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EDITED BY

HENRY WOODWARD, F.G.S., F.Z.S.

HONORARY MEMBER OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, AND NORWICH; CORRESPONDING MEMBER OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE LYCEUM OF NATURAL HISTORY, NEW YORK.

ASSISTED BY

PROFESSOR JOHN MORRIS, F.G.S., &c., &c.,

AND

ROBERT ETHERIDGE, F.R.S., L. & E., F.G.S., &c.

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No. LXXIX.—JANUARY, 1871.

ORIGINAL ARTICLES.

I.—The Geological Bearings of Recent Deep-Sea Soundings.

By A. H. Green, M.A., F.G.S., etc.

Of the immense value of the recent deep-sea soundings there can be no doubt, but whether geologists will side with Dr. Carpenter in the deductions he has attempted to draw from these explorations seems to me a matter of considerable doubt: and I propose to discuss here several difficulties that have occurred to myself on this head. I shall take as my text Dr. Carpenter's last exposition of his views in a letter to *Nature* of Oct. 27th.

1st. With regard to the statement that we may be said to be still living in the Cretaceous epoch.[1]

I take it that by a geological epoch we mean a period of time during which there lived and flourished a group of animals, which, *when looked at in a large way*, has a character of its own, which marks it off in an unmistakeable manner from a group which went before and from another group which followed it. This characteristic stamp, which distinguishes the fauna of any epoch from that of all other epochs, is spoken of as its *facies;* and when, in ascending or descending through a series of stratified rocks, we find at any point a marked change in the *facies* of the contained fossils, we say that at that point we have passed from one geological epoch to another. Whether the hard and fast lines which we are thus enabled to draw between successive geological epochs are due or not to great unrepresented gaps in the record of the earth's history furnished by the stratified rocks, does not now concern us: it is enough that such lines exist, and that by means of them we can parcel out bygone time into geological epochs.

Can, then, the fauna of the sea on whose bed the Chalk of to-day is forming be said, *on a broad view*, to be the same as the fauna whose

[1] This theory was, we believe, put forward, in the first instance, on the authority of Prof. Wyville Thomson, F.R.S., Dr. Carpenter's colleague in the Government Dredging Expeditions.—Edit. Geol. Mag.

remains are preserved in the Chalk of Dover? I am not surprised that certain low forms should be common to the two, because the conditions under which such creatures live do not in all likelihood involve that struggle for existence to which specific change is probably due; they have ample space and ample sustenance for animals of their simple requirements. Some few forms too, somewhat higher in the scale, seem to have lived on in "the dark unfathomed caves of ocean" but little affected by the round of changes that have so largely altered the dwellers on the upper world, though here it seems that the modern representatives are only generically allied, and not specifically identical, with the older forms, a point of the highest importance. But, leaving these cases out of the question, are the two faunas, *as a whole,* a bit alike? Take one simple instance. The older Chalk swarms with Ammonites, Scaphites, Baculites and Belemnites, all well-marked and typical forms, not one of which will be embedded in the Chalk of to-day; and the old Chalk has not yet furnished a single fragment of a marine mammal, many species of which will be preserved in the modern Chalk. A palæontologist would readily point out any number of similar contrasts between the two faunas; but what I have said will, I think, make it clear why it is that I cannot understand how any one can say we are living in the Cretaceous epoch, unless he at the same time asserts that the age of a geological formation is to be determined from those beds only which are formed out of Foraminifera, and by the Foraminifera alone of the fossils contained in such beds.

2nd. Dr. Carpenter very clearly explains the striking difference, both in mineral character and fossil contents, between the deposits now forming over the "cold area" overflowed by the frigid arctic current, and the Globigerina-mud which is accumulating in the "warm area" bathed by the more genial equatorial current; and he is uneasy lest the geologist of the future should, unless he is more wide awake than the geologist of to-day, refer two such widely differing deposits to epochs far apart, and, finding them occur side by side, be led to the rash step of inserting a hypothetical fault between them.

I beg to assure Dr. Carpenter that no *field-geologist* would ever run the risk of falling into such a blunder. The two areas, as Dr. Carpenter states, interpenetrate one another; their deposits will not, therefore, be marked off from one another by a sharp boundary, but will dovetail into each other over the sloping sea bottom, and there will be a gradual blending of one into the other, both in lithological character and fossil contents; probably, too, the animals typical of each area will, as they approach the uncongenial neighbourhood of the other area, become step by step less numerous, and perhaps dwarfed and stunted. These facts, noted in the field, will show clearly to the geologist that he is not dealing with two deposits of different ages; in spite of the vast lithological and palæontological differences between the two groups of rocks, he will be able to trace the gradual passage of one into the other, and he will thence conclude that they were accumulated at the same time, but under different circumstances. With some such vague explanation as this, the geologist of the past might have had to content himself; thanks to the labours of Dr. Carpenter and his colleagues, the geologist of the future will be able to say more definitely in what this difference probably consisted.

3rd. Dr. Carpenter, if I understand him aright, states that the unhappy geologist of the future will be further bewildered by finding hills 1,800 feet high capped by Chalk containing the remains of warm-water-loving animals, while the hills themselves, and the land from which they rise, will be formed of Sandstone full of the exuviæ of Boreal forms, and will again fall into the error of referring such dissimilar beds to geological epochs far apart from one another.

If the floor of the ocean shows anywhere a plateau rising 1,800 feet above the surrounding sea-bottom, and *bounded all round by vertical cliffs or slopes so steep that no deposit will lie upon them,* and if the warm current flows over the top of such a plateau, while the surrounding depths are filled by the lower cold current, Dr. Carpenter's fears may be realized, and there may be a "fix" in store for the geologist of the future. But if, as seems more likely, the sides of these elevated spaces have an easy gradient, then along the slopes there will be that gradual passage from one form of rock to the other, and that intermixture along the border region of the fossils, elsewhere peculiar to one or other of the deposits, which will, as already mentioned, show clearly that both are of the same geological age.

4th. Dr. Carpenter warns geologists against any longer regarding "the occurrence of Boreal forms in any marine deposits as adequate evidence *per se* of the general extension of Glacial action into temperate and tropical regions." But have geologists ever rendered such a warning necessary? The evidence by which such extension is proved to have taken place does not consist one bit in palæontological data, but in such broad physical facts as these: The extensive land-glaciation of countries now free from ice; the carrying of huge unrounded boulders far away from their parent rock; the occurrence of what is known as Boulder-Clay; the heaping up of masses of débris resembling in every respect the moraines of modern glaciers, and resembling nothing else we know of. On these and such like broad physical grounds geologists base their belief in Glacial Periods; and when they find arctic forms of mollusca in associated beds, they are glad, because, though the hypothesis stood well enough on its own legs, this confirmation of it by palæontological evidence is gratifying. The only thing I can think of at all like the case suggested by Dr. Carpenter is the inference that there was "a continual refrigeration of climate during the Pliocene period in Britain,"[1] drawn from the increasing percentage of northern forms of mollusca which is found as we ascend from the Coralline to the Norwich Crag. But, if we had looked at the Crag alone, I do not

[1] Lyell. Elements of Geology, 6th Edition, p. 205.

think this fact would have gone for much. We have independent physical evidence that the Crag was followed by a period of intense cold; and, knowing this, we are justified in looking upon the arctic character of the Crag fauna, which in itself would not have been much to lean upon, as a proof that the refrigeration began during the Crag period.

I have spoken very plainly, because the man who speaks plainly is most likely to make himself understood; but I will venture, though it is hardly necessary, to say that nothing could be further from my thoughts than to show any want of respect for the eminence and scientific attainments of Dr. Carpenter, whom it would be impertinence in me to praise.

II.—A Census of the Marine Invertebrate Fauna of the Lias.

By Ralph Tate, Assoc. Lin. Soc., F.G.S., etc.

THE Marine Invertebrate Fauna of the Lias would, if one consulted Morris's Catalogue of British Fossils, published in 1854, be regarded as exceedingly poor, especially in certain classes, relative to the thickness of the rocks constituting that system. Thus, I count, eliminating synonyms, 130 species of Cephalopoda, 5 of Gasteropoda, 57 of Conchifera, 37 of Brachiopoda, 1 of Crustacea, 2 of Annelida, 21 of Echinodermata, and 2 of Zoantharia, and if to these we add the fish and other forms of life, we obtain a total of 426 species of plants and animals. But during the lapse of 16 years, this number has been nearly tripled, and to those classes, which were either unrepresented or characterized by a paucity of species, great accessions have been made. Notably, the number of Gasteropoda has risen from 5 to 269; the Conchifera from 57 to 297, the Brachiopoda have been augmented by the addition of 39 species, the Corals now number 67, and the Polyzoa and Sponges, previously unrepresented, now have a place in the list.

In the last decade the following monographs have appeared in the publications of the Palæontographical Society:—The Liassic Starfishes, by Dr. Wright; the Liassic Belemnitidæ, by Professor Phillips; and the Liassic Corals, by Professor Dr. Duncan. These bring up our information on the classes treated of to a satisfactory and determinate position; and Memoirs by Mr. Day, Dr. Lycett, Dr. Oppel, Mr. C. Moore, Mr. H. Woodward, Dr. Wright, and myself, have contributed also largely to our knowledge of the Liassic Invertebrate Fauna of this country. These materials have formed the basis on which I have taken the census, so to speak, of the British Liassic population; but the labour has been more than merely docketing the published names of species, quoted for the System, as the claims of each new species have, to the best of my ability, been investigated, and the names have been rejected or accepted accordingly. The exercise of this caution I have found necessary, chiefly because, from the great number of separate palæontological memoirs extant, estimated at upwards of 130, authors are liable, from inadvertency, to describe as new what may have already been figured. The variability of certain species is also a fruitful source of multiplication of specific names; and the synonyms of certain species, whose limits are ill-defined, are most voluminous; such are *Cardinia ovalis* and others, *Pecten dextilis*, *Rhynchonella variabilis*, *Spiriferina rostrata*, etc., etc.

My own labours have been more especially directed to the Mollusca, but much remains to be done before an approximate estimate of the number of species belonging to this sub-kingdom can be given. Several species not included in my census have been described, the claims of which to a place in a catalogue can only be determined by an examination of the type specimens. The determination of such dubious species will necessitate a visit to several public museums. Thus, the Whitby Museum contains the types of 130 Cephalopoda, and 122 species of other classes of Mollusca, the names of which have not been generally accepted. Indeed, with the exception of the Cephalopoda, very little is known respecting the species of the Yorkshire Lias, and till we know more of them and of their distribution, the sub-divisions of the Liassic rocks of Yorkshire cannot be brought, with any degree of confidence, into juxtaposition with those of the more typical district of the south-west of England.

Distribution of the Genera.—In the accompanying table are given the names of all the genera known in the Lias, and the numbers in the first column refer to the number of species of the genus in the British Lias, whilst those in the second column indicate the total number of species, British and Continental.

The Rhætic species are excluded from these enumerations, as we are in possession of full information respecting them[1]; but the species from the Supra-Liassic Sands are included.

The total number of marine invertebrate species in the European Lias is 2,126; of these 997, or nearly one-half, are found in Great Britain. Singularly enough, this proportion holds good for the majority of the classes (see Summary, Table II.).

If to the number of marine invertebrate fossils we add those of the Foraminifera, insects, plants, and the vertebrata, we have a total of 1,228 species in the British Liassic deposits.

Class Cephalopoda.—All the genera are, at least, Mesozoic; one only, *Xipthoteuthis*, is peculiar.

Class Gasteropoda.—A large proportion of the genera date from the Trias, such are *Acteonina*, *Chemnitzia*, *Cerithium*, *Fusus*, *Neritopsis*, etc.; a few range upwards from the older rocks, as *Chiton*, *Dentalium*, *Litorina* (?), *Patella*, *Natica*, *Pleurotomaria*, *Turbo*, and *Trochus* (?); *Cryptænia* became extinct in the Middle Lias; *Alaria* and *Trochotoma* commence in the Rhætic; whilst *Bulla*, *Cryptolax*, *Exelissa*, *Onustus*,

[1] M. Jules Martin, E'tage Rhætién.

Purpurina, *Pileolus*, *Pterocera*, *Rimula*, *Puncturella*, *Pyrula*, *Tectaria*, *Tornatella* (?), and *Turbinella* begin with the Lias. No genus of Gasteropodous shells is peculiar, if we except *Pterocheilos* and *Pleuratella* (Moore), which appear to be founded on immature individuals, and, consequently, may prove eventually to belong to known genera.

Class Conchifera.—Here, also, the majority of the genera commenced in the Trias, whilst a few range from Palæozoic times through succeeding formations, such as *Cypricardia*, *Pinna*, *Solemya*, *Inoceramus*, etc. *Axinopsis* and *Myophoria* do not pass beyond the Lower Lias. *Protocardium*, *Cythere*, *Pholadomya*, *Gastrochæna Placunopsis*, *Saxicava*, and *Tancredia* date from the Rhætic; whilst *Exogyra*, *Fistulana*, *Gresslya*, *Goniomya*, *Homomya*, *Limopsis*, *Pleuromya*, *Pholas*, *Pteroperna*, *Sowerbya*, *Spondylus*, *Thracia*, *Trigonia*, *Teredo*, *Unicardium*, and *Venus* are not older than the Lias. The following genera are peculiar, *Cardinia*, *Conchodon*, *Hippopodium*, and *Terquemia*.

Class Brachiopoda.—The majority of the genera have an extensive range; *Leptæna* becomes extinct in the Upper Lias. *Megerlea*, *Terebratella*, *Terebratulina*, and *Zellania* commence in this system, and *Suessia* is confined to it.

Class Polyzoa.—With the exception of *Berenicea*, all the genera of Polyzoa date from the Lias.

Class Crustacea.—All the Malacostracous Crustaceans belong to Mesozoic genera; *Scapheus* is peculiar. Of the Entomostraca, all have a wide range, if we except *Aspidocaris*, recalling the Palæozoic genus *Discinocaris*, which is Triassic and Liassic. Of the Cirripedia, *Pollicipes* dates from the Rhætic, and *Zoocapsa* is peculiar.

Class Annelida.—*Terebella* and *Vermicularia* commence in the Lias, the other genera are much older.

Class Echinodermata.—Excepting *Cidaris* and *Rhabdocidaris*, which are also Triassic, all the genera of Echinidea date from the Lias; *Microdiadema* is peculiar. All the genera of Ophiuridea are represented in existing seas; so also the Asteriadea, excepting *Tropidaster* and *Plumaster*, which are peculiar. The Crinoidea comprises *Pentacrinus* ranging from the Trias, *Apiocrinus*, *Cotylederma*, and *Eugeniocrinus* from the Lias, and *Extracrinus* and *Microcrinus*, which are peculiar.

Class Zoantharia.—About one-half the genera of corals are represented in the Trias, a few are peculiar, whilst the rest range upwards from the Lias.

Class Spongida.—*Neurofungia* is doubtfully peculiar.

If we confine our attention to the succession of life in the British strata, then the generic grouping in the three members of the Lias becomes more pronounced:—the Middle Lias being the horizon at which appear *Rotella*, *Niso*, *Opis*, and *Limea;* the Upper Lias the same for *Trigonia*, *Corbis*, *Cythere*, and *Macrodon*.

The distribution of some of the peculiar and restricted genera in the three members of the Lias is represented in the following table:—

	Lower.	Middle.	Upper.		Lower.	Middle.	Upper.
Beloteuthis	.	.	x	*Terebratulina*	x	x	.
Teudopsis	.	.	x	*Stomatopora*	x	.	.
Xiphoteuthis	.	x	.	*Neuropora*	x	x	.
Bulla	.	x	.	*Proboscina*	x	.	.
Cryptœnia	x	x	.	*Semimulticlausa*	x	.	.
Cryptolax	.	.	x	*Lichenopora*	x	.	.
Exelissa	.	x	.	*Spiropora*	.	x	.
Pileolus	.	x	.	*Magila*	.	.	x
Purpurina	.	x	.	*Uncina*	.	.	x
Puncturella	.	x	.	*Megacheirus*	x	.	.
Onustus	.	x	x	*Scapheus*	x	.	.
Axinopsis	x	.	.	*Æger*	x	.	.
Cardinia	x	x		*Hefriga*	.	.	x
Gresslya	.	x	x	*Pollicipes*	x	.	.
Hippopodium	x	x	.	*Zoocapsa*	?	.	.
Isocardia	.	x	.	*Holectypus*	.	x	.
Limopsis	.	x	.	*Heterocidaris*	.	.	x
Pholas	.	.	x	*Pygaster*	.	x	.
Spondylus	.	.	x	*Uraster*	.	x	.
Terquemia	x	x	.	*Tropidaster*	.	x	.
Trigonia	.	x	x	*Luidia*	.	x	.
Teredo	.	.	x	*Plumaster*	.	x	.
Venus	.	x	.	*Astropecten*	.	x	.
Leptæna	.	x	x	*Cotyloderma*	.	x	.
Megerlea	.	x	.	*Microcrinus*	x	.	.
Suessia	.	x	.	*Oppelosmilia*	x	.	.
Terebratella		x	.	And most Corals*	x	.	.

* The distribution of the Corals is the inverse of that of the Star-fishes.

DESCRIPTIONS OF NEW SPECIES:

Cerithium Huttoni, nov. spec.—Shell small, turriculated, spire acute, whorls six, angulated; penultimate whorl ornamented with four very prominent obtuse encircling smooth ribs, the upper two smaller than the lower ones, the superior one of the latter carinating the whorl; the lower half of the last whorl with a few smooth ribs; interspaces apparently smooth. Aperture subquadrate. *Marlstone.* Dumbleton (Coll. Mrs. Hutton, *neé* Holland, to whom the species is dedicated).

