the W.S.W., and passing over the long extent of fore-shore, carries inland large quantities of sand, which rise in Dunes to a height of 80 feet above the sea. The passage of these sands have in the neighbourhood of Formby overwhelmed cultivated fields and gardens, and near Birkdale the name of the Lost Farm alone recalls the existence of a once prosperous homestead. Of later years the growth of the Starr Grass, or Marram, as it is locally called, has much arrested its onward progress. The sand between the Dunes is to some extent cemented together by lime, the result of the decomposition of the shells of mullusca in the sand hills, and supports small sheets of water, locally called "slacks," around which grow many rare plants.

Less than a century ago the site of Southport was marked only by a few fishermen's huts in a cleared space in these sand hills.

The hamlet was called South Hawes and was situated in the parish of Meols, a place of some antiquity, which still contains the "mother church" of Southport. The district was well described by Jamieson in 1636, in his *Iter Lancastrensi* (Cheetham Soc. Ed.) :—

> " Ormeschurch and ye Meales
> Are our next journey. We direct no weales
> Of state to hinder our delight. Ye guize
> Of those chuffe sands which doe in mountains rise
> On shore tis pleasure to behould, which Hoes
> Are called in Worold: windie tempest blows
> Them up in heapes."

"Worold" is the hundred of Wirral, the northern promontory of Cheshire, which is similarly fringed by *Sand Dunes*, villages in which are still called "Great" and "Little Meols." The name is found in "Ravensmeols," a destroyed village on the Lancashire coast, and the name "meol" also occurs in the names of villages on the coast of Iceland, where Dunes of volcanic sand occur.

VI.—On a Supposed Case of Metamorphism in an Alpine Rock of Carboniferous Age.[1]

By Prof. T. G. Bonney, M.A., F.R.S.

A FEW years since it would have been flat heresy to assert that very clear proof would be necessary before we could accept a crystalline schist as the metamorphosed representative of a rock of Palæozoic age. Yet at the present time many who have made a special study of this branch of petrology would not hesitate to go thus far, and some would even declare that we do not know of any completely metamorphic rock which is not of Archæan age. Certainly the stock instances of metamorphism in Wales, and especially in Anglesey, in Cornwall, in Leicestershire, in Worcestershire, have utterly broken down on careful study. Outside the English Geological Survey probably no person who can use a microscope believes that the schists of Anglesey are altered Cambrian, or that the slates of this age are melted down into the quartz-porphyry of Llyn Padarn. It is becoming evident that even the metamorphic fastnesses of the Highlands are in danger, and that at any rate even there the realm of "altered Lower Silurian" will be grievously curtailed. Startling facts are now and then adduced by the defenders of what we may call the 'established' (*i.e.* non-progressive) geology; fossils are said to have occurred in crystalline non-calcareous rocks, Calamites in gneiss, Trilobites in mica-schist, and so on; but those who are familiar with the molecular changes which take place in the formation of such rocks as these will require the clearest evidence before they can accept statements so antecedently improbable.

It may be worth while then to describe the result of my examination of a deposit in the Western Alps, which is often quoted as an example of metamorphism in a later Palæozoic rock. The subject

[1] Read before Section C, British Association, Southport Meeting, 1883.

is not novel, for the Poudingue de Valorsine, as the deposit is called, has been noticed by geologists again and again since the days of De Saussure, who described it with his usual accuracy; but when I state that more than one geologist of importance holds that the rock exhibits a considerable amount of metamorphism, I may be pardoned for directing attention to it. The Poudingue de Valorsine is a conglomerate, often of considerable thickness, at the base of the Carboniferous series in the Western Alps. For its distribution and the literature of the subject I may refer to Prof. Favre's classic work—*Recherches géologiques de la Savoie,* etc. I have examined this conglomerate, especially in the neighbourhood of Vernayaz. All authors agree that it contains fragments of gneiss and various schists with vein quartz. De Saussure, however, states that he did not find "any schist (*i.e.* slate) simply argillaceous or any limestone." It should, however, be mentioned that he is not speaking quite of the same locality as I describe, though he had probably seen it, and his remark appears intended to be general.

The conglomerate, together with a grit and dark slate, which in aspect resembles some of the Bala slates of Wales, occurs on the left bank of the Rhone, near Vernayaz and the opening of the famous Gorge de Trient. This last has been excavated in a hard gneiss, and the beautiful Pissevache cascade a little further down the valley is precipitated over a similar rock. Between the two, all seemingly interstratified, and now in an almost vertical position, come the conglomerate, grit, and slate of the Carboniferous series. Of course the last is simply caught in a great fold of the earlier rock, after the usual Alpine fashion, and there has perhaps also been some further disturbance of the nature of faulting. But as no one disputes that the gneiss and the conglomerate differ greatly in age, it is needless to enter into details on this point. The conglomerate crops out along the winding road which leads from the level of the Rhone to the elevated bed of the Val de Trient, and can be traced for a very considerable distance up the latter valley.

The conglomerate passes into and is interbanded with grits, and these are succeeded by slate, as may be well seen during the above-named ascent. The transition from the supposed metamorphic rock to the only mechanically altered is so rapid, that our suspicions as to the former may well be aroused. The fragments in it are generally subangular, of various sizes, commonly up to 2 or 3 inches in diameter, but occasionally as much as 5 or 6 inches. The materials are chiefly vein-quartz, gneiss, mica-schist, and a purplish argillite. The proportions of these rocks vary somewhat, as might be expected. The gneiss is a rather fine-grained one, with silvery mica ; it belongs to the same group as that exposed in the immediate neighbourhood—that which in the Alps usually occurs some distance above the coarse granitoid gneisses or protogines—the lowest known rocks of the district—and the large group of variable schists, part of which is the Pietra Verde group of some authors. Silvery mica, however, seems more abundant in the fragments than in the rocks which occur *in situ.* The mica-schist is one of the ordinary strongish mica-schists, which are associated with or rather higher in position than the above gneiss. The purplish slaty rock is much less common than the other, but it is indubitable, and shows no sign of metamorphism. The matrix is a dark leaden-grey colour, composed of scales of mica, mostly silvery, with a variable amount of quartz; it often weathers a bright iron-brown; the scales lie rather parallel one with another, and the whole mass undoubtedly looks extremely like a rather tender and somewhat massive mica-schist. The extremely sharp boundaries of the fragments however have a suspicious appearance, and in order to account for the presence of argillite among them, we must credit the metamorphic agents with very selective action indeed.

But the more we examine the rock even in the field, the more we become convinced that the metamorphic aspect is illusory, and that the mica scales are exogenous and not endogenous. Microscopic examination fully confirms this. The rock consists of the following minerals—1. *Quartz* in single subangular grains and granular aggregates evidently derived from a mica-schist or gneiss. 2. *Mica*: the greater part is a white mica, with silvery lustre, showing brilliant chromatic polarization, resembling that common especially in the more silvery mica-schists of the Alps; the remainder is a dull brownish mica, evidently somewhat altered. 3. A granular, somewhat earthy-looking mineral, sometimes pretty evidently replacing fragments of felspar, which is also more or less disseminated among the other constituents. Examined with the two Nicols it shows a peculiar scaly to granular speckling, very familiar to those who have investigated rocks of similar nature to this, as an alteration product of felspar,[1] though it is not easy to assign to it a definite name. There is the usual dark dust—ferrite or opacite—and a few grains of a black mineral, probably iron peroxide: also one or two grains of a clear brown, strongly dichroic mineral, probably tourmaline.[2] It is evident from the structure of the rock that it is of fragmental origin, and practically unaltered, only such micro-mineralogical changes having taken place as are usual in Palæozoic or even more recent rocks. The rock obviously has been greatly compressed, and the result of this has been to give a general parallelism to the mica flakes and so enhance the resemblance to a foliated rock, but of metamorphism in the technical sense of the word there is no trace.

Below the Pissevache fall, where some of the gneiss is so crushed that without microscopic examination it is impossible to say whether it has been crushed *in situ* or is a compressed arkose, we find an infold of a flinty greenish rock. The cliffs make examination difficult or impossible, and my knowledge of it is mainly derived from fallen blocks. It appears to vary from a very compact flinty-looking greenish-grey rock, with slight indications of cleavage (rather like some of the siliceous argillites or "hornstones" not uncommon in the older rocks of Britain), to a more granular and micaceous rock,

[1] It may be worth noting that in some *remanié* rocks the felspar is no longer recognizable, in others it is excellently preserved.

[2] This mineral has been noticed in the fragments.

presenting some resemblance to a *remanié* gneiss much compressed. One great block showed distinct interbanding of the compacter and more micaceous varieties, but the former is the more abundant. Prof. Favre considers this rock to belong to the Carboniferous series, though, as is needful, he expresses himself with caution. I have examined microscopically one of the coarsest and one of the finest varieties, and though they have no very direct bearing on the main questions of this paper, may record the result, as it is rather curious. The coarser fragment is so like a crushed gneiss that were it not for the label I could not distinguish it. Even under the microscope this resemblance is maintained; so much that I should not have liked to express a positive opinion from a single slide. The chief minerals are quartz, felspar, orthoclastic and plagioclastic, rather decomposed but recognizable, and mica, brown and white, the former in this case rather predominating. Not seldom two things are certain: that the minerals are associated as in the original gneiss, and that they have been broken *in situ*. I conclude then that we have here a seam made up largely of comparatively unrolled gneiss fragments, subsequently subjected to enormous pressure which has cracked some and welded all together. The structure of the compact flinty "argillite" is even more remarkable. I expected to find the usual minutely granular aspect of this rock, specks or fragments of clear quartz in a slightly earthy base, full of ill-defined crystallites. On the contrary, we see a fairly well-defined fragmental structure, in a minutely granular ground-mass into which the fragments seem sometimes to melt away. Crossing the Nicols a good deal of the minute filmy mineral, often called sericite, becomes visible, with the usual sub-parallel rootlet-like arrangement, common in schistose rocks. This of course is of the nature of foliation, but it is a change which in rocks of proper chemical composition readily takes place under pressure, and is as far away from the true foliation of a gneiss or mica-schist, to use a rough illustration, as the caterpillar is from the butterfly. Crossing the Nicols, the sericite becomes more conspicuous, being most highly coloured when the general direction of the fibres makes an angle of about 45° with the vibration planes of the Nicols, but the clastic aspect of the slide becomes far less marked. Many fragments are wholly replaced by a chalcedonic structure, speckly-translucent granules interspersed among darker, others are traversed by irregular bands showing this structure; the edges of most appear to melt through it into the surrounding ground-mass, so that not seldom one might reasonably have doubted whether the apparent fragments were not rather segregations.

On inserting a quartz-plate, the original structure is not only restored, but rendered far more distinct. It is then evident that even this remarkably compact and homogeneous looking rock has been made up to a large extent of fragments, sometimes as much as 0·06″ in diameter, of quartz and felspar derived from a gneiss (I do not see any fragmental mica in the slide). This material has been subjected to immense pressure, the quartz grains have been broken, the felspar crushed; from the latter and from the interspersed earthy dust, minute micaceous minerals have been formed, and the free silica been deposited as chalcedonic quartz or perhaps sometimes opal—and as the result a rock is produced to the eye indistinguishable from one of those formed from similar mineral matter much more finely divided.

In conclusion, I will venture upon two remarks. One, that no inferences with regard to metamorphism can be accepted until they have been fully confirmed by the evidence of the microscope, and in this particular branch of investigation the observer must be contented to serve a rather long apprenticeship. The other, that in the Val Orsine conglomerate we have distinct proof that the principal Alpine metamorphism occurred long before the Carboniferous period. When that conglomerate was deposited, the rocks from which it was derived and on which it rested were schists and gneisses not materially differing from those which now form the great central masses of the Alps. Go where you will in the Western, Central, and the greater part of the Eastern Alps (for of all these I can speak from personal knowledge), you pass abruptly from the comparatively unmetamorphosed rock, whose age you know, to a highly metamorphosed rock, of which you can only say that it is immensely older. Further, in the latter series you can trace a certain lithological and stratigraphical sequence, which leads upwards through a series of groups, how far separable I will not now attempt to say, from the coarse granitoid gneisses and protogines to the topmost well-stratified, but still truly metamorphic, schists; so that we seem justified in demanding very clear evidence before we can accept any of the crystalline foliated rocks of the Alps as of Devonian or Silurian age, even if we carry the latter group to the lowest limit of the late Sir R. Murchison.

VII.—Note on the Nagelflue of the Rigi and Rossberg.[1]

By Prof. T. G. Bonney, F.R.S., F.G.S.

THE remarkable conglomerate, called nagelflue, which fringes a considerable extent of the northern district of the Swiss Alps, and in places forms almost mountain masses rising some 5000 feet above the sea, has already received much attention from geologists. One might then fear to handle a subject almost as well worn as its pebbles. Still there are one or two points to which in the present state of our knowledge it may be worth while to call attention.

During the last quarter of a century I have frequently passed over the beautiful sub-Alpine district of Switzerland in which the nagelflue and the molasse are the dominant rocks, the former affording the bolder, the latter the gentler scenery of the region; but last summer I devoted three or four days to a special examination of the great masses of nagelflue in the neighbourhood of the Rigi. I examined this mountain on both sides, and spent some time in investigating the vast blocks which fell from the Rossberg and overwhelmed the ill-fated village of Goldau. Without lingering

[1] Read before Section C, British Association, at Southport Meeting, 1883.

over facts already well known to geologists, I will simply call attention to three points which specially attracted my notice.

1. The pebbles of the conglomerate are not seldom indented one by another. These imprints, made by the more acutely curved surfaces of one pebble upon the less convex surfaces of another, are perceptible upon the harder grits, more strongly marked upon the softer, and most of all conspicuous upon the calcareous pebbles. The "pitting" of the last named is frequently very marked. I do not think it wholly due to pressure, but to the action of water localized and intensified by the pressure of the adjoining pebbles, while in the other two rocks the indentations are probably wholly of mechanical origin.

This marking of the pebbles has been already noticed by foreign authors, and I should not have drawn attention to it had it not been for a communication made to this section last year by Prof. James Thomson entitled "Mention of an Example of an Early Stage of Metamorphic Change in Old Red Sandstone Conglomerate."[1] Of course indentation—being a change of form—is an instance of metamorphic change, but the author hints at something more than this. It needs but a glance at the list appended by Mr. Topley to see that the cases adduced by Prof. Thomson are no proof of the effect of high temperature, or of "reduction to a plastic state," whether by "hot water or hot gases." In short, this indentation of the pebbles is no proof of metamorphic action at all in the ordinary sense of the term. No rock is perfectly rigid. The extraordinary flexures, gigantic and microscopic, which under pressure are produced alike in schists, quartzites, sandstones, limestones, slates, and shales, are proof of this. No one, however, who has examined the pudding-stone of the Swiss Miocene or the conglomerate of the English Bunter (where the hardest quartzite pebbles are thus indented) can for a moment regard this deformation as an indication of metamorphism on which the slightest stress can be laid. I should have not deemed it worth while to call attention to the subject did I not know from experience that in petrology an erroneous idea seems to possess a more than feline vitality.

2. The next point to which I would call attention is the lithology of the nagelflue of this district. This was the point to which my attention was more especially directed, because of its bearing on the physical history of the Alps. It is probable that the areas drained by the rivers of the Miocene Alps bore some relation to those which feed the existing streams. We may regard the conglomerates of the Rigi and the Rossberg as the delta of a Miocene Reuss, whose water system had a general correspondence with that of the present river and its tributaries. At least if we do not accept this view, we must allow a larger influence to catastrophes than is generally admitted by the geologists of this age. At the present time the upper waters of the Reuss flow almost without exception over districts occupied by crystalline rocks—some of these being among the most granitoid in the Alps. Speaking in general terms the Mesozoic

[1] See Report British Association 1882 (Southampton), p. 536.

rocks which inclose the famous Bay of Uri terminate at the Maderanerthal on the right and at the Maienthal on the left bank of the Reuss. Thus the pebbles of the Reuss valley are largely made up from crystalline rocks. Alpine schists and gneisses abound in the erratics which are scattered along the flanks of the Rigi on either side to a height of about 3500 feet above the sea. I was anxious to ascertain to what proportion these rocks entered into the conglomerate. While travelling from Lucerne to Schwytz by the new railway I thought that I saw a few pebbles of gneiss in the conglomerate blocks built into walls above the Lake of Zug, but satisfied myself that if present they were far from common, and that grits and limestones predominated. When I was able to search the Rigi more carefully, I did not meet with a single pebble of schist or gneiss either between Weggis and the Rigi-kulm, or between that and Goldau. In the débris of the Rossberg I found, after searching for nearly two hours, three pebbles of a greenish schist, obviously one of the most modern among the crystalline rocks of the Alps, and one (extremely decomposed) of coarse Alpine gneiss. With the exception of a granite, presently to be noticed, the great mass of the conglomerate consisted of a variety of grits, sometimes coarse, more often fine, sometimes almost a quartzite, sometimes ordinary hard sandstones, and of limestones, pure and impure, light and dark; consisted in short of a great variety of rocks representing the Mesozoic and perhaps the early Kainozoic deposits of the Alpine region. There are occasional pebbles of chert, both dark and reddish-coloured. Vein quartz is very rare, if not absent. The one exception is a number of pebbles of a granitic rock. These were not noticed by me till I got some distance above Weggis, but they occur over the other parts of the mountain which I traversed, including the descent to Vitznau and the conglomerates by the lake shore between it and Weggis, and in the débris of the Rossberg. They vary in their proportion to the others; commonly I should say they form not more than 1 or at most 2 per cent. of the whole, but now and then, especially on the northern side of the Rigi, they amount to 5 per cent., and in one case I counted eleven exposed in about a square foot of stone (the largest being a little over two inches in diameter). The rock is a moderately coarse granite, consisting mainly of whitish quartz and reddish felspar, with a variable small quantity of a dull green mineral, decomposed black mica or hornblende. Occasionally we find specimens of a compacter and more porphyritic rock, either a "quartz-porphyry" or "granite-porphyry" of continental writers; probably, however, this is from the same region as the other rock. These granites are totally unlike any Alpine granite or protogine known to me; but there is a small quantity of granite on the Bristenstock and a "red porphyry" on the Windgelle which I have not seen. I am not aware that Swiss geologists have succeeded in identifying the sources of these pebbles any more than of the blocks of the Habkerenthal.

The lithological character of the nagelflue then entitles us to assume that at the time of its deposition the rivers which drained the mountain chain to the south-east had but rarely cut down to its crystalline foundations and that the visible portion of the Miocene Alps in this part of Switzerland consisted of Mesozoic and early Kainozoic rocks.

3. The third point to which I would draw attention is the analogy of the nagelflue to some British rocks. Petrologically its likeness to the Bunter conglomerate of Central England is most remarkable. It resembles the latter in its confused assemblage of pebbles large and small, generally well rounded, though perhaps it contains blocks over 6″ diameter more frequently, and is a little coarser. The matrix generally is harder, but this is due to the more quartzose character of that in the Bunter. The latter rock is commonly redder, though hardly more so than that which forms the fine crags above Vitznau. There are the same irregular partings of sand, often some feet in thickness, nay, here and there in the Rigi a sort of flagstone banded with marl may be noted which recalls the waterstones of England. As we wander over the flanks of the Rigi we can hardly resist the conclusion that the two deposits are records of like physical causes. I may indeed add that except in colour the ordinary Swiss molasse has considerable resemblance to the softer sandstones in our Triassic series below the Keuper Marls.

In Britain the beds which have a close petrological resemblance to the English Bunter are the Old Red Sandstones of England, Wales, and Scotland (excluding the volcanic rocks) and certain parts of the Lower Carboniferous series of Scotland, as, for example, the conglomeratic sandstones of the Isle of Arran. All these closely resemble the gravels of recent formation in the great river valleys of the Alps; they differ from all marine pebble beds which I have examined in several particulars, difficult to describe, but readily recognized in the field. The nagelflue with much of the molasse, the Old Red Sandstone, the Calciferous Sandstone group of Scotland, are recognized without hesitation as of fluviatile or fluvio-lacustrine origin.[1] We seem then justified in adding the Bunter series at least of Central and Northern England to the list of beds similarly formed, rather than in regarding it as the result of currents in a sea. In an inland sea it is improbable that adequate littoral currents would exist; in one communicating with the ocean we could hardly fail to obtain traces of marine organisms. It seems then to me that in the lower part of the English Trias we have a condition of things analogous to that of the Swiss nagelflue and molasse:—terrestrial fluviatile deposits not very distant from a sea, of which the Continental Muschelkalk is one representive. For the product of a true inland sea in Britain we must look to the Keuper.

[1] In some very valuable remarks made after the reading of this paper, Mr. W. T. Blanford, F.R.S., referred to a series of conglomerates (which he considered of Pliocene age) largely developed in the Upper Siwalik in the north-west of India, on the flanks of the Himalayas, and west of the Indus in the Punjab and Sind (described as he informs me by Mr. Medlicott in the Manual of Geology of India, vol. ii. pp. 466, 525, 532, 541, and 570). These he compared with the gravel slopes along the base of the Himalayas (vol. i. p. 403), expressing the opinion that all of them, with the nagelflue, were very probably the results of subaerial fluviatile action.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science, Fifty-Third Meeting, Southport, 19th September, 1883.

[Professor A. Cayley, M.A., LL.D., F.R.S., etc., *President.*]

A.—Titles of Papers Read in Section C. (Geology).

President: Professor W. C. Williamson, LL.D., F.R.S., etc.

Address by the President (*Professor Williamson*).—On the Present State of our Knowledge of the Fossil Vegetation of the Carboniferous Age.

C. E. De Rance.—Notes on Geological Sections within 40 Miles Radius of Southport. (See p. 500.)

G. H. Morton.—Section Across the Trias recently exposed by a Railway Excavation in Liverpool.

Professor W. Boyd Dawkins, M.A., F.R.S.—The Master Divisions of the Tertiary Period.

R. J. Ussher, M.R.I.A.—Report on Exploration in Caves in the Carboniferous Limestone of the South of Ireland.

J. W. Davis.—Report on the Exploration of Raygill Fissure, Yorkshire.

J. W. Davis.—On the Occurrence of Labyrinthodonta in the Yoredale Rocks of Wensleydale, Yorkshire.

J. W. Davis.—On some Fossil Fish Remains found at Leyburn, Yorkshire.

H. W. Crosskey, LL.D.—Report of the Boulder Committee.

Professor W. C. Williamson, LL.D., F.R.S. (President).—On some Supposed Fossil Algæ, from the Carboniferous Rocks.

Professor W. C. Williamson and W. Cash.—Report on the Fossil Plants of Halifax.