Cerithium ligaturalis, nov. spec.—Shell cylindrical, turreted, spire acute, whorls about 15, imbricating, ornamented with a broad depressed band encircling the upper suture, and a narrow one around the lower suture; the carina at about the anterior third of each whorl. Transverse striæ oblique and distant; last whorl with three ribs below the keel. Base convex, smooth; aperture elongated; canal obsolete. Allied to *C. Sidæ* (D'Orb.) and *C. Ibex* (Tate). *Marlstone.* Red Mile, Lincolnshire. (Coll. Geol. Surv.)

Cerithium Dayii, nov. spec.—Differs from *C. subreticulatum* (D'Orb.), in its excavated suture, fewer (4) longitudinal and transverse lines, which produce denticulations rather than granulations, and from *C.*

Ilminsterensis (Moore), in having four rows of subspinous costulæ. *Middle Lias.* Down Cliff, Charmouth. (Day-Coll., Geol. Surv. Mus.)

Cerithium subfistulosa, nov. sp.—Related by its form and ornamentation to *Chemnitzia fistulosa,* Stol., and *Turritella inæquicinctum,* Münst.; from the former it differs in its serrated median rib, in being proportionately broader, and in the absence of transverse striæ; and from the latter chiefly in its fewer ribs. *Marlstone.* Red Mile, Lincolnshire. (Coll. Geol. Surv.)

Cerithium raricostati, nov. sp.—Elongated, whorls 10, convex, upper ones subangulated, with a broad and deep suture, ornamented with about 25 *strongly-curved, thick,* transverse ribs, crossed by about 8 lamelliform costæ. *Zone of Ammonites raricostatus.* Churchdown. (*Rev. F. Smithe.*)

Chemnitzia trivia, nov. sp.—Shell elongated, of about 15 convex whorls; closely allied to *C. Carusensis* (D'Orb.), but not so slender; the posterior whorls with numerous, stout, oblique, not arched, ribs (the anterior ones, occasionally with abruptly curved ribs), crossed by fine longitudinal lines. *Lower Lias Limestone.* Bridgend. (*R. T.*)

Chemnitzia complicata, nov. spec.—Whorls rounded, suture impressed; last whorl ornamented with about fifty thick oblique ribs, which as they approach the anterior suture split up into fine raised lines; and about ten inequidistant longitudinal sulci; those bounding the posterior suture forming granulations. Base striated. *Marlstone.* Hyde, near Yeovil. (Geol. Surv. Mus.)

Natica pilula, nov. sp.—Very small, globose, spire depressed, slightly convex, whorls 4 to 5, ornamented with fine longitudinal lines; aperture narrow. *Upper Lias.* Dumbleton, very abundant. (*Rev. P. B. Brodie, etc.*)

Trochus inconstans, nov. sp.—Very similar to *T. turriformi,* K. and D., from which it differs chiefly in the variable form of the whorls. Turreted, conical, apex acute; whorls from 15 to 20, smooth, flat, or with a broadly chanelled suture, or as sometimes they are slightly imbricating. *Lower Lias.* Bridgend. (*R. T.*)

Solarium inornatum, nov. sp.—Very small, closely allied to *S. Thomsoni* (Tate); orbicular spire obtuse, subdepressed, whorls four, convex, smooth, shining with fine striæ of growth; base flat with radiating wrinkles and striæ; umbilicus narrow, aperture subquadrate; columella straight, callously thickened in front. *Middle Lias.* Chipping Campden. (*Rev. P. B. Brodie.*)

Solarium lucens, nov. sp.—Differs from *S. inornatum* in its more elevated and acute spire, and the raised margin bounding the anterior suture of the upper whorls. Whorls four, smooth, shining, coarsely wrinkled; reddish-yellow in colour; last whorl sub-angulated. *Middle Lias.* Mickleton. (*Mr. Gavey.*) The last two species are provisionally referred to *Solarium,* and may, with some others, belong to a genus not yet defined.

Monodonta modesta, nov. sp.—Small, turbinated, conical, spire short, composed of four nearly flat, smooth, shining whorls; suture linear; last whorl large, obtusely angulated; base oblique and imperforate. *Marlstone.* Churchdown, Cheltenham. (*R. T.*)

Acteon tessellatus, nov. spec.—Ovate elongated, whorls six, convex, bluntly keeled at the suture; last whorl ornamented with about twenty narrow, equidistant, longitudinal sulci, and fine, close, perpendicular striæ, which produce a punctated appearance within the sulci. Aperture oval. Total length, eleven-twentieths of an inch. Differs from *A. Broliensis* (Buv.), chiefly in its ovate form. *Marlstone.* Gratton, Gloucestershire. (*Coll. Dr. Holl.*)

Opis Deslongchampsi, nov. sp.—Shell subtrigonal, ventricose, somewhat compressed; umbones anterior, acute, and subspiral; posterior side truncated, anterior rounded; obliquely keeled posteriorly and anteriorly. Ornamented by a few imbricating lamellæ of growth, and by numerous flat, transverse costæ. *Middle Lias.* Gasteropod bed; May! Marlstone; Uley, Gloucestershire. (Coll. Geol. Surv.)

CATALOGUE OF MARINE INVERTEBRATA OF THE LIAS.[1]

	No. Specs.	
	Brit.	Euro
TABLE I.		
CLASS *CEPHALOPODA*.		
Ammonites	128	266
Belemnites	57	105
Nautilus	9	17
Sepiadæ	1	11
Xiphoteuthis	1	1
CLASS *GASTEROPODA*.		
Acteonina	12	35
Alaria	6	21
Bulla	.	2
Capulus	.	2
Cerithium	40	79
Chemnitzia	19	55
Chiton	.[2]	3
Cirrus	.	3
Cryptœnia	6	16
Cryptolax	1	1
Dentalium	8	11
Emarginula	3	5
Hydrobia	.	1
Fusus	3	7
Exelissa	1	1
Litorina	2	6
Monodonta	1	1
Natica	5	15
Neritina	3	4
Neritopsis	4	11
Niso	3	17
Onustus	3	5
Patella	7	12
Phasianella	3	11
Pileolus	.	1
Pitonillus	2	4
Pleurotomaria	23	67
Pterocera	1	2
Puncturella	.	2
Purpurina	1	1
Pyrula	1	1
Rimula	.	1
Rotella	.	1
Solarium[3]	15	31
Stomatia	.	1
Tectaria[4]	22	40
Tornatella	8	14
Cinulia	.	1
Trochotoma	1	9
Trochus	27	79
Turbinella	1	1
Turbo	31	59
Turritella	6	26
CLASS *CONCHIFERA*.		
Anatina	5	8
Anomia	4	8
Arca	5	13
Astarte	14	36
Avicula	21	37
Axinopsis	.	1
Cardinia	16	49
Cardita	3	6
Cardium	5	11
Ceromya	2	3
Conchodon	.	1
Corbis	1	2
Corbula	.	3
Cucullæa	13	19

[1] MS. species are not included.
[2] Certain forms referred to this genus are *Opercula Neritopsis.*
[3] Including *Discohelix* and *Straparolus.*
[4] Including *Amberleya* and *Eucyclus.*

	No. Specs. Brit.	Euro
Cypricardia	12	22
Cythere	.	1
Exogyra	2	2
Fistulana	.	1
Gastrochæna	1	1
Gervillia	10	16
Goniomya	4	9
Gresslya	5	8
Gryphæa	3	3
Hinnites	3	3
Hippopodium	2	2
Homomya	1	3
Inoceramus	7	12
Isocardia	1	2
Leda	15	31
Lima	23	33
Limea	1	4
Limopsis	1	1
Lithodomus	.	2
Macrodon	1	1
Myoconcha	3	5
Myophoria	.	1
Mytilus	18	27
Opis	8	10
Ostrea	2	5
Pecten	25	50
Perna	3	5
Pholadomya	9	30
Pholas	.	1
Pinna	4	9
Placunopsis	2	4
Pleuromya	8	30
Plicatula	8	30
Posidonomya	1	5
Pteroperna	1	1
Saxicava	2	6
Solemya	.	1
Solen	1	2
Sowerbya	1	1
Spondylus	.	3
Tancredia	3	17
Teredo	.	1
Terquemia	2	5
Thracia	2	6
Trigonia	4	7
Unicardium	4	16
? *Venus*	2	3
CLASS *BRACHIOPODA.*		
Crania	3	4
Discina	5	6
Leptæna	5	6
Lingula	4	6
Megerlea	2	2
Rhynchonella	19	28
Spiriferina	8	12
Seussia	1	2
Terebratella	1	1
Terebratula	4	10
Terebratulina	1	2
Thecidium	7	16
Waldheimia	12	20
Zellania	4	4
CLASS *POLYZOA.*		
Berenicea	2	3
Lichenopora	.	1
Neuropora	1	6
Proboscina	.	1
Porosmilia	.	1
Semimulticlausa	.	1
Spiropora	1	2
Stomatopora	1	2
CLASS *CRUSTACEA.*		
I. Malacostraca.		
Æger	1	1
Eryma	3	9
Eryon	6	9
Glyphæa	4	8
Hefriga	1	1
Magila	.	1
Megacheirus	.	2
Palinurina	2	2
Penæus	2	3
Pseudoglyphæa	2	5
Scapheus	1	1
Uncina	.	1
II. Entomostraca.		
Aspidocaris	.	1
Bairdia	.	5
Cythere	3	11
Cytherella	0	10
Estheria	.	1
Moorea	1	1
Pollicipes	2	3
Zoocapsa	1	1
CLASS *ANNELIDA.*		
Ditrupa	4	4
Galeolaria	1	2
Serpula	7	22
Spirorbis	1	2
Terebella	.	1
Vermicularia	1	1
CLASS *ECHINODERMATA.*		
Acrosalenia	1	2
Cidaris	2	10
Collyrites	.	1
Diademopsis	.	3
Diplocidaris	1	1
Hemicidaris	.	1
Hemipedina	4	12
Heterocidaris	.	1
Holectypus	1	1
Microdiadema	.	1
Pseudodiadema	1	3
Pygaster	.	1
Rhabdocidaris	1	3
Ophioderma ?	1	1
Ophioglypha	8	8

	No. Specs. Brit.	No. Specs. Euro
Ophiura ?	1	1
Astropecten	1	1
Luidia	1	1
Plumaster	1	1
Tropidaster	1	1
Uraster	2	2
Apiocrinus	1	1
Cotylederma	2	5
Eugeniocrinus	.	2
Extracrinus	2	2
Microcrinus	.	1
Pentacrinus	9	24
Plicatocrinus...	1	2
CLASS *ZOANTHARIA*.		
Actinastræa	.	1
Antillia	.	2
Astrocœnia	12	13
Cladophyllia	.	1
Cladosmilia	.	1
Cyathocœnia	4	4
Elysastræa	2	2
Epismilia	.	3
Isastræa	8	15
Latimæandra	1	1
Lepidastræa	.	1
Lepidophyllia	2	2
Microsolena	.	2
Montlivaltia	18	47
Oppelosmilia	1	1
Pleuropora	.	1
Rhabdophyllia	2	2
Septastræa	4	4
Stephanastræa	.	1
Stylastræa	.	2

	No. Specs. Brit.	No. Specs. Euro
Thecocyathus...	2	2
Thecoseris	.	2
Thecosmilia	11	15
CLASS *SPONGIDÆ*.		
Cliona	.	2
Grantia	1	1
Neurofungia	1	1

TABLE II.

SUMMARY.

	Brit.	Euro
Cephalopoda	196	400
Gasteropoda	269	650
Conchifera	297	622
Brachiopoda	76	119
Polyzoa	5	17
Crustacea	29	76
Annelida	14	32
Echinodermata	42	93
Zoantharia	67	124
Spongiadæ	2	4
	997	2126
The life of the British Triassic Rocks is completed by the following:—		
Reptiles	31	
Fish	114	
Insects	24	
Foraminifera...	49	
Plants	12	
	230	
Grand Total	1227	

III.—The Development of Land.

By J. Clifton Ward, F.G.S.; Associate of the Royal School of Mines; of the Geological Survey of England and Wales.

WHENEVER a bone is about to be produced in the animal body, its form is first sketched out in connective tissue or cartilage, and then ossification commences at one or several points; if there is but one centre of ossification, or if several centres unite, but one bone is formed; if the several centres do not completely unite, as many *separate* bones are produced.

Now, in the growth of continental land there is something very akin to this. The present form of many countries has been sketched out in a general way long ages ago, and is due to growth around a single centre or several centres. One of the most simple examples of this is perhaps to be found in the geological history of Italy.

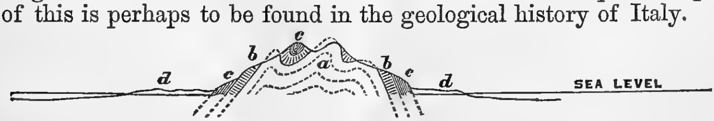


Fig. 1. Diagrammatic Section across Italy in about the latitude of Rome.
a. Jurassic. *b*. Cretaceous. *c*. Eocene. *d*. Miocene and Pliocene.

A section across the peninsula in about the latitude of Rome would exhibit somewhat of the following structure, seen in Fig. 1, where the Jurassic, which are the oldest rocks of the country, form the nucleus of the Apennine chain, and the Cretaceous and Eocene lie on their flanks, with some minor patches left on or near the summit, while rocks of Miocene and Pliocene age form the low-lying tracts of land between the base of the mountains and the sea. The central mass of Jurassic rocks stretches along the median line of the peninsula from a point east of Naples to one some way south of Florence, and south and north of these respective points it is wrapped round by a narrow framework of Cretaceous rocks, and then by those of Eocene age, which last continue the ridge of the Apennines onward to a little east of Genoa.

The history of Italy, so far as can be deduced from these stony records, seems not to go back further than the Jurassic period;[1] and the first decided production of land of which we have any knowledge occurred not until the close of the Middle Eocene.[2] Then it was that this great thickness of strata, which had been accumulating for so long, was slowly upheaved along a line which now constitutes the chain of the Apennines in Southern Italy and great part of the Alps in Northern. The elevation, accompanied by contortion of the strata, was gradual, so as to allow of an enormous denudation of Eocene and Cretaceous rocks, which over a considerable part of the elevated area were, with the exception of minor patches, entirely swept away, thus exposing the Jurassic rocks at the surface. This denudation, therefore, deprived the slowly-rising land of much of its height; and had the elevation taken place rapidly, the present range of the Apennines might have been twice or more as lofty as it is at present.

The geography of Italy at about the close of the Eocene and commencement of the Miocene period must have presented somewhat the form shown in Fig. 2, where the dotted line shows the present contour, and the shaded part the then existing land.

In the seas around this land were deposited strata, first of Miocene, then of Pliocene age; but it would seem as if that force, which had before been manifesting itself in producing a slow upheaval of the ocean's bed, being able to produce no further effect in that direction, now broke fairly through the solid crust in several points, and gave rise to the phenomena of volcanoes.[3] The Vicentine and the Euganean Hills, near Padua, are formed of volcanic rocks interstratified with deposits of Pliocene age; and by some of the eruptions in the seas of this period great numbers of fish were suddenly destroyed and preserved in calcareous ash.

[1] Rocks of Silurian age occur in *Sardinia*, according to General della Marmora (Voyage en Sardaigne).

[2] There may have been some *minor* upheavals, producing local unconformities in the several groups of strata.

[3] In Sardinia are evidences of volcanic eruption in Miocene times; and very probably some of the eruptive rocks of the neighbourhood of Genoa date from this period.

Fig. 2. Ideal form of the Italian Peninsula at the close of the Eocene period.

Towards the close of the Pliocene, volcanic activity began to show itself along the western side of the island, north and south of the present districts of Rome and Naples, and about the same time a further upheaval took place, raising the recently-formed Pliocene strata high and dry, and thus giving to the old land a framework of new and comparatively flat country, and causing it to assume very much its present outline, many of the peculiarities of which, however, have been produced by denudation and minor oscillations of level acting through Post-Pliocene and modern times.

There is little question but what the first eruptions in the district of which Naples is now the centre took place ere the final upheaval, and the ashes showered forth fell in the surrounding sea and were deposited in strata which now form the fertile Campagna Felice, just as the ashes of Vesuvius have, for many centuries, from time to time been falling into the waters of the Bay of Naples, where they will have formed beds alternating and mixed up with purely marine deposits.

After the elevation of the land just spoken of, the eruptions, being sub-aerial, gave rise to many volcanic hills, which now agreeably relieve the monotony of the plains.

At what precise period Vesuvius began to exist,[1] whether at first as a sub-marine volcano, or not until the post-Pliocene elevation took place; whether its first eruptions were coeval with those of the Phlegræan Fields; or whether the Neapolitan group, as a whole, came into activity simultaneously with that around Rome; are points not easily determined. It is sufficiently evident, however, that the birthtime of most, if not of all, was just about the close of the Pliocene period; that is to say, their products of eruption directly overlie strata of Pliocene age.

Such, in brief, is a sketch of Italian geological history; some of the most noteworthy points of which seem to be the following:—

1. The geological records date back only to Jurassic times, and there is no direct evidence of land over this area until late Secondary or early Tertiary.

2. The formation of Italy has been effected in a very simple manner, namely, by the upheaval of three consecutive marine formations into a long chain of mountains, and by the deposition round this long island of marine strata belonging to the Miocene and Pliocene periods, and their subsequent moderate upheaval.

3. The time through which this history carries us back divides itself into three separate periods as regards action from below. 1. A period of tranquillity, or slow depression, during which tranquil marine deposition was going on. 2. A period of vast internal force manifested in the form of upheaval of land, and formation of lofty mountains. 3. A period, not yet entirely over, of the same force manifested in an outward, or volcanic form.

In the case of Italy, which we have just considered, growth took place *around* one long island or peninsula, and the first formed *centre* seems not to have been subsequently depressed so as to allow deposition unconformably *upon* it. When, however, we consider the geological history of England, we find its case to be far otherwise. Two centres of ossification seem from very early times to have been established, both along the western margins of our present land, and corresponding to the districts of Wales and Cumberland. In Mid-Silurian times land clearly existed in Wales and adjacent parts, though this early nucleus—as well as one which probably existed in Cumberland at the same time—was soon depressed, and the deposits of Upper Silurian age, which were first formed *around*, gradually overlapped, and were formed *upon* the old land surface. These original *centres* reappeared in a measure in Old Red times, and probably did not entirely disappear in Carboniferous times, at the close of which they were again more fully developed.

Through the Permian and Triassic periods the Welsh and Cumbrian centres remained distinct and separate,[2] while deposition was

[1] Etna dates clearly from the Pliocene period; its earlier eruptions being submarine, ashes and lavas interbedded with Pliocene strata.

[2] See "Geological Dream on Skiddaw," in "Ice," a Lecture, etc.

going on all *around*, and very probably a new centre was produced along quite the south-eastern edge of England. In Oolitic times the two former had probably united to form one western stretch of land, which gradually extended itself eastwards towards the close of that period, while the south-eastern mass of land was depressed, and received deposits upon it.

In Cretaceous times the land had retreated somewhat westwards, occupying rather more than the present western half of England, and then again during Tertiary ages increased slowly eastwards, until the whole of the present England was represented.

Lastly, during the Glacial period, such a submergence took place as to leave only parts of the original Welsh and Cumbrian centres above water, with perhaps a southern mass of land, thus, as it were, restoring the embryonic condition of England for a brief space at the close of its long history.

In the case of English geological history we have then to observe the following points:—

1. The geological records date back to Cambrian times, and there is clear evidence of land-centres as far back at least as the Mid-Silurian.

2. The early land-centres of Wales and Cumberland received depositions of strata *around and upon* them until the close of the Carboniferous, since which time they have been completely above water, with the exception of the partial submergence of the Glacial period. Thus, England may be considered a much older country than Italy, and to have had a more complex origin.

3. The long periods during which these two centres have remained as dry land, explains the enormous amount of sub-aerial denudation which seems to have taken place[1] in these districts.[2]

The study of ancient physical geography, which hitherto has received so little attention, is becoming daily of more and more importance and interest, inasmuch as by its consideration alone shall we probably be able to work out the great question of the succession and distribution of life upon the globe.

IV.— On the Transport of the Wastdale Crag Blocks.

By James Croll, of the Geological Survey of Scotland.

CONSIDERABLE difficulty has been felt in accounting for the transport of the Wastdale Granite Boulders across the Pennine chain to the east. Professors Harkness[3] and Phillips,[4] Messrs. Searles Wood, jun.,[5] Mackintosh,[6] and I presume all who have written on the subject, agree that these blocks could not have been

[1] "On the Denudation of the Lake District," Geol. Mag., January, 1870.

[2] It is curious to think how much older our English mountain districts are than the great ranges of the Alps, the Apennines, the Himalayas, the Andes, and the Rocky Mountains.

[3] Quart. Journ. Geol. Soc. xxvi., p. 517.

[4] British Assoc. Report for 1864 (Sections), p. 65.

[5] Quart. Journ. Geol. Soc., xxvi., p. 90.

[6] Geol. Mag., VII., p. 349.

transported by land-ice. The agency of floating ice under some form or other is assumed by them all.

We have in Scotland phenomena of an exactly similar nature. The summits of the Ochils, the Pentlands, and other mountain ranges in the east of Scotland, at elevations of from 1,500 to 2,000 feet, are not only ice-marked, but are strewn over with boulders derived from rocks to the west and north-west. Many of them must have come from the Highlands distant some 50 or 60 miles. It is impossible that these stones could have been transported, or the summits of the hills striated, by means of ordinary glaciers. Neither can the phenomena be attributed to the agency of icebergs carried along by currents. For we would require to assume not merely a submergence of the land to the extent of 2,000 feet or so,—an assumption which might be permitted,—but we should have to assume that the currents bearing the icebergs took their rise in the elevated mountains of the Highlands, a most unlikely place, and that these currents radiated in all directions from that place as a centre.

In short the glacial phenomena of Scotland is wholly inexplicable upon any other theory than that, during at least a part of the glacial epoch, the entire island from sea to sea was covered with one continuous mass of ice of not less than 2,000 feet in thickness.

In my paper on the Boulder-clay of Caithness,[1] I have shown that if the ice was 2,000 feet or so in thickness, it must, in its motion seawards, have followed the paths indicated by the curved lines in the diagram accompanying that paper. In so far as Scotland is concerned, these lines represent pretty accurately not only the paths actually taken by the boulders, but also the general direction of the ice-markings on all the elevated mountain ridges. But if Scotland was covered to such an extent with ice, it is not at all probable that Westmoreland and the other mountainous districts of the North of England would have escaped being enveloped in a somewhat similar manner. But if we admit the supposition of a continuous mass of ice covering the North of England, all our difficulties regarding the transport of the Wastdale blocks across the Pennine chain disappear. An inspection of the diagram above referred to will show that these blocks followed the paths which they ought to have done upon the supposition that they were conveyed by continental ice.

That Wastdale Crag itself suffered abrasion by ice moving over it, in the direction indicated by the lines in the diagram, is obvious from what has been recorded by Dr. Nicholson and Mr. Mackintosh. They both found the Crag itself beautifully moutonnéed up to its summit, and striated in a W.S.W. and E.N.E. direction. Mr. Mackintosh states that these scorings run obliquely up the sloping face of the crag. Ice scratches crossing valleys and running up the sloping faces of hills and over their summits are the sure marks of continental ice, which meet the eye everywhere in Scotland. Dr. Nicholson found in the drift covering the lower part of the Crag, pebbles of the Coniston flags and grits from the west.[2]

[1] Geological Magazine for May and June, 1870.
[2] Trans. Edin. Geol. Soc., vol. i., p. 136.

The fact that in Westmoreland the direction of the ice-markings, as a general rule, corresponds with the direction of the main valleys, is no evidence whatever that the country was not at one period covered with a continuous sheet of ice; because, for long ages after the period of continental ice, the valleys would be occupied by glaciers, and these, of course, would necessarily leave the marks of their presence behind. This is just what we have everywhere in Scotland. It is on the summits of the hills and elevated ridges, where no glacier could possibly reach, that we find the sure evidence of continental ice. But that land-ice should have passed over the tops of hills 1,000 or 2,000 feet in height is a thing hitherto regarded by geologists as so unlikely that few of them ever think of searching in such places for ice-markings, or for transported stones. Although little has been recorded on this point, I hardly think it likely that there is in Scotland a hill under 2,000 feet wholly destitute of evidence that ice has gone over it. If there were hills in Scotland that should have escaped being overridden by ice, they were surely the Pentland Hills; but these, as was shown on a former occasion,[1] were completely buried under the mass of ice covering the flat surrounding country. I have no doubt whatever that if the summits of the pennine range were carefully examined, say under the turf, evidence of ice-action, in the form of transported stones or scratches on the rock, would be found.

Nor is the fact that the Wastdale Boulders are not rounded and ice-marked, nor found in the Boulder-clay, but lie on the surface, any evidence that they were not transported by land-ice. For it would not be the stones *under* the ice, but those falling on the upper surface of the sheet, that would stand the best chance of being carried over mountain ridges. But such blocks would not be crushed and ice-worn; and it is on the surface of the clay, and not imbedded in it, that we should expect to find them.

It is quite possible that the dispersion of the Wastdale Boulders took place at various periods. During the period of local glaciers the blocks would be carried along the line of the valleys.

All I wish to maintain is that the transport of the blocks across the pennine chain is easily accounted for if we admit, what is very probable, that the great ice covering of Scotland overlapped the high grounds of the North of England. The phenomenon is the same in both places, and why not attribute it to the same cause?

There is another curious circumstance connected with the drift of England which seems to indicate the agency of an ice-covering.

As far back as 1819, Dr. Buckland, in his Memoir on the Quartz Rock of Lickey Hill,[2] directed attention to the fact, that on the Cotteswold Hills there are found pebbles of hard red Chalk which must have come from the Wolds of Yorkshire and Lincolnshire. He pointed out also that the slaty and porphyritic pebbles probably came from Charnwood Forest, near Leicester. Mr. Hull, of the Geological Survey, considers that "almost all the Northern Drift of this

[1] Geol. Mag. for June, 1870.

[2] Trans. Geol. Soc., vol. v., p. 516 (First Series).

part of the country had been derived from the débris of the rocks of the Midland Counties."[1] He came also to the conclusion that the slate fragments may have been derived from Charnwood Forest. In the Vale of Moreton he found erratic boulders from two feet to three feet in diameter. The same northern character of the drift of this district is remarked by Professor Ramsay and Mr. Aveline, in their Memoir of the Geology of parts of Gloucestershire. In Leicestershire and Northamptonshire the officers of the Geological Survey found in abundance drift which must have come from Lincolnshire and Yorkshire to the north-east.

Mr. Lucy, who has also lately directed attention to the fact that the Cotteswold Hills are scattered over with boulders from Charnwood Forest, states also that, on visiting the latter place, he found that many of the stones contained in it had come from Yorkshire still further to the north-east.[2]

Mr. Searles Wood, jun., in his interesting paper on the Boulder-clay of the North of England,[3] states that enormous quantities of the chalk débris from the Yorkshire Wold are found in Leicester, Rutland, Warwick, Northampton, and other places to the south and south-west. Mr. Wood justly concludes that this chalk débris could not have been transported by water. "If we consider," he says, "the soluble nature of chalk, it must be evident that none of this débris can have been detached from the parent mass, either by water action, or by any other atmospheric agency than moving ice. The action of the sea, of rivers, or of the atmosphere, upon chalk, would take the form of dissolution, the degraded chalk being taken up in minute quantities by the water, and held in suspension by it, and in that form carried away; so that it seems obvious that this great volume of rolled chalk can have been produced in no other way than by the agency of moving ice; and for that agency to have operated to an extent adequate to produce (a quantity that I estimate as exceeding a layer 200 feet thick over the entire Wold), nothing less than the complete envelopment of a large part of the Wold by ice for a long period would suffice."

I have already, on a former occasion, assigned my reasons for disbelieving in the opinion that such masses of drift could have been transported by floating ice.[4] But if we refer it to land-ice, it is obvious that the ice could not have been in the form of local glaciers, but must have existed as a sheet moving in a south and south-west direction, from Yorkshire, across the central part of England. But how is this to harmonize with the theory of glaciation, which is advanced to explain the transport of the Shap boulders?

The explanation has, I think, been pointed out by a writer in the "Glasgow Herald," of the 26th November last, in a review of Mr. Lucy's paper.

[1] Quart. Journ. Geol. Soc., vol. xi., p. 492. Memoir of the Country around Cheltenham. 1857. Geology of the Country around Woodstock, 1859.

[2] Geol. Mag., Vol. VII. p. 497. [3] Quart. Journ. Geol. Soc., vol. xxvi. p. 90.

[4] Philosophical Magazine for November, 1868.

In my paper on the Boulder-clay of Caithness, I had represented the ice entering the North Sea from the east coast of Scotland and England, as all passing round the North of Scotland. But the reviewer suggests that the ice entering at places to the south of, say, Flamborough Head, would be deflected southwards instead of northwards, and thus pass over England. "It is improbable, however," says the writer, "that this joint ice-sheet would, as Mr. Croll supposes, all find its way round the north of Scotland into the deep sea. The southern uplands of Scotland, and probably also the mountains of Northumberland, propelled, during the coldest part of the Glacial period, a land ice-sheet in an eastward direction. This sheet would be met by another streaming outward from the south-western part of Norway—in a diametrically opposite direction. In other words, an imaginary line might be drawn representing the course of some particular boulder in the *moraine profonde* from England met by a boulder from Norway, in the same straight line. With a dense ice-sheet to the north of this line, and an open plain to the south, it is clear that all the ice travelling east or west from points to the south of the starting-points of our two boulders, would be 'shed' off to the south. There would be a point somewhere along the line, at which the ice would turn as on a pivot—this point being nearer England or Scandinavia, as the degree of pressure exercised by the respective ice-sheets should determine. There is very little doubt that the point in question would be nearer England. Further, the direction of the joint ice-sheet could not be *due* south, unless the pressure of the component ice-sheets should be exactly equal. In the event of that from Scandinavia pressing with greater force, the direction would be to the south-west. This is the direction in which the drifts described by Mr. Lucy have travelled."

I can perceive no physical objection to this modification of the theory. What the ice seeks is the path of least resistance, and along this path it will move, whether it may lie to the south or to the north. And it is not at all improbable that an outlet to the ice would be found along the natural hollow formed by the Valleys of the Trent, Avon, and Severn. Ice moving in this direction would no doubt pass down the Bristol Channel and thence into the Atlantic.

Might not the shedding of the North of England ice-sheet to the north and south, somewhere not far from Stainmoor, account for the remarkable fact pointed out by Mr. Searles Wood, that the Boulder-clay, with Shap boulders, to the north of the Wold is destitute of Chalk, while on the other hand, the chalky Boulder-clay to the south of the Wold is destitute of Shap boulders? The ice which passed over Wastdale Crag moved to the E.N.E., and did not cross the Chalk of the Wold; while the ice which bent round to the south by the Wold came from the district lying to the south of Wastdale Crag, and, consequently, did not carry with it any of the granite from that Crag. In fact, Mr. Searles Wood has himself represented on the map accompanying his Memoir this shedding of the ice north and south.

These theoretical considerations are, of course, advanced for what they are worth. Hitherto geologists have been proceeding upon the supposition of an ice-sheet and an open North Sea; but the latter is an impossibility. But if we suppose the seas around our island to have been filled with land-ice during the glacial epoch, the entire Glacial problem is changed, and it does not then appear so surprising that ice should have passed over England.

V.—On *Dicellograpsus*, a New Genus of Graptolites.

By John Hopkinson, F.G.S., F.R.M.S.

(PLATE I.)

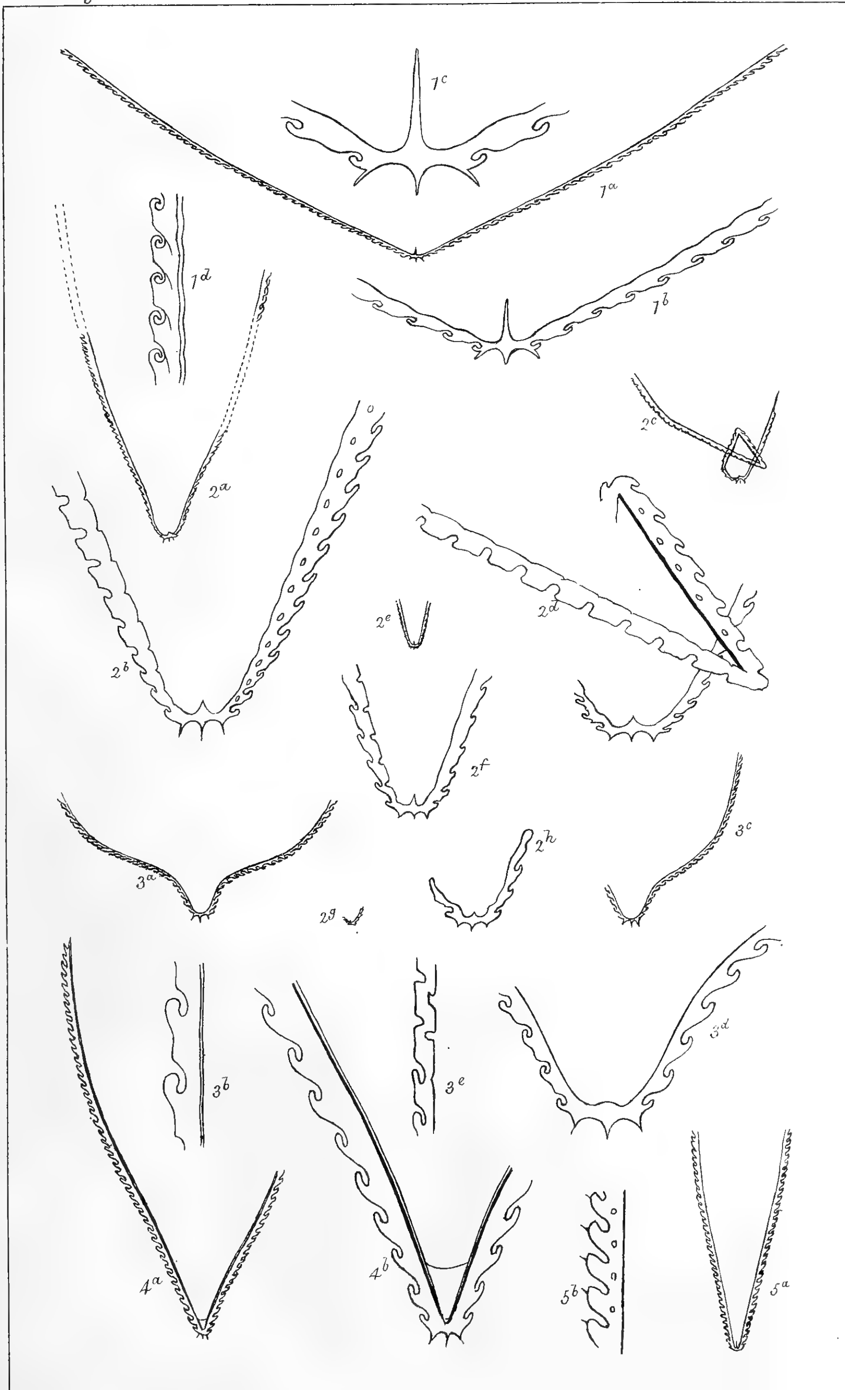
The Graptolites for which the name *Dicellograpsus* is here proposed are usually included in the genus *Didymograpsus*, which is thus made to comprise two groups of species which are not only generically distinct, but belong to entirely different sections of the Graptolite family, the species properly belonging to *Didymograpsus* (*D. Murchisoni* for example) having hydrothecæ similar to those of *Graptolithus*, while the species erroneously included in the genus (*D. Forchhammeri* and others) have hydrothecæ of the type of *Climacograptus*. This was first pointed out by Prof. James Hall. In his "Graptolites of the Quebec Group" (p. 57) he removed these species from *Didymograpsus*, and placed them in his new genus *Dicranograptus*; the species previously known as *Diplograpsus ramosus* being considered the type of the genus. To this species, and to another then first described, the genus was afterwards restricted by Mr. Carruthers, the remaining species being again included in *Didymograpsus*.[1] Though fully agreeing with Mr. Carruthers in thus restricting *Dicranograptus*, I cannot consider the species removed from it as having any alliance to *Didymograpsus*. I therefore propose to consider these species as forming a distinct genus, the diagnosis of which is as follows:—

Genus *Dicellograpsus*, gen. nov. (from δίκελλα, a fork; γραφω, I write).