Principal J. W. Dawson, C.M.G., F.R.S.—Geological Relations and Mode of Preservation of *Eozoon Canadense.*

Professor E. Hull, LL.D., F.R.S.—On the Geological Age of the North Atlantic Ocean.

Baldwin Latham.—The Influence of Barometric Pressure on the Discharge of Water from Springs.

W. H. Baily.—Additional Notes on *Anthracosaurus Edgei* (Baily, sp.); a large Sauro-Batrachian from the Lower Coal-measures, Jarrow Colliery, near Castlecomer, Co. Kilkenny.

W. T. Knowles.—On Basalt apparently overlying Post-Glacial Beds, Co. Antrim.

Mark Stirrup.—On some Recent Opinions respecting the Loess-Deposits of the Valley of the Rhine.

G. P. Hughes.—On the Former Physical Condition of Glendale, Northumberland.

James Thomson.—On a Conglomerate with Boulders in the Laurentian Rocks of North Uist, Scotland.

James Thomson.—On a Coral Atoll on the Shore-line at Arbigland, near Dumfries, Scotland.

G. R. Vine.—Report on the British Fossil Polyzoa.

C. E. De Rance.—Report on the Underground Waters of England and Wales.

Professor John Milne.—Report on the Earthquake Phenomena of Japan.

H. J. Johnston-Lavis.—On the Earthquake of 1881 in the Island of Ischia.

H. J. Johnston-Lavis.—On the Earthquake of 1883 in the Island of Ischia.

Rev. A. Irving, B.A., B.Sc.—Dyas *versus* Permian.

Rev. A. Irving.—On the Coloration of some Sands, and the Cementation of Siliceous Sandstones.

H. G. Fordham.—Note on a Boulder from the Chloritic Marl of Ashwell, Herts.

Professor T. R. Jones, F.R.S.—Report on the Fossil Phyllopoda of Palæozoic Rocks. (See p. 461.)

W. H. Baily.—Report on the Fossil Plants Associated with the Basalts of the North of Ireland.

Professor T. G. Bonney, M.A., F.R.S.—Note on the Nagelflue of the Rigi and Rossberg. (See p. 511.)

Professor T. G. Bonney.—On a Supposed Case of Metamorphism in an Alpine Rock of Carboniferous Age. (See p. 507.)

Professor J. F. Blake, M.A.—On the Pre-Cambrian Igneous Rocks of St. David's.

J. S. Diller.—On the Topography and Geology of the Troad.

John Gunn, M.A.—On the Causes of Change of Climature during Long Periods of Time, and of Coincident Changes of Fauna and Flora.

G. V. Smith.—Preliminary Note on the Further Discovery of Vertebrate Footprints in the Penrith Sandstone.

C. S. Bate, F.R.S.—On *Archæaslicus Williamœsi*, a new genus of Eryonidæ from the Lias of Lyme Regis.

B.—Titles of Papers, Bearing upon Geology, read in other Sections.

Section A.—Mathematical and Physical Science.

Professor A. Schuster, F.R.S.—Report of the Committee on Meteoric Dust.

G. Johnstone Stoney, M.A., F.R.S.—On the Cause of Crystalline Form.

I. Roberts.—On the Attractive Influence of the Sun and Moon in Causing Tides, and the Variations in Atmospheric Pressure and Rainfall, causing Oscillations in the Underground Waters in Porous Strata.

J. Glaisher, F.R.S.—Report of the Committee on Underground Temperature.

Professor Schuster.—On the Motion of Swiss Glaciers in 1883.

Section B.—Chemical Science.

G. Johnstone Stoney.—On the Relation between Chemical Constitution and Crystalline Form.

R. Warington.—On the Nitrates in Soil.

SECTION D.—BIOLOGY.

Messrs. Scott and Osborne.—On the Origin and Development of the Rhinoceros Group.

A. R. Hunt, M.A.—On the Influence of Wave-Currents on the Marine Fauna of Shallow Seas.

DEPARTMENT OF ANTHROPOLOGY.

W. Pengelly, F.R.S., F.G.S.—Address of the President.

W. Pengelly.—On a Flint Implement found on Torre Abbey Sands, Torbay.

A. R. Hunt, M.A.—The Borness Cave, Kirkcudbrightshire.

W. J. Knowles.—The Antiquity of Man in Ireland.

SECTION E.—GEOGRAPHY.

Lieut.-Colonel H. H. Godwin-Austen, F.R.S., F.G.S.—Address of the President.

Cuthbert E. Peek.—On the Hot Spring Regions of Iceland and New Zealand, with Notes on Maori Customs.

W. Hancock.—On the Volcanic and Earthquake Regions of Central America.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

Major the Hon. D. Erskine.—The Gold Fields of South Africa.

SECTION G.—MECHANICAL SCIENCE.

Hyde Clarke.—Morecambe Bay in 1836 and 1883.

G. H. Daglish.—The Rosebridge Colliery.

A. W. Darbishire.—The Working of Slate Quarries.

A. R. Hunt.—The Action of Waves on Sea Beaches.

REVIEWS.

I.—ON THE FOSSIL FISHES OF THE CARBONIFEROUS LIMESTONE SERIES OF GREAT BRITAIN. By JAMES W. DAVIS, F.G.S. (Scientific Transactions of the Royal Dublin Society, vol. i. series ii. pp. 327–600. Plates xlii.–lxv. 4to. Dublin, 1883.)

WITH the history of fossil fishes in this country four names will naturally be associated, viz. Agassiz, Egerton, Enniskillen, and Mantell. For world-wide as in later years became the reputation of Louis Agassiz, his earliest researches in fossil fishes were mainly carried out in conjunction with Sir Philip Grey-Egerton, the Earl of Enniskillen, and Dr. Mantell; and it is their collections which contain the largest proportion of the "types" of his great works. It is no small satisfaction to geologists and palæontologists to know that all three of these magnificent collections (Mantell, Egerton, and Enniskillen) now form part of the National treasures, and their choicest specimens may be seen assembled in one gallery at the new Natural History Museum, Cromwell Road.

Of these vast and varied treasures it is not our intention to speak generally here, but rather to direct attention specially to a single group of fossil fish-remains from the Carboniferous Limestone, in which the collection formed by the Earl of Enniskillen is exceedingly rich. These remains consist, for the most part, of detached teeth and spines of a great number of species of cartilaginous fishes evidently closely related to the existing Cestracionts, whose jaws (like the living Port Jackson shark) were armed with numerous obliquely-disposed crushing teeth which covered like a pavement the working borders of the mouth, while the anterior teeth were small and pointed. The dorsal (and often the lateral) fins of these old sharks were, like their modern representatives, armed with formidable spines more or less recurved and usually ornamented with ridges and tubercles and often strongly serrated. Of the rest of their remains we know nothing; for, as their skeletons were cartilaginous, they must have perished before they had time to become fossilized; and it is rarely that more than two or three teeth are found associated together; hence the great difficulty which has always been felt by naturalists in correctly classifiying these remains, for although Prof. Agassiz *named* a great many specimens in MS., he described but very few.

The work before us is a most praiseworthy effort on the part of Mr. J. W. Davis, of Chevinedge, Halifax, to gather up all the literature relating to these fragmentary fish-remains, and following Agassiz's intentions, so far as they can be detected by his MS. labels on the large series of Mountain Limestone teeth and spines in the Enniskillen collection, to name, describe and figure all these varied forms of Plagiostomatous fishes in a carefully prepared and exhaustive monograph.

The author is probably indebted to the powerful interest of a noble Irish peer for the fortunate circumstance that his work has been published under the auspices of the Royal Dublin Society, and forms a part of the new series of their Transactions. The text fills 274 quarto pages, and is illustrated by 24 chromo-lithographic plates, several of which are folding plates of large size.

"The fish-remains," writes Mr. Davis, "found in the Mountain Limestone formations have hitherto not proved very numerous, nor have they been discovered in a great number of localities, considering the large area occupied by this group of rocks, its great vertical thickness, and the large extent to which it has been excavated for commercial purposes. The Limestone in the great majority of localities does not appear to contain any remains of fishes, and with the exception of the Armagh district and that of Bristol, other localities, including Wensleydale, Kendal, Derbyshire, and Oreton in Salop, have added few, either specimens or species, to enrich the knowledge of the ichthyic fauna of that ancient period.

The fish-remains hitherto found in the Carboniferous or Mountain Limestone belong with few exceptions to the Plagiostomata—the sharks and rays—and consist of an almost endless variety of teeth, and a large number of spines. A very slight consideration of the anatomical constitution of an existing shark will give an idea of the difficulty attending the determination of the species of the several fossils, and still more of the almost utter impossibility of reconstructing, on a sufficiently certain and scientific basis, anything approaching a correct idea of the form and parts of the extinct fish. In existing sharks the whole framework of the body is frequently cartilaginous. The skull and mandible are well developed, but are entirely composed of cartilage; the pectoral and pelvic arches are the same; the vertebræ are in many fishes cartilaginous, in others a slight ring of bone is imbedded in the vertebræ, and there is further modification in the direction of a completely osseous centrum. The teeth, the spines placed in front of the dorsal or pectoral fins or other parts of the body, and the dermal tubercles or shagreen, are the only parts of the fishes which are composed of an osseous or other hard substance which would be capable of resisting speedy decomposition after death. As might be naturally inferred, these are the only parts of the fishes of Carboniferous age which are found fossil; even the vertebræ appear to have been entirely devoid of calcareous deposit and with the remaining cartilaginous portions of the fish have been decomposed and lost. The cartilaginous framework which held the teeth and spines together having decayed, these less destructible organs speedily became separated, and may have been carried considerable distances apart by currents or tides before they were eventually imbedded. It is an extremely rare occurrence to find the various teeth, spines, and dermal tubercles, in such relationship that they can be identified as belonging to the same fish. Not only is this the case with the separated spines and teeth, but the greatest confusion may, and no doubt does to a large extent, exist in the determination of the many forms of teeth, and it may easily happen that the teeth which have lain side by side in the palate of one fish, may be considered by the ichthyologist as representing, not only different species, but present so marked differences in form as to lead to their being placed under separate genera. An interesting example of this kind, in which the two genera *Cochliodus* and *Helodus*, instituted by Professor Agassiz, though they had been found in several countries in Europe as well as in America, and for more than thirty years considered as separate genera, were ultimately found, by the fortunate discovery of a specimen with the teeth undisturbed, to be one and the same genus.[1] The organs on which modern classification is based: the non-decussating optic nerves; the muscular *conus arteriosus* with its varied rows of valvular openings; and the spiral valve of the intestine, have no existence in a fossil state, and it is only by analogy that it can be reasoned that as in recent fishes it is found that certain functional relations exist between the soft and hard parts of the fishes, so having procured the hard bony *disjecta membra* of the extinct fishes, and these exhibiting certain relationships with the recent forms, it may be inferred that the more perishable portions have also borne a similar relationship to those of recent forms" (pp. 329—330.)

Of the 59 genera described and figured by Mr. Davis in his

[1] Geol. Surv. Illinois, vol. ii. pp. 88–89.

Monograph, 14 are founded on the spines of Hybodonts; 4 generic names denote various peculiar cranial bones and dermal plates, of which it is often difficult, if not impossible, in the present state of our knowledge, to determine the true anatomical relations; the other 41 genera are founded on the various forms of teeth of the types of *Orodus, Petalodus, Cochliodus, Psammodus,* and *Copodus.*

The author refers to the fact that in the Liassic formation the teeth of *Hybodus* have been found in such connexion with the dermal spines as to place their relation to each other beyond a doubt. Yet he observes, "The teeth and spines of *Ctenacanthus* have not been so found, but judging from analogy, it appears probable that the teeth of *Cladodus* may have been associated with the spines of *Ctenacanthus.* Except that the *Cladodi* are more formidable and that the coronal prominences are more prominent, they bear a close resemblance to the teeth of *Hybodus.*" (p. 331.)

Notwithstanding the large development and wide distribution of the Carboniferous Limestone Formation in the British Islands, the number of localities yielding fossil fish-remains is comparatively few.

Of the ten localities tabulated (pp. 545–548), Armagh takes precedence of all the others for the richness of its ichthyic treasures, no fewer than 117 species having been obtained by Lord Enniskillen from this important locality. Probably the same careful investigation of other less prolific localities might have produced an equally rich harvest. From Hook Point only one species, *Streblodus Egertoni*, seems to have been obtained. Bristol has 21 species to its credit; Oreton and Farlow in Shropshire, 15 species (chiefly obtained by Mr. Weaver Jones and Mr. Baugh); Richmond probably claims most of the 26 species attributed to Yorkshire, where the labours of the late Mr. Edward Wood, F.G.S., added so many new forms to the Mountain Limestone fauna. Derbyshire yields 13 species; Kendal in Westmoreland, 5; the West of Scotland, 35 species; Lowick, Northumberland, 11; and Tortworth, Gloucestershire, which has yielded a single ichthyodorulite to the Earl of Ducie, in whose collection may also be seen the largest fish-spine from the Carboniferous Limestone, found near Bristol, 27 inches in length and stout in proportion (drawn natural size on pl. lxv.).

It is interesting to observe that out of 163 species recorded by Mr. Davis, 117 have been obtained from one locality, viz. Armagh.

In a work like the present, it seems very difficult to offer many remarks of a critical nature; we may perhaps be permitted, without undue severity, to suggest that, as a matter of utility, the coloration of the plates might have been, for the most part, omitted, as it seldom has any pretension to be a reproduction of the colour of the original matrix or fossil. The pieces of dermal and other bones represented upon pl. lxii. are (for the most part) too fragmentary to assist us in arriving at their true nature. At a future time, no doubt, many of the species formed upon single specimens of teeth, or on fragmentary ones, will have to be eliminated.

In his determinations and deductions, Mr. J. W. Davis has closely followed the lead of Prof. L. G. de Koninck as expressed in his

"Faune du Calcaire Carbonifère de la Belgique," especially in reference to the spines of *Oracanthus* (*Antacanthus*, Dewalque). Many of the specimens of these spines in the British Museum show palpable evidence of wear along their distal extremity, as so well seen in the pectoral spines of *Gyracanthus* from the Coal-measures and in those of the living *Silurus*.

It seems probable that they may have occupied a lateral position on the head of these old Elasmobranch Fishes. That these spines of *Oracanthus* were not true dermal plates is proved by their apices being solid, and decorated on both sides. That they were lateral and not dorsal defences is proved beyond doubt by the worn condition of their apices; but there is no reason to justify the idea (p. 530) "that they formed the posterior termination of the body."

Space does not permit us to enter upon a detailed discussion of the numerous genera and species which Mr. Davis brings before us in his Monograph. At a future time we may venture again to refer to his work. Suffice it to say, that for one who has to accomplish his task as Mr. Davis does, in the hours of leisure (often few and far between) which a busy manufacturer can spare from his daily avocations, and with the drawback of being located at a distance from the great museums and libraries, one cannot but feel that he is entitled to our most favourable consideration and our best thanks.

II.—The Agricultural Geology of Hertfordshire. By J. Vincent Elsden, B.Sc., F.G.S. From the "Transactions of the Hertfordshire Natural History Society," vol. ii. part 4, 1883.

After some remarks on the relation of Agriculture to Geology, and especially on the differences in cultivatible lands in different parts of England and Wales as being due to geological structure, and to relative rainfall on the high and low grounds, Mr. Elsden proceeds to describe the climate and physical features of Hertfordshire in particular. The annual rainfall (ranging from 25·7 to 34·6 in different parts of the County) is given in a table; and the more important physical properties of the soils of Herts are carefully tabulated, showing their relation to water and temperature; and all the results are found to be in accordance with the local geology.

The range, limits, and characters of Alluvium, Boulder-clay, Glacial Gravels and Sands, Brick-earth, Clay-with-flints, Pebble-gravel, London Clay, Woolwich and Reading beds, Chalk, and Gault are concisely dealt with, and illustrated with a map. So also the local soils are described and mapped, and their probable origin from the several underlying or neighbouring stratified deposits clearly indicated. Thus (see table on page 522):—

The influence of the geological constitution on the agricultural features of Hertfordshire is further considered topographically; the local water-supply being also taken into account. The reason why the Chalk district of Herts differs from those of the Southern Counties is explained by the presence of extensive argillaceous and sandy coatings and cappings.

Nature of Soil.	*Acres occupied.*	*Probable Geological Origin.*
Loamy clay	132818	Great Chalky Boulder-clay of East Anglia, except on the north of the Chalk escarpment, on the outcrop of the Gault.
Yellow clay	5365	London Clay.
Blue Pebbles and Clay	5851	Drift, derived from Woolwich-and-Reading beds.
Tenacious clay	20193	London Clay.
Flinty loam	57802	Disintegration of the Chalk; Clay-with-flints; and Drift.
Sandy loam	13340	Alluvium of the Lea.
Mixed soils; clay, sand, gravel	66080	Drift, derived from the Lower Tertiaries, also the Clay-with-flints.
Gravelly soil	35647	Mid-glacial sands and gravels and alluvial gravels.
Chalk soil	32834	Disintegration of the Chalk.
Peat or marshy soil	3000	Alluvium of existing rivers.
Mixed stony soil	14550	Glacial Drift and Clay-with-flints.

The firestone and phosphatic nodules of the Upper Greensand,—the flint, the Totternhoe building-stone, and lime got from the Chalk,—the brick-clays, sand, and cement-stones of the Eocene Tertiaries,—and the younger brick-earths and gravels, are noticed as the economic products of the rocks of the County.

An interesting comparison of agricultural results obtained in ten Counties of South-east England and two others (Wilts and Hants) is given in a tabulated form. These Counties geologically consist largely of Cretaceous, Eocene, and Drift deposits. Cambridgeshire and Wilts have a larger per-centage of land devoted to agricultural purposes than Hertfordshire; but this County ranks with the Eastern Counties generally as the largest corn-growing district in England, owing almost entirely to the nature of its Drift deposits and the comparative dryness of its climate. Clover and rotation grasses are in less quantity than in Norfolk and Suffolk, so also turnips and beans. Herts is also low as to acreage of permanent pasture, the Chalk not being bare, and thus not forming "Downs." In the south portion, however, and still further in Middlesex, the London Clay carries rich hay-farms. The valley of the Lea has market-gardens and nurseries on its fertile alluvium. Arable culture, especially with barley, and hence with an extensive malting business, occupies the Boulder-clay district in the eastern part of the county; whilst the wheat-growing heavy loamy district in the north has led to the manufacture of straw-plait around Luton and St. Albans.

In alluding to the influence which the nature and features of a country have upon the industries and character of its inhabitants, the author observes with truth that "the history of every nation has its natural beginning on the soil upon which it has sprung up; geological influences from the beginning have impressed their stamp upon it, and have determined, in a great measure, even its social and political position."

T. R. J.

CORRESPONDENCE.

CONTINENT FORMATION.

Sir,—Having just returned from my usual summer vacation trip to the mountains, I have only now seen the June Number of your Magazine containing Mr. Crosby's article on "Continent Formation," in which he criticizes the views of Prof. Dana and myself on this subject. No one can be more aware than myself of the extreme uncertainty of any views yet proposed on this most difficult subject. So far from objecting to such criticisms, therefore, I hail with pleasure anything whether in the way of advancement of new, or the criticism of old, views. My object in this communication is merely to correct what I conceive to be some misunderstandings.

1. Mr. Crosby (p. 242) says, "According to Prof. Dana's theory, the continents during the *course of geological times* have become higher and broader, and the oceans deeper and narrower. But *just the reverse is an unavoidable deduction from Prof. Le Conte's theory;* for as the refrigeration of the earth continues, the contraction along the longer or continental radii must, sooner or later, begin to gain on that of the shorter or oceanic radii, and from that moment the continents begin to subside beneath the surface of a universal ocean." The italics are my own.

I have two objections to make to this. (*a*) It is by no means "an unavoidable deduction," *unless*, while the conductivity on different sides were different, *the coefficient of contraction were the same.* But this is extremely improbable. (*b*) But even supposing the coefficient of contraction were the same, and that therefore "sooner or later" the inequalities would begin to grow less, it is quite evident that *that time has not yet arrived*, and probably will not while the earth is habitable. It is evident that the inequalities would increase to a limit which is yet far from being reached; for with the exception of a very thin crust, the mass of the earth is still incandescently hot.

2. Again, Mr. Crosby says (p. 243), "These theories rest at outset on an assumption which is not supported by a vestige of evidence, viz. that the earth was originally, and is now, of unlike composition along different radii or on different sides." "Where are the facts supporting it? Where are the analyses showing essential difference between continents and ocean-bottoms?"

In answer to this objection, I would simply say that Mr. Crosby overlooks the enormous size of the contracting body, and the comparative minuteness of the deformation by contraction. The *average* difference between continental and oceanic radii is only three miles,[1] or $\frac{1}{1300}$ of the whole. In a globe of 2 ft. in diameter this would be less than $\frac{1}{100}$ of an inch—a difference too small to be perceived. Now I am quite sure that a ball of clay 2 ft. in diameter, turned to a true sphere *while in a wet condition* and allowed to dry, would deform by contraction more than this. I think that even a ball of

[1] Extreme elevations are due to mountain-making, not continent-making causes.

metal such as iron or copper turned to a true spherical form while red-hot and allowed to cool, would deform more than that amount. Is not the burden of proof, then, on the other side? Ought not the objector to show cause why he assumes so preternatural a homogeneity?

3. But says Mr. Crosby, p. 244, "If we admit that the earth is of different composition on different sides, it would certainly be contrary to all analogy to suppose that the areas of different composition are sharply marked off from each other. Yet the steep slopes of oceanic depressions require according to these theories an abrupt change in radial contraction."

I would remind Mr. Crosby that according to my view (and also to Prof. Dana's) this *steep slope of oceanic basins is due to mountain-making not continent-making causes.*

4. In making some estimates of the amount of contraction, p. 244, Mr. Crosby takes account only of the contraction by solidification. But manifestly this is only a part, and perhaps but a small part of the whole contraction by cooling; and in addition to this there may be other causes of contraction besides cooling.

There are several other points which I might notice, but I fear it would make this letter too long. JOSEPH LE CONTE.

BERKELEY, CALIFORNIA, U.S.A.

THE PERMANENCE OF OCEANIC AND CONTINENTAL AREAS.

SIR,—As a believer in and advocate of the "hypothesis of the permanence of oceanic and continental areas" now "becoming fashionable," and in the course of many years' daily work among rocks never having seen or heard of an actual case of a true "deep-sea" deposit, I should like to make a few remarks on Mr. Mellard Reade's paper on the "Age of the Earth."

First, I fail to see the slightest connexion between the area of exposed igneous rocks and the number of times sedimentary beds have been "worked over" again. Surely at the beginning of geological time *all* the land was igneous, and practically that area has been diminishing ever since. This can therefore afford no clue to the question.

Secondly, as to the maximum thickness of rocks, which is what Mr. Wallace deals with, the tendency is rather to overestimate than underrate it. For example, it is usual to estimate the thickness of the Cretaceous rocks by adding together the maximum thicknesses in different localities, but this gives quite an erroneous result, and if applied to West Norfolk would make the result too great by about 2700 feet. In other words, 2800 feet of rock in various other localities were formed while only 100 feet were deposited in East Anglia. I am not taking account of beds removed by denudation; for there is no proof that the Maestricht beds, Upper Greensand, Gault, or Wealden ever existed there, and the Neocomian is under 100 feet. But to add together all these beds and take the sum as indicating the time of deposition, is as incorrect as it would be to take the beds now forming in the Black, Caspian, and Mediterranean Seas, and calculate their age from the sum of their thicknesses. This I believe has been a frequent source of error in estimating geological time, and it would be easy to give many illustrations of this from other beds.

Thirdly, Mr. Reade supposes the denudation of sedimentary rocks would reduce the mean thickness. This could only be the case if the area of deposition were continually changing its site or increasing its area. It is true that any given sediment *may* be spread over a wider area than the material originally occupied (though this is probably only the case in fluviatile beds), but as a broad fact the area of the land—or denuded surface—is greater than the area of deposition, as we know that all sediment is thrown down near the shore. We must treat this question as a whole, and not take isolated facts. Moreover, we believe the actual area of deposition not only is not increasing, but, viewed on as large a scale geologically as we have just done geographically, remains practically the same. Hence every ounce of freshly denuded igneous rock swells the actual thickness, and no amount of redistribution can reduce it, as Mr. Reade seems to think.

Supposing, lastly, that Mr. Wallace's calculations were all wrong, and Mr. Reade's curious figures (such as $\frac{12}{9326} = 777$) all right, it does not touch the main point at issue, namely, the question of the permanency of oceanic areas. I have not yet seen a single fact that tells against this view.

SYDNEY B. J. SKERTCHLY.

THE OLIGOCENE STRATA OF THE HAMPSHIRE BASIN.

SIR,—Your correspondent, Mr. Henry Keeping, is quite in error in supposing that in any remarks made at the Geological Society I had any desire to question the general excellence of his memory. The principle on which I did insist—and it is one which I am sure will command the assent of all geologists—is this, that when we have the observations of competent investigators carefully recorded on the spot, these ought not to be lightly set aside in favour of other observations, quoted from memory only, after an interval of thirty years. Under similar conditions, I should be quite as ready to distrust my own memory as I am that of your correspondent.

The case in question stands as follows:—Webster and Lyell, in their accounts of Hordwell Cliff, did not notice the so-called "Upper Marine Band." It appears to have been first discovered by the late Mr. F. Edwards, about the year 1840. In 1846 the late Mr. Searles Wood, who worked in conjunction with its discoverer, gave a full description of the bed and described it as being clearly underlaid and overlaid by freshwater strata. Dr. Wright, who described the section in 1851, and the late Marchioness of Hastings, who published her final account in 1853, independently studied the section, and both of them assert that the marine bed was covered with freshwater strata, the thickness and succession of which they minutely describe.

Now both the last-mentioned authors state that they employed your correspondent to assist them in exposing and measuring the several beds. Mr. Keeping says that he suspected at the time that the "Marine bed" was not in place, and that he spoke to both Dr. Wright and the Marchioness of Hastings on the subject. As both of these authors describe the bed in regular sequence, and enumerate a number of freshwater strata as lying unequivocally above it, is it not clear that they, after a careful examination of the question, regarded the objections of your correspondent as unfounded?

In 1881 Mr. Keeping stated that the Marine bed at Hordwell had not been seen for twenty-eight years. This statement, though not literally correct, may be taken as sufficient evidence that since the date when the Marchioness of Hastings' description was written, your correspondent has had no opportunity of correcting or confirming his early impressions.

For thirty years and upwards, the statements of Mr. Searles Wood and Mr. Frederick Edwards, of Dr. Wright, and of the Marchioness of Hastings, that the Marine bed was overlaid by freshwater strata, has remained unchallenged and uncontradicted, and has been quoted again and again. Now, when most of the original observers have passed away, your correspondent comes forward and would have us believe that they all committed a most egregious blunder, and this in spite of distinct warning on his part.

Now for the accuracy of your correspondent's recollections. He states that when described by Mr. Searles Wood, the marine bed was a patch "just above high-water mark, and only extending some 20 yards in length." Mr. Searles Wood, writing in 1846, with the section before him, says, "The bed occurs at an elevation of ten or twelve feet above high-water mark, and only traceable for about forty yards." But he also states that when the bed was first discovered by Mr. F. Edwards, it could be followed for three hundred yards, though it soon became so covered by debris from above, that three years after, when he himself first visited it, the bed could not be traced for a third of this distance.

Am I wrong, under such circumstances, in appealing to geologists not to set aside as unworthy of credence the carefully recorded observations of very competent observers, in favour of the crude recollections of your correspondent?

The importance of this so-called "marine-band," which is only nine inches in thickness, has been much overrated. It is not a distinct formation, as your correspondent would have us believe, but only one of numerous local intercalations of brackish-water bands, among the Oligocene strata of this area. When Mr. Keeping undertakes in twenty minutes to convince me of the identity of this insignificant bed with certain strata, themselves very inconstant, on the opposite side of the Solent, he certainly overrates his powers of persuasion or my faculty of belief.

Your correspondent is also mistaken in supposing that I am the authority for the statement that the coast at Hordwell is receding at the rate of a yard per annum. The estimate of the rate of loss of this part of the coast was made by a very competent observer, Mr. Codrington (Q. J. G. S. vol. xxvi. p. 532). Every one who knows how Hordwell Church has had to be rebuilt inland, and who remembers how the old site of the churchyard is near the edge of the present cliff, will be surprised to hear that in this part the coast is not receding at all.

I may perhaps be allowed to take the present opportunity of recording one or two new facts concerning the interesting Oligocene strata of the Hampshire basin. A year or two ago I discovered a single vertebra of a true Cetacean in these strata, and the bone was described by Prof. Seeley. Prof. van Beneden has now recorded the discovery of vertebræ, similar in many respects to the British specimen, in strata of the same age at Helmstedt. These two examples are probably the oldest known non-zeuglodont Cetaceans. Hitherto no Bryozoa have been recorded from the British Oligocene; but recently Mr. F. Chapman, one of the staff of the Geological Laboratory here, has found on oyster shells from Colwell Bay a form regarded by Mr. Vine as identical with the *Membranipora Lacroixi*, which Mr. Busk found encrusting shells from the London Clay. JOHN W. JUDD.

SCIENCE SCHOOL, SOUTH KENSINGTON, S.W.

THE MIDDLE HEADON MARINE BED AT HORDWELL.

SIR,—Mr. H. Keeping, of Cambridge, has asked me to send an account to your MAGAZINE of some work we have been doing together at Hordwell Cliff, Hants; viz. the re-opening of the Middle Headon Marine bed.

This bed has not been seen *in situ* here for upwards of thirty years, it having been obscured by talus from the superincumbent gravel, and its exact position has been disputed.

The earlier writers on this subject state that it underlies many feet of freshwater strata. This appears to be an error due to the fact that the bed seen by them was a slip close to the shore. Mr. Keeping opened the bed in its true position many years ago, and has now succeeded in finding it again. The spot selected by him for the digging is situated on the west side of a pathway down the cliff called "Paddy's Gap," about 600 steps to the east of the boundary bank between the Hordwell and Newlands estates, which is marked on the road running close to the cliff by a gate-lodge.

A pit eight or ten feet deep having been sunk through the talus, the following section was obtained:—

1. Soil, 1 foot.
2. Gravel, 25½ feet. The gravel immediately over the Tertiary beds is stained a very dark brown colour, with iron oxide.
3. Whitish sand, 1 foot to 1½ ft.
4. Marine bed, 1 foot to 1½ ft. Sand and comminuted shells, containing an abundant fauna chiefly of small and minute species of mollusca, estuarine and marine, including such common and characteristic species as the following:—*Pisania labiata, Murex sex-dentatus, Cancellaria muricata, C. elongata, Scalaria lævis, Nerita aperta, Neritina concava, Cerithium*

pseudo-cinctum, *C. ventricosum*, *Ostrea velata*, *Cytherea incrassata*, *Cyrena pulchra*, *Corbicula obovata*, etc.; while the characteristic and purely marine fauna of the Brockenhurst zone is almost entirely absent.

5. Light bluish-green clayey sand, in which specimens of *Paludina* and *Unio* were found.

The position of the marine bed was estimated to be at least 13 ft. above the shore.

About a third of a mile to the east, near Westover Lane End, there is a slight upthrow, showing the Unio bed, and also about 10 feet of the underlying green clays; it was under this that the previous writers had placed the Middle Headon marine bed, instead of above it.

A sufficient quantity of the bed excavated was thrown out to enable geologists to identify it for many years to come. I also had some of it brought away to work for the small species.

The pit was inspected by Professor Boyd Dawkins, and by Messrs. H. Willett, of Brighton, and T. W. Shore, of the Hartley Institution, Southampton. These gentlemen were quite satisfied as to the position of the bed. I must add that Mr. Willett, with characteristic generosity, has defrayed the expense of the excavation. Mr. Shore also gave help.

John W. Elwes.

Otterbourne, near Winchester,
October 1*st*, 1883.

OBITUARY.

JOACHIM BARRANDE.

Born 1799: Died 1883.

We regret to record the death of this veteran palæontologist, who, since about 1845, has devoted himself to the investigation of the geology and palæontology of his adopted country, Bohemia. Born in France and educated in Paris, he was early attached to the Bourbon family and went into voluntary exile with them in 1830, taking up his abode thenceforth in the city of Prague. His labours in elucidating the Silurian System of Central Bohemia extending over nearly 40 years have resulted in the production of 22 massive quarto volumes of text, and admirably executed plates of fossils, probably the most elaborate and costly work ever produced by a single worker. (We shall give a full account of Barrande's labours, with his portrait, in our next Number.—Edit. Geol. Mag.)

We have also to record the death, in his 75th year, of The Rev. Dr. Oswald Heer, Professor of Botany in the University of Zurich —the well-known palæobotanist, and author of the admirable work entitled "Urwelt der Schweiz" (Zurich, 1865), published in this country by Mr. James Heywood, F.R.S., in 1876, under the title of "The Primæval World of Switzerland" (translated by W. S. Dallas, F.L.S., Sec. Geol. Soc.). Dr. Heer is the author of nearly 100 papers on Palæobotany and Entomology.

J. Barrande

THE

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ORIGINAL ARTICLES.

I.—Sketch of the Life of Joachim Barrande, of Prague.

With a Portrait.[1] (PLATE XIV.)

THE usually quiet city of Prague in Bohemia, with its population of 235,000 inhabitants, considerably more than half of whom are Czechs, has been deeply moved by the recent death of an old French exile, who for more than half a century had made his home there, and, having taken up the geology of the country around Prague for his study, had endeared himself to the people by learning their language and interesting them in his pursuits. After publishing at great cost his geological works, and amassing a vast collection of fossils, he has at his death bequeathed his Library and Collections (valued at £20,000) to the Prague Museum, together with funds for the completion of his scientific labours. "To-day," writes Dr. Fritsch,[2] "I have opened a 'Barrande Fund' with 1,000 florins, which I hope will soon reach to fl. 20,000; its object being to promote the study of the Silurian formations of Bohemia. We also wish to place a large slab inscribed with the name of 'Barrande' on the Silurian rocks in Kuchelbad, near the celebrated locality Wiskočilka, where he picked up his first fossil *Orthoceras Bohemicum.*"

Joachim Barrande was born at Saugues, in the Department of the Upper Loire, France, August 11th, 1799, and was educated in the Polytechnic School at Paris. He was selected by Charles X. as tutor to his son, the young Duc de Bordeaux. When the King abdicated in 1830, Barrande accompanied the Royal exiles to England and Scotland, and afterwards to Prague, where for a time they resided. The King dying at Goritz in 1836, the constant attendance of Barrande was no longer greatly needed by the Count de Chambord, who removed to Frohsdorf, and became, as he advanced in years, more and more engrossed by the clerical party; but he always retained Barrande's services and regarded him as a dear and personal friend. About 1833 Barrande, finding himself more at leisure, took much

[1] We are greatly indebted to Dr. Anton Fritsch for kindly sending us the portrait-engraving of M. Barrande which accompanies this notice, and also for various German newspaper and other notices, from one of which, by Prof. J. Krejči, this Memoir has been chiefly compiled.—Edit. Geol. Mag.

[2] Director of the Natural History Museum in Prague.

interest (as a trained engineer by profession) in a horse-railway then in course of construction along the river Beraun to the Radnitz Coal-basin, and to Pilsen. Following the line he discovered in the inclined slaty rocks near Skrej and Tejřovic a most interesting quarry, rich in the primordial fauna of Bohemia. His attention had, however (writes Prof. Krejči), been previously attracted to fossil-remains in a walk through a little ravine at Zlichov, where he obtained an *Orthoceras* and the fragment of a Trilobite (*Dalmanites*).

The discovery of these fossils, and the examination of the small collection in the Bohemian Museum formed by Count Sternberg and Prof. Zippe, incited Barrande to commence the systematic study of fossil remains and their distribution in the various strata of Central Bohemia, and to publish the results. He had already become acquainted with the researches of Murchison and other geologists in England during his visit to that country; and when Murchison proposed the name "Silurian System," in the Philosophical Magazine for 1835, Barrande was one of the first Continental Geologists to apply it to the Transition rocks of Bohemia.

The sight of a copy of Murchison's "Silurian System" (published in 1839) in Vienna caused Barrande to resolve from that time to devote himself to the examination, description, and illustration of the fossils of Bohemia, a task which he continued with unabated energy for 43 years, until his death in October last.

The area to which Barrande devoted himself, and which forms the classic ground of his "Système Silurien du Centre de la Bohême," is about 140 square miles in extent, and, looked upon from the stand-point of Geology and Palæontology, was a veritable *terra-incognita*. Until the date of Barrande's first publication in 1846, no attention had been paid to stratigraphical geology and palæontology in Bohemia; Prof. Zippe, whose researches were published in 1831, having devoted himself entirely to the Mineral aspect of Geology.[1] This neglect of stratigraphical geology was no doubt due to the powerful influence exercised by Prof. Mohs over Zippe and his other pupils, which led them to study Crystallography and Mineralogy, rather than stratigraphical geology, then but little understood or cared for.

Even Corda, the able Curator of the Prague Museum (just before Barrande had published his Bohemian Trilobites), proved to his own satisfaction that the Fauna of the Transition rocks of Bohemia was only local, and that from it neither its relative age nor its distribution could be determined.[2]

But all these and similar geological heresies vanished before the ray of scientific sunshine which Barrande cast upon it by his investigations and researches. From 1840 Barrande devoted all his time and resources to the investigation of the Silurian System of Bohemia, especially to the task of describing, naming, and figuring the abundant series of fossils which his labours had brought to light.

In the summer months of the years 1840–50 he travelled on foot

[1] See "Uebersicht der Gebirgsformationen in Böhmen," 1831.
[2] See his Prodrom einer Monographie der Böhmischer Trilobiten, 1847.

over the whole Silurian district of Bohemia, and having thus made a preliminary survey of the region which he had resolved to explore palæontologically, and having determined the relative position and outcrop of the various beds, he engaged 10 or 12 intelligent workmen, who were taught how to search for fossils, and provided with all the necessary tools, including magnifying glasses. Under Barrande's superintendence these men then proceeded to open and work numerous quarries wherever there seemed a promise of obtaining fossils, and solely for that object. "This labour" (writes Sir Charles Lyell, in 1851) "had continued uninterruptedly for ten years, with the result of the discovery of 1100 species of fossils in rocks in which the combined labours of Sternberg, Boeck, and Zenker had only resulted hitherto in the production of about 20 forms."

Barrande frequently visited Paris in these years, and was in constant correspondence with Murchison, Sedgwick, Phillips, Hall, Forbes, Ramsay, Portlock, Davidson, M'Coy, Lyell, de Verneuil, Keyserling, Beyrich, and many other eminent Geologists and Naturalists. Murchison paid him repeated visits in Prague, in 1843, 1847, 1853, and again in 1857; on one of these occasions (1853) he was accompanied by Professor John Morris, M.A., F.G.S., and on another (1857) by Professor T. Rupert Jones, F.R.S.[1] Nor was Sir Charles Lyell a less interested observer of his labours. In 1851 the Council of the Geological Society of London awarded Barrande the "Wollaston Fund" to assist him in prosecuting his arduous and costly geological work, and on that occasion, and also in 1857, when the same Society presented him with the "Wollaston Medal," Sir Charles Lyell bore the highest testimony to the value and importance of M. Barrande's work. On the latter occasion Sir Charles alluded to his having visited him in 1856, and explored with him the field of his successful researches. "I saw," said Lyell, "several of the large quarries, which he had opened at his own cost for the express purpose of collecting fossils, and heard him converse in their native Bohemian with the workmen whom he has taught to be his skilful fellow-labourers. I believe I am under the mark if I estimate at 1500 in number of new species of Invertebrata which M. Barrande has added to palæontology; and it is a singular fact that all the Bohemian fossils found by him in Palæozoic strata older than the Devonian have proved, with the exception of a few Brachiopods, to belong to species unknown elsewhere. When I beheld the quantity and beautiful preservation of the fossil stores heaped up in his Museum at Prague, they appeared to be more like the results of a Government Survey than the acquisitions of a private individual, and I felt convinced that no amount of zeal or pecuniary resources could have achieved this object had not the collector possessed also a profound knowledge of many distinct branches of natural history. M. Barrande's investigations have for ever set at

[1] The writer of this notice had also the happiness to visit the illustrious Barrande in his unpretentious apartments in the Kleinseite No. 419, Choteksgasse, Prague, in 1876.

rest a question once so keenly controverted, namely, whether there existed in Palæozoic as in Neozoic times distinct natural history provinces of Mollusca and of other classes of invertebrata. He has shown, not only in regard to the fauna called by him Primordial, but also in respect to his second and third faunas, corresponding with what we have usually termed Lower and Upper Silurian, that distinct assemblages of species inhabited simultaneously different marine areas. The Palæozoic species, for example, of Bohemia differed from those of Scandinavia, and the North-American species from both. After examining, with M. Barrande as my guide, the beautiful Sections of Silurian rocks laid open on the banks of the Moldau, I felt convinced that he had correctly interpreted the order and succession of the rocks, and in whatever manner we may endeavour to account for the intercalation in the midst of the Lower Silurian strata of certain distinct groups of species (called by M. Barrande 'Colonies'), we must at least accept the facts as true, and believe the exact position of the fossiliferous formations to be as they are described by this accurate observer." (Anniversary Address President Geol. Soc. 1857.) Barrande's first work, "Notice préliminaire sur le Système Silurien et les Trilobites de Bohême," appeared in 1846, and also "Noveau Trilobites, supplement à la Notice préliminaire, &c." In 1847 two other works followed (the larger in the "Verhandlungen der Gesellschaft der Naturwissensch. in Wien") and one on the *Brachiopoda* of the Silurian formation in Bohemia. The State-Geologist, Ritter von Haidinger, referred to Barrande's work at the first Session of the Royal Academy of Sciences in Vienna in 1848, and stated that it had cost its author 25,000 gulden from his own private means to publish those works. In October of that year (1848) the Society granted him 1500 gulden in aid of his first publication.

The first volume of his great work appeared in 1852, in which is an admirable geological introduction, giving a summary of the entire Silurian System of Bohemia arranged in eight divisions represented by the letters A to H, the minor subdivisions being represented by *a*1, *a*2, or *b*1, *b*2, etc.

In the same manner he gives a concise summary of all the distinctive characters of the head-shield and pygidium of every genus of Bohemian Trilobites, with figures in most elaborate detail of each species, all the plates being exquisitely executed and rendered with microscopic accuracy, and surpassing in beauty any previous palæontological work of the kind ever before attempted.

The work as left at Barrande's death consists of 22 huge quarto volumes partly of text and partly of plates; these were issued from 1852 to 1881, and contain 6,000 pages of letterpress and 1160 plates of fossils.

Although many copies of his work were sold to foreign scientific institutions and libraries, the receipts barely covered the cost of production, yet Barrande employed no publisher and carried out with enormous labour every detail of this great work under his personal care. To accomplish it, he shunned neither personal privation nor material sacrifice. His income was expended in paying the numerous collectors and workmen in his employ. In his rooms the draughtsmen and lithographers worked under his immediate superintendence and received their payment from his hand. It is estimated that he expended 100,000 gulden, or nearly £10,000 on this great work.

The published volumes contain figures and descriptions of

	Genera.	Species.
I. Fishes	6	6
II. Crustacea, viz., *Trilobita*, *Phyllopoda*, *Ostracoda*, &c.	68	447
III. Mollusca, viz.,		
Cephalopoda	20	1,127
Pteropoda	7	68
Brachiopoda	26	640
Acephala	58	1,269
genera ...	185	3,557 species.

There remain the Gasteropoda, Echinodermata, Bryozoa, and Corals, the greater part of the text and plates for which are already nearly complete. This will probably increase the number of species by 1500, so that we may conclude that Barrande's labours will have resulted in making known at least 5,000 species of organic remains from the Silurian Rocks of Bohemia. The largest number probably ever obtained from any single area in any part of the world before.

Barrande's valuable library, together with all the types of his work, and his entire collection of fossils found in Bohemia or procured from other countries for comparison, are now by his will to find a resting-place in the Natural-History Museum of Prague, for which it will be necessary to provide a new building.

Prof. Dr. W. Waagen will undertake the publication of the *Gasteropoda* and *Echinodermata*; Dr. Otomar Novák, the Corals and Bryozoa. The general work of superintendence is to be entrusted to a Committee composed of Prof. Dr. J. Krejči, Prof. Dr. A. Fritsch, Prof. Dr. Ritter Kořistka, Dr. J. Stanisl, Prachenský, and Dr. Emil Bellot.

All plates already finished, together with text and manuscript, are handed over to the above Trustees, together with 10,000 florins, to defray the expenses of publication of the remaining volumes.

So fitly and nobly ends the life of one, who, without ostentation or display, devoted half a century to the task of working out the Silurian geology and palæontology of his adopted country, Bohemia, purely for the love of science and intent on achieving a great work and doing it thoroughly and well.

Of Barrande it may indeed with truth be said that "Whatsoever his hand found to do, he did it with his might."

II.—Synopsis of the Genera and Species of Carboniferous Limestone Trilobites.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(*Continued from p.* 487.)