Polypary, consisting of two simple monoprionidian branches, united only at the proximal end, and bearing hydrothecæ on their outer aspect; radicle, or initial process, on the same side of the polypary as the hydrothecæ.

From a slender radicle, flanked by two lateral spines, the simple monoprionidian branches immediately diverge in elegant symmetrical curves; usually very divergent at their origin, they soon become less so, then spring out again, and continue with a slight inward curve, until, towards their extremity, they are almost straight. They do not appear to be divided by any septum at their origin,—the cœnosarc of one branch most probably having been continuous with that of the other. The solid axis, commencing as the initial process, or radicle, bifurcates in the axil of the branches, on the inner or dorsal aspect of which it may in some species be detected. In others it cannot be made out beyond the axil, but from analogy

[1] Geological Magazine, Vol. V., p. 129.



A. T. Hollick lith. M & N. Hanhart imp.

BRITISH SPECIES OF THE GENUS DICELLOGRAPSUS.

we suppose it is present in all. In one species, at the axil, the polypary is slightly enlarged; in others, a spine of variable length takes the place of this enlargement; while in another, the branches are sometimes connected for a short distance by a membrane very like the corneous disc of *Dichograpsus*. The hydrothecæ are undistinguishable from each other for the greater portion of their length, from their apertures to their proximal end being intimately united with the body of the polypary. Towards their distal end they are for some distance free, their outer margins forming a continuous curve; curving outwards from their commencement, then more or less convex, nearly parallel to the axis, and slightly produced as a rounded lobe; their apertures being situated in the rounded, pouch-like cavity formed by this prolonged portion. In the several species the hydrothecæ differ more in the extent of their free portion and the depth of the cavity, than in general form, except when the polypary is twisted so that they appear in various positions on the shale in which they are imbedded. Thus they are often preserved as "scalariform impressions," or with their apertures appearing as transverse oval markings on the exposed surface of the polypary. It is when thus preserved that we realize most fully the intimate alliance of this genus with *Climacograptus*. Except for the difference in the width of the polypary, a fragment of a branch of *Dicellograpsus*, or of *Dicranograptus*, could not be distinguished from a fragment of *Climacograptus*.

There are one or two points in this description which demand special attention. In the first place, the position of the radicle, and its relation to the entire organism, is a controverted question. Dr. Nicholson, in an elaborate paper "On the British Species of *Didymograpsus*," maintains that the spine I have mentioned as being developed in the axil of the branches, is the true radicle, and consequently he has been compelled to figure the species having this spine in an inverted position, while those without it are correctly figured.[1] Mr. Carruthers considers that (in this genus) the theoretical position of the initial process is in the axil of the branches, whether a spine is present or not,[2] and gives figures of species with and without this spine, in their correct position; thus making his "initial process" proceed from the side of the polypary which is opposite its proximal or initial end.[3] Whatever be the nature of the, so-called, radicle, or initial process, it could not occupy such a position, for in all Graptolites it unquestionably forms the proximal termination of the organism, and in *Dicranograptus*, the most nearly allied genus, and also in several species of other genera, it is flanked by two lateral spines, just as it is in *Dicellograpsus*. The conclusion is inevitable—this is the true radicle, and the axillary spine, which is only occasionally present, whatever it may be, is, as far as we know at present, an organ without its analogue in any other genus.

This determination settles another disputed point. Dr. Nicholson

[1] Ann. and Mag. Nat. Hist., series iv., vol. v., p. 351.
[2] Mr. Carruthers has verbally informed me that the above is his opinion.
[3] Geological Magazine, Vol. V., Pl. v.

has, on more than one occasion,[1] urged the importance of "defining exactly what is understood by the 'angle of divergence,' since this term," he says, "has been very loosely employed, and has led to a great deal of confusion." This angle he correctly defines as the angle included between the branches on the opposite side of the polypary to the radicle, while the angle formed by the branches on the same side as the radicle, he terms the "radicular angle." This must necessarily in every case be the "defect" of the angle of divergence from four right angles or 360°, and therefore we may here disregard it. It is evident that the correct use of either term depends upon our right conception of the position of the radicle. A perusal of Dr. Nicholson's paper on "*Didymograpsus*" will show that whatever confusion previously existed upon this point, would, to say the least, be greatly increased if we were to consider the axillary spine, when present, as the true radicle, and when it is not present were to take the proximal spine as the radical; and this is just what he has done. That this latter does represent the radicle, whether the axillary spine is present or not, I have already shown, and thus the determination of the true angle of divergence is rendered certain. In *Didymograpsus* it is the angle included within the polypiferous margins of the branches; in *Dicellograpsus* and *Dicranograptus* it is the angle included within the dorsal or non-polypiferous margins.[2] In neither genus is it known to exceed two right angles, or 180°.

We have next to consider the evidence we possess of the continuity of the cœnosarc of the two branches. The beautiful symmetry of the branches favours the idea that they were connected at their origin by living tissue; the continuous or unbroken curve between the branches in the spineless species, points to the same conclusion; and no dividing septum has been observed. But, in the absence of specimens preserved in the round, we can get no section, and therefore cannot be certain upon this point. In *Dicranograptus* we are equally uncertain, for in two of its species (*D. ramosus* and *D. Clingani*) the stem divides acutely into branches, the periderm of each branch seemingly being continued through the stem; while in the other three species (*D. sextans, D. formosus*, and *D. Nicholsoni*) the periderm of one branch seems continuous with that of the other, as in *Dicellograpsus;* apparently showing that in these species at least the branches are organically connected; and I believe this will be found to be the case throughout both these genera, and also in their near ally *Climacograptus.*

The hydrothecæ are similar in form and structure to those of *Dicranograptus,* and as these have, in a previous paper,[3] been fully described, and shown to agree in all essential points of structure with the hydrothecæ of *Climacograptus,* I will here only draw attention to the fact that these three genera form a distinct and well-marked group of the Graptolite family, differing from all others in the form and structure of their hydrothecæ.

[1] Ann. and Mag. Nat. Hist., series iv., vol. iv., p. 240; vol. v., p. 338.

[2] In *Diplograpsus*, *Cephalograpsus*, and *Climacograptus*, theoretically, the angle of divergence is *nil*, while the radicular angle is 360°.

[3] Geological Magazine, Vol. VII., p. 353.

The genus *Dicellograpsus* is exclusively Lower Silurian, and in our Lower Silurians is eminently characteristic of the Llandeilo formation, as developed in the south of Scotland. Not a single species has hitherto been detected in the Arenig of the British Isles or other countries, in the Llandeilo of Wales, nor in the Caradoc of Westmoreland, Wales, or Scotland; while in the Llandeilo rocks of Dumfriesshire, which are most probably very near the base of the Caradoc, all its species are found. Two species occur in Ireland, associated with other Llandeilo graptolites, the general fauna being of Caradoc age. One, *D. Moffatensis*, occurs in the Caradoc of New York, and another, *D. Forchhammeri*, the earliest known species, was originally described from the Island of Bornholm, where it occurs in strata which most probably represent the Caradoc formation. It seems, therefore, most probable that the genus first appeared in the locality where it most abounds—where it is both specifically and numerically abundant—and that from this locality (Dumfriesshire) it has migrated elsewhere.

The genus comprises the following species:—

1. *Dicellograpsus Forchhammeri*, Gein., sp. *Cladograpsus Forchhammeri*, Gein. (1852), Die Graptolithen, p. 31, pl. v., fig. 28-31. *Didymograpsus Forchhammeri*, Baily (1862), Expl. Sh. 133, Geol. Surv. Irel., p. 14, fig. 6. Journ. Geol. Soc. Dubl., vol. ix., p. 305, pl. iv., fig. 7.—Pl. I., Fig. 1.

Branches of polypary nearly straight, diverging from each other at a wide angle, and with a long and slender axillary spine. Hydrothecæ about 25 to the inch; two or three times as long as the width of the polypary, and free for but a small portion of their length. Radicle and lateral spines very minute.

The long and slender branches, varying in different individuals from 1-50th to 1-30th of an inch broad at their origin, gradually increase until a breadth of fully 1-20th of an inch is attained; in the longest, and therefore oldest, individuals, becoming narrower towards the distal end. They diverge at an angle of from 90 to 120 degrees, and attain a length of several inches. The axillary spine is always well developed, is frequently more than 1-20th of an inch long, and averages 1-200th in breadth. The radicle is usually very minute, but in some specimens it ends abruptly without coming to a point, appearing as if it had been broken. The very slender lateral spines proceed from near the apex of the first formed thecæ, and diverge from each other at a wide angle. The hydrothecæ, which are very similar in all the species of this genus, are for a very short distance free, and this free portion is closely appressed to the body of the polypary, and sometimes very much incurved. At about half their length they are slightly indented, and opposite this depression the back of the polypary is slightly enlarged, giving it a waved appearance.

The persistent and usually very conspicuous axillary spine should suffice to prevent this species being considered identical with *D. Moffatensis*. But as yet *D. Forchhammeri* has never been correctly figured, or fully described. Neither from Geinitz' nor from Baily's figures (all we have), could the character of the proximal end be determined. Three of Geinitz' figures (29, 30, and 31) show the axillary spine; in the other (28) it is not shown; but this is only a restoration from a single branch, according to Geinitz himself.[1] The enlarged drawing (28*a*), intended to show the structure of the hydrothecæ, is incorrect. The "round eyes," which are figured and described as the apertures of the hydrothecæ, are merely the indentations between each theca; the apertures themselves, though opening out towards these indentations, are not visible. Mr. Baily appears to have had the same idea of this structure as Geinitz.

[1] Die Grapt., expl. pl. v. fig. 28.

In our only other description, that of Mr. Carruthers,[1] the presence of the axillary spine is recognized, and, for the first time, the species is stated to have three proximal spines, the central one being, as I have shown, the true radicle. Of the hydrothecæ, however, he merely says that they are "not very marked, in contact throughout their whole length; about 28 in an inch."

Loc. *Llandeilo*:—Dobb's Linn and Hartfell, near Moffat, Dumfriesshire. *Caradoc:* —Kilnacreagh, Co. Clare, Ireland.[2] Bornholm, Baltic Sea.

Dicellograpsus Morrisii, sp. nov. *Didymograpsus flaccidus*, Nich. (1867), Geol. Mag., Vol. IV., p. 110, Pl. VIII., Fig. 1-3. *Didymograpsus elegans*, Carr. (in part), Geol. Mag., Vol. V., Pl. V., Fig. 8*b* and 8*c* (*non Graptolithus flaccidus*, Hall).—Pl. I., Fig. 2.

Branches of polypary slightly curved, diverging from each other at an angle of from 40 to 60 degrees, and with a short, obtuse, axillary spine. Hydrothecæ from 25 to 30 to the inch; twice as long as the width of the polypary, and free for about a third their length. Radicle and lateral spines short and thick—rarely slender.

The branches, frequently not 1-60th of an inch broad at their origin, rapidly widen, and maintain an average width of 1-20th of an inch throughout their length. At first widely divergent, they almost immediately attain their normal position, making an angle with each other of about 40 degrees; they then gradually widen, increasing this angle, and again curve slightly inwards, making the same angle as before. The persistent axillary spine varies from 1-50th to 1-30th of an inch in length; the radicle and its lateral spines usually corresponding with it, and with each other, in form and size. The hydrothecæ differ but little from those of *D. Forchhammeri*. They are a little more prominent, but scarcely so much elongated, and more frequently appear as scalariform impressions. Opposite the depression in each hydrotheca, in well-marked impressions, a row of minute pustules, or scars, may be observed.

From *D. Forchhammeri* this species differs in the general form of the polypary, and the lesser divergence of its branches; in its shorter axillary spine, and more conspicuous radicle.

From Hall's *Graptolithus flaccidus*, for which it has been mistaken by Dr. Nicholson, it is generically distinct. In this species the radicle is on the opposite side of the polypary to the hydrothecæ, the branches diverge at an angle of about 180 degrees, and the hydrothecæ are of a very different form. From their similarity—in the specimens I have examined, as well as in Hall's figure[3]—to those of the genus *Nemagrapsus* of Emmons (= *Cladograpsus*, Carruthers), I believe *G. flaccidus* will prove to belong to this genus, though it is not as yet known to have secondary branches. From *D. elegans*, as the young form of which, Mr. Carruthers has figured it, *D. Morrisii* may be distinguished by its possession of an axillary spine, and by the form and dimensions of the polypary.

I dedicate this species to my valued friend, Professor Morris, who has always, from his great store of scientific knowledge, most generously assisted me in my researches.

Loc. *Llandeilo*:—Beld Craig Burn, Dobb's Linn, and Hartfell, near Moffat, Dumfriesshire. (In black anthracitic shale). Bilberry Rock, Waterford, Ireland (?).

3. *Dicellograpsus elegans*, Carr., sp. *Didymograpsus elegans*, Carr. (1868), Geol. Mag., Vol. V., p. 129, Pl. V., Fig. 8*a* (*non* 8*b* and 8*c*). —Pl. I., Fig. 3.

Branches of polypary slightly curved and very slender, diverging from each other at various angles, and slightly enlarged in the axil. Hydrothecæ about 25 (rarely fewer) to the inch; two or three times

[1] Geol. Mag. Vol. V. p. 129.

[2] The specimen in the Geological Museum (Draw. vi. Tablet 19), labelled "*Didymograpsus sextans*, Kilnacreagh," is a good example of *Dicellograpsus Forchhammeri*, showing the axillary spine, though indistinctly.

[3] Grapt. Quebec Group, pl. ii., fig. 19.

as long as the width of the polypary, and very distinct and deeply divided. Radicle and lateral spines always well developed.

From their origin to their distal end, seldom exceeding 1-40th of an inch in breadth, the gracefully curved branches present an aspect very different from that of any other species. Springing from the median radicle in opposite directions, just beyond the lateral spines, and where the hydrothecæ first commence, they take a sudden bend which sometimes brings them nearly parallel; they then spring out again, making a very wide angle with each other, and again curve gracefully inwards, gradually becoming almost straight. The slight enlargement in the axil is not so marked as in any way to represent a spine. It is sometimes almost imperceptible. The radicle is about 1-30th of an inch in length, the lateral spines being somewhat shorter, and diverging very slightly from each other. Owing to the slender nature of the branches, and their consequent liability to twist and expose to view different surfaces of the polypary, the hydrothecæ appear to vary very much in form, and are frequently preserved as scalariform impressions.

Mr. Carruthers figures two distinct species as *D. elegans*. His "two young specimens" (Fig. 8*b* and 8*c*) differ from *D. elegans* (Fig. 8*a*) in the presence of a well-developed axillary spine, in the general form of the polypary, and in the form of the hydrothecæ; and are referable to *D. Morrisii*. I have never seen *D. elegans* with thecæ so slightly divided, or rather with the indentations between them extending for such a slight distance across the polypary, as is shown in the enlarged figure (8*d*), so suppose that this also should be referred to *D. Morrisii*, though it really more nearly resembles *D. Moffatensis*.

Loc. *Llandeilo*:—Dobb's Linn and Hartfell, near Moffat, Dumfriesshire.

4. *Dicellograpsus Moffatensis*, Carr., sp. *Didymograpsus Moffatensis*. Carr. (1858), Proc. Royal Phys. Soc. Edin., vol. i., p. 469, fig. 3, *Graptolithus divaricatus*, Hall (1859), Pal. New York, vol. iii., Suppl., p. 513, fig. 1-4. *Dicranograptus divaricatus*, Hall (1865), Grapt. Quebec Group, p. 57. *Didymograpsus divaricatus*, Nich. (1870), Ann. and Mag. Nat. Hist., series iv., vol. v., p. 351, pl. vii., fig. 4.—Pl. I., Fig. 4.

Branches of polypary slightly curved, diverging from each other at a considerable angle, and frequently connected at their origin by a corneous membrane. Hydrothecæ from 20 to 25 to the inch, as long as the width of the polypary, and free for about half its width. Radicle and lateral spines long and slender.

The branches, about 1-40th of an inch broad at their origin, gradually widen, attaining a width, towards their distal end, of 1-25th of an inch. Diverging rather acutely at their origin, they slightly expand for a short distance, continuing with a slight inward curve throughout their length; their angle of divergence being from 60 to 90 degrees or more. They are frequently united for about 1-20th of an inch by a corneous membrane, and are then less divergent than when they are not so united. The radicle, in some specimens, appears to be only a slight mucronate extension of the polypary, and the lateral spines are scarcely perceptible; but in others it is fully 1-20th of an inch long, the lateral spines being about half this length, and diverging slightly from each other. The hydrothecæ are not so deeply divided in proportion to the width of the polypary as in any other species. They are very gracefully curved, and have no depression as in *D. Forchhammeri* and *D. Morrisii*; their free portions curving slightly inwards towards the body of the polypary. Hall states that "the surface is marked by a row of small nodes placed obliquely to the direction of the axis, and situated just below, and a little on one side of the bottom of the serrature," but in British specimens these have not been detected.