(PLATE XIII.)

IV.—Brachymetopus, M'Coy, 1847.—General form elliptical; head-shield semicircular, and slightly pointed, about one-third wider than long; glabella small, somewhat elevated, one-third the width of the entire shield, and about one-half the length, having a basal lobe on each side, but no short lateral furrows on the glabella; neck-furrow distinctly marked, equal in width to the posterior border of free cheeks; eyes small, smooth, equal to half the length of the glabella; no facial suture visible, only the axal furrow surrounding the glabella and the neck-furrow; free-cheeks slightly convex, nearly twice as long as they are broad, with no visible suture separating them from one another in front of the glabella; margin broad and slightly grooved, angles of cheeks produced posteriorly into spines. The entire surface of the head covered irregularly with a small bead-like ornamentation.

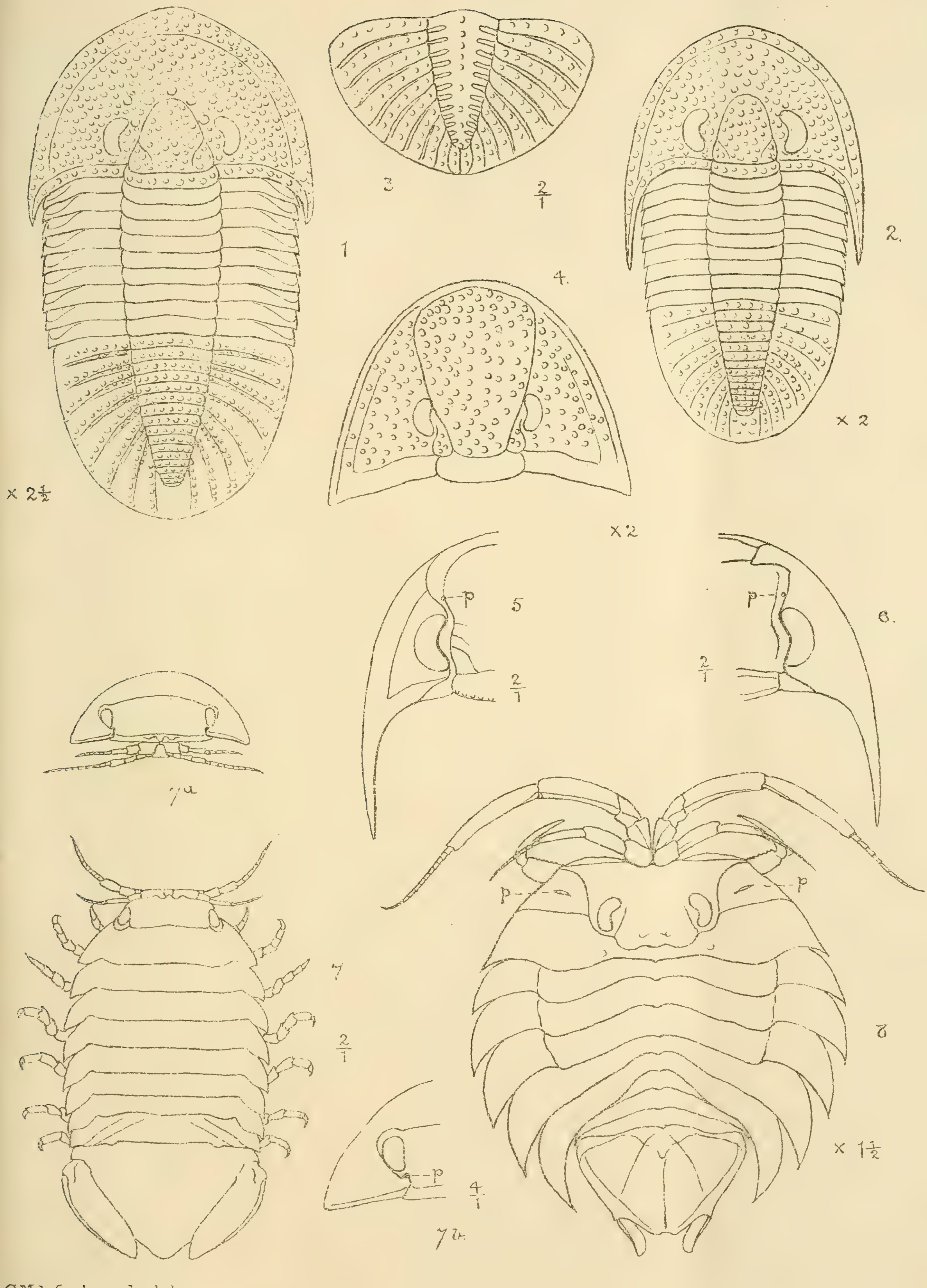
Thoracic segments not known, probably nine in number.

Pygidium consisting of a variable number of segments from ten to seventeen, the axis tapering rapidly to a bluntly-rounded extremity, each segment of axis ornamented with bead-like granulations; ribs with a double furrow extending nearly to the border, which is smooth and rounded.

Brachymetopus Ouralicus, De Vern. sp. 1845. Pl. XIII. Fig. 1.

Phillipsia Ouralica, De Vern. 1845. Geol. Russ. vol. ii. p. 378, tab. 27, fig. 16*a*, *b*.
——— *Jonesii,* De Kon. 1844. Anim. Foss. p. 606, t. 53, fig. 6 (*non* Portlock).
Brachymetopus Ouralicus, Morris. 1854. Cat. Brit. Foss. p. 101.
——— ——— J. W. Salter and H. Woodw. 1867. Cat. and Chart. Foss. Crust. p. 16, fig. 118.
——— ——— ? V. von Möller. 1867. Bull. Soc. Nat. Moscou, pp. 24–27, and pp. 67, 68, pl. ii. figs. 32–35.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 28.

Head-shield nearly twice as broad as it is long, slightly pointed in front; glabella small, tumid, very obtusely conical, only half the length of the head-shield, and one-third its breadth, no short lateral furrows visible, only the two small basal lobes which truncate the posterior angles of the glabella; axal-furrows inclosing the glabella antero-laterally; neck-lobe narrow, rounded distinctly, separated by the neck-furrow from the glabella; eyes small, placed close to the glabella, prominent, reniform, surface smooth; no facial suture visible; free-cheeks convex, confluent around the glabella, with a broad flattened slightly concave margin, the rim of which is slightly raised; posterior margin of free-cheeks separated by a furrow continuous with the neck-furrow; the posterior angles of the head produced into short slightly recurved spines; entire surface of head covered with small bead-like tubercles, five larger ones being placed around the front border of the glabella, and one in advance of each eye on the free-cheeks.



G.M. Woodward. del.

Fig. 1 — 6. Carboniferous Trilobites. Brachymetopus, etc.
Fig 7. Sphæroma. Fig. 8. Serolis.

Thorax not known.

Pygidium circular, one-fourth wider than long, consisting of seventeen coalesced somites, the axis forming one-third the entire breadth of the shield where it joins the thorax, but diminishing rapidly to a rather blunt extremity at about one-fifth of its length from the margin of the tail-shield, which encircles it; each ring of the axis ornamented by a row of small granular tubercles (somewhat irregular in size); about eight grooved pleuræ are seen on each side the axis, each pleura forming a raised rib, extending to and becoming wider at its rounded extremity near the border, marked by a row of small tubercles, and having a shorter intermediate rib similarly ornamented, placed behind it, in the furrow; the pleuræ, as well as the axis of the pygidium, are convex; the margin has a slight narrow rim around it.

Formation.—Carboniferous Limestone.

Localities.—Settle, Yorkshire; Caldbeck, Cumberland; Castleton, Derbyshire; Little Island and Blackrock, Cork; Ardshanbally, Limerick.

Many specimens have been examined from the British Museum, the Woodwardian Museum, the Museum of the Geological Survey of Ireland, and from the collections of the Rev. E. O. de la Hey, Cheshire, and Mr. Joseph Wright, F.G.S., of Belfast.

Brachymetopus Maccoyi, Portlock, sp. 1843. Plate XIII. Fig. 2.

Phillipsia Maccoyi, Port. 1843. Geol. Rep. Londonderry, p. 309, t. xi. fig. 6.
Brachymetopus Maccoyi, M'Coy. 1847. Ann and Mag. Nat. Hist. vol. xx. p. 230.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 101.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 27.

Carapace not quite twice as broad as it is long, rather pointed in front; surface sparsely covered with small tubercles; base of the glabella equalling one-third the breadth of carapace, and one-half the length of shield (without the neck-lobe); basal lobes small, distinct, no facial suture visible; eyes large, placed on the highest point of cheeks and wider apart than the base of the glabella: rim of the head-shield ornamented by a single row of tubercles, margin strongly grooved or channelled, outer rim slightly raised; posterior border of cheeks marked by a distinct margin equal in width to the neck-lobe and separated by a groove corresponding to the neck-furrow; latero-posterior angles produced into spines.

Thoracic somites not known. Axis of pygidium composed of fifteen coalesced segments, tapering to an obtuse extremity; each somite having about five small tubercles on the axis, and about as many on the eight simple lateral lobes; ribs ending abruptly near the margin of pygidium.

Formation.—Carboniferous Limestone.

Localities.—Ballysteen and Monaster, Ireland.

Specimens of this species have been examined from the Museum of the Geological Survey of Ireland, and from the collection of Mr. Joseph Wright, F.G.S., Belfast.

BRACHYMETOPUS DISCORS, M'Coy, sp. 1844.

Phillipsia (?) *discors*, M'Coy. 1844. Synop. Carb. Foss. Irel. p. 161, t. 4, fig. 7.
Brachymetopus discors, M'Coy. 1847. Ann. and Mag. Nat. Hist. vol. xx. p. 230.
——— ——— Morris. 1854. Cat. Brit. Foss. p. 101.
——— ——— Salter and H. Woodw. 1865. Cat. and Chart. Foss. Crust. p. 16, fig. 120.
——— ——— H. Woodw. 1877. Cat. Brit. Foss. Crust. p. 27.

This species is founded on a pygidium only, and was in the first instance (1844) referred by M'Coy to *Phillipsia*, with a query.

He afterwards, in 1847, placed it under his genus *Brachymetopus*.

"Sp. Ch. Pygidium semielliptical; axal lobe reaching to the margin, one-third less in width than the lateral lobes, very convex, composed of 17 narrow segments, the third and fourth united in the middle of the lobe to form one large tubercle, and towards the apex there are four or five small tubercles, irregularly disposed; the lateral lobes have only six large rounded segments each, terminating at the margin in a large rounded tubercle, and having usually between the margin and the axal lobe, two other large obtuse tubercles, one of these on the last being probably spiniferous; beside these there are a few irregular granules, especially towards the apex, all the lateral segments seem forked from nearly their origin."[1]

We have no further information to give concerning *B. discors*, and the only additional specimen we have seen is from the Carboniferous Limestone of Little Island, Cork; it consists of a very small decorticated pygidium, and was obtained by Joseph Wright, Esq., of Belfast. The specimen is very obscure and not well preserved.

BRACHYMETOPUS HIBERNICUS, H. Woodw., sp. nov. Pl. XIII. Fig. 3.

Cephalothorax unknown. Pygidium broadly semicircular, 13 millimètres wide and 8 mm. long; axis narrow, $3\frac{1}{2}$ mm. broad and $6\frac{1}{2}$ mm. long, composed of eleven coalesced segments, each alternate ring ornamented by a small tubercle on the centre; border composed of ten rounded pleuræ which extend to the margin, becoming gradually more and more oblique until the last pair become nearly parallel behind, uniting the extremity of the axis with the posterior border. There is no ornament on the pleuræ. This pygidium slightly resembles *B. discors* in general form, but is quite distinct and well marked. I feel satisfied that it belongs to *Brachymetopus*, but it cannot be referred to any species hitherto described, nor have I seen but one specimen, which, however, is very perfect.

Formation.—Carboniferous Limestone.

Locality.—Kildare, Ireland.

Obtained by the present Earl of Enniskillen (when Lord Cole), and now preserved in the British Museum (Natural History).

NOTE ON THE NATURE OF CERTAIN PORES OBSERVABLE IN THE CEPHALON OR HEAD-SHIELD OF SOME TRILOBITES.

AMONG the numerous specimens of Carboniferous Trilobites which I have had the opportunity to examine during the last three years, many examples exhibit a peculiarity of structure which had already arrested the notice of such keen observers as Portlock,

[1] M'Coy, Ann. & Mag. Nat. Hist. 1847, vol. xx. p. 230.

M'Coy, Oldham, Salter, Barrande, and Valerian von Möller. I allude to certain pores more or less well-marked, and placed usually one on either side of the glabella in the axal furrow, and upon the facial suture which separates the free-cheek from the fixed one, forming the margin of the glabella, and just in front of the compound eyes (see Plate XIII. Fig. 5. *p.*).

In working at the Silurian Trilobites Professor F. M'Coy, in his "Synopsis of the Silurian Fossils of Ireland collected by Sir Richard Griffith" (Dublin, 1846, 4to.), writes (p. 43), "I have observed in several Trilobites a peculiar pore situated in the furrow which separates the glabella from the cheeks near the anterior margin on each side, which seems to have escaped general notice, and which it is not impossible may be the remains of setaceous external antennæ." Professor M'Coy thinks these pores occupy just the position which the antennæ would have occupied, and that antennæ, being hollow organs, would leave a hole in the external integument if broken off. He then proceeds to observe that, "In *Ampyx* these punctures are extremely remarkable and obvious, and it is only in this group that they have, to my knowledge, been observed by naturalists, Captain Portlock [1] having noticed them, but without any remark, in the description of his *A. Sarsii*; they are to be seen, but not exactly in the right place, in his figure of that fossil, in which they form two, very deep, oblong punctures, communicating with the interior; they are situated in the furrow before-mentioned, about their own length within (or posterior to) the anterior margin. I have likewise observed them in all the species of the genus *Trinucleus*. In *T. Caractaci* they form two rather large circular punctures, as large as one of the punctures of the wings; they are in the furrows before mentioned, close to the anterior margin of the cheeks, communicating with the interior; in *T. seticornis* they form two small circular punctæ, within the margin; they are in the same furrows, penetrate to the interior, and are smaller than the punctures of the wings; in *T. radiatus* they hold the same position as in *T. Caractaci*, that is, very close to the anterior margin of the cheeks. They are rather larger in *T. elongatus*, in which they occupy the same position as in *T. Caractaci*, but are smaller, and placed rather more within the margin. In *T. fimbriatus*, though small, they are very conspicuous, being about the size of one of the punctures of the margin of the shield, and their own diameter within the margin. It is very remarkable that those organs are most obvious in what are considered *blind* Trilobites; whether it may be as a compensation for the want of eyes that they are furnished with better-developed antennæ,—organs seeming so mysteriously to combine in themselves the exercise of all the senses, besides their own aeroscepsin, as Lehmann calls it,—I am unable to conjecture."

He adds, "That these punctures exist, although very much reduced, in Trilobites with eyes, I have also ascertained, as they are found, although exceedingly minute, in the common *Griffithides globiceps* of

[1] Report on the Geology of the County of Londonderry, and of parts of Tyrone and Fermanagh (Dublin, 1843), p. 261.

the Carboniferous Limestone, holding the same position as in the other genera alluded to, being seated in the same furrows, but farther back from the anterior margin."

Dr. T. Oldham, F.R.S., in the Journ. Geol. Soc. Dublin, 1846 (vol. iii. part 3, p. 189), writes in his description of *Griffithides globiceps*:—"In the furrows which separate the cheeks and glabella, about half way between the front of the eye and the anterior margin, I have observed in all the tolerably-preserved specimens which I have seen, a small hole or indentation. These are constant and therefore obviously connected with the structure of the creature, although I cannot offer an explanation of their use. They are similar to those noticed by Portlock in his *Ampyx Sarsii*" (*op. cit.* p. 261).

In 1847 Mr. J. W. Salter communicated a paper to the Geological Society, "On the Structure of *Trinucleus*, with remarks on the species" (Quart. Journ. Geol. Soc., 1847, vol. iii. pp. 251–254), in which he observes:—"The peculiar perforated border is the most interesting part of these animals, and I propose to examine it critically.

"The puncta are almost always arranged in radiating rows, three, four, or more holes in each row, and these being at equal distances they form concentric lines. In *T. granulatus*, two of these rows are separated by a furrow from the rest; in *T. seticornis*, three are distinct from the remaining two or three, by the front rows being sunk in a deep concentric furrow. Other modifications take place: in *T. fimbriatus*, the two front rows are turned downwards; lastly, in *T. ornatus*—for by that name we must call *T. Caractaci*—the dots occur most frequently in quincunx order, *i.e.* the radiant rows appear zigzag and not direct; this appearance is due to the great obliquity of the ray. I wish to call attention to this, because I consider it enables us to understand the nature of the enigmatical puncta.

If we suppose a head furnished with a produced membranous margin instead of a perforate one, we shall get at the explanation by supposing the membrane to collapse at regular intervals, become plicate, then perforate, and lastly, separate into linear processes. Now we have in *Harpes* the flat border, with rows of impressed puncta, which have not yet perforated the fringe. In *Trinucleus fimbriatus*, we have a plicate border, the thin interstices of which have contracted into pores, which is a step beyond the simple perforation in linear series exhibited by *T. ornatus*. Lastly, in *Ceraurus* (*Acidaspis*, Murch.), we have the structure completed, the linear processes being quite separated into spines. This structure is not anomalous, for the cellular membrane which forms the inner peristome of the mass passes through an exactly similar course, becoming in different species perforate, in others separated into distinct teeth.

That these perforate or spinous fringes are not essential, but only supplementary parts of the head, may easily be shown, by the fact that the width of the head, without the fringe, is exactly that of the body, and when the animal is doubled up, the fringe projects freely on all sides. We still require to find anomalous specimens in which all, or some of the above modifications—plications, perforations, or partially cleft borders,—may be exhibited together, in order to demonstrate the supposed origin of the structure" (p. 253).

In another paragraph in the same paper, Salter refers to the discovery by himself and Emmrich of the facial suture in *Trinucleus ornatus*, "its course (he states) is obliquely upwards from the eye tubercle to the upper end of the glabella, where it appears to terminate in a solitary deep perforation, similar to those which surround the head" (*op. cit.* p. 251). It is to these pair of deep puncta, one on either side of the head, that we would specially draw attention.

Later on (in 1852), Mr. Barrande, in his "Système Silurien de la Bohême" (vol. i. *Trilobites*, p. 230) thus wrote, "On the antennæ of Trilobites—Prof. M'Coy in his work already cited (p. 43) announces what he deems to be the discovery of the remains of antennæ in the form of a deep pore on either side of the frontal lobe in the groove which surrounds the glabella. He enumerates the genera *Trinucleus*, *Acidaspis*, *Calymene*, *Ampyx*, *Griffithides*, etc., in all of which this observer states he has succeeded in tracing these organs. We have also remarked these puncta long since in a variety of Trilobites from Bohemia, notably in *Calymene*, *Trinucleus*, *Cheirurus*, but we have been led to offer a different interpretation to that indicated above.

"First we have to observe that if this cavity does not appear to be anything else but a pore in those species with a border, as *Trinucleus*, it assumes larger and larger dimensions as it approaches the edge of these Trilobites, and forms a funnel-shaped opening nearly 2 mm. in diameter in the head of *Cheirurus claviger*."[1]

"When the shell exists, as we have seen it in specimens of *Calymene Baylei*, *Cheirurus gibbus*, etc., it is bent inwards, as a funnel-shaped depression. We have thought that this bending inwards of the shell was simply designed to afford points of attachment for the muscles of the jaws and that they had the same origin as the similar indentations which we have indicated in the pleuræ of various species of Trilobites. We have observed the conformity of the position of these pits in the depression of the axial furrows of the thorax as in the head. We recall again the indentations of the shell on the glabellal furrows and on those of the axis of the pygidium in *Dalmannia*.

"We were satisfied with these analogies and we sought no other explanation for these little indentations. But after having read the opinion of Prof. M'Coy we have studied all the specimens afresh which might serve to elucidate this question, and we have found a portion of a *Cheirurus gibbus* which seems to explain the matter satisfactorily to our views. This fragment is broken along the line of the dorsal groove and the length of the glabella exposing to view one of the alæ of the hypostome *in situ*. This wing of the hypo-

[1] This is not shown in Barrande's figures of *Cheirurus claviger*, pl. 40, figs. 1—12, nor in *Ch. gibbus*, figs. 35—39, but is seen in pl 41, fig. 17; it is also well shown in *Trinucleus ornatus*, pl. 29, figs. 1—8, and in *Placoparia Zippei*, pl. 29, figs. 30—34; and in *Calymene Baylei*, pl. 43, fig. 49, and in many others, not referred to by Barrande.

stone fits at its extremity to the interior of the little funnel-shaped projection formed upon the underside of the head-shield. These details are very distinct, owing to the very perfect preservation of this specimen with its shell. After this we cannot accept any other interpretation for the genus *Cheirurus* than that which we have given. We leave to savans the task of pointing out the value of these analogies, and they may be able to apply this method of explanation to other genera mentioned by Prof. M'Coy" (*op. cit.* p. 230).

Valerian von Möller in his paper ("Ueber die Trilobiten der Steinkohlenformation des Urals") contributed to the "Bulletin de la Société Impériale des Naturalistes de Moscou," 1867, p. 44, notices these same pores in the head of *Phillipsia Eichwaldi* as "very distinct deep funnel-shaped openings which run a little obliquely and enter into the underside of the cephalothorax." He cites the opinions of M'Coy and of Barrande, and says in conclusion, "I quite agree with the observations of Barrande, and I feel sure, the more one examines these indentations, the more one feels satisfied that they are only superficial openings."

I have carefully examined these puncta in the Carboniferous Trilobites, and have sought for some satisfactory explanation in various other members of the class Crustacea, both recent and fossil.

And first I would observe, in reference to the varied forms of *Trinucleus*, with corrugated, punctate, perforate, and serrated margins, to the head-shield, that we may see in the larval "King Crab" or "Horse-shoe Crab" (*Limulus polyphemus*) of North America, just before hatching, that the head-shield retains indications, in the well-marked fimbriated hepatic lobes, of the presence of a once divided border, corresponding with the five or six distinct cephalic somites. This fimbriated margin to the cephalic shield, seen in the young of *Limulus*, is observable also in the head-shield of *Hemiaspis limuloides*, from the Lower Ludlow of Shropshire. As to the explanation given by M. Barrande for the series of depressions, or invaginations, of the crust, of various Trilobites which are seen to correspond with each thoracic somite, and are placed exactly in the depression of the furrow on each side of the dorsal axis and are even observable in the axial furrows of the pygidium of *Dalmannia*, we agree with him entirely, and there can be, I think, no doubt whatever that they are perfectly homologous with the similar pits or indentations of the crust, observable in the thoracico-abdominal shield of *Limulus*, which give rise to six powerful calcareous processes within (*apodemata*, Milne Edwards; *entapophyses*, Owen), for the attachment of the muscles required for the locomotory organs.