The entire absence of an axillary spine suffices to distinguish this species from all others but *D. elegans*, and from this it differs in the form and dimensions of the polypary; the branches being more robust and not so much curved, and originating at a more acute angle than in *D. elegans*.

Loc. *Llandeilo*:—Dobb's Linn, Hartfell, and Glenkiln Burn, near Moffat, Dumfriesshire.[1] *Caradoc*:—Albany, New York (Hudson River Group).

5. *Dicellograpsus anceps*, Nich., sp. *Didymograpsus anceps*, Nich. (1867), Geol. Mag., Vol. IV., p. 110, Pl. VIII., Fig. 18-20.—Pl. I., Fig. 5.

Branches of polypary nearly straight, diverging from each other at a very small angle, and with or without an axillary spine. Hydrothecæ from 25 to 30 to the inch; as long as the width of the polypary, and free for about half its width. Radicle and lateral spines not known.

The branches are "very little narrower at their origin than elsewhere," and retain a nearly uniform width of about 1-20th of an inch, varying slightly in different individuals. They diverge from each other at an angle of from 5 to 10 degrees. The axillary spine, when present, varies in length "from a mere node up to nearly one line." In the few specimens as yet obtained, no radicle or lateral spines have been detected. The hydrothecæ differ but little from those of the other species of this genus. They are described as having "their outer margins curved and nearly parallel to the axis;" they are rounded off distally, and their apertures open towards oblique pouch-like indentations, as in the other species of *Dicellograpsus*. In some specimens the first few hydrothecæ "are provided each with a short blunt spine proceeding from the centre of their outer margins;" and sometimes there are minute pustules in the centre of each hydrotheca.

Not having seen this species, I have drawn up the above description from that given by Dr. Nicholson in his paper on "*Didymograpsus*." For its specific distinctness, the small angle of divergence of the branches, the presence of an axillary spine, and the absence of proximal spines, are the chief points relied on.

Loc. *Llandeilo*:—Dobb's Linn, Moffat, Dumfriesshire.

Perhaps I may here be permitted to express my obligations to Mr. Carruthers, who very kindly allowed me to select from his extensive collection of Graptolites most of the specimens from which the figures in the accompanying plate have been drawn; and to Mr. Etheridge, for enabling me to examine the collection in the Museum of Practical Geology.

EXPLANATION OF PLATE I.

Fig. 1. *Dicellograpsus Forchhammeri*, Gein., sp. 1*a*. A specimen natural size. 1*b*. A portion of the same magnified 5 diameters. 1*c*. The proximal end of the same mag. 10 dia. 1*d*. Part of a branch of another specimen, slightly restored, mag. 5 dia. (for comparison with Geinitz' fig. 28*a*).

Fig. 2. *Dicellograpsus Morrisii*, Hopk. 2*a*. A specimen nat. size. 2*b*. A portion of the same mag. 5 dia. 2*c*. A specimen much bent and showing prolonged solid axis, nat. size. 2*d*. Part of the same mag. 5 dia. 2*e*. A young specimen nat. size. 2*f*. Part of the same mag. 5 dia. 2*g*. One much younger, nat. size. 2*h*. The same mag. 5 dia.

Fig. 3. *Dicellograpsus elegans*, Carr., sp. 3*a*. A specimen nat. size. 3*b*. Two hydrothecæ of the same mag. 10 dia. 3*c*. Another specimen nat. size. 3*d*. The proximal end of the same mag. 5 dia. 3*e*. The extremity of a branch of the same mag. 5 dia.

Fig. 4. *Dicellograpsus Moffatensis*, Carr., sp. 4*a*. A specimen nat. size. 4*b*. Part of the same mag. 5 dia. (The branches in this specimen diverge at a smaller angle than usual).

Fig. 5. *Dicellograpsus anceps*, Nich., sp. 5*a*. A specimen nat. size. 5*b*. A portion of a branch mag. 5 dia. (Restored from the drawings and descriptions of Dr. Nicholson.)

[1] Dr. Bigsby, in his "Thesaurus Siluricus," (p. 82) gives "West of Stiper Stones, Shropshire," as a locality for this species, but this is most probably an error.

NOTICES OF MEMOIRS.

I.—On the Parallel Ridges of Glacial Drift in Eastern Massachusetts. By Professor N. S. Shaler.

(Proc. Boston Society of Nat. Hist., vol. xiii., February, 1870.)

In the immediate neighbourhood of Boston the unstratified Drift does not lie in anything like a continuous sheet, but is distributed in long and rather narrow ridges, which, with varying height, on account of long-continued denudation, may be traced for miles across the country. These ridges are particularly conspicuous in the islands of the harbour of Boston, where, although much worn by the action of tidal currents, the parallelism is quite apparent. They exhibit two sets of trends, the one being north-west and south-east, the other north-east and south-west; and a comparison of the sections, given at various points in the islands of the harbour, at Chelsea, Somerville, Cambridge, Brighton, South Boston and elsewhere, has shown that throughout this region the Drift is remarkably similar at the same height above the sea.

The Drift contains pebbles of various sizes, five-foot boulders, and fragments of every gradation down to coarse sand. The whole is imbedded in a fine mud, which so binds the materials together that, in the lower parts of the mass, where it has been subjected to considerable pressures, it has become a hard conglomerate. Nowhere is there any attempt at stratification.

In regard to the origin of these Drifts, Professor Shaler agrees with Agassiz in considering them as the materials which rested in and upon the glacial sheet at the close of its history, and which were dropped in the places they now occupy by the melting of the ice upon which they rested. As this Drift deposit must have originally been at least one hundred and fifty feet thick, it is difficult to conceive how such a mass of detritus as that in question could have ever been contained in a glacial stream, and the supposition is necessary that the mass of the Drift must have been rent from the floor of the glacier as it moved along.

But there is evidence, according to Professor Shaler, that the glacial sheet was at many points over half a mile in depth, and, therefore, this action may readily be conceded to it.

Moreover, in a section exposed at Cambridge, large masses of the clay slate, grooved and scratched by long working on the solid rock, were found in the Drift, at a height of several feet above the bed from which they had been torn.

It follows, as the author observes (if these conclusions be accepted), that this deposit of detrital matter must have covered, with something like uniformity, the whole of this part of the coast; and indeed the relation of the separate masses of Drift is irreconcileable with any other hypothesis—for they could not be the terminal or lateral moraines of a glacier.

The cause of the peculiar parallelism of the two series of ridges is difficult to arrive at; but it is known that the district around

Boston is affected by two lines of upheaval, each marked by dykes and by considerable dislocations of strata. With the direction of these disturbances the lines of Drift exactly correspond, and Professor Shaler concludes that these Drift-hills are only cappings of glacial detritus lying upon ridges of the more solid rock of the country; the solid pedestal having prevented the wearing action of the streams from affecting the detrital matter which rested upon them. He concludes with some remarks upon the Glacial period.

II.—The Mammalia and other Remains from Drift Deposits in the Bath Basin.

By Charles Moore, F.G.S.

[A Paper read before the "Bath Natural History and Antiquarian Field Club." 8vo. Bath, 1870.]

THE "Drift deposits" here described comprise the Alluvial beds and Post-Pliocene gravels, due to the action of fresh water, and which have been deposited in the valleys since the country assumed the general physical configuration which it now possesses. Although some of the derived materials have been brought from considerable distances, in general they have been washed down from the higher grounds, or from the sides of the valleys upon which the ancient streams operated, in much greater volume than those which now follow their courses.

The area to which Mr. Moore's remarks are applied comprises the low ground, west of Bath, and the valleys running immediately out of it to the east, namely, those of Box, and that extending by way of Limpley Stoke and Freshford to Bradford.

He treats first of the Historic Period, mentioning the discovery, at a spot twelve feet below the city of Bath, of two stone coffins, in which he obtained a small collection of fossils, which had been washed in. Mr. Moore shows that, subsequently to the Roman occupation, the area upon which Bath stands became a swamp, as remains of this period occur covered up by mud, vegetable remains, and drift wood, the deposit in some instances being almost converted into peat. Mixed with it are many mammalian remains. He explains, by means of well-sections, the characters and thicknesses of the different deposits of Historic, Pre-Historic, and Post-Pliocene times, which are met with in the vicinity of Bath.

Under the term "Mammal Drift" are included all the gravel deposits of the district. In it are found remains of *Elephas primigenius, E. antiquus, Rhinoceros tichorhinus, Ovibos moschatus,* Wild Boar, Horse, Reindeer, and *Bos primigenius.* No traces of Man have as yet been determined.

Mr. Moore gives lists of the land and freshwater mollusca, and other remains from the different drifts, and he also records the species of derived fossils which he has met with in them. Concluding with some theoretical remarks, he expresses his opinion that evidences of glacial action occur in the deep and long-continued furrows in the stiff Liassic clays on which the Mammal Drift now lies.

H. B. W.

REVIEWS.

I.—The Gravels of the Severn, Avon, and Evenlode, and their Extension over the Cotteswold Hills. By W. C. Lucy, F.G.S., F.A.S.L.

ONE of our most important local societies is the Cotteswold Naturalists' Field Club, both in subject-matter and illustration; its volumes of *Proceedings* maintain a high value, and will bear favourable comparison with those of any other natural history club.

The number last issued (being the volume for 1869) contains two elaborate papers, one by Dr. Wright, to which we drew attention in the December Magazine; the other by Mr. Lucy, which forms the subject of our present remarks.

This paper is illustrated by an excellent geological map, which at once attracts notice. It is on the scale of half an inch to one mile, and includes the country between Chipping Norton and the Malvern Range in one direction, and between Stroud and Alcester in the other. Few districts of equal size contain so great a variety of geological formations, for in it are to be met with representatives of almost every rock, from the Lower Llandovery to the Oxford Clay. The boundaries of these several formations seem to have been very carefully drawn, and the colours by which they are represented are clear and distinctive. But we should mention, as the author of the paper, through an oversight, has omitted to do so, that this part of the map has been reduced from the Geological Survey Sheets (chiefly from Nos. 43, 44, 45, and 54), and the colours adopted are the same in each. It is not, however, with these formations that the present paper deals; nor is the map entirely a reproduction on a smaller scale of the work of our Government field-geologists. The distribution of the Quaternary gravels, as traced out with great care and labour by Mr. Lucy, is denoted by means of coloured dots over the various subjacent formations, and it is this which gives a special value to, as it is the principal object of, the map. The gravels which are represented are included under two heads, namely, "Northern Drift," and "Oolitic Gravel."

The author first treats of the geological position and physical characters of the various beds of gravel, and then explains his views of their origin and age.

The Oolitic gravel appears to be chiefly composed of Secondary rocks, to be of local derivation, lying near and flanking the Cotteswold Range, towards which it increases in thickness.

The name Northern Drift is applied to gravels containing materials derived from nearly every formation, from the Silurians to the Chalk, besides Igneous rocks; and associated with it is a good deal of fine quartzose sand. With the exception of a trace of Oolitic gravel at Highnam, all the gravel on the western side of the Severn belongs to this. On the other side both gravels are found, and where they come together, as at Gloucester, the Oolitic gravel rests upon the Northern drift. But this latter gravel occurs at all elevations, being found at the height of 750 feet on the Cotteswolds, and also lying in terraces 15 to 50 feet above the river-levels.

The Northern drift, which at Cropthorne was described by Mr. Strickland, contains mammalian remains and numerous species of mollusca—marine, land, and freshwater. 80 feet is the highest point at which the mammalian remains have been found in the gravel. In the clay bands of the Oolitic gravel, land and freshwater shells occur.

Mr. Lucy describes a great many sections in detail, carefully recording their altitudes, and he gives lists of the organic remains which have been found. Quartz pebbles have been discovered in clay which fills fissures in Oolite quarries on the Cotteswolds, at an elevation of about 750 feet. These are considered as a relic of the Northern drift. Analyses of the clays are given, and the author hints at their being Boulder-clay, though of course this is extremely doubtful.

There is, in addition to the other gravels, a small sub-angular Oolitic gravel found in parts of the Cotteswold Range, at heights varying from 500 to 700 feet, which is due to the denudation of the Inferior Oolite. It contains no fossils nor recent shells, and seems to attain a uniformity of character. It was this deposit that Mr. Hull called raised sea-beaches in his Memoir on the geology of the country around Cheltenham. Mr. Lucy is opposed to this opinion. He attributes the gravel to frozen snow or land-ice, which when the thaw set in would slip down, carrying with it the detritus of the Inferior Oolite; and he regards it as formed, after the rigour of the Glacial period, at an age when the climate had become comparatively mild.

It is not uncommon in gravel pits to notice a marked majority of the pebbles lying with their longer axes vertical. The origin of this peculiar position of the pebbles has attracted the attention of several geologists. The Rev. O. Fisher, in his interesting paper on the "Warp," remarks that this effect is probably not always produced in the same way, and he suggests, as one of the possible causes of the phenomenon, the fact that in a pebble sinking through mud the *friction* would play a more important part than the *resistance,* especially if its motion were slow; and the effect of friction would be to place the pebble on end. Mr. Boyd Dawkins notices similar cases when "the long axes of the pebbles are in the main vertical, instead of occupying the horizontal position of those which have been deposited by water," and he refers to the deposit as beyond all doubt of Glacial origin—to have been borne down by ice, and deposited on its melting. Mr. Lucy draws attention to the remarks of Mr. Dawkins when speaking of the phenomenon, but he explains it as "showing lateral pressure."

Coming to the denudation of the Cotteswold Hills, Mr. Lucy maintains that the flat table-land of the Cotteswolds is mainly attributable to the denuding power of forces that brought the pebbles which occur there at the high level, most of which were swept away at the time. At this period, he believes, the Oolite probably extended over the New Red Marl to May Hill and Malvern.

The apparent absence of Chalk flints from the higher patches of Northern Drift seems to indicate that the Chalk was not then in a position in this part of the country to furnish materials for the gravel. Mr. Lucy's observations lead him to conclude that the denudation of the Cotteswolds took place early in the Glacial period; whereas, as he mentions, Professor Ramsay seems to be of opinion that the Valley of the Severn existed prior to the Glacial period, because Glacial deposits are found in it as far as Tewkesbury. When the Severn Valley was originally formed the Professor admits it is difficult to say, although England, having probably been above the sea during the greater part, or perhaps the whole of the Miocene epoch, it is likely that some of our great contours were then first begun, or, if not begun, carried on and very seriously modified.

We have not space to discuss at length Mr. Lucy's account of the origin of the Gravels. They appear to show alternations in the level of the country, commencing with the deposition of the Pebbles at the highest level when the land was beneath the sea, and giving evidence in the valleys of the High- and Low-level Gravels due to river-action, and of another encroachment of the sea, which is evidenced by the presence of marine shells in some of the Lower river Gravels. Here and there evidences of ice-action are met with.

Commencing in the Glacial period, and marking stages in the denudation of the country, the deposition of Gravels continued long after its close.

Their separation into "Northern Drift" and Oolitic Gravel, appears, so far as we can understand, to rest merely upon the composition of the Gravels, and does not mean that any distinct agencies need be invoked to account for them.

Some of the Gravels appear to be of marine origin, others of fluviatile, but the distinctions are not marked upon the map.

The term "Northern Drift," as Mr. Lucy acknowledges, is not altogether satisfactory. But he uses the word "Drift" (in speaking of the Oolitic Gravel also) to denote all those superficial accumulations of transported materials, which cannot have been produced by the tranquil causes which are in daily operation in the district. Much yet remains to be done in determining the exact boundaries of the superficial deposits over the Valleys of the Severn and its tributaries, and indeed Mr. Lucy remarks that several points of considerable interest and importance require to be dwelt upon more fully to complete the subject. So that while all geologists will thank Mr. Lucy for what he has done, they will hope at a future time to have some further contributions from his pen.

Mr. Lucy alludes to the earlier writings of Murchison, Strickland, Buckman, Hull, J. Jones, Witchell, Symonds, and Maw, and we may mention that subsequently to the reading of his paper before the Cotteswold Club, a communication on the same subject was made to the Geological Society of London, by Mr. T. G. B. Lloyd.[1] In this paper Mr. Lloyd described the gravels of the Avon Valley between Tewkesbury and Rugby, and of the Severn Valley above and below the town of Worcester.

The absence of horizontal sections, to illustrate Mr. Lucy's paper, is to be regretted, for although he explains that, owing to the smallness of the scale, it would be difficult to show the different kinds of gravel in a satisfactory manner, yet we cannot see why, with the vertical scale magnified, they could not have been rendered as clear as those which so admirably illustrate Mr. Codrington's paper in the November number of the Quarterly Journal of the Geological Society.

II.—American Geology.

(1.) Geological Report on the Yellowstone and Missouri Rivers. By Dr. F. V. Hayden. Washington, 1869.

(2.) United States Geological Survey Report on Colorado and New Mexico. By F. V. Hayden. Washington, 1869.

TAKEN together, these two reports present us with a more or less detailed description of the geology of a broad strip of country, extending from New Mexico on the South, to the British possessions on the North, and bounded on the West by the Rocky Mountains, and on the East by the Lower Missouri. The Northern half of this large area has been considerably more elaborated than the rest, and Dr. Hayden speaks of his report respecting it as being the final one. That on Colorado is merely a preliminary report; and, in the absence of figures or maps, is not always by any means as clear as might be desired, especially as many of the localities mentioned are not to be found in ordinary maps. Added to this, the narrative form given to both reports (the various sections, etc., observed being noted under successive dates) renders their perusal somewhat laborious, and detracts not a little from their unquestionable value. These drawbacks apart, however, the two thin volumes will be welcomed by every geologist as the first really scientific description of a large and important tract, which, until quite recently, was a perfect *terra incognita*, so far as science was concerned. The mere amount of hard work which they represent is enormous; and the chief points elicited by it are not only of local, but, in many cases, of general interest also.

Quite remarkable appears to be the simplicity of the stratigraphical arrangement of the sedimentary rocks in the Northern district, which affords a key to their distribution in the somewhat more intricate area of New Mexico and Colorado. The backbones of the main ridges, and the cores of the isolated hills belonging to the Rocky Mountain system, are universally composed of granitoid rocks, and on their flanks all the stratified deposits seem to be uniformly ex-

[1] "On the Superficial Deposits of Portions of the Avon and Severn Valleys and adjoining Districts." Quart. Journ. Geol. Soc., May, 1870.

We should also recall attention to Mr. Lucy's paper "On the Post-Pliocene Drift of Charnwood Forest," published in the Geol. Mag. for November, 1870, p. 497.

posed in succession, their dip diminishing as they recede from the mountains, thus showing, in the words of Dr. Hayden, "that the whole country west of the Mississippi to the Pacific, may be regarded as a vast plateau, and that it was gradually elevated until the crust of the more central portions was strained to its utmost tension, and that it then burst, and along here evolved the lofty ranges which, taken collectively, now pass under the name of the Rocky Mountains."

The lowest recognized stratum in this series is the representative of the true Potsdam Sandstone, and this is the only record of Silurian times visible in these regions; neither is the Devonian present in any form; and the Potsdam Sandstone is directly succeeded by a heavy formation of Carboniferous age, consisting, for the most part, of yellowish limestones and sandstones, with fossils which, with us, would be characteristic of the Lower Carboniferous, but which, in the States, indicate the Upper beds of this age; neither on their mountain exposure, nor at their Eastern outcrop in Kansas, do these beds give any promise of workable seams of coal. No distinguishable Permian is to be seen in this Western series, though well known in the East; but a conspicuous unfossiliferous series of red arenaceous deposits overlie the Carboniferous strata; they are occasionally saliferous and gypsiferous, and Dr. Hayden, with some hesitation, refers them to the Triassic period. The upper beds of this formation pass insensibly into those above, which contain unmistakeable evidence of their Jurassic age. These are especially interesting, as giving us, in Nebraska, by far the most important and best authenticated series of this formation, to be found in the United States; towards the South, however, they seem to thin out very considerably, or even to disappear altogether. Above these again comes a vast thickness (3,000 to 4,000 feet) of Cretaceous beds, to the division and determination of which Dr. Hayden has devoted much time and trouble. These Cretaceous rocks, being farther removed from the nucleus of the mountain range, dip at a lower angle than the older beds; and still less in amount is the very thick series of Tertiaries, which cover the whole country, from the base of the mountain land to the re-appearance of the Cretaceous beds to the East. Although he divides these deposits into Lower, Middle, and Upper Tertiary, Dr. Hayden denies that they can be considered as exact equivalents of our Eocene, Miocene, and Pliocene.

Dr. Newberry, who supplements Dr. Hayden's Memoir with a very interesting paper on the Cretaceous and Tertiary plants collected in these districts, goes further, and pronounces the Lower Tertiary to be of Miocene age. It certainly, in our opinion, bears very little resemblance to what we are accustomed to as characteristic of Eocene deposits. This will at once be evident, when we quote the author (Dr. Hayden) respecting this formation, to which he gives the name of Fort Union or Lignite Group: "It was evidently deposited in large bodies of water, which were at first brackish, and then gradually became fresh. The great number of fossil leaves, and numerous beds of Lignite contained in it, clearly show that the shores of these ancient estuaries, lakes, etc., in which this formation was deposited, supported dense forests of large trees, and a growth of other vegetation far exceeding in luxuriance anything now met with in these latitudes."

The Middle Tertiaries have yielded a magnificent series of vertebrate remains, including numerous species of Hyænodon, Oreodon, Hyracodon Machairodus, Rhinoceros, Hippopotamus, etc., with a large number of extinct Chelonians. The Upper Group, besides remains of Equus, Mastodon, etc., seems to be chiefly characterized by recent species.

In the Colorado district, Igneous rocks appear to be much more prevalent among the sedimentary deposits than they are in the North; and in that beautiful valley of the Middle Park, a number of outpourings of Basalt are described as being interstratified and commingled with rocks of every age.

In the mining districts the loads of precious and other metals are restricted, it would seem, to those areas occupied by granitic and gneissic rocks, and consequently to the mountains. In the plains, however, lies one of the chief resources of the country—the numerous and thick seams of excellent Lignite, contained in the Lower Tertiary series.

Accompanying Dr. Hayden's Colorado Report, is a description of the various mines visited during the Survey by Mr. Persifer Frazer, jun., mining engineer to the expedition, which is a mere transcript of his rough field notes. With regard to the gold mining, all the evidence given in this volume tends to prove the very transitory value of the primitive Placer system of gold-seeking, and that gold loads, to be properly won, require labour and expense quite as great as do any other metallic veins.

Before parting with Dr. Hayden, we will quote his description of the famous Red Pipe-stone Quarry, which may perhaps be acceptable, if not to every geologist, to every reader of "Hiawatha":—

"On reaching the source of the Pipe-stone Creek, in the valley of which the Pipe-stone bed is located, I was surprised to see how inconspicuous a place it is. . . . . . A single glance at the red quartzites here, assured me that these rocks were of the same age as those before mentioned at James and Vermilion Rivers, and at Sioux Falls. The layer of Pipe-stone is about the lowest rock that can be seen. It rests upon a grey quartzite, and there are about five feet of the same grey quartzite above it, which has to be removed with great labour before the Pipe-stone can be secured. . . . . . The Pipe-stone layer as seen at this point is about eleven inches in thickness, only about two inches and a quarter of which are used for manufacturing pipes and other ornaments. The remainder is too impure, slaty, fragile, etc. This rock possesses almost every colour and texture, from a light cream colour to a deep red, depending upon the amount of Protoxide of Iron. Some portions of it are soft, with a soapy feel, like Steatite, others slaty, breaking into thin flakes, others mottled with red and grey. . . . There are indications of an unusual amount of labour on the part of Indians, in former years, to secure the precious material."

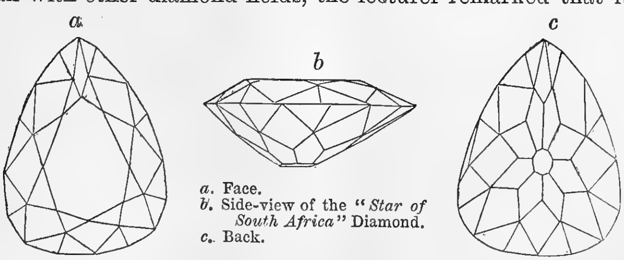
It may perhaps serve to intensify the legendary sacredness with which the Pipe-stone Quarry has been so often invested when we add, that the age of the layer itself, and of its accompanying rocks, is still a mystery to geologists. G. A. LEBOUR.

WOODBURN, *3rd December*, 1870.

REPORTS AND PROCEEDINGS.

SOCIETY OF ARTS.—Nov. 23rd, 1870. Sir Henry Barkly, K.C.B. in the Chair. Professor Tennant delivered a lecture before this Society on "South African Diamonds."

The lecturer gave the following history of the discovery of diamonds at the Cape of Good Hope: In March, 1867, Dr. Atherstone, of Graham's Town, received by post, in an unsealed, unregistered letter, a rough diamond, which had been picked up on a farm in the Hope Town district, and forwarded by Mr. J. O'Reilly to Mr. Lorenzo Boyes, Clerk of the Peace for the district of Colesberg. who sent it to Dr. Atherstone, in order that he might give his opinion as to the probability of its being of any value. He had not seen a rough diamond before, but, after taking the specific gravity, testing the hardness, and examining it by polarized light, he decided that it was a genuine diamond of considerable value; and perceiving the great importance of such a discovery to the colony, he at once wrote to the Colonial Secretary, suggesting that it should be sent to the Paris Exhibition, and afterwards sold for the benefit of the finder. This fortunate person was a Dutch farmer, named Schalk van Niekerk, who, seeing the children of a neighbouring boer playing with some bright stones, was struck by the appearance of one, which he offered to buy of the mother. She laughed at the idea of selling the gem, and gave it to him at once. He showed it to Mr. O'Reilly, who was returning from a distant hunting expedition, and so it finally reached Dr. Atherstone. At the close of the Paris Exhibition the stone was purchased by Sir Philip Wodehouse, then Governor of the colony, for £500. Passing on to compare the South African with other diamond-fields, the lecturer remarked that it had



a. Face.
b. Side-view of the "*Star of South Africa*" Diamond.
c. Back.

hitherto been unusual to receive more than one large diamond—say 40 carats—in the course of a single year, either from India, Borneo, or Brazil; but the new fields had yielded no less than five stones exceeding this weight within that time. He had models of many. There was one of 56 carats, and another of 83 carats, which arrived last year, and produced a stone of great beauty, weighing 46½ carats. This was the largest in the market, and was valued at £20,000. It had been named the "Star of South Africa." The three sketches here given show the exact size, *a* representing the face, *b* side view, and *c* the back of the stone, as cut. It is now in the possession of Messrs. Hunt & Roskell, who have kindly promised to allow any one who wished to see it. The lecturer proceeded, by means of diagrams, to explain the technical terms used in describing the forms in which the crystals of diamonds were found, and described some peculiarities of the stone by which it might be readily distinguished from other crystalline minerals of somewhat similar appearance. The diamond, although the hardest of substances, was one of the most brittle; and it was probably owing to ignorance of this fact and carelessness on the part of the diamond-seekers, that so many of the diamonds brought from the Cape were broken. The principal diamond-bearing districts at present discovered were the valleys of the Vaal, Orange, and Roit rivers. A great variety of other minerals had been found in the same neighbourhood. The pebbles consisted of rock crystal of different colours, and, together with agate, jaspers (black, red, and ribboned), quartzite, garnet, spinel, peridot, and blue corundum, were abundant.

Discussion.—Mr. Rawlinson drew attention to the great importance of diamonds to the artisan, the mechanic, and the engineer.

Mr. Fordred observed that the discoverers of diamonds at the Cape frequently made the mistake of placing a value exorbitantly high on the stones they sent over here to be sold.

Mr. Le Neve Foster said they made no allowance for the loss of weight in cutting.

In replying, Professor Tennant said that only about ten per cent. of those found were of the first water. In the large one of which he had spoken, weighing 56 carats, there were three flaws; nevertheless £5,000 was offered to the finder while it was still in the "rough." [1]

[1] In the "Graaff Reinet Herald" of October 29th, received by the last mail, it is stated that one party found fifty-four diamonds, one of 150 carats, another 27, the others smaller: altogether estimated at £150,000.

Geological Society of London, November 23, 1870.—Joseph Prestwich, Esq., F.R.S., President, in the Chair.—1. "On some points of South-African Geology."—Part I. By G. W. Stow, Esq. Communicated by Professor T. Rupert Jones, F.G.S.

In this paper, which was illustrated by numerous sketches, sections, tables, and specimens, observations were made on the stratification of the Jurassic beds of Sunday's and Zwartkop's rivers, resulting from researches made by Mr. Stow, with the view of determining the exact position of the several species of fossils found at the exposures on the cliffs of these rivers, and from this the sequence of the various beds. He indicated the existence of at least nine separate fossiliferous bands, pointing out the relative positions of the several *Trigonia*-beds, Hamite-beds, Ammonite-beds, etc.

He next treated of the so-called Saliferous beds of the district, and gives his reasons for regarding them as later in age than the *Trigonia*-sandstones above alluded to, and therefore not equivalent to that part of the series named "Wood-beds" by Dr. Atherstone.

Other researches of the author related to the Tertiary beds both inland and on the coast. He distinguished three zones on the coast later in date than the high-level shell limestones (Pliocene ?) of the Grass Ridge and other parts of the interior. One of the coast-zones he named the *Akera*-bed, from the prevalence of a delicate species of that genus. Another zone was described as following the river-valleys in the form of raised terraces, characterized by the presence of a large *Panopæa*. The latest shell-banks have been thought to be Kitchen-middens, but the author regarded them as shore-deposits in place. The author concluded by tracing the probable climatal and geographical changes in this region during geological times, and indicated, as far as his material allows, the probable migrations of the Mollusca, especially of the *Venericardia* characterizing the Pliocene Limestone.

Discussion.—Mr. Gwyn Jeffreys remarked that all the shells belonging to the genus *Akera* which he had examined were shallow water or littoral shells.

Dr. Duncan remarked on one of the corals as being of a well-known Crag form, the *Balanophyllia calyculus*.

Mr. Searles Wood, Jun., observed that there appeared some probability on the face of the paper of the shells of the older Post-tertiary beds denoting a warmer climate than the present, instead of, as here, a colder.

2. "Note on some Reptilian Fossils from Gozo." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author described the remains of two reptiles said to have been brought from Gozo by the late Captain Strickland. One of them was a fragment of the symphysial part of the slender mandible of an *Ichthyosaurus*, having teeth of precisely the same character as those of the form from the Kimmeridge Clay described by the author under the name of *Enthekiodon*. For this species the name of *Ichthyosaurus gaudensis* was proposed. The other was the skull of a species of Crocodile, for which the author proposed the name *C. gaudensis*.

Discussion.—Dr. Duncan suggested that the Ichthyosaurian fossil might be derivative from some Secondary rock. He mentioned that Dr. Leith Adams had once sent him an *Aspidiscus cristatus* from the Hippurite Limestone, which was stated to have come from Malta. To account for this, he suggested that the Miocene of Malta might have been supported on beds of Cretaceous age, so fossils from that source might have become imbedded in the coral reefs of the later date.

Capt. Spratt expressed a doubt of the fossil having really come from Gozo. He did not recognize the Cretaceous-looking matrix among any of the rocks of that island, with all of which he was acquainted. The nearest approach to that kind of rock was to be found in the lowest of the deposits near Cairo, which were probably Eocene.

Prof. T. Rupert Jones suggested an examination of the Foraminifera in the matrix, with the view of determining its Secondary or Tertiary age. He mentioned the occurrence of rolled nodules of older rocks in beds of later age at Gozo.

Mr. Busk stated that a stone of similar character to the matrix occurred in Malta, if not in Gozo, but probably in both.

Mr. Hulke, in reply, observed that he had in this paper intentionally left the stratigraphical part of the question untouched, and confined himself to the palæontological aspect of the remains.

3. "On the discovery of a 'Bone-bed' in the lowest of the 'Lynton Grey Beds,' North Devon." By F. Royston Fairbank, M.D. Communicated by Prof. Duncan, M.B., F.R.S., Sec. G.S.

In this paper the author called attention to the occurrence of a thin bed of rock to the west of the harbour of Lynmouth, containing an immense number of fragments of bone, some of them of large size, and associated with massive bodies which he regards as coprolites. The author proposed to call this the "Lynton Bone-bed;" and he thought that its discovery might throw some light on the relative age of the whole series of rocks of North Devon.

Discussion.—Mr. Whitaker had examined the beds in company with Mr. Wetherell. He did not agree with the author as to the amount of iron in the beds. The bone-remains appeared to him to be those of *Steganodictyum*, which had already been found in the lowest of the Devonian beds. He was not prepared to accept the nodules described as being undoubtedly coprolites.

Mr. Valpy stated that there were at least a dozen beds on different horizons of much the same character as that described along the coast of North Devon, an account of which had already been published at Ilfracombe.

Geological Society of Glasgow.—Nov. 3rd.—Mr. John Young, Vice-president, in the chair.

Carboniferous Fossils.—Mr. James Thomson, F.G.S., submitted to the Society some remains of fish and molluscan life recently discovered in the neighbouring Coal-fields, and which were new at least to the west of Scotland. These were *Acanthodes Wardii*, from Airdrie; *Athyris pisum*, from Brockley; and *Anomia corrugata*, from Dalry. He pointed out the characteristics of these species, and the relative position of the beds in which their remains occur.

1. The *Acanthodes* was a well-preserved specimen, showing the dorsal and anal spines in their natural position. This was of some importance, as these spines had frequently been found singly, and could not be referred to any known genus; but this discovery enabled palæontologists to name and classify these ichthyodorulites. Its dimensions are fifteen and a half inches long; dorsal spine, seven and a half inches; anal spine, fully seven inches; from the anal to the pectoral spine, six inches. The deepest part of the body is at the pectoral spine, where it measures four and a half inches. The head is wanting.

2. *Athyris.*—This little fossil occurs at Brockley, Lesmahagow, and Roughwood, Ayrshire. From its resemblance to *Terebratula sacculus*, it had often been mistaken for that shell.

3. *Anomia corrugata.*—This is the first well-authenticated specimen of *Anomia* that has been recorded from the Scottish Mountain Limestone. It is found in a band of shale which underlies the "Linn" Limestone, near Dalry.

Arctic Shell-bed.—Mr. D. C. Glen, C.E., gave some notes on the Boulder-clay laid open in the excavation now going on for a new dock at Cartsdyke, near Greenock, and referred to the abundance of Arctic marine shells, and other organisms, found embedded in it. The shell-bed seems to occur in a hollow of the Boulder-clay, which has been exposed to view by a deep cutting running parallel to the river, or east and west. On the northern side of this cutting, nearest the river, the bed is several feet in thickness; but on the other side it thins out, and finally disappears as we recede from the shore. In the other direction, from east to west, it is seen to abut suddenly against the Boulder-clay, and thus occupies a hollow of no great extent, in which, however, an immense number and variety of marine organisms are crowded together, forming one of the richest beds of such clay yet discovered on our western coast. At the same time, there was reason to doubt whether the deposit is now found in its natural position, or has not been dug out from some neighbouring part of the shore, and laid down to improve and level the ground, many years ago, in forming the policies where the excavation is being made. On this point, however, he would not express a decided opinion, and other members who had visited the spot were not unanimous regarding it.