But whether the two pits, or pores, placed one on each side of the glabella, in front of the compound eyes, are of the same nature (as Barrande assumes them to be), is an open question. That they are not the remains of *antennæ*, as was supposed by Prof. M'Coy, I think we may feel quite satisfied, as we know of no crustacean whatever with antennæ arising from the *dorsal* aspect of the cephalic shield in the manner supposed by M'Coy.

The antennæ are either on the *margin* of the head as in many

Isopods (see Plate XIII. Figs. 7 & 8), or *beneath*, as in *Limulus*, *Apus*, and other forms of Entomostraca.

Mr. John Young, F.G.S., of the Hunterian Museum, in the University of Glasgow, a most careful observer, and to whom I am indebted for the loan of many interesting specimens of Carboniferous Trilobites, several of which illustrate this point in an admirable manner, suggests, in a note to me, that he has long thought that these puncta might possibly prove to be *ocelli*. Whether this be the correct interpretation or not, at any rate it seems a more plausible hypothesis than that suggested by Prof. M'Coy.

It is true that such an association of larval eye-spots with compound eyes has not as yet been met with in any of the Trilobita, but it occurs in the Merostomata both recent and fossil (*Pterygotus*, *Slimonia* and *Limulus*), and its discovery would be hailed as further evidence in favour of the undoubted close affinities of both these groups with the *Scorpionidæ*, and so with the Arachnida.

We have noticed two instances of pores in the Isopoda, and it is probable that the researches into the "Challenger" collections now in progress will reveal many others in this interesting group. In one instance, *Sphæroma* (Pl. XIII. Fig. 7), the pore seems really to be on the line of the suture of the glabella, the free-cheeks in the Trilobite being represented in the Isopod by the first thoracic somite which wraps around the sides of the head in a similar manner.

In *Serolis* (Pl. XIII. Fig. 8) the pore, which forms rather an elongated slit (*p*), is in the centre of the margin of the first thoracic somite, and at a distance from the compound eye has no relation to any suture. These puncta may be, like the *fenestræ* in the head of *Blatta orientalis*, either rudimentary ocelli or the seat of some other nerve-sense, and may have been, as in *Blatta* and in *Serolis*, covered with a thin transparent portion of the integument, which served either as a simple eye, a tympanum, or an olfactory pore. We have referred to these *fenestræ* in the head of *Blatta* because they are placed like those in the Trilobites, *on a suture* of the head, and in front of the compound eyes.

We hope to have some further information to offer on this subject upon a future occasion, meantime other workers may be able to assist with suggestions and specimens to elucidate this interesting point, for which we shall be only too thankful.

EXPLANATION OF PLATE XIII.

Figs. 1—6. Carboniferous Trilobites.

Fig. 1. *Brachymetopus Ouralicus*, De Vern. sp. (Outline figure restored, enlarged 2½ times natural size.)

,, 2. *Brachymetopus Maccoyi*, Portlock, sp. (Outline figure enlarged twice natural size.)

,, 3. *Brachymetopus Hibernicus*, H. Woodw., sp. nov. (Pygidium enlarged twice natural size.)

,, 4. *Griffithides moriceps*, H. Woodw., sp. nov. Carboniferous Limestone, Settle, Yorkshire. (Head only known, enlarged twice natural size.) [For description see Geol. Mag. p. 487.]

,, 5 & 6. Upper and under side of head of *Phillipsia Eichwaldi*, showing pore (*p*) on the upper side as an invagination of the crust, and below as a perforate projection upon the inner surface of the tergum. (Mr. John Young's Collection.)

FIG. 7. *Spheroma gigas*, Kerguelen's Island.

,, 7*a*. Front view of head. 7*b*. Half of the same enlarged to show pore (*p*.)

,, 8. *Serolis paradoxa*, Sandy Point, Straits of Maghellan. Showing pore (*p*) near margin of thoracic somite.

III.—NOTICE OF NEW FISH-REMAINS FROM THE BLACKBAND IRONSTONE OF BOROUGH LEE, NEAR EDINBURGH.—No. IV.

By DR. R. H. TRAQUAIR, F.R.S., F.G.S.

Gyracanthus nobilis, n.sp.

HITHERTO I have been in the habit of referring the *Gyracanthus* spines commonly occurring in the Borough Lee Ironstone to *G. formosus* or *tuberculatus* of Agassiz, being disposed to believe in the specific identity of those two forms, as has already been suggested by Messrs. Hancock and Atthey, and hinted at by Agassiz himself. In fact, the salient point of difference between the two is the greater extent of the tuberculation of the ridges in the latter, while in the former it is principally seen on the proximal parts of the ridges, which, as they converge towards the anterior middle line of the spine, become first simply undulated and then smooth. The original figured specimen of *G. tuberculatus* is from the Coal-measures of Sunderland; that of *G. formosus* is from the same formation at Dudley; but though Agassiz refers to it as occurring also at Burdiehouse, in Midlothian, and Burntisland in Fifeshire, it seems to me very doubtful if these Calciferous Sandstone specimens are really the same. And certainly the study of a large quantity of additional material from Borough Lee has convinced me that the species of *Gyracanthus* characteristic of this Ironstone of Carboniferous Limestone age is specifically different from both *formosus* and *tuberculatus*.

These spines are elongated and rather slender, showing very little lateral curvature, though every specimen and every fragment which I have examined shows that marked want of lateral symmetry which I have described in my last communication on the Borough Lee fossils. The posterior ridge is strongly denticulated, save in worn specimens. But the salient specific mark lies in the disposition and mode of tuberculation of the sculptured ridges. Commencing at the proximal end of the spine, these ridges are at first strongly and closely tuberculated along their whole extent, but near the closure of the posterior sulcus or hollow, this close tuberculation becomes limited to the anterior aspect,—each ridge as it arises, and advances upwards and forwards, showing first a comparatively distant tuberculation, then a smooth space (sometimes very minutely crenulated) on the side of the spine, and then becoming thick and coarsely tuberculated as it turns round to the front aspect. Where this feature of the ridges commences, they also become *excessively oblique* and very delicate, and in some specimens they occasionally also bifurcate along the sides of the spine, but in front where the tuberculation appears they become coarse, and *curve a little forwards* so as to become also less oblique. Towards its extremity the ridges become entirely smooth on the sides of the spine, their slight curvature also ceases, and the tuberculation of the anterior aspect gives way to simple undulation. Finally, at the point, all ornamentation becomes completely worn off.

As I know of no other species of *Gyracanthus* with which the present can be confounded, I propose for it the specific name of *nobilis*. It must have attained a very large size—fragments occasionally indicate a length of two feet or more.

Gyracanthus Youngii, n.sp.

Spines attaining a length of probably two feet: usually displaying gentle curvatures both antero-posterior and lateral. Ridges of sculptured portion *so little oblique as to be nearly transverse*, though beyond the middle of the spine they become somewhat sigmoidal in their direction, turning towards the apex above, towards the base below. Only towards the apex have the ridges any marked obliquity in their middle portions, and they are closely tuberculated over their whole extent, excepting towards the apex, where occasionally the tuberculation becomes irregular. The groove on the posterior surface is less prominently marked, and the lip or ridge on the medial or concave side of the spine not so prominent as in other species: usually the floor of the groove is covered with tubercles at its commencement, where the sulcus closes. Medial edge on lip of posterior groove often denticulated, denticles sometimes also seen on the outer lip.

I first observed a fragment of this spine from Bo'ness, in the Collection of Mr. Mowbray Cadell; subsequently I have seen it from Borough Lee, Cowdenbeith in Fife, Possil in Lanarkshire (Collection of Mr. J. Young), Dalry in Ayrshire (Collection of Mr. R. Craig). All these specimens are from ironstone of Carboniferous Limestone age. In proposing a name for this undoubted new spine, I beg to call it after my friend Mr. John Young, of the Hunterian Museum, Glasgow, who has done so much for the elucidation of the palæontology of the West of Scotland.

Ctenodus obliquus, var. *quinquecostatus*.

In the first of the present series of communications, I mentioned a fragmentary specimen of a tooth of *Ctenodus*, which so far as could be seen had some resemblance to *C. obliquus*, Hancock and Atthey. Since that time I have got together a considerable number of more perfect examples, which seem to show that the tooth is at least to a certain extent new.

Palatal teeth of this species are more frequently found than mandibular ones, and are usually attached to a palatopterygoid bone of the usual form. The tooth itself is narrow, elliptical in shape, its breadth being rather less than half the length. The inner margin is bluntly angulated, arched, sometimes simply arched; from the angle (or a point corresponding to it), which is placed behind the middle, radiate *five* stout ridges, of which the inner and anterior is the longest, the others rapidly diminishing in succession from within outwards, and before backwards: the number five is very constant, though in one instance I find the posterior ridge bifurcating so as to form six at the outer margin. The free margins of those ridges are prominent and pretty regularly and gently convex, though rather more so towards the outer aspect, and are divided into a variable number of denticulations, which, when the enamel covering is gone, as is often the case, are blunt and rounded; otherwise these denticles are compressed, triangular, trenchant, pointed, and brilliant. The furrows between the ridges are smooth. The mandibular tooth resembles the palatal one in the number and character of the ridges, but is somewhat narrower as well as somewhat more convex in general aspect.

This is a small species, though not so minute as *C. angustulus;* the largest palatopterygoid with tooth which I have seen measuring $1\frac{1}{4}$ inch from the anterior extremity of the tooth to the posterior-external angle of the bone. In shape it most resembles *Ct. obliquus* of Hancock and Atthey, from which it differs, first in its small size, secondly in the constant or nearly constant presence of five ridges, whereas in *Ct. obliquus* there are six to eight. Considering, however, the great tendency to variation in teeth of the genera *Ctenodus* and *Ceratodus*, I hardly think it safe to devote *quinquecostatus* to the rank of a species at present.[1]

IV.—The Pleistocene Geology of the Firth of Tay and the "Elevation and Subsidence" Question.

By James Durham, F.G.S.

WITHIN the last few months a good deal has been written upon the question of upheavals and depressions in the crust of the earth both in the Geological Magazine and in "Nature." By far the majority of these writers have maintained with some show of reason that depressions are the result of the deposition of material of some sort on a part of the earth where it was not previously, in consequence of which the newly loaded part sinks down, just as a weight placed upon an air cushion causes the part on which the weight rests to be depressed. This novel view has been supported by pointing to the fact that numerous instances are met with in which vast thicknesses of rocks have been superimposed one upon another, while throughout their whole depth traces of shallow or comparatively shallow water are found, it being inferred that the sedimentary deposit being the cause of the depression, the bottom sinks exactly in proportion to the amount of the deposit. The Carboniferous system has been advanced as a conspicuous instance of this state of matters; the same holds true of the lower Old Red Sandstone, which appears to have been deposited in lakes.

It has been further shown that Greenland, which is at present covered with ice, is being depressed, and the depression is supposed to be directly caused by the great weight of snow and ice which buries its mountains and fills its valleys.

[1] For previous communications on this subject see Geol. Mag. 1881, pp. 34, 491, and 334, and 1882, p. 540.

The argument is brought nearer home to us when the submergence to a great depth of a large part of the British Islands during the "Great Ice Age," is put forward as evidence that the weight of ice and snow is sufficient to press the land so encumbered down into the sea. It is this last part of the argument that I propose to briefly examine.

Now there is no doubt whatever that during the Glacial period very considerable subsidences of the land took place, which looked at in a broad and superficial way seem to support the new theory; but a closer examination of the details of these depressions and subsequent elevations fails to show that they give that satisfactory support to these speculations which is expected of them.

The estuary of the Tay and its neighbourhood perhaps affords as good examples of the traces of these changes of level as are to be met with within such a limited area, while the hills that approach its margin or can be seen from it, bear very striking testimony to the enormous effects of glaciation.

In looking at the valley of the Tay, one immediately recognizes as perhaps the most interesting feature of the landscape, the smoothed and rounded appearance of the hills, on all hands soft and waving outlines, just relieved here and there by comparatively insignificant escarpments, the result of subaerial denudation, the cutting of streams, or the battering of the sea. The hard and intractable gneisses of the far-off Highland mountains, the hard sandstones and associated volcanic rocks of the nearer hills, are all reduced to one uniform smooth contour, pointing out unmistakably that throughout the whole, or almost the whole, Glacial period these rocks must have been subjected to the grinding action of the ice-sheet, which could only have been the case if the land stood at least as high as at present during its continuance. As has been shown by the presence of certain strata of sand and shells intercalated between beds of Till, a depression of the land to a depth of at least 500 feet took place in the comparatively early part of the "Ice Age," but the fact that these stratified beds exist upon the ground moraine of the ice-sheet seems to show conclusively that at the time of their deposition, the ice was very greatly reduced, had retired from the coast-line, and possibly disappeared altogether. It is further evident that the duration of this great submergence was relatively short, for while the ice has left such tremendous record of its presence all over the land, the encroachment of the sea, as far as I can find, has left no other evidence than the beds of sand, etc., referred to.

Traces of the last great advance of the ice-sheet and the changes that afterwards took place are necessarily much more distinct than that of the first and greatest extension of the ice, and they in a remarkable manner repeat the same line of evidence as the first.

Rocks sheltered from the action of the waves frequently bear well-marked glacial striæ, and these can be seen to pass under the level of the sea, showing that at the last glaciation of the land it stood higher, than at present. The thickness of the ice must have been very considerable as it flowed over Dundee Law, a conical hill upwards of 500 feet high, which has on its north-west side, near the top, a layer of till partly composed of finely ground red sandstone of the neighbourhood and partly of a dark clay derived from the dolerite of the hill, with the usual admixture of angular and smoothed stones, while the projecting parts of the rock are smoothed from below upwards. Similar testimony to the thickness of the ice so close to the sea is borne by the neighbouring hills, though none of them are quite so high as the Law.

A very remarkable feature of the low grounds in the neighbourhood of the Firth of Tay is a great and far-extending raised plain or terrace, composed of well-stratified sand and gravel; the fine even layers of sand show that it must have been laid down in the tranquil depths of the sea; it is largely composed of stones foreign to the immediate neighbourhood, its flat top is exactly 100 feet above the datum-line and is usually known as the 100-feet terrace; it fringes the hills over which the ice has flowed, but its even stratification from top to bottom affords undoubted evidence that at the time of its deposition the ice had disappeared from the shore and at the time of the disappearance of the ice that the land was submerged upwards of 100 feet.

Thus as we found that the first great depression of the land took place during a temporary recession of the ice, this depression occurred when the glaciers were in their final retreat.

As the glaciers disappeared, they must have left the land strewn with morainic débris; a very large proportion of this matter would be more or less rapidly swept into the sea by torrents of water from the melting ice, and great swollen rivers, and spread over its bottom, which explains why the constituents of the terrace are nearly all rocks of more or less distant origin.

After this vast load of material was deposited in the sea, a great elevation took place, the land and a great part of the sea-bottom being raised to a considerably greater height than at present, which is shown by a more recent formation than the terrace usually known as the "submerged forest" or "peat" bed. This consists of a bed of bluish sandy clay, imbedded in which are numerous trunks, branches, and twigs of trees, along with leaves and nuts, occasionally bones of deer are met with as well as fragments of insects, all characteristic of a luxuriant forest growth, which would not likely thrive just at the sea-level. This bed in the Firth of Tay is found between high- and low-water limits, and passes below the latter.

This forest bed is in turn overlain by a considerable thickness of sand and clay, evenly stratified, and evidently deposited in water of some depth, so that after the forest period, during which the climate appears to have been very much as it is now, the land was again submerged, from which depression it is possibly at the present moment slowly recovering.

From the foregoing it seems evident (1) that throughout the first maximum extension of the ice-sheet the land stood at least as high as at present; (2) that *after* the ice had disappeared, or at least withdrawn, from the sea-shore, the great submergence of 500 feet took place; (3) that during the last maximum extension of the ice-sheet the land stood higher than at present; (4) that when the great load of ice was *removed* from the land, the submergence of upwards of 100 feet took place; (5) that after a vast mass of morainic débris had been laid down on the sea-bottom, it *rose up* higher than at present, so that a forest flourished upon what is again the bed of the ocean; and (6) when all abnormal conditions had disappeared, the land was again depressed and re-elevated to its present level.

A series of geological phenomena more inconsistent with the new theory it is impossible to conceive.

It is no doubt extremely difficult to account for all these "ups and downs in the world," but it seems to me that the theory of depression by loading and elevation by lightening does not help us much in explaining them. At any rate the Glacial and Post-glacial history of Scotland gives no countenance to the theory.

V.—The Human Skull found near Southport.

By T. Mellard Reade, F.G.S.

The author of a paper on the above subject read before the Anthropological Section of the British Association at Southport having made the startling assertion that, "In immediate proximity (to where the skull was found) were numerous bones of the Irish Elk and Reindeer," I feel it incumbent on me to relate the facts of the case. Unfortunately I was not at the meeting when the paper was read, so could not contradict the statement on the spot.

The Human Skull in question was discovered in cutting a trench for a sewer in Gloucester Road, Birkdale, while I, as engineer of the work, was carrying out the main sewerage of Birkdale in 1872. Mr. Kershaw, who lives opposite the spot, happened to secure it from the workmen, but through my influence he presented it to the Royal College of Surgeons, and before sending it, I had two casts made of it, one of which I gave to the Liverpool Museum, the other I still possess. It was on the Museum cast that Dr. Barron's paper was founded—at all events, the cast was exhibited at the reading of the paper, so there can be no doubt as to its identity. A paper on the skull from materials prepared by me was read soon after its discovery by Professor Busk, at the Anthropological Society.

The skeleton from which the skull was severed by the sheet piling of the trench lay at a depth of 8 feet below the then surface, and upon an old land surface of peaty soil; being covered only by blown sand. This old land surface is at the same horizon as the submarine Forest-bed,[1] but nowhere at Birkdale in several miles of sewers did we come on the remains of anything that could be dignified by the name of "trees"; there were in the peat small birch branches and stems. The soil or peat bed was underlain by an

[1] A section of the sewer trench and peat bed may be seen in my "Post-Glacial Geology of Lancashire and Cheshire," Proc. of Liverpool Geol. Soc., 1871–2.

estuarine deposit, containing *Scrobicularia piperata*, *Cardium edule*, *Tellina solidula*, *Buccinum undatum*, and is locally called "Scotch." In the land-surface or peat bed were found a few bones of the Horse and Red Deer, and also in the "Scotch" or silt underlying it. This was not penetrated to the Boulder-clay, but from my knowledge of the locality, I should say that the Boulder-clay did not lie nearer than from 30 to 40 feet of the surface at the spot.

Similar soil surfaces and peat beds are, I have proved, continuous under the blown sand, with the submarine Forest-bed on the shore at Hightown,[1] but the remains found on them are not necessarily of the age when the "Primeval" Forest flourished. The silt beneath belongs to a very extensive series of deposits I have termed the "Formby and Leasowe Marine Beds," and though I have directed my attention to the subject for fourteen years, and am in possession of pretty nearly all the information to be obtained from excavations and borings, some being made under my personal directions, and particulars of others given me by brother engineers and by contractors, I have never succeeded in finding any organic remains older than *Bos longifrons*, the Red Deer, and the Horse, and there are not any authenticated instances by others of older finds than these. I believe I have collected more bones from these beds than any other geologist. Most of these are in the Liverpool Museum, and can be seen on application to the Curator, Mr. T. J. Moore, who has also named them.

As such mis-statements are apt to live long and mislead many, I have thought it due in the interests of sober science to correct Dr. Barron's ardent imaginings. The age of the whole series of beds is later than that of the "Cave Man," if that individual was a contemporary of the Irish Elk and the Reindeer, therefore the human remains lying nearly at the top of the series cannot have been of the age of the "Cave Man." The only mode at present open to us of estimating the age of the remains found on the old land surface is by internal evidence, and by the accumulation of blown sand above them. I have elsewhere calculated from the rate of accumulation of blown sand on the sand dunes now, that the whole 22 square miles of sand on this coast cannot have taken less than 2500 years in accumulating.[2] If we put the maximum age of the skull down as 2000 years, I consider it would be a liberal estimate, but the *minimum* age it would be impossible to fix from present data. I may add that there are no remains of the Ash in the "Forest Bed," but the Oak, Pine, Birch, Alder, and Willow abound.

[1] "On a Section of the Formby and Leasowe Marine Beds at Hightown," Proc. of Liverpool Geol. Soc., Sess. 1881–2.

[2] "On the date of the last change of level in Lancashire," Quart. Journ. of the Geol. Soc., August, 1881, pp. 436–437.

NOTICES OF MEMOIRS.

James Thomson, F.G.S., on a Fossil Coral Atoll on the Shore Line at Arbigland, near Dumfries, Scotland.

Abstract of paper read before the British Association, Southport Meeting, 1883. (Section C, Geology.)

THE author briefly described the stratigraphical position of the rocks on either side of the Solway Frith, and stated that the centre of the Solway was a line of depression or fault, that the series of rocks to which he wished to refer belonged to the lower members of the marine series of the Carboniferous system. In all the sections that he had visited he found the beds dipping at various angles inwards and downward on either side of the Frith, and referred to the abundance of the coralline remains in many of the sections he had examined along the shore-line.

The rocks on the shore at Arbigland consist of Limestone bands belonging to the lower members of the Carboniferous Limestone Series. The lower bed is exposed along the shore-line as a linear reef for about two miles, and is largely composed of corals of several genera and species. The Limestone along the inner margin becomes more or less arenaceous, and passes into a calcareous shale, largely composed of marine exuviæ. Imbedded in this shale are a series of dome-shaped masses of *Lithostrotion* of varied species. These beds are overlaid by another band of limestone, which is also composed of species of corals around the inner margin, the conditions are similar to those of the former beds, the dome-shaped masses also belong to the genus *Lithostrotion*, but belong to different species, and the matrix is largely composed of similar forms of coralline remains. The next reef becomes more or less circular, and is overlaid by a series of reefs, all more or less composed of coralline remains; the outer marges of the reefs recurve and present an open face to the south. Here the domes of coral assume gigantic proportions. While around the inner portion of this reef the domes are smaller on the whole, they vary from an inch up to eleven feet in diameter, and consist of many species. The series from this, inwards to the centre, consists of twelve successive reefs, all circular in outline, and composed of limestone with interstratified shale, all more or less made up of corals of varied genera and species. The inner of these reefs is circular and more conspicuous, and 240 feet in diameter, it passes from a compact limestone, made up of coralline remains, into an arenaceous shale, in which are imbedded numerous domes of corals and other marine exuviæ, the centre of this circular reef is filled up with calcareous sandstone. The entire series of these semicircular and circular reefs is 2976 feet in diameter, and dipping at angles varying from 12° to 15° inwards and downwards, which, from calculation, implies that the water inside the original reef was about four hundred feet deep. A mile to the east there is another series of circular reefs; these, however, dip outwards, fold round and clasp a central mass. On the whole we thus have exposed a series of conditions similar to the conditions of linear, and semi-circular reefs and Atolls of more recent times, and have reason to believe that the Atoll at Arbigland is unique. A more fully detailed description, with a list of both genera and species, will at no distant date be published.

REVIEWS.

EARTHQUAKE-PREDICTIONS.

(1) M. J. Delauney. Nouveau principe de Météorologie fourni par l'examen des tremblements de terre. Comptes Rendus (Nov. 17, 1879), vol. lxxxix. pp. 844–5.

(2) M. J. Delauney. Note relative aux indications formulées par lui, il y a quelques années, sur les époques probables des grands tremblements de terre. Comptes Rendus (Sept. 10, 1883), vol. xcvii. p. 609.

(3) M. Faye. Sur certaines prédictions relatives aux tremblements de terre. Comptes Rendus (Sept. 17, 1883), vol. xcvii. pp. 620–3.

(4) M. J. Delauney. Note sur les époques probables des tremblements de terre. Comptes Rendus (Sept. 24, 1883), vol. xcvii. pp. 699–700.

(5) M. Daubrée. Sur l'insuffisance des relevés statistiques des tremblements de terre pour en tirer des prédictions. Comptes Rendus (Oct. 1, 1883), vol. xcvii. pp. 728–9.

"THE power of prediction," says Prof. Judd, "is alike the crucial test and the crowning triumph of a scientific theory." It may even, as in the case of eclipses, precede the accurate knowledge of the theory. M. Delauney has recently attempted another example of this curious inversion in his endeavour to point out certain years as more especially liable to seismic disturbances.

Towards the close of 1879, he presented a memoir to the French Academy, published in abstract as the first of the above-mentioned papers. His calculations were founded on the tables of earthquakes between 1750 and 1842, compiled by M. Alexis Perrey, and he points out that there are certain groups of years recurring at regular periods which are more than usually fruitful in earthquakes. Two of these groups have a period of 12 years each, one commencing in 1759, and the other in 1756. Two other groups have a period of 28 years each, the first commencing in 1756, the second in 1773. M. Delauney notices the approximate equality of these two periods with those of Jupiter and Saturn, which are about 11·9 and 29·5 years respectively, and remarks that the epochs of the maxima of the first two groups coincide with those when the planet Jupiter attains the mean longitudes of 265° and of 135°, whilst the epochs of the last two groups coincide with those when the planet Saturn attains the same mean longitudes. He concludes that "earthquakes appear to pass through a maximum when Jupiter and Saturn are found in the neighbourhoods of the mean longitudes of 265° and

135°;" and that the influence of these two planets is due to their passages through meteoric swarms situated in these mean longitudes. He also gives an approximate table of future earthquake-years, mentioning especially the years 1886, 1891, 1898, 1900, etc.

In *La Nature* for Oct. 23, 1880, M. Delauney gives a new table of these epochs up to the year 1920, distinguishing those which would be epochs of peculiar agitation. The year 1883 is mentioned, though not under the latter heading. The note concludes with the words: "The coming seismic tempest should be due to the meeting of Jupiter and the August swarm; the date of 1883·5 [*i.e.* July 1st or 2nd, 1883] should be that of the commencement of the phenomenon."

Almost exactly at the time mentioned came the great Ischian earthquake of July 28, 1883, followed about a month afterwards by the terrible disturbances in Java, and later by earthquakes in Asia Minor and other places. The peculiar coincidence between his prediction and the event called forth M. Delauney's second note, and has even, according to M. Faye, occasioned inquietude in the minds of some people, it having been stated in the French newspapers that, according to M. Delauney, the most critical epoch would be in April, 1886.

M. Faye argues that if the Moon produces scarcely any appreciable effect upon the occurrence of earthquakes, still less should Jupiter and Saturn, on account of their enormously greater distances. If, again, the August shooting-stars, when coming in contact with the earth, exercise no influence upon seismic disturbances, much less should they when the meteor-ring is traversed by Jupiter or Saturn. He shows also that, though this ring does meet the *plane* of the orbit of Jupiter in the longitude of 138°; yet, at the time of the Ischian earthquake, Jupiter and the meteor-ring were separated by a distance three times as great as that which separates the earth from the sun. He points out, in conclusion, that direct observation alone will lead us to the means of prediction, for it is well known that great earthquake-shocks never take place without giving some warnings in advance.

M. Delauney, in reply, very justly remarks that he had stated a law, and afterwards interpreted it; that M. Faye had only shown the hypothesis to be inadmissible, but in no way shook the foundations of the law.

The truth of the law itself is, however, attacked by M. Daubrée. He asserts that our earthquake-statistics are as yet far too incomplete to establish general laws of chronological distribution of earthquakes over the whole surface of the globe; for, even admitting that we are well-informed as to European earthquakes, we must remember that our continent forms only one-fiftieth of the earth's surface, while earthquakes may take place unknown to us on other land-areas, and are almost unperceived in oceanic areas, which are nevertheless studded or lined with the principal volcanic groups.

It cannot be said that attempts to connect the occurrence of earthquakes with a cosmical cause have been very successful. The tendency of physical geologists at present is to consider them as a consequence of the slow secular cooling of the earth, to look upon them as but an accidental step in the process of evolution of mountain-chains and continents. This view is certainly more attractive; let us take care that its very grandeur does not lead us to overlook minor, though perhaps insignificant, accompaniments, which may possibly be the result of external actions.

CHARLES DAVISON.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

November 7, 1883.—J. W. Hulke, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Geology of the South Devon Coast from Tor Cross to Hope Cove." By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

The author, after a brief reference to the literature of the subject, stated that the chief petrographical problem presented by this district was whether it afforded an example of a gradual transition from slaty to foliated rocks, or whether the two groups were perfectly distinct. He described the coast from Tor Cross round by the Start Point to Prawle Point, and thence for some distance up the estuary leading to Kingsbridge. Commencing again to the north of Salcombe, on the other shore of this inlet, he described the coast round by the Bolt Head and Bolt Tail to Hope Cove. These rocks, admittedly metamorphic, consist of a rather thick mass of a dark mica-schist, and of a somewhat variable chloritic schist, which also contains a good deal of epidote. In the lower part of this are some bands of a mica-schist not materially different from the upper mass. It is possible that there are two thick masses of mica-schist, one above and one below the chloritic schist; but, for reasons given, he inclined to the view that there was only one important mass, repeated by very sharp foldings.

The junction between the admittedly metamorphic group and the slaty series at Hope Cove, as well as that north of Salcombe, is clearly a fault, and the rocks on either side of it differ materially. Between the Start and Tor Cross the author believes there is also a fault, running down a valley, and so concealed. On the north side of this the rocks, though greatly contorted and exhibiting such alterations as are usual in greatly compressed rocks, cannot properly be called foliated, while on the south side all are foliated. This division he places near Hallsands, about half a mile to the south of where it is laid down on the geological map.

As a further proof of the distinctness of the two series, the author pointed out that there were clear indications that the foliated series had undergone great crumpling and folding after the process of foliation had been completed. Hence that it was long anterior to the great earth-movements which had affected the Palæozoic rocks of South Devon. He stated that the nature of these disturbances suggested that this district of South Devon had formed the flank of a mountain-range of some elevation, which had lain to the south. Of the foundations of this we may see traces in the crystalline gneisses of the Eddystone and of the Channel Islands, besides possibly the older rocks of South Cornwall and of Brittany. He also called attention to some very remarkable structures in the slaty series near Tor Cross, which appeared to him to throw light upon some of the structures observed at times in gneisses and other foliated rocks.

2. "Notes on Brocchi's Collection of Subapennine Shells." By J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.G.S.

In this paper the author gave the results of an examination of the collection of fossil shells from the Subapennine Pliocene described by Brocchi in his "Conchiologia fossile Subapennina," and now preserved in the Museo Civico at Milan. He stated that the collection appeared to have been more or less tampered with, several species are unrepresented, and in other cases the specimens on the tablets with Brocchi's labels have evidently been subsequently and erroneously placed in their present situation. There are, however, many undoubted types. The author cited 55 of Brocchi's species, upon most of which the collection furnished more or less interesting information. In conclusion, he remarked upon the importance of identifying Brocchi's species with forms still living in the neighbouring seas, and also upon the difficulty of distinguishing between the Upper, Middle, and Lower Pliocene in Italy. From his examination of Italian Pliocene shells he concluded that the deposits containing them were for the most part formed in comparatively shallow water, probably not more than 50 fathoms in depth, a remark which also applies to the Italian Miocene; and that in the case of species still existing no difference can be recognized between Pliocene and recent specimens.

3. "British Cretaceous Nuculidæ." By J. Starkie Gardner, F.G.S.

The author commenced by discussing the question whether the Nuculidæ should be separated as a family from the Arcadæ, and stated that species of *Leda* and *Nucula* exist, and sometimes abound in the marine Cretaceous deposits, with the exception of the White and the Red Chalk, from which, however, he thought that the shells may have been dissolved out. He also referred to the probable derivation of the species from pre-existing forms, and discussed the question of how far the relationships thus established could be expressed in the nomenclature of the species, his researches upon the Nuculidæ leading him in some cases to suggest a trinomial nomenclature. The probable lines of descent of the shells described in the present paper were also discussed at some length.

In the genus *Nucula* the author distinguished certain groups typified by particular species, his trinomial system nomenclature consisting in the intercalation of the names of the latter between the generic name and the definitive specific name of the individual species. These groups, with their included species, were as follows:

Group Ovatæ.

Ovatæ lævigatæ:—*Nucula ovata*, Mant., Gault; *N. obtusa*, Sow., Blackdown; *N. planata*, Desh., Neocomian; *N. capsœformis*, Mich., Gault.

Ovatæ reticulatæ : *N. Meÿeri*, sp.n., Blackdown ; *N. arduennensis*, Orb., *pumila*, var. nov., Gault.

Group Impressæ.

N. albensis, Orb., Gault ; *N. impressa*, Sow., Blackdown ; *N. Cornueliana*, Orb., Neocomian ; *N. simplex*, Desh., Neocomian.

Group Angulatæ.

Angulatæ pectinatæ :—*N. pectinata*, Sow., Gault ; *N. pectinata cretæ*, sp.n., Grey Chalk ; *N. bivirgata*, Sow., Gault ; *N. antiquata*, Sow., Blackdown.

Angulatæ lævigatæ :—*N. gaultina*, sp.n.

Of the genus *Leda* no formal grouping was proposed ; ten British Cretaceous species were described. In conclusion, the author discussed the stratigraphical distribution of the two genera.

Edinburgh Geological Society. Jubilee Meeting.

Address delivered at the Science and Art Museum, Edinburgh, before the Members of the Edinburgh Geological Society, by His Grace the Duke of Argyll, K.T. ; D.C.L. (Oxon.) ; Trust Brit. Mus. ; F.R.S ; Hon. V.P. R.S. Edin. ; F.G.S. ; on Thursday, November 1st, 1883, at 8 o'clock,—David Milne-Home, Esq., M.A., F.R.S.E., F.G.S., President, in the Chair. (Being the 50th Anniversary of the Society.)

After some introductory remarks, the Duke of Argyll, who is the Patron of the Society, continued as follows :—

Fifty years is but a fragment of time in the history of many sciences; but it is a whole age in ours. It is only two years more than the half century since Smith, who has been called the Father of Geology in England, received the Wollaston Medal for his grand discovery that each series of rock marking each geological age was distinguished by separate and peculiar forms of life. Yet this may be said to have been the foundation-stone of geology as a real science. Far more than half of all we know about it has been gained since then. Whole epochs in the history of creation—epochs of immense duration and of immense fertility in the development of life—have since then first risen into view. The very names by which we now know them have been since invented. Words which are now household words in all the homes of science were then unheard of, or heard of only in some different sense by the learned or the curious in some local history. Allow me to illustrate this by a curious personal recollection. Most of you probably know that our distinguished countryman, the late Sir Roderick Murchison, began his life in the army, and it so happens that I first heard his name mentioned just about fifty years ago. And I heard it in this way : A brother officer of his was an old friend of my father, and used sometimes to visit him at his residence, Ardincaple Castle, on the Clyde, where I was born and brought up. I recollect, as vividly as if it were yesterday, hearing that officer speak of his friend Murchison, almost with tears in his eyes, as a man who had been a most delightful comrade and companion, but one who had lately become lost to all agreeable society from his entire engrossment with some wild, wonderful new theory to which he had given the name of the "Silurian System." Now, the selection of this name by Murchison occurred exactly forty-eight years ago, and all the new and wider views which have since been opened up to us on the earlier ages of the history of the globe, and of the forms of life by which it was then inhabited—the whole of this knowledge has been gained within the half century of our existence as a society for the prosecution of geological science. Within that period all the fathers of the science in our country have done their work, and have now, alas! all of them passed away. Buckland, and Conybeare, and Phillips, and De la Beche, and the still greater names of Murchison, and of Sedgwick, and of Lyell, are names which within the last few years have been added to the number of the illustrious dead. Let us stand back, gentlemen, from the picture which they have left, as artists sometimes stand back from the work of their own or of other hands, to get rid of details, and to grasp in one view the general effect. What is the general result of the facts which they discovered and of the principles which they have established as founded on those facts? And in order to answer this question, let us compare their work with the work of the half century which preceded them. That half century carries us back to the very dawn of geology as a science—to the time when men were still spending their energies in speculating on cosmical theories, instead of patiently collecting and investigating facts. And yet it cannot be said that their time was wasted. In a diamond necklace the whole value lies in the individual stones, and there is little or no intrinsic value in the strings or in the tissues which connect them. But this is not so in the jewellery of knowledge, in the brilliant acquisitions of the mind. Facts—bare facts—facts single and alone—are comparatively worthless. It is in their setting that all their value lies. It is in the connecting-links of thought, and in these alone, that they shine as guiding stars in the march of intellect—and take their final place in the firmament of knowledge. It was not for nothing, therefore, that in geology, as in other sciences, there was a time of wild speculation—of keen and rival theories—of Plutonists and Neptunists—which preceded the time of patient and laborious investigation. Without these golden threads of thought there would have been no possibility of stringing the pearls and precious stones which were dug out of the earth or recovered from the depths of ancient seas. But under the stimulus of rival theories, the digging and the diving have been vigorously prosecuted; whilst under the guidance of purely intellectual conceptions, the products of all this labour have been gradually set in that order which enables them to reflect and reveal the light. If any of us desire to see a signal illustration of the infinite value of speculation working on facts comparatively few and rare—a signal illustration of the power of the human mind, when well exercised, to penetrate by exercises of Reason—almost instinctive—into the secrets of Nature—let us study that most remarkable work, Dr. Playfair's "Explanation and Defence of the Huttonian Theory," published in 1803. I never look back to that book, remembering how little was then known of all that we now know, without rising from it with the feeling that it is indeed an immortal work, and that we may well be proud of the two illustrious Scotsmen to whom we owe it. Apart altogether from the main drift of the argument, and from the general theory as a whole, it contains in numerous individual passages the germs of much subsequent thought, and almost prescient anticipations of many subsequent discoveries. But, above all, I would call your attention to the connection in which it stands to one of those higher questions of philosophy which rise above all the special sciences, and by their contribution to the solution of which all sciences must take their rank in the scale of intellectual interest and importance. You know, gentlemen, the leading idea of the Huttonian theory—it was the uniformity, or the almost mechanical regularity of geological causation. You recollect how it was shown that in looking into the nature and history of the physical changes affecting the structure of the rocks, we can see only an everlasting series of the same kinds of operation, in endless repetition, till they are lost in the obscurity which lies beyond the range of human observation. This theory was embodied in the famous formula that in geology there is no trace of a beginning, no symptom of an end. This theory was charged with an atheistic tendency, absurdly enough, since Dr. Playfair explained that Hutton did not maintain either that there had been no beginning, or that there would be no end. All he maintained was that for either of these things we must go beyond the boundaries of geological phenomena, which were strictly limited to a certain series of physical facts, and could have no concern with things which may have been before, or with things which may yet come to be. But although this theory of eternal and mechanical repetition—of the mere grinding down of rocks, and of their reconsolidation in the sea, and of re-elevation into land—although this view of that which constituted the whole of geology was no more atheistic than any other theory on the mechanics of creation, it was nevertheless not a theory which could really satisfy the mind. Holding, as I do, above all things in science, to the fundamental doctrine of the intelligibility of nature—that is to say, to the deep-seated harmony between all the operations and workings of nature, and the operations and workings of the human mind—it was not possible in my opinion, to be really satisfied with the Huttonian theory as a full and final account even of geological facts. Some other key, some other clue, was sorely needed to the order of these facts than that of mere mechanical repetition. Nothing in our own nature, nothing in nature round us, corresponds to any conception so dreary and so monotonous. Everywhere, and in all things, there is a continual passage from one set of conditions to another, and generally, in proportion as our knowledge is complete, we can see that this passage is one from a lower to a higher level. And accordingly so it has been in the progress of geology since the days of Hutton and of Playfair. The last fifty years have revealed what during the previous half century had remained unknown. Those traces of a beginning, the existence of which Playfair did not deny, but which only he resigned as not belonging to geology, have now appeared in fact and in objective form more clearly than they had ever appeared before in the imagination of cosmogonists. And this appearance has arisen not outside the boundaries of our science, but strictly within them, so that the successive formations by deposit and by consolidation, by depression and elevation, have come to be recognized and distinguished mainly by the records they contain of a rising and expanding Fauna. I know, gentlemen, all that has been said and written against the dangers of *a priori* reasoning in science, and beyond all doubt it has often been misleading. But I know also that all the discoveries of science must take their place and rank in proportion as they fulfil and come up to the understandings and expectations of the mind. For these understandings and expectations are part of our nature, and our nature is an epitome and an image of the vast system in which we live, so that we have a right to expect, in all physical research, that which we do actually find—namely, a more and more intimate correspondence between the facts of Creation and the intellect of Man.