Mr. Young said the section of Boulder-clay and the shell-bed referred to were of great interest, and he hoped would receive a careful examination from the members of the Society. He alluded to the number of large boulders, found principally in the upper portion of the deposit, the majority being sandstone of local origin, and the remainder granite, trap, and schist, from more distant localities. Many of these boulders were beautifully smoothed and striated by the action of ice. With regard to the puzzling features presented by the shell-clay—the way in which the shells are huddled together, the absence of any distinct stratification in it, and the manner in which it abuts suddenly against the Boulder-clay on either hand—these circumstances, together with its being of a looser texture, or less firmly compacted than most of the Arctic shell-beds found on our coast, undoubtedly suggest that it has been disturbed and removed. On the other hand, he read a note from Mr. David Robertson, whose opinion in such matters was entitled to very great weight, pointing out that a thin bed of fine clay, in which marine organisms occur, extends continuously between the shell-bed and the underlying Boulder-clay—which seems opposed to the supposition of the shell-clay having been laid down on an old land surface. Apart from this point (Mr. Young added), the deposit is worthy of attention as being exceedingly rich in organic remains, about 140 species having been already obtained from it, including some rare and many well-known Arctic forms.

An arranged series of these shells, polyzoa, etc., was exhibited by Mr. Young and Mr. Glen. Several other members also remarked on the deposit, and arrangements were made to revisit the locality at an early date.

CORRESPONDENCE.

On Supposed *Pholas*-burrows in Millers Dale, near Buxton, Derbyshire.

Sir,—From a letter in the Geological Magazine (Vol. VII., p. 586), I perceive that Mr. Edwin Brown, F.G.S., was unable to find the burrowings in Limestone which I described as occurring in Millers Dale. Perhaps he may have overlooked them, or possibly, as they were not numerous, some other person may have broken them away. I was reluctantly obliged to detach a specimen myself (which I send herewith) for the confutation of the incredulous. To insinuate that I do not know 'Toadstone' from 'Limestone,' or should write in a scientific periodical after an examination called 'careful' by myself, but in reality so hurried as to mistake the one for the other, or indeed the "vesicular cavities" of toadstone for "the borings of animals," attributes to me ignorance so gross, or carelessness so reprehensible, that Mr. Brown might as well have said that he considered me unworthy to write F.G.S after my name.

St. John's College,
Cambridge, *Dec.* 5.

T. G. Bonney.

P.S.—With regard to the principal subject of Mr. Brown's communication, I may remark that the following instances confirm, if it be needed, the idea of some, at least, of the Toadstones not being intrusive. (1). In a small cliff close by Litton Mills, at the opening of Cressbrook Dale (left bank), we have the following section:—(A) High talus overgrown with bushes, showing projecting ledges of limestone: (B) Cliff of Toadstone, upper part sandy and decomposing, lower part more solid and amygdaloidal: (C) well marked bed of very compact Toadstone: (D) sandy and shaly band, volcanic ashes: (E) ashy bed, nodular and concretionary in places, with fossils, *Spirifera Productus*, etc.: (F) Limestone, very compact, perhaps somewhat altered. (2). In descending by the road that leads over the flanks of the Heights of Abraham from Matlock Bath to Bonsall, after quitting the sheet of Toadstone that caps the hill, I observed many blocks in the wall containing volcanic ash. One variety is a purple rock of clayey fracture, containing angular or subangular fragments of limestone, and yellowish brown or greenish bits and specks, which I believe to be decomposing volcanic ash; the other a calcareous rock (? brecciated in places) with many specks of greenish grey and brown colour, also decomposing ashes. This bed contains fragments of small crinoids. If I mistake not, both these beds are exposed *in situ* by the road-side a short distance apart, and about fifty yards from the first cottage in Bonsall village.—T.G.B.

In the Geological Magazine for June last (Vol. VII., p. 267) we published an article on supposed *Pholas*-burrows in Millers Dale, by the Rev. T. G. Bonney, M.A., F.G.S.

Another article "on the supposed occurrence of *Pholas*-burrows in the upper parts of the Great and Little Ormesheads," by the same author (accompanied by a Plate), appeared in Vol. VI., 1869, p. 483.

Mr. Bonney's observations tend to disprove their *Pholas*-origin, and to support the conclusions of M. Bouchard-Chantereaux, Miss Hodgson, and others, that they are the work of *Helices*.

In a letter published in the December number of this Magazine

(p. 586, Vol. VII.), Mr. Edwin Brown calls in question the fact of perforated Limestone occurring in Millers Dale, and supposes that Mr. Bonney may have mistaken vesicular cavities in Toadstone for the borings of animals in Limestone.

Mr. Bonney very justly complains of the unfairness of Mr. Brown's insinuation, which, we regret to say, did not strike us in reading Mr. Brown's letter before publication. We have received from Mr. Bonney a specimen of the perforated Limestone from Millers Dale, referred to in his article, and it is, as our readers would expect, a *true Limestone,* the perforations of which *agree exactly* with those from Ulverston, in Lancashire, originally described by Miss Hodgson (see the "Geologist," Vol. vii., 1864, p. 42), and subsequently by Mr. J. Rofe, F.G.S. (See Geol. Mag., Vol. VII., 1870, p. 4, Pl. I.)

The estimate our readers and other scientific men have formed of Mr. Bonney's contributions to science, would prevent any one accepting the suggestion in Mr. Brown's letter. We are sorry this paragraph formed a portion of an otherwise valuable communication; and we do not doubt that Mr. Brown will be as ready as we are to regret what he must now see was an unjust criticism on the observations of a brother F.G.S. Edit. Geol. Mag.

THE BLUE CLAY OF THE WEST OF ENGLAND.

Sir,—Miss Eyton states (Geol. Mag., p. 545) that the shell-bearing gravels often rest "upon a bed of blue or grey clay . . . described . . . in Lancashire and Cheshire, by Mr. Binney; and more recently by Prof. Hull," and mentions that Mr. Hull gives its thickness at Llandudno at 150 feet. To Prof. Hull's name she gives a reference to a paper on the "Glacial Phenomena of Lancashire and Cheshire." I wish to state (1), that I am the writer of a paper with that title, read before the Geological Society, on June 22nd. (2), That Prof. Hull has not, I believe, written a paper with that title. (3), That the Lower Till he has always described as precisely resembling the Upper Till, being of the same red colour, general character, and including the same erratic boulders. (4), That this is so much the case, that Mr. Binney considers (in all his papers) the two clays to be one, with an intercalated Middle Sand. (5), That in my paper, above referred to, I describe a Lower Till, of the nature mentioned by Miss Eyton, as occurring in Lancashire, at levels above 300 feet, formed by an ice-sheet, and mention that in North Wales a similar clay is eroded, and overlaid by the *ordinary* Lower Boulder-clay of marine origin. (6), That I consider that at Llandudno it never reaches a greater thickness than 20 feet. (7), That I cannot admit, with Mr. S. V. Wood, that the Upper Till of Lancashire is the representative of the Hessle clay, or any other recent bed.

H. M. Geological Survey, Morecambe. C. E. De Rance, F.G.S.

ON SUPPOSED THERMAL SPRINGS IN CAMBRIDGESHIRE.

Sir,—A paper was read at the late meeting of the British Association by Mr. Harmer, "On some Thermal Springs in the Fens of Cambridgeshire." I have not had an opportunity of visiting them, but, knowing the general character of the district, I have thought over the matter, and asked myself whether, since they are stated to be shallow farmyard wells, the temperature of the water may not be due to fermenting manure. To-day I went into a farmyard in this village, and found them laying up the manure in heaps, previous to carting it away upon the land. The manure was already hot and steaming when they removed it from the area of the yard, on which it lay two feet deep. There stands a pump in the centre of the yard; and I asked the farm-servant, who lives on the spot, whether the water was warm. "Yes," said he, "almost as warm as new milk. And so is the water from the other well" (which stands on the edge of the yard). I fetched a thermometer, and found the water in the yard at 65° Far., that in the well on the edge of the yard at 54°, while the temperature of the air was 44°. Snow has been lying on the ground for five days, and disappeared only last night. In thawing it has gone into the farmyard well, and discoloured the water; else probably the temperature might have been higher, for the workman considered the water less warm than usual. In these wells the water stands at about twelve feet from the surface. They are fed by springs from the lower chalk, the water being held up by the gault. In such a country as this, the idea of Thermal springs being fed by faults from below seems improbable, since, though there may be faults, it is scarcely possible that open fissures can exist in the soft clays of the district.

Harlton, Cambridgeshire, *Dec.* 13, 1870. O. Fisher.

THE ALLEGED OCCURRENCE OF *MACHAIRODUS LATIDENS* IN KENT'S CAVERN, TORQUAY.

Sir,—Your readers are doubtless aware that in certain English museums there are canines of *Machairodus latidens* (formerly known as *Ursus cultridens*), said to have been found in Kent's Cavern, by the late Rev. J. MacEnery; and that some palæontologists, including M. E. Lartet and the late Dr. Falconer, have doubted whether they really did belong to the Cavern series.

In 1869 I printed all the evidence which existed on the subject, so far as was then known,[1] and have reason to believe that the doubts mentioned above were fully disposed of.

My present object, however, is to ask for sufficient space in your Magazine to record an unpublished fact having an important bearing on the question. Through the kindness of Professor Phillips, I have recently found that in May, 1826, Mr. MacEnery sent to the Museum of the Yorkshire Philosophical Society a set of specimens

[1] See Trans. Devon Assoc., vol. iii., pp. 481-494. 1869.

from the Cavern, with a cast of one of the canines in question, accompanied by a descriptive letter, in which were enclosed a copy of a letter from the Baron Cuvier and of part of a letter from Dr. Buckland.

These documents are all preserved at York, and, through the kindness of the Rev. J. Kenrick, I have been courteously permitted to copy them, with a view to publication. At present, however, it is not necessary to trouble you with anything more than the following:

"Extract from Dr. Buckland's letter to Rev. J. MacEnery respecting the serrated tooth, of which a cast is enclosed in the Collection :—

"LYONS, 14 *March*, 1826.

"My dear Sir,—I should have forwarded the enclosed from Paris had I not waited to visit a spot in Auvergne, where they have recently discovered a deposit of animals exactly similar to those of Kent's Cave in a bed of Diluvial sand and gravel.

"The resemblance is still more striking from the fact of there being among them the teeth of your unknown animal,[1] which turns out to be the *Ursus cultridens* of Cuvier, which had, till now, been found only in the Val d'Arno. There is an entire skull of this bear in the Collection at Florence.

"I think it is more satisfactory to have *this analogy established than to have discovered a new species at Torquay.*

"M. Cuvier was much pleased with the identity of the teeth. . . ."

Allow me, in conclusion, to recapitulate briefly the points that appear to be now established respecting the Kent's Hole *Machairodus* :—

In January, 1826, Mr. MacEnery found, mixed with the remains of the ordinary Cave Mammals, five canines, and subsequently one incisor, of *Machairodus latidens* (= *Ursus cultridens*), in that part of the Cavern which he named the Wolf's Den. Sir W. C. Trevelyan saw all the specimens at Torquay in the following month. Casts of the canines were taken to Paris, and submitted to M. Cuvier by Dr. Buckland, who, writing from Lyons on March 14th, informed Mr. MacEnery that M. Cuvier had identified them as the teeth of *Ursus cultridens*.

Finally, the canines have been thus distributed: One is in the British Museum, ; one in the Museum of the Geological Society of London; one in the Museum of the Royal College of Surgeons, London; one in the Oxford Museum; and one in the private collection of Sir W. C. Trevelyan.

WM. PENGELLY.

TORQUAY, *December* 10*th*, 1870.

[1] It is, perhaps, noteworthy that, in the brief contents of Kent's Cavern, written before his letter from Lyons, Dr. Buckland mentioned the remains of rhinoceros, elephant, horse, elk, deer, ox, hyæna, bear, tiger, wolf, fox, "and of an unknown carnivorous animal, at least as large as a tiger, the genus of which has not yet been determined." (See Edin. Phil. Journ., vol. xiv., pp. 366–64, 1826). This great *unknown* was, no doubt, *Machairodus*.

MESSRS. RUTLEY AND WOLLASTON ON DRIFT.

SIR,—Having examined most of the sections described in my article in the GEOL. MAG. for October, 1870, a number of times, especially the sections to which I attached much theoretical importance, I feel called upon to rebut any charge of inaccuracy unaccompanied by instances, with diagrams or detailed explanations. Instead of Mr. Rutley (in your last number) substantiating any such charge, his facts (which I have no doubt have been very accurately observed) corroborate my observations, while any want of theoretical agreement between us consists to a great extent in the application of terms. He calls the small mounds in the lower part of Kentmere "moraine stuff with scratched stones"; I look upon them as an upland extension of the boulder-drift of the plains. He confirms my observations relative to the glaciation and striæ of the higher sides of valleys taking an oblique direction to the "valley axis." This obliquity of direction, however, I have found, in many instances, to extend to the bottoms of the valleys. Mr. Rutley's discovery of striæ crossing the high ground between Kentmere and Long Sleddale, viewed in connexion with my observation of longitudinal striæ, can, I think, be more easily explained by floating ice than by two great ridge-concealing and valley-ignoring ice-streams flowing in different directions at different periods. I cannot agree with Mr. Rutley in calling the stones found in the drift on the high ground between Kentmere and Long Sleddale "moraine stones," and do not believe that moraine matter, properly so called, could ever have been spread over elevated moors, or shed on the summits of high ridges, such as those which separate the larger valleys of the Lake District.[1] With regard to the origin of the parallel ridges S.E. of Windermere, Mr. Rutley's remarks, as he himself implies, lead to no definite conclusion on the subject. If he will look for them in the neighbourhood of Windermere, I think he will have no difficulty in seeing several small rocky escarpments, with pinel underneath, like some of the fragmentary cliffs and raised beaches in the Channel Islands and S.W. of England, though differing from them in exhibiting traces of ice-action.

I cannot agree with your other correspondent, Mr. Wollaston, in believing that the able and comprehensive papers by Messrs. De Rance and Ward have well nigh exhausted the subject of drifts and glaciation in the Lake District; and I am sure that these able, accurate, and diligent surveyors would be among the last to entertain any such idea. I have devoted almost exclusive attention to the drifts of N.W. Lancashire,[2] W. Yorkshire, the Lake District, and the neighbourhood, for two years; and I feel that the whole ground I

[1] For remarks on the difference between valley-glacier moraines in which polished and striated stones very seldom occur, and boulder-drifts in which the proportion of such stones, though very variable, is generally considerable, and often very great, see works and papers by Forbes and Lyell (Alps), Close (Ireland), and Jamieson and Milne-Home (Scotland).

[2] See paper in Quart. Journ. Geol. Soc., vol. xxv., June, 1869.

have gone over requires re-examination, and that six years would be too short to enable one person to divide and correlate correctly, and arrive at satisfactory conclusions as to modes of accumulation. In connexion with this subject, I may express my belief that in order to prevent any geologist assigning too much to the depositing power of ice in an extensively glaciated region like the Lake District, it is important that he should be acquainted with the drifts of the adjacent plains, and of neighbouring or distant hilly districts in which traces of glaciation are exceptional or altogether absent. It is likewise important that he should not be ignorant of the *versatility* of the sea as a depositing agent.

The question asked by Mr. Wollaston relative to the absence of Skiddaw slate and granite from Dunmail Raise, applies with nearly equal force to the theory of transportation by great streams of land-ice. In its bearing on ice-laden marine currents, I think it can be satisfactorily answered. Currents impinging on an island (such as Skiddaw must once have been) do not necessarily flow through all the gaps or passes within sight of the island; and a current may have been prevented from flowing southwards from Skiddaw by an east or west current traversing Keswick and Threlkeld vale. We know that a current laden with boulders from Wasdale Crag flowed over Stainmoor pass,[1] but no trace of such a current has been found in the Lune valley pass, south of Tebay railway-station. Granite-laden currents must have flowed south and south-west from the Eskdale Fells, but there are no indications of such currents having flowed in any other directions.

MILLOM, *8th December*, 1870. D. MACKINTOSH.

OBITUARY.

PROFESSOR BISCHOF, FOR. MEMB. GEOL. SOC., LOND.

Amongst the losses which science has sustained during the past year, it is our melancholy duty to record the death of Professor Bischof, of the University of Bonn, in Rhenish Prussia, who died in that city on the 29th of November, in his seventy-ninth year. As a tribute of respect to a man of science, of so throughly cosmopolitan reputation, and whose labours have nowhere been more appreciated than in England, we lay before our readers the following short sketch of his scientific career.

Carl Gustav Bischof was born on the 18th of January, 1792, at Wörd, in the suburbs of Nürnberg, in Bavaria, where his father, subsequently Rector of the Latin School of Fürth, then resided. In the year 1810 he entered the University of Erlangen, with the special

[1] Professor Harkness, in the last number of the Quart. Journ. Geol. Soc., submerges the Lake District to a greater height than 700 feet above the level of Dunmail Raise, and brings up false-bedded marine drift to 1,100 feet above the present sea-level, or 100 feet higher than I have ventured to assert.

intention of devoting himself to mathematics and practical astronomy; but in a short time he became so impressed by the chemical lectures of Professor Hildebrandt, that he entirely changed his course of studies, which resulted in his qualifying himself as a lecturer on chemistry and physics; and upon the decease of Hildebrandt, in 1816, he succeeded to his position, and also undertook the continuation and conclusion of his "Lehrbuch der Chemie," published at Erlangen in 1816.

About this period his attention appears to have been more specially directed to Geology, and, in conjunction with his friend Professor Goldfuss, he brought forward, in the "Physicalische Statistischen Beschreibung des Fichtelgebirgs," (2 vols., Nürnberg, 1817), the results of the geological and physiographical exploration of this mountainous district.