And this brings me to the successor of Hutton and of Playfair during the last fifty years—to Lyell, who has practically been the great law-giver in the philosophy of geology since the first publication of his "Principles." In him the doctrine of mechanical repetition and of uniformity of sequence has found a prophet and an interpreter who has done as much as skill and knowledge can ever do to reconcile it with facts, and to give it a greater width of meaning. It is not too much to say that in this country, at least, although not on the Continent, Lyell's authority has been supreme during the last thirty years; and no explanation of geological facts which was not supposed to coincide with his views has had a chance of favourable hearing. And yet, gentlemen, it is consistent with my personal knowledge that one, at least, of the most illustrious of our geologists—one of those who must ever be remembered as amongst the greatest teachers and greatest discoverers in the science—our countryman Sir R. Murchison, never did accept the doctrines of Lyell as an adequate or consistent explanation of numberless facts respecting the succession and the condition of rocks. Over and over again he has expressed to me his conviction that these facts could not be all accounted for on what he called the "bit-by-bit theory." Now, as a matter of authority, I must express my own strong impression that the mind of Murchison had a more instinctive touch with Nature than the mind of Lyell. He was less under the dominion of one idea. He had a more open vision, and a more rapid and intuitive spirit of interpretation. He had not the same literary power, and he was less disposed to construct abstract theories, which are attractive from their apparent simplicity and completeness. I would not have it thought for a moment that I undervalue the immortal services which Lyell has rendered to geology. He has taught us, as no other man had ever done before him, to appreciate the power of existing operations as we see them working every day around us, when these are multiplied by periods of indefinite duration. This was a lesson which we had much need to learn, for in the attainment of our own ends and aims we are apt to be impatient of delay, and, transferring these weaknesses of our own character to our explanations of Nature, we are apt to forget the infinite patience of her operations, and her majestic indifference to the limitations of space and time. I have a vivid recollection of the keenness and enthusiasm with which Lyell has often told me of some new discovery illustrating the vast antiquity of even the last and latest changes on the surface of the earth, or the identity of the causes which produced them with the causes which produced other changes in the far vistas of the Palæozoic Age. It was a grand conception, which had taken entire possession of his mind, and in the light of which he saw and interpreted every fact. Nor was it more grand than true—for my own belief is that if it led, and does still lead, to some misinterpretations of geological phenomena, these misinterpretations arise, not from over-estimating, but from under-estimating the immense contents of that conception, and the vast variety of changes which it is large enough to cover. Lyell himself did much to show how great were the catastrophes—how violent and sudden were the destructive agencies of which man has had experience even in the historic ages. It was part of his argument to ransack every record he could find of great volcanic outbursts, of great areas of country covered with lava, or suddenly and considerably elevated above the sea. We have only to pursue this argument a little farther, and all may be reconciled. We must not stop when human records cease. We must include all the changes of which we have any other record—any other proof, or even any other indication. We need not make any adverse assumption, however probable. We need not assume that as progress and development has been discovered to be the law and the history of organic beings, so have corresponding changes passed over the forces determining the conditions of the habitat of life. We need not assume, however reasonable the supposition may be, that the difference between man and "dragons of the prime, which tore each other in their slime," is a difference which ran parallel with a corresponding difference in the restfulness of nature, and in the fittings of our planet. Nor is it necessary to go to other sciences than our own, and call in the help of such abstract conceptions as the "Dissipation of Energy" to dispose us to believe that as we go back in time there may have been—probably there must have been—greater activity in the agencies of change. It is quite enough that we take due note of many familiar facts of geology—of the broken and contorted strata—of the cliffs and precipices far from any possible river, or from any possible lines of coast—of the caves which very recently were the beds of streams, and are now absolutely dissociated from existing lines of drainage—of the gravels which cover our plains and ascend high up the slopes of our highest mountains—of the evidences of glacial action in times so recent that the phenomena are apparently those of yesterday. We have only to look at all these things, or indeed at any one of them, to be convinced that our earth has been the scene of operations not only in the far but in the immediate past, which are not represented in any visible operations now. I say "visible" operations, because there is a grand distinction here—and I suspect that it is in this distinction that the reconciliation lies between the fundamental idea of Lyell's philosophy and the fundamental facts of nature. I suspect that he, and all of us, at times, have been confounding two very different things—one is the continuity of causes, and the other is uniformity of effects. I believe in the first of these: I disbelieve in the second. Nay, more, it is because I believe in the first that I find it impossible to believe in the second. It is because everything which appears to us to be in stable equilibrium is being attacked by causes acting with infinite slowness—it is because of this that a time always comes, and must come with varying degrees of suddenness, when the pre-existing equilibrium is overthrown. Then come what we are pleased to call catastrophes, and which may be so to us, but which are all inseparably connected with the perfect continuity of causes, and the slow accumulative effects of their invisible and ceaseless operation. Do we not know this by experience in the little sphere of our own creations? In many of the ancient palaces of our fathers it was the fashion to decorate the ceilings with flowers and fruits, often cast in massive moulds, and suspended over our heads by means adequate to secure stability. And so they will remain, and have remained for centuries. But the slow continuities of physical causation have never ceased to work, and bit by bit operations as slow as any ever conceived by Hutton or by Lyell have been steadily undermining the conditions of that stability, until at last in one moment of time the whole mass is precipitated upon the floor, to the imminent danger of many lives. I am not drawing on my fancy for this illustration. It actually happened in a case I knew—a case in which many persons had a narrow escape from death or from serious injury. There are innumerable other cases of sudden violent action being the inevitable result of the slow continuity of causation. The great tidal wave which accumulated a few years ago in the Bay of Bengal, and which—invisible in that wide area—became terribly visible in the Hoogly and the Ganges—drowning in a few minutes of time thousands of the teeming population. The breaking up of the ice on the great frozen rivers of North America and of Northern Asia is an annual catastrophe, the magnitude and magnificence of which has been often described. The rending of ice-cliffs on the coast of Greenland, and the launching of monstrous icebergs upon their majestic voyages to the south, is another of the superficial catastrophes which are seen by few, but has always vividly impressed those who have been so fortunate as to see that sudden result of slow causation. Similar phenomena on a still grander scale take place in the Antarctic Circle, when whole miles of ice-cliff break off from the great southern barrier, and float in vast islands, probably for many years, round that tempestuous ocean. And yet the forces which are ever acting in cases such as these are weak and local in comparison with the tremendous energies which are at work, as we have every reason to believe, under that crust of the globe upon which we stand. The usual illustration of these energies, the example of which is continually referred to, is that of volcanic action. And no doubt we may well refer to it, for perhaps never in historic times, and perhaps never in pre-historic times, have outbursts of volcanic energy been more tremendous than they have been during the time in which we are now living, nay, even during the single year which is drawing to its close. And yet I think we may say with absolute conviction that the energy of volcanoes is not the most deep-seated or the most tremendous of which geology must take account. The movements which have given a definite direction of dip and strike to the whole masses of sedimentary deposits, occupying an extensive region—such, for example, as the dip and direction of the rocks which are so marked in the geography and geology of Scotland north of the Clyde—those movements, again, which have broken and bent, so as even to bend over and reduplicate, the beds round the flanks of the Alps—those, again, which have occasioned immense faults, such as that which marks the deep line of the Caledonian Canal—these are forces evidently far deeper-seated and far more powerful than any, even the greatest, which find their vent in the raising or destruction of volcanic cones. And if, in the action of these greater and more deep seated forces, the same law has prevailed as that which we know to have prevailed in the action of volcanic heat, then we may be certain that the slow, majestic continuity of physical causation has been compatible in this case also with what we call catastrophes—that is to say, with the occurrence of moments of accumulated effects. And as the outbursts of a volcano are only the sudden revelation of causes which have long been silent, but have never ceased to work, so it is reasonable to suppose that like sudden revelations have been made from time to time of those more central forces operating on the crust of the globe, which are even more continuous and more unsleeping, and of which volcanic heat and volcanic outburst are but the local symptoms and effects. The truth is, that, when we come to look closely into the matter, it becomes evident that nothing can be more unphilosophical than the antithesis and opposition which is set up between what is called the law of continuity and what is called the doctrine of catastrophes. Thoughout all nature, and throughout all those operations of the human intellect which depend on the manipulation of natural forces, we see the two doctrines to be perfectly harmonious—strains and tensions maintaining themselves in absolute silence up to the bending or the breaking point—pressures pressing with tremendous but noiseless energy up to the bursting point—and then moments of rapid and sometimes of instantaneous change; change as dreadful as that which comes in the spring and roar of the tiger—this is the usual sequence of events—this is the rule and law which seems to govern all things around us; aye, and very often all things that we depend upon within us too. For every physician knows the terrible continuities of disease—how the thinning of the walls of vessels, and the weakening or degeneration of other organic tissues, go on, often unseen and unsuspected, until their appropriate result emerges in some catastrophe which destroys in a moment of time the reason or the life. And if it is irrational to quote the continuity of nature as affording any, even the least, presumption against sudden and great effects, it is still more irrational to quote it as irreconcilable with effects which, though catastrophes to us, whose scales of measurement are often the scales of pigmies, are in reality nothing but movements of infinitesimal magnitude in the scale of nature. I remember well hearing the late Principal James Forbes describe the impression made upon him by seeing a total eclipse of the sun from the top of a high tower upon a hill near Turin. We all know that the light of the solar disc is so intense that the deep shadow of an eclipse does not make itself apparent till every fragment of that intense surface has been shut out from shining, till, in short, the moment of "totality," and how, consequently, the maximum effect from a very slow motion is produced in a moment of time. Principal Forbes, standing on a point which commanded the whole range of the Alps from Turin to the Adriatic, and having the whole vast plain of Lombardy at his feet, was thus enabled to see the rush of that mighty shadow, and to form some conception of the velocity of cosmic motions as measured upon the distances of our earthly surface. The sight was, he told me, the most impressive it had ever been his lot to witness. But we need not leave the surface of our own globe, or compare its magnitudes with the magnitudes of surrounding space, to be convinced of the childishness of our language when we apply the word catastrophe to movements upon or in the crust of the earth, which in reality are movements of extreme minuteness, even as measured by the units of magnitude with which we are familiar on its surface. I had occasion the other day, in delivering a popular lecture in Glasgow, to exhibit a section of the globe drawn on the scale of one-tenth of an inch to a mile. On that scale, which I have taken from my friend Mr. James Nasmyth, the globe is represented by a circle 64 feet in diameter, and I was able to show that on that portion of the curve which represents one-eighth of the circumference, the elevation of the highest mountain in Europe, Mont Blanc, was wholly invisible to the spectators who were half-way down the hall, and could hardly be seen even by those who were close at hand. The truth is, that when we come to realize the almost infinitesimal smallness of the irregularities of the earth's surface as compared with its circumference, the whole range, from the highest height to the deepest deep, being somewhat less than 60,000 feet, the wonder comes to be that if subterranean forces are at work at all in modifying, from time to time, the perfect smoothness and sphericity of the surface, not that their work should be so great, but that it should be so very small.

The general result of these considerations is to show, in the first place, that the continuity of physical causation is not only consistent, but is usually and normally connected with alternations of activity and of repose, and that in the periods of activity the results of long-continued action are apt to become apparent in effects both sudden and extensive. The next result of these considerations is to show further, that, as regards any visible effect of subterranean forces upon the crust of the earth, there is no so-called "catastrophe" which has ever been evoked, even in the most extreme theory, which is not very far within the reach and compass of the forces to which they are ascribed. I have urged this—as it may appear to many—somewhat abstract argument, because, like many other abstract arguments, it has a most practical bearing. It seems to me that the dogma or doctrine of uniformity, as it has been understood and applied in England, has long been exercising a most injurious effect on some of the most pressing problems of geological science. I call them the most pressing, because they concern the most recent events and facts. If we cannot interpret, as yet, with any approach to unanimity, those changes on the surface of the earth which have taken place most recently—even, it may be said, in our own time—as regards the introduction of our race, how can we attempt to interpret the changes which took place in Palæozoic and Mesozoic times? It may be humbling to our pride, but it seems to be strictly true, that the questions raised with respect to Pleistocene geology are by far the most difficult—I will not say the most insoluble—with which we are called to deal. Take this short list of these questions:—The coming on of the glacial age: the great submergence which unquestionably accompanied some portion of it; the coming in of the great Pleistocene mammalia; the destruction of them, and the breaking up of old surfaces and of old lines of drainage which again accompanied that destruction; the distribution of gravels and of muds over the surface of the country—what a volume of difficulties are involved in this series of events, all either immediately preceding or accompanying the birth and the dispersion of mankind! Yet how various and how contradictory are the theories which are now being advanced on each and all of these questions! And are not many of these difficulties of interpretation directly due to the preconceptions and prejudices which the doctrine of uniformity has established in many minds, indisposing them to believe in particular kinds of change and movement, which they are pleased to consider as catastrophes, and disposing them, on the other hand, to invent other kinds of movement and of change, which, however violent, can be more easily conceived as slow? I shall now specify a few geological problems on which, as it seems to me, the prejudices and prepossessions of the Uniformitarian Theory have prevented or impeded the natural interpretation of patent facts. And first, with regard to the phenomena of the glacial period. I accept as one of the most certain conclusions of our science that there has been, very lately in the scale of geological time, a period when the climate in these latitudes was glacial. I live among the facts which prove this. I see them in profusion every day, and indications in abundance surround me in every walk and in every drive, showing most clearly the conditions under which the ice has worked. I have no time or space now to go into detail. Suffice it to say that ice has, in my opinion, worked among the Argyleshire hills in the two great forms of glaciers and of floating ice, and in no other form whatever. Moreover, the floating ice has worked at two different levels, mainly; one of these is at or within some thirty feet of the existing level of the ocean, the other is at a level high up the flanks of the hills, and as regards the lower ranges, especially over their very summits. As regards the first or lower of these two levels, probably there will be no dispute. But as regards the higher level, we come at once upon conclusions which do not fit easily and smoothly into the grooves of the uniformitarian hypothesis. It is, of course, one of the most elementary conceptions of geology that the areas now occupied by mountains of sedimentary strata have been all, more or less often, in the position of sea-bottoms or the beds of lakes. But this is quite a different conception from that which supposes that our existing mountains have been lower to the depth of two, or perhaps three, thousand feet, and that along all their flanks and over their summits a glacial sea has sent its floe-ice and its icebergs, grating, grinding, smoothing, polishing, and finally stranding, upon every surface and protuberance which opposed itself to the prevailing tides and currents. It is quite certain that this glacial sea, if it ever existed, has not left any evidence of a prolonged stay upon these mountain slopes. There are no beds containing marine shells which appear to have lived and died upon the spot. In the rare cases in which marine shells are found at all, they are generally broken, or so grouped as regards littoral and deep-water species as to show that they were dead shells when they came to be drifted and embedded where they now are. The submergence, therefore, of our mountain contours under a glacial sea must have been a submergence essentially transitory in its character, whilst the extreme recency of both the submergence and of the re-submergence, belonging as both do to the times of the existing fauna, compels us to face the supposition of movements which have been relatively very rapid. This is where the shoe pinches, and where accordingly the Uniformitarian hypothesis makes vigorous exertions to betake itself to some convenient slipper. Placing one foot upon ice in the form of glaciers, and the other foot upon ice in the form of an assumed "ice cap" or "ice sheet," it tries to walk among the relics of this swelling sea without hearing its voice or looking at its waves. The stones and boulders which its ice-rafts scattered over the land—those which these rafts, stranding upon rocks which were then reefs and shoals, have in melting let down upon spots which are now peaks and pinnacles—all these are ascribed to glaciers or to an ice cap. Those who daily look upon these boulders in the curiously balanced and perilous position in which they are often placed, or those who study the facts of their distribution in the labours of Mr. Milne Home's Boulder Committee, will be able to appreciate the futility of ascribing that position and distribution to glaciers. Glaciers have had their own appropriate effects, which are quite distinguishable and absolutely distinct. A glacier is a frozen river in a rocky bed, and with rocky banks. Upon those banks, and at its termination where it ceases to flow, its lateral and its terminal moraines may occasionally leave or occasionally deposit fragments of rock in the position of perched boulders. But this is not and cannot be the normal action of a glacier. The remains which they have left are conspicuous in the Highlands, especially in all the larger glens which could form the beds of glaciers of considerable size. I know no better example of the peculiar manner in which they transport and deposit material, than the example to be seen in the valley of the Teith, from Callander to Dunblane. The eagle eye of our great national poet, Robert Burns—so sensitive to every aspect of nature—had caught, without knowing the cause, the peculiar moulding of the surface which adds such a charm to that part of the scenery of the Teith, and it is the moraine mounds of an ancient glacier that he has immortalized in his beautiful song, "Ye Banks and Braes o' Bonnie Doon." But glaciers cannot have distributed boulders where they never themselves existed, and for one perched boulder in the Highlands, which can be accounted for by the lateral moraines of a glacier, there are hundreds of thousands which lie where no glacier can ever have placed them, because they are places where no glacier can ever have been generated. Turning, then, to the other alternative of an ice cap—that is to say, the passage of a mass of ice higher than the highest of our mountains, and burying the whole of them deeply out of sight—I must repeat the opinion I have often before expressed: first, that there is no proof that it ever existed; and, secondly, that if it ever did exist, there is no proof that it could have placed boulders as we find them placed. This, however, is understating the objections to the ice-cap theory, because these objections are not merely negative. Other objections are positive in their testimony. The glaciation of the rocks upon our mountains seems to me to prove conclusively that it was not done by one continuous sheet pressing itself with enormous weight into all the sinuosities or inequalities of the surface, but was done by the impingement of floating sheets and masses upon particular portions only of the surface —those portions almost always explaining most clearly the agency which abraded them by their relation to currents such as existing contours would modify and direct.

I object, also, on physical grounds, as well as on the ground of rebutting evidence, to the theory of an ice-cap, or of ice masses under whatever name, which at all approach in magnitude those which are continually invoked by the extreme glacialists. There is no proof that such masses ever existed any more than they exist now. But if they ever did exist, I see no possibility of their ever having had the movements which are habitually ascribed to them. There may be some points not yet perfectly understood in the motion of true glaciers. But I am satisfied with the explanation of Principal Forbes and others. In gravitation we have a true cause—a *vera causa*—of motion in ice-masses resting on the slopes of a mountain. But there is no proof that gravitation would produce a forward movement upon ice-masses which do not rest upon the slopes of a mountain, but upon level surfaces. Still less is there any adequate cause assigned for such motion when it is actually opposed to gravitation, and is assumed to have carried mountains of ice up the slopes and over the tops of mountains of rock. Such suppositions have always appeared to me to be catastrophism in its most extravagant form. It is one thing to explain effects by invoking greater energy of action for causes which are at least known to exist and to be certainly capable of producing them—it is another and a very different thing to invoke agencies which are not known to exist at all, and which if they did exist are not known to be capable of producing the effects ascribed to them. Greenland is sometimes quoted as a case of an ice-cap. But Greenland is in reality nothing but a case of one enormous "nevé" and a series of gigantic glaciers. It is a high mountain country, buried under an excessive snowfall, with that snow consolidating into a series of glaciers in all the valley beds. The cause of motion in the ice-masses which debouche into the sea round the coast of Greenland is precisely the same cause of motion which brings an ice cliff into the Valley of Chamounix. Then as to the ice-masses which occupy the highest latitudes of the Antarctic Circle, it will be time enough to reason upon its phenomena when we really know them. As matters now stand, we have no proof whatever that the ice of the Great Southern Barrier moves steadily over a high mountain surface under any unknown impelling force. I have dwelt longer upon this question of the ice-cap or ice-sheet, because it is not in the geology of our own island only that it is invoked to get rid of the conception of a great submergence, and of a great re-elevation of the land —both of them effected in the most recent times. On the continent of Europe, too, we know that a large part of its central area is occupied by a formation (the "Loess") which Lyell calls "inundation mud," and which he designates as the last and latest of all the great formations known to geology. The difficulty of accounting for it is proved by the number of theories which have been propounded. The shells in that formation are not fluviatile, nor are they lacustrine. On the other hand, they are not marine. They are terrestrial. They are land shells—the shells of damp woods or morasses—in short, of a land surface which has been covered with this "inundation mud." One possible explanation is obvious. The sea establishes its own forms of life where itself is established for any length of time. But if its invasion of any land area be not lasting, but temporary, it may well fail to carry its mere dead shells over that area, whilst its living fauna would not have had time to grow. But here, again, at all costs, this notion of a submergence temporary and transitory must at all hazards be dismissed. And so the ice-cap again comes into play. There are no banks within which to confine a great European lake, but in the ice-sheet banks are always ready; and so it has been supposed, among other explanations, that enormous masses of ice, walking of their own sweet will about the world, came down from the north and dammed back the waters of the Rhine, or of some other greater river which then took its place, and thus formed a lake in which this vast sheet of inundation mud was deposited. I do not pretend to be able to solve all the difficulties of the problem connected with the great formation of the "Loess." But I am sure that any theory is better than this; and, further, I am sure that many difficulties will be removed if we can but face the conclusion that there has been in very recent times, and over a large area of the northern hemisphere, a great depression and a great re-emergence of the land towards the close of the glacial epoch.

I pass now to another fact and problem connected with Pleistocene Geology, which is of the highest interest and importance. I refer to the bone caves of the south of Europe—caves not like almost all those found in this country, into which bones more or less numerous have been brought by men or by hyænas, but caves packed from floor to ceiling with a breccia mainly consisting of the skeletons of the great Pleistocene Mammalia, of the Rhinoceros, the Hippopotamus, the Mammoth, the Lion, and the large associated Graminivora. Chiefly in the countries bordering on the Mediterranean such caves have been found in abundance, containing such a mass of animal remains that it is certain that no agency but that of water could have brought them and huddled them up together in such heaps at one spot. For many years it has appeared to me that no existing theory accounted satisfactorily for such an assemblage of such creatures under such conditions. Lyell's explanation seems to me very unsatisfactory. In the Morea, and in other limestone countries, it is said some rivers lose themselves in swallow-holes, and run the rest of their course—or long distances of their course—through channels under ground. It is assumed that the great pachyderms, during a long course of ages, were perpetually tumbling into such rivers, and were being carried, each separately and singly, into the subterranean channels, until at last in particular places those channels become choked with their remains. I confess I doubt whether it is usual for the great pachyderms to die in the beds of rivers after this fashion, and to be carried down so often into swallow-holes. These great creatures generally retire to the depths of the forests when they sicken, and under ordinary conditions the cases would be rare in which they would be entombed in this way. But there are other conditions, not ordinary but occasional, under which it is very easily conceivable that they should be swept into such openings in the rocks; and what are such conditions? Why, simply these—that some inundation submerged the haunts of these creatures before they had time to escape, and that this inundation was accompanied and perhaps partly caused by simultaneous movements of the earth's crust, which opened swallow-holes both more numerous and more capacious than those which had existed before. And here it must be observed that one important part of this explanation is not theory but unquestionable fact. It is certain that these caves and fissures so packed with carcases are now almost universally dissociated and broken off from the old lines of drainage in which they discharged the function of river channels. It is certain, therefore, that the old surfaces of country in which they occupied this position have been totally destroyed; and this destruction can only have been due to great fractures and great bendings of the underlying rocks. At what period did these great changes take place? Is it certain that it has always been long subsequent to the entombment of the remains? May it not have been to some extent contemporaneous? May not the breaking-up of the old surfaces, by subsidences or otherwise, have been part of the process which caused the inundations? And may not the rush of waters have been determined in their direction by the opening of new channels or the enlargement of old ones? Let any man go even to the cave of Brixham, which overhangs the beautiful spot in Torbay where William III. landed to accomplish the English Revolution, and he will see at a glance that since that cave can have been the bed of a stream—as beyond all question it was very lately in geological time—the whole physical geography of that part of the earth's surface must have been entirely broken up and changed. Precisely the same proof, although in many cases even more striking, applies to the wonderful bone caves of the shores of the Mediterranean. Nothing, I think, but the bondage of a theory which is not founded on any sound philosophy could banish from our consideration the high probability of one simple explanation, which is this, that in very recent times great changes in the moulding of the earth's surface over a great part of Europe occurred with sufficient rapidity to cause great destruction of animal life, and during the progress of a wide submergence to sweep the bodies of the drowned creatures into fissures and swallow-holes which were opened or enlarged at the time. There is a curious question which arises out of these bone-caverns and bone-fissures. The Uniformitarian theory assumes that there has never been anything new under the sun; that in every age there has been the same round of mechanical repetition, each age simply repeating the phenomena of the ages that went before. Well, let us apply this doctrine as far as it is presumably true, and let us look at the result.

It is true that there have been immense limestone deposits since the earliest Palæozoic ages. These have been over and over again upheaved into land surfaces, and have doubtless formed cliffs and hills just as they now do; and so likewise the constancy of natural causes demands our belief that rain-water has always contained its percentage of carbonic acid, and has in all ages acted on limestone as it acts at present. Consequently, there must always have been the same tendency to the formation of underground channels by rivers running in limestone areas. Again, these rivers must always have had the same liability to floods, and the same power of carrying off and crowding into swallow-holes the sickly and the dying land animals that may have existed at the time. Consequently the phenomena of bone-caves and bone-fissures must be supposed to have been produced in all ages; for in all ages the land animals must have been always dying, and always being swallowed in underground passages of running water. But, strange to say, this presumption of the Uniformitarian hypothesis is contradicted by facts. Professor Boyd Dawkins, who holds to the inference, and avows his own belief in its certainty, admits, nevertheless, that as a curious and singular fact, no such packed assemblages of animals have been preserved to us belonging to any other geological horizon than the Pleistocene. Yet we know that the Eocene and Miocene epochs had each a rich fauna of their own, and nothing could be more interesting than to find bone-caverns and fissures out of which we could restore the skeletons of these lost creatures. The only explanation the Professor gives for this discrepancy between theory and fact is that all such pre-existing caves have been destroyed by denudation; an explanation which does not appear to me to be even plausible, considering how protected the great majority of such fissures are from all superficial causes of obliteration, and what immense sections we have of limestone strata of all ages. My own explanation would be, at least as a possible supposition, that during the Pleistocene period the continuity of physical causation had brought about certain special effects, and that among these was some sudden diluvial action, accompanied by and perhaps caused by extensive fractures of a pre-existing surface.

But the bone caves and fissures do not present the only conditions under which the aggregation and entombment of the extinct Pleistocene mammalia requires explanations not easily reconcilable with the Uniformitarian hypothesis. I am glad to see, however, that great authorities among the most orthodox geologists are beginning to call in agencies which imply catastrophes. Thus Professor Boyd Dawkins accounts for the accumulation of the Pleistocene mammalia in the deposits now constituting the Dogger Bank, by saying that "the dead carcases had evidently been collected in the eddies of a river." Here we have the agency of rapid waters invoked for the transport of drowned animals, and the eddies of these waters invoked for the heaping of them at particular spots. But there are many places, as I know well from our western coasts, in which the waters of the sea rush precisely as rivers rush, and form eddies precisely as rivers form them; and Professor Boyd Dawkins does not seem to me to use an argument which will stand examination when he argues in favour of fresh-water as against marine currents on the plea that sea-water would have sifted the smaller animals from the larger, and would not have deposited them all in one place. So far as I know, marine currents would act upon carcases precisely in the same manner as currents of fresh water, and neither of them would separate drowned beasts according to their size. Surely the opposite assumption arises from a confusion of thought, because in so far as water sorts and sifts materials which fall into it, the sorting and the sifting depends on differences of specific gravity. But the specific gravity of animal carcases does vary with the size of the animal. A dead cat is very much the same specific gravity as a dead donkey, and a dead beaver would float readily alongside of a dead mammoth. But really it matters little whether the eddies which carried these carcases in such numbers are supposed to have been marine or fresh. The question equally remains how these rivers came to be in such roaring flood, and to be charged with the dead bodies of animals floating and eddying pell-mell together. Then, again, in a distant but over an immense area of the globe we are confronted by the problem of the sudden destruction of the Mammoth and its contemporaries, now preserved in millions in the Tundras of Siberia from the Gulf of Obi to Behring's Straits. The facts upon this point, as well as on many others, have lately been collected and presented, in their mutual bearing and connection, in the very able papers of Mr. Howorth contributed to the GEOLOGICAL MAGAZINE. One main fact and difficulty in the problem presented to us is the preservation of many carcases in the flesh by having been frozen up immediately after death, and never having been unfrozen from that date to the date of discovery in our own times. The difficulty may be stated thus:—Under glacial conditions so severe these animals could not have lived, whilst at the same time, under glacial conditions equally severe, these animals must have died. From this dilemma I can only see one method of escape. It seems to compel us to believe in a rapid congelation accompanied by an inundation. The sudden advent of very hard frost within the limits of our own climate is a familiar phenomenon. But we must suppose the advent, with at least a like suddenness, of a cold far more extreme, and of a permanent refrigération of all the seasons. I propound no theory as to the explanation of facts so unquestionable and yet so mysterious. I am quite sure there has been no break in the perfect continuity of physical causation. But I am disposed to think that this very continuity has brought about, and that suddenly, some very extensive and very violent changes in those configurations of sea and land which have the most powerful effect on climate.

Lastly, I desire to point to the earliest traces of mankind, and to the conditions under which they have been found, as another great problem of Pleistocene geology on which the prepossessions of the Uniformitarian theory have prejudiced the natural interpretation of facts. And be it remembered that this is the loftiest theme which belongs to our science. It is, indeed, the loftiest theme which belongs to any of the physical sciences. There is not one of them which teaches any fact, or even deals with any conception, so significant or so impressive as the fact that the birth of man is a thing of yesterday. And if there be any fact or any conception which is even more significant or more impressive, it is the farther fact that, as regards the method of that new birth—so recent, so fresh—with the times before and the times after—so clear and close at hand, we have not as yet, so far as the physical sciences are concerned, one single ray of light. And yet the intelligibility of nature does not fail us. But the kind of intelligibility which we find lies in an appeal to higher faculties than those which deal with physical conceptions. We *can* see a reason; but we cannot see a cause. The reason which we can see is simply this—that up to a certain epoch the house and the home of man was not sufficiently ready for him. Those creatures which are his best servants, and some of which are the indispensable elements of his culture and civilization, had not been introduced. This is a fact, again, which belongs to our science. And if there be any other facts touching the earliest relics of man which can be found in geological deposits, surely these are facts on which we are bound to observe most carefully and to reason most closely. Let me go to the point at once. It is almost universally assumed that the beds of gravel, of brick-earth, in which or under which human implements of the palæolithic type have been found, are all river gravels, and fluviatile silts. I question this assumption altogether. In order to make it square with facts, it is continually necessary to assume that rivers existed where none exist now, and that other rivers which do exist have once run along the tops of the hills which now enclose them; and further, that in no other way can water have overflowed the whole existing drainage. These assumptions are always more or less arbitrary, and in some cases are demonstrably unsound. The marine gravel with dead shells of existing species found high up on the Welsh mountains, and also found near the top of the Midland Watershed of England, render it all but certain that the whole of England has been under the sea, in times so recent that zoologically they belong to the epoch in which we now live. All the older gravels which pre-existed upon the surface so inundated must have been then widely broken up and redistributed; and new gravel beds must have been formed by the washing away of the finer materials from out of stony soils. Accordingly, we find that the gravels which are called river gravels are very often full of foreign material—foreign, I mean, to the drainage basin of the rivers with which they are connected. And here let it be observed that whilst the absence of such foreign materials would not disprove marine redistribution, the presence of them in any one case may be conclusive proof of a much wider marine submergence than any affecting only the spot on which they are found. The distance to which the sea might scatter pre-existing gravels would depend entirely on the violence of currents or the gentleness of submersion. But if we find anywhere in gravels, high above the lines of existing drainage, quantities of material which must have been brought from a great distance, we may be sure that the currents which brought them there have simply run with less rapidity over the areas where no such materials are found. I can testify by my own observation that what are called the high level gravels connected with the valley of the Thames are full of lumps and pebbles of rock which do not belong to the drainage of the Thames valley, but must have come, at least, from the older gravels of the centre of England, if not directly from the Welsh mountains. Now, the palæolithic implements of man have been found constantly in gravels which cannot with any probability be assigned to existing rivers, and may with tolerable certainty be assigned to the same marine submergence which has piled heaps of gravel with dead shells on the top of Moel Tryfaen, and on the hills above Macclesfield. In the latest work of Sir Charles Lyell, which is the last edition of his volume on the "Antiquity of Man," he indicates his own clear recognition of the difficulties attending any explanation of the gravels and of the drift-boulders found in Scotland, which is based on the action of land-ice alone. He refers to the great beds of gravel, sand, and silt—one section alone showing some 2000 layers, which Mr. Jamieson, of Ellon, has described—on a mountain rising out of the valley of the Tummel, in the Pass of Killiecrankie, beds which are traceable to the height of 1550 feet above the level of the sea. He refers, also, to huge angular fragments of mica-schist lying on the very tops of the Sidlaw Hills, also 1500 feet above the sea, and separated from the rocks whence they came by the broad and deep valley of Strathmore. He refers, yet further, to stratified gravels on the top of the Pentlands, 1100 feet above the sea; and he confesses that "it seems hardly possible to refer these beds to any but a marine origin," and this, despite the fact that they are devoid of marine shells. Hardly possible, indeed! and equally impossible to doubt that the sea which deposited these beds was so transitory that no time was allowed for the establishment of molluscan or other marine forms of life. Here, then, we have a great submergence and elevation as clearly proved as any conclusion in the whole range of geological science; and yet, as it seems to me, the inevitable consequences of that conclusion have not been worked out with even tolerable consistency in its bearing on another question connected with Pleistocene times. As to the cause of that submergence, the facts seem to me equally fatal to the theory of Mr. Jamieson and to the theory of Dr. Hall. One of these eminent authorities relies on the pressure—on the mere weight—of an enormous mass of land-ice sinking down the land. The other relies on the mere attraction, under the laws of gravity, of the same great mass exercised upon the ocean, dragging the waters of the sea in a huge accumulation towards itself. Both theories equally rely on ice-masses which are pure assumptions, and the existence of which is positively disproved by the demonstrable access of the sea to naked mountains at the very time of the maximum submergence.

I cannot pursue this subject farther on this occasion. I have not thought it best to spend this lecture on songs of triumph over the achievements of the past, or recapitulations of the work done by the dead or by the living members of our Society. Let it not be thought, on this account, that I am insensible to the immense services they have rendered. Some of the greatest of these services have been rendered in furtherance of theories and explanations which I believe to be erroneous; but these theories have never affected the perfect honesty of the work. Now, as ever, speculative opinions are inciting to inquiry, and sharpening the vision of rival theorists in the detection of natural facts. I need not here or now mention names. Suffice it to say, that some of the very best workers have been, and are, the very men whose conclusions I venture to question or dispute. At all events, I have thought it a more profitable theme to dwell on the immense extent of our remaining ignorance, rather than on the little area over which our knowledge has been securely established—on the difficult, and, as it seems, the almost insoluble problems which lie before us, and are pressing close around us, especially those which are involved in the very last and the very latest changes which have taken place on the surface of our globe.—*The "Scotsman,"* Nov. 2nd, 1883.

CORRESPONDENCE.

MR. MELLARD READE'S REPLY TO MR. WALLACE ON THE AGE OF THE EARTH.

Sir,—In replying to Mr. Wallace's letter in the October Number of the Geological Magazine, I shall only refer to those points that I think really touch the question in dispute between us. Fortunately the issue is considerably narrowed by certain admissions which I will proceed to notice.[1] But before doing so I may perhaps be permitted to say that the letter is full of misconceptions and extraneous matter that have no bearing on and are no elements in the calculation.

Mr. Wallace states that his 3 million of square miles 177,200 feet thick represents the matter which *actually exists* on the globe in the form of stratified deposits, which he estimates took 28 millions of years in accumulating, using as his measure the present rate of denudation. Also that this deposit equals a stratified crust of from 9,000 to 10,000 feet thick, if spread over the whole of the existing land. So far, this is satisfactory and explicit. There is, however, this fundamental omission in his calculation and reasoning. He does not allow for the material having been worked up again and again to form this *actually existing* deposit. By the average number of times these particles of rock have been re-used, by so much—even if we assume the other elements to be correct—is Mr. Wallace's calculation in error. Every geologist knows that nearly all stratified rocks are more or less made up of the ruins of pre-existing stratified rocks, and the question to be answered is, how often have the particles been so re-used? If, as I estimate, the materials have on an average been re-used twelve times, then Mr. Wallace's result would have to be multiplied by 12, or instead of 28 millions as he estimates, the Earth would be 336 millions of years old.

My mode of arriving at a rough approximation of the number of times the materials of the sedimentary rocks have been re-used, though "incomprehensible" to Mr. Wallace, is really a very simple process, and until Mr. Wallace or some one else points out a better way, I suppose I may be permitted to use it. It is this. Stratified deposits if only derived from stratified deposits would make the age of the earth infinite. This would hardly suit Mr. Wallace. From

[1] In making these "corrections" it is evident that the origin of Mr. Wallace's difficulties is that he does not realize fully the conditions of the problem he set himself to solve.

what then have they in addition been derived? The only other form of rocks we know of are the igneous rocks, granites—when not metamorphic—syenites, basalts, etc.; but no one can affirm that even these are parts of the original non-sedimentary globe; they are no doubt largely re-melted sediments. But for my purpose I assume that they are, and I find that the area of igneous rocks exposed to denuding agencies is about $\frac{1}{12}$ the area of the whole land, and there is reason to suppose that this proportion has endured since the earliest rocks we know of were formed.[1] It follows that if all the land areas, igneous and sedimentary, were denuded at the same rate —as no doubt they have been in the aggregate—the process of accumulation of the existing thickness of sedimentary rocks has taken 12 times as long as if they had been derived directly from a bare original crust. Now it is only on the latter supposition, which we know to be contrary to fact, that Mr. Wallace's calculation could be true in principle or result.

But whether I was right or wrong in the figures given, it is a fact admitted by all geologists since the time of Hutton, that the sedimentary materials of the globe have been used up over and over again, and any calculation of the age of the Earth based upon the rate of accumulation of sediments and their aggregate bulk which ignores this, as Mr. Wallace's does, is either incomplete or fundamentally wrong. T. Mellard Reade.

Oct. 5th, 1883.

REPLY TO MR. SKERTCHLY.

Sir,—Since the above reply to Mr. Wallace was written Mr. Skertchly has published a letter in the Geological Magazine, on the same subject, in which he says, "First, I fail to see the slightest connexion between the area of exposed igneous rocks and the number of times sedimentary beds have been 'worked over' again. Surely at the beginning of geological time *all* the land was igneous, and practically that area has been diminishing ever since. This can therefore afford no clue to the question." To which I reply, *Geological Time* is the time of which we have *geological* knowledge, and Mr. Wallace's calculation as well as my own is limited to that time. The earliest recognized system of sedimentary rocks are Laurentian, and there is absolutely no data to prove that the igneous areas even in this period were greater in proportion to the sedimentary than they are now—if there is, I shall be glad to hear it. The hypothetical period between the Laurentian and the time when *all* the land was igneous is anterior to the date at which any calculation of the "Age of the Earth" based on sedimentation can commence, for there are no data on which to work. An inspired seer might perhaps tell us something of this period; but as I have no pretence to fill that rôle, it is useless for me to attempt it.

Mr. Skertchly also says, "Thirdly, Mr. Reade supposes the denudation of sedimentary rocks would reduce the mean thickness." As

[1] This question is discussed in my Chemical Denudation in Relation to Geological Time.

I am not aware that I ever held such an extraordinary view, I ask in what part of my letter this supposition is supposed to be contained, My reasoning is altogether based upon the *mean* thickness and superficial extent of the sedimentary strata of the earth, or otherwise their actual bulk, so the question as to whether Mr. Wallace has under or over-estimated the *maximum* thickness is quite immaterial.

Your correspondent says in conclusion that he has "never seen a *single fact* that tells against the view of the permanency of oceanic areas." I feel that this statement of what he "cannot see" is conclusive, and that further argument is useless.

Nov. 3rd, 1883. T. Mellard Reade.

MIDDLE HEADON AND MEADEND BEDS OF HORDWELL CLIFF.

Sir,—What could have induced Mr. Keeping to charge my father with error, and with saying that a bed which he had described as underlying the *Upper* Freshwater *only*, underlay the *Lower* Freshwater?

One of the objects of my father's paper was to correct antecedent errors, as to the extension of the Lower Freshwater into Barton Cliff (where Lyell had asserted that it occurred), and to show that the marine bed theretofore known only at Headon Hill, where it occurred between the Upper and Lower Freshwater, and was then known as the "Upper Marine" (now called the Middle Headon), but which had not been observed in Hordwell Cliff (and indeed had been expressly stated by Lyell not to occur there), did occur there, viz. at the ravine near Milford, 10 to 12 feet above high-water mark; and my father proceeded to describe it as occupying exactly the same position, relatively to the Upper and Lower Freshwater, that it did at Headon Hill, *i.e.* between the two, which is the position Mr. Keeping claims for it.

As the only bed which answered to Mr. Keeping's version of my father's description, viz. close to the beach and underlying all the Lower Freshwater, was the one which my father had described at Meadend, I naturally took him to mean this; for he named no locality.

"Paddy's Gap" is this ravine where my father described the then called "Upper Marine" as occurring, and *over*lying the Lower Freshwater, "the remaining portion of the Cliff to the eastward being, he considered, more from position than from its organic contents, the *Upper* Freshwater;" and from Mr. Elwes' letter, it appears that he, Mr. Keeping, Mr. Dawkins, Mr. Willett, and Mr. Shore have found the bed exactly in the position my father assigned, both geologically and actually; for even to the comparatively unimportant particular of its position, 10 to 12 feet above high-water mark, Mr. Elwes's statement that it is *in situ* "13 feet above the shore" shows that my father was right, and that what he described was no slipped mass as Mr. Keeping asserted, and as Mr. Elwes, strangely enough, repeats. Instead therefore of these gentlemen having, as they think, proved my father's error, they have demonstrated his accuracy in all respects.

As Mr. Keeping has distinctly stated that my father was "clearly wrong" in putting the Lower Headon Freshwater above this bed, and that he had been unable to convince him of his error for reasons which he assigns (my father, however, never had any communication with him, I am sure, on this, or, I think, on any other subject), I trust that he will see fit to apologize to my father's memory, and bear witness to his accuracy instead of impugning it.

The Paddy's Gap bed is the one which Prof. Judd in his letter says "appears to have been first discovered by the late Mr. Edwards about the year 1840." That at Meadend, on the contrary, was discovered by my father in July, 1843, and was unknown to Mr. Edwards until he joined us a fortnight after. It is an important bed, for it shows the transition from the Upper Eocene to the Lower Oligocene in England, and seems to me to have the same "gisement" as the "Laekenian" of the Belgian area, though from the latter (as well as the "Bruxellian" below it, which is regarded as the equivalent of the Barton Clay) being purely marine, while the Meadend Bed is very fluvio-marine, there are not many species in common; and there are more common to it and the "Sables moyens" of the French area. It is rich in fossils, and it is most desirable that a proper list of the shells from it should be published. Were I physically capable of properly examining the Edwards collection at Kensington, I would make this; but I cannot trust merely to the materials I have, and which alone are available to me to make it.

Nov. 14th, 1883. SEARLES V. WOOD.

THE RUSSIAN TERTIARY.

SIR,—Dr. Trautschold commences his article in your November Number, by referring to geology having entered the order of exact sciences, and concludes it with the remark that "evidently during the whole Tertiary period the land [of the northern half of Russia] was deprived of vegetation till the Diluvial period," and an inquiry whether this should not be attributed to a great accumulation of ice in this part of the earth during the Tertiary period.

Considering that the vegetation of a temperate climate flourished during Eocene or Miocene times (probably during both) in Spitzbergen, in lat. 80°, and that the Tertiary beds of the province of Cherson in lat. 51°, in South Russia, contain a molluscan fauna of a tropical character, about half the species published from which are identical with, and nearly all the rest closely allied to species from one or other stages of the Eocene, and Oligocene, of England, France, Germany, and North Italy, and that this Eocene and Oligocene extends, between latitudes 44° and 52°, across the meridians from 0° to 35° (east of Greenwich), the longitude of Cherson, while Spitzbergen lies between the meridians 10° E., and 25° E., it seems to me simply impossible, upon any hypothesis of climate whatever, that this inquiry can be answered in the affirmative; and that the making it is scarcely in accordance with that exactness which Dr. Trautschold assigns to the science of geology.

Nov. 14th, 1883. SEARLES V. WOOD.

"KAMES AND DENUDATION."

Sir,—In last month's Geological Magazine (which it happened I did not read until to-day) there is a descriptive paper on Kames and Eskers in Norfolk and Cumberland by Mr. T. V. Holmes, in which he describes certain conclusions regarding subaerial denudation arrived at in my paper on the kames in this neighbourhood, published in the Geological Magazine six years ago, as "an instructive example of what invincible determination on behalf of a favourite agency can effect where zeal is untempered by discretion."

Leaving aside for the present the general question of the origin of kames, permit me to point out certain facts which prove that accumulations of sand and gravel do not enjoy that immunity from the action of atmospheric erosion which the theories of some geologists seem to demand.

In describing the Newport Kames I grouped along with them (for reasons which it is unnecessary to enter into now) what is known as the 100-feet terrace. Whatever view Scotch geologists may take of the origin of kames, they are at one as to the terrace having been laid down in the depths of the sea, indeed extending for miles over all the low-lying grounds of the North-east of Fife, perfectly flat and even-bedded it stands patently and undeniably a raised sea-bottom, but it is no longer the continuous plain it must have been when first elevated above sea-level. In the neighbourhood of the lofty kames and in many other parts it has been eroded into mounds, cones, and ridges quite undistinguishable in form from the kames and even the broad flat remains of it, which form its most striking characteristics, when examined closely, are seen to be worn into considerable hollows by the action of the rainfall.

Now when this comparatively recent accumulation of sand and gravel is so worn by atmospheric denudation, it seems to me impossible to conceive that similar formations situated nearly 800 feet above the sea-level, which Mr. Holmes says can be seen in Cumberland, can have remained practically unaffected by its ceaseless action throughout the much longer period which must have elapsed since Cumberland was submerged to 800 feet.

Yet Mr. Holmes seems not only to deny, but to ridicule the idea that rain and rivers must have played the most important part in giving their present shape to such loose aggregations.

This may not be "zeal untempered by discretion," to quote Mr. Holmes's elegant phrase; but it seems to me to be a striking example of the *un*scientific use of the imagination. Jas. Durham.

Newport, Fife, *4th, November*, 1883.

OBITUARY.

Rev. Professor Dr. Oswald Heer, of Zurich.[1]

In Dr. Oswald Heer, who died on the 27th of September, at the age of 75 years, we have lost the greatest of Fossil Botanists, and

[1] A brief notice of Dr. Heer appeared in our November Number, p. 528.—Edit.

one whose place it will be hard to fill. He possessed a power almost of divination which led him from the first sight of fragments of a leaf to assign genus and species to it, and his determination in hundreds of cases was confirmed by the subsequent discovery of flowers and fruit. We may say that our knowledge of the Arctic Secondary and Tertiary Floras is entirely due to Heer's labours, and Heer's leaf-determinations.

He was born near a celebrated fossil locality in the Canton Glarus, well known for the remarkable Fossil Fishes which are met with in its Eocene slate-quarries. His father, a Lutheran pastor, who had been a schoolmaster, tried to keep the boy at Latin and Greek; but he spent all his spare time in collecting all the insects and plants within his reach. He bribed his schoolfellows to add to his collections, by giving them singing lessons on Sundays. He was once lent a book on Natural History, the whole of which he copied out!

From the splendid collections made by young Heer in these and later years in the Miocene Tertiary deposits of Oeningen, near Lake Constance, and sent chiefly to his father's friend, Prof. van Breda at Harlem, in Holland, he maintained himself and paid his University fees.

In 1828 he entered the University of Halle, where he was to study theology; but he associated mainly with naturalists, among whom were Junghuhn, also Burmeister of Buenos Ayres, the last of whom alone survives him. When he left the University in 1832, he was ordained, and he had to choose between accepting the post of pastor at Schwanclen and that of Curator of the Entomological Collection of Escher and Zollikofer in Zürich. He chose the latter, and at Zürich he worked for half a century. He speedily became connected with the University, and was Professor of Botany to the well-known "Polytechnicum" from its first establishment in 1855. Here his lectures were delivered regularly, and were not even suspended when he was confined to his bed. Some idea of his marvellous energy can be formed from the fact that the Royal Society's Catalogue assigns 95 titles of separate papers to him up to 1874. His first papers were on Entomology, and his first great work was "On the Fossil Insects of Oeningen and of Radoboj in Croatia." He soon however took to Palæophytology, and his name will best be known by his books on this subject, namely:—

1. "Flora Tertiaria Helvetiæ" (1855—59), 8 vols. and 156 plates.
2. "Die Urwelt der Schweiz," 1865, and Second Edition, 1879. French Translation by Gaudin 1857. "Primæval World of Switzerland" (English translation), 1876.
3. "Flora Fossilis Arctica," 1868—83, 7 vols. and 398 plates.
4. "Flora Fossilis Helvetica," 1876, 1 vol. 70 plates.

When we consider that for the greater part of the last ten years Heer worked in his bed or on his sofa, the list we have given of his publications seems simply marvellous. He leaves to all his friends the memory of one of the most instructive of companions and the most genial of men.—R.H.S.

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