In the year 1819 his "Lehrbuch der Stöchiometrie" appeared, and also, in conjunction with Von Esenbeck and Rothe, a memoir on "Die Entwickelung der Pflanzensubstanz;" and in the spring of the same year he removed to Bonn to act as Professor of Chemistry and Technology in the newly-founded University, in which, in 1822, he was appointed Professor of Chemistry, a position he retained for little less than half a century.

A treatise on chemistry, "Lehrbuch der reinen Chemie," was commenced by him in 1824, but only the first volume ever was published, he having given up the study of pure chemistry, in order to devote his entire energy and time to chemical and physical geology, in which branches of science he afterwards became so distinguished. His first production in this line was his work, brought out in 1826, "On the Volcanic Mineral Springs of Germany and France," as well as a memoir on the mineral spring of Roisdorf, which appeared in the course of the same year; and was followed, some ten years later, by "Die Wärmelehre des Innern unseres Erdkörpers," (Leipzig, 1837), a work which gave rise to his "Physical, Chemical, and Geological Researches on the Internal Heat of the Globe," published in London, in 1841.

During the interval from 1837 to 1840 he had been ordered by the Government to inquire into the nature of the inflammable gases of coal-mines, and the safety-lamps employed in their exploration; and the results of these investigations will be found in several communications to "Karsten und von Dechen's Archiv für Mineralogie" and the Edinburgh New Philosophical Journal, as also in a memoir on "Des Moyens de soustraire l'Exploitation des Mines de houille aux dangers d'Explosion," (Brussels, 1840), to which the premium offered by the Academy of Brussels was awarded.

In the following years numerous memoirs were contributed by Professor Bischof to the different scientific Journals, amongst which may be mentioned "The Glaciers in their Relations to the Elevation of the Alps," 1843; "The Formation of Quartz and Metallic Veins," 1844, etc.; and in 1847 he commenced the publication of the first edition of his greatest work, the "Lehrbuch der Chemischen und Physicalischen Geologie," (2 vols., Bonn, 1847–1854), which was finished in 1854, in which year an English translation (so much augmented as in reality to be a second edition) was published by the Cavendish Society, under the personal superintendence of the author, which work, for the first time, supplied a notable deficiency in our scientific literature. In 1866 an entirely re-written new German edition of this work, in three volumes, was completed; and up to the last days of the worthy Professor's life, he was occupied in completing a supplement to this edition, which will bring it up to date, and is expected to appear immediately.

Space does not admit of our even giving the titles of the numerous scientific papers and minor communications, or alluding to the popular lectures and letters on scientific subjects, which appeared in print between the years 1842 and 1849. The posthumous fame of Professor Bischof will rest, however, mainly upon his most important work on Chemical and Physical Geology, which embodies a vast amount of data for future generalization. Even those men of science who may not be inclined to adopt the late Professor's views in their entirety, cannot but admire the wonderful perseverance and sagacity which he brought to bear upon his chosen field of investigation, and admit that he must be regarded as the founder of the study of chemical geology, a branch of science which every day is asserting its claims to more distinct recognition.

Professor Bischof had, what is rarely accorded to scientific men, the happiness of seeing his labours universally appreciated during his lifetime. Prussia gave him the decoration of the Red Eagle, whilst from Russia he received the Order of St. Ann; in England he was awarded the gold Wollaston medal by the Geological Society, and in 1861 was elected a honorary member of that body, whilst most of the principal scientific institutions of Europe enrolled him amongst their members. Up to the very last Professor Bischof preserved his mental faculties quite unimpaired by either age or infirmity; and whilst, in his public capacity, he was esteemed by all, it must also be added, that in private life he was one of the most amiable of men, as all who knew him can testify. D. F.

Death of the President of the Royal Microscopical Society.—With deep regret we announce the death of the Rev. Joseph Bancroft Reade, F.R.S., F.R.A.S., President of the Royal Microscopical Society. He was a Scholar of Caius College, Cambridge; and obtained his B.A. degree in 1825, when he took high honours in the Mathematical Tripos. He was curate of Rigworth, Leicestershire, till 1829, and was successively curate and afternoon lecturer at the parish church, Halifax, till 1832, and incumbent of Harrow Weald till 1834. In 1839 he was presented by the Royal Astronomical Society to the vicarage of Stone, near Aylesbury, and in 1859 to the rectory of Ellesborough. Archbishop Longley gave him the rectory of Bishopsbourne, near Canterbury, in 1863, and he held it until his death, in his 70th year, early on Monday morning, December 12, 1870. His talents and discoveries have justly entitled him to a place amongst the eminent men of the day, and the loss of him will be generally felt by men of science. His kindness of heart and geniality of disposition endeared him to all who came in contact with him, and those who had the privilege of his friendship will sorrow most of all that they shall see his handsome, benevolent face no more.—*Land and Water,* Dec. 17th, 1870.

MISCELLANEOUS.

The Student's Elements of Geology.—By Sir Charles Lyell, Bart., F.R.S. *London,* 1871, John Murray. 8vo. pp. 624, with more than 600 illustrations on wood.—This is an abridged edition of Sir Charles Lyell's much larger volume, "Elements of Geology," and is an endeavour, on the author's part, to meet the demand for a more elementary text-book than his former publications furnish. As we only received it just before going to press, we will not attempt to notice it here, but only to call attention to the fact that it is now to be had. We hope to give it a proper notice next month.

Chair of Geology and Mineralogy in the University of Edinburgh.—Some time since Sir Roderick Murchison offered the munificent sum of £6,000 for the endowment of a Chair of Geology and Mineralogy in the University of Edinburgh, on the understanding that the annual proceeds of this sum would be supplemented by a grant from Parliament. We are happy to state that Government has consented to this proposal, and has agreed to recommend an annual grant of £200. We believe the University is largely indebted for this desirable result to the earnest co-operation of its member, Dr. Lyon Playfair. It is also an evidence that the Government are not so indifferent, as they have been supposed to be, to the claims of scientific education.—*Nature,* Dec. 22, 1870.

The Chair of Natural History in the University of Edinburgh, the duties of which were so long and ably discharged by Professor Allman, has been given to Professor Wyville Thomson, F.R.S., until lately Professor of Natural History at Queen's College, Belfast. This of course creates a vacancy, the applicants for which are, we understand, numerous, but we have not as yet heard of any one being selected.

Health of Sir Roderick Murchison, Bart., F.R.S., etc.—We are glad to be able to announce that a very considerable improvement has taken place in Sir Roderick Murchison's health. The Director-General is progressing most favourably towards recovery.

Annual International Exhibitions.—Intending Exhibitors who have not yet intimated their wish to submit objects for selection, are reminded that they must do so *at once,* on a form provided for the purpose, which may be obtained on application to the Secretary. The offices are at Upper Kensington-gore, London, W., Lieut-Col. Scott, R.E., *Sec.*

THE

GEOLOGICAL MAGAZINE.

No. LXXX.—FEBRUARY, 1871.

ORIGINAL ARTICLES.

I.—On the Diamond Fields of South Africa.

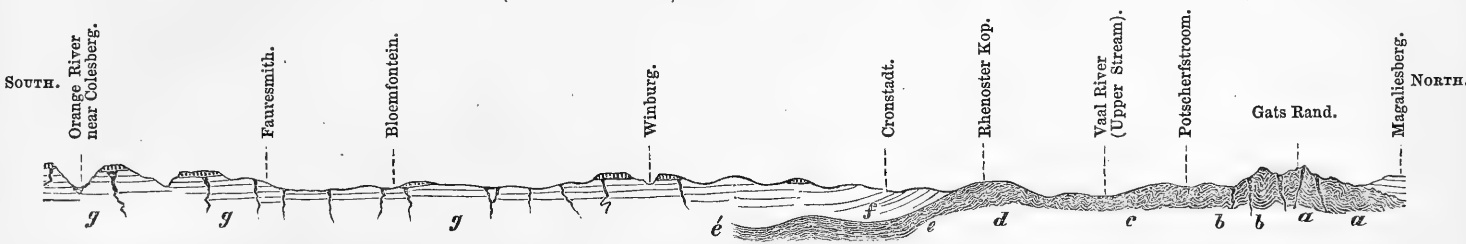
By T. Rupert Jones, F.G.S., Professor of Geology, Royal Military and Staff Colleges, Sandhurst.

Diamond Region.—The diamond-bearing region in South Africa, as at present known, is chiefly within the valley of the Vaal River and some of its tributaries (as the Modder and the Vet); but it is known also to extend down the Orange (Gariep) Valley for a few miles after the junction of its two great branches, the Ky Gariep (Vaal) and the Nu Gariep (Cradock River). Bloemhof on the Vaal, two hours (12 miles) south-west of Potscherfstroom (Transvaal), is the reported locality of the most northern diamond-find. Below, for a distance of 370 miles, the plain has yielded diamonds, at several places, on both sides of the river, at Hebron, Klipdrift (near Pniel), Zitzikamma, Vogelstruis Pan, Sitlacomie's Village, Sikoneli's Village, Nicholson's Farm, Kalk Farm (near Litkatlong), etc.; and on the south side of the Orange River, they have been found some miles north-west of Hopetown, at Probeerfontein, Roodekop, David's Pan, etc. Diamonds are also said to have been found a few miles east of Fauresmith, on a branch of the Modder, about 100 miles south by east of Litkatlong; also a few miles south of Winburg (also in the Orange River Free State), in the upper drainage of the Vet River, about 80 miles from the Vaal.

Geology of the Diamond Region.—Owing to the country being mostly flat and very much coated with loose sand, its geological structure has not been fully understood as yet; and the endeavours of travellers and colonists to describe the rocks and minerals they have met with on the Vaal are, with few exceptions, so much enfeebled by want of exact knowledge, both of geology and mineralogy, that the very numerous and indifferently printed letters, lectures, and notices in the colonial periodicals fail to give us more than an imperfect sketch of the geological features and characters of this interesting region.

Among those who have contributed to our knowledge of the geology of the Orange and Vaal Valleys, are Mr. A. G. Bain, Dr. R. N. Rubidge, Mr. Wyley, Dr. W. G. Atherstone, Mr. Higson, Dr. John Shaw, Dr. Exton, Dr. Muskett, Dr. G. Grey, Mr. E. T. Cooper, Mr. Gilfillan, Mr. G. W. Stow, and Mr. C. L. Griesbach.

DIAGRAM SECTION OF THE ORANGE RIVER FREE STATE AND THE TRANSVAAL, IN SOUTH AFRICA.



h Karoo beds of the Transvaal (supposed place).
gg Karoo strata and their igneous rocks.
f Probable place of the Trap-breccia. Possibly, however, only the upper portion of the Karoo formation reached thus far North.
e Sandstone (old).

e' Probable continuation of Palæozoic (Carboniferous) rocks Southwards, beneath the Karoo formation (upper beds only perhaps), and thus bringing the old coal-beds in immediate proximity to the overlying Secondary coal-beds.

d Gneiss and quartzite.
c Gneiss and steatite.
bb Gneissic schists and volcanic craters.
aa Schists, quartzite, marble, and granite dykes.

DIAGRAM SECTION OF THE STRATA OF ALBANY, SOMERSET, AND CRADOCK, IN SOUTH AFRICA.

ff Post-tertiary beds.
bb Ecca beds, including the Trap-breccia.
ee Jurassic strata.
d Enon conglomerate.
aa Palæozoic rocks.
cc Karoo beds, with igneous rocks.

In Mr. Bain's geological map and sections of South Africa (Trans. Geol. Soc., 2nd ser., vol. vii., pl. 20 and 21), the middle strata of his great "Karoo formation" range up to the Orange River in Lat. 29° 30′ S., thence along the Modder River, and, skirting the north side of the Winburg Road, they extend for a great distance to the north-east, thereby including the diamond-fields near Hopetown and Fauresmith; whilst that near Winburg lies on the upper portion of the Karoo series, according to his map and his section "No. 3." Whether or no the Karoo beds extended as far as the Vaal, was not clear when his work was published. Since then, however, more information has been obtained by Rubidge, Wyley, Higson, Gilfillan, Stow, Griesbach, and others.

Dr. Rubidge[1] noticed the occurrence of the Dicynodont strata in the Vaal Valley at Winburg and Harriesmith, also in the Draakenberg, and in the Transvaal at Magaliesberg.

Mr. A. Wyley (in "Notes of a Journey across the Colony in 1857–8") described the Hopetown district as consisting of sandstones and shales, intersected by dykes of igneous rocks, and as the same as the Karoo series to the south.

Mr. Gilfillan ("Grahamstown Journal," July, 1870) has noted the occurrence of horizontal, hard, blue shales (Karoo) between Hopetown and Litkatlong. Mr. Higson has satisfactorily described the Karoo beds on the Modder and the Vaal (see further on, p. 52).

Mr. Stow, in a paper lately read before the Geological Society of London, indicates that the Karoo beds pass northwards across the Free State. Lastly, Mr. Griesbach has informed me that he has seen sections of Karoo beds on the Vaal, and in its branches or "spruits" coming from the north; and not only that these beds exist in the Transvaal (Magaliesberg), but also further north on the Zambesi.

It is observable that such scattered information as is given respecting the valley of the Vaal refers to a striking difference of scenery between that of the Cape Colony and that of the Orange River Free State;[2] where low and often rounded hills, in flat sandy tracts, have taken the place of high flat-topped hills, sharp points, and steep-sided valleys, of sandstones, shales, and trap-rocks. Such rocks, however, as have been observed in place in the Vaal Valley, where the superficial deposits have been removed by wind and rain, are referred (by Mr. Gilfillan, as above noticed) to "hard blue schist," north of Hopetown, between the Orange and the Modder, and to "yellow schist and conglomerate," at the junction of the Modder and the Vaal, with igneous rocks at both places. These, taking "schist" to mean hard shale, are not different from some of the Karoo beds further south, and their intrusive dykes, especially as the bedding is said to be horizontal. Quartzite ("quartzose crystalline sandstone"), however, is alluded to by Dr. John Shaw,[3]

[1] Quart. Journ. Geol. Soc., vol. xii. p. 237; 1856.

[2] Mr. Bain incidentally mentions that between the Bambus Bergen and "the magnificent Nu Gariep or Orange River . . . detached hills, separated by extensive and dreary plains," are the features of the country. Trans. Geol. Soc., 2nd ser., vol. vii., p. 58.

[3] "Grahamstown Journal," January 20, 1869; "Cape Monthly Magazine," September, 1869; "Nature," November 3, 1869.

together with some kinds of gneissic and igneous rocks ("amygdaloidal wacké"), as occurring in a ridge parallel with, and distant a few miles on the north from the lower Vaal (reaching as far as Sitlacomie's village) in the same district. These are probably palæozoic rocks, cropping up from beneath, to the north of the river. Dr. Shaw says that "trap, metamorphic, and conglomerate rocks," occur all through the Vaal Valley, and that frequently there is "basalt protruding through conglomerate and amygdaloid trap;" but these so-called "metamorphic" rocks are not clearly defined, and the "binary granite,"[1] "syenite," "clay-schists," and "sandstone," if not débris of rocks from the Transvaal, to the north and north-east, may be remnants of the Karoo beds and of their igneous dykes, intercalations, and included boulders; whilst his "chalk or something like it" is probably the well-known superficial tufa of the district.

Dr. Muskett has noticed that sandstone, passing upwards into conglomerate, regularly stratified, traversed by trap-rocks, and similar to that in most of the hills between Graaf-Reinett and Port Elizabeth, forms the base of the (Lower ?) Vaal Valley. This indicates the continuance of the Karoo beds.

Some extracts from the diary of Mr. G. S. Higson, published by Professor Tennant (with some notes on diamonds, etc.) in 1870, give the clearest account of the geology of the diamond-fields of the Vaal. He left Bainsvlay, near Bloemfontein, in March, and next day on the Modder, opposite Wonderkop, he saw blue and ochreous shales of the Karoo series, "capped with the common blue basaltic trap or 'ironstone' of the country." In the Middelveld, at the end of the next stage, he noticed that "one of the hills had a thick coat of coarse sandstone under the trap, and overlying the clay-shales." Passing several farms, he came to Bultfontein (or Du Toit's Pan), where many small diamonds had been found. Here in two water-pits "good sections of the shale-formation are brought to view, intersected and upraised by the basaltic dykes; in one, to an angle of about seven degrees, sloping off from each side of the dyke, and striking east and west; in the other the shales are tilted up to about 25°. This is contrary to the experience of the late eminent geologist, A. G. Bain, in similar Dicynodont formations in the Old Colony, where effusions of trap have not disturbed the horizontality of the shales. May not this have something to do with the local distribution of the diamonds?" Having left Pniel, he came upon a section "by the side of the road, going up the river, between the station and Mr. Hayward's farm," showing "where the clinkstone and amygdaloid had run over the basaltic trap." At the diamond-diggings below Pniel "the formations on both side of the river are similar — basaltic, greenstone, and quartz dykes intersecting the ground, and crossing through the river from side to side." Mr. Higson then adds — "Went about the hills searching, but without success. Examining a gully about 1½ miles down the river, I was

[1] A granilite, or binary granite, is alluded to by Mr. Higson (see further on, p. 53), as being the fundamental rock of the Vaal Valley.

successful in discovering an immense deposit of the underlying rock of the diamond region. It is a porphyritic gneiss, and no doubt has a very extensive range in South Africa. Mr. Hübner showed me specimens of the same fundamental rock, which he had found covering a large area of country to the north: it is the underlying stratum at the Tatin and northern gold-fields, at the Chief Machin's town, in the Bamangwato hills, and forms the great mass of the Maquassie range of mountains in the Transvaal; but Mr. Hübner had been unsuccessful in tracing it again after leaving the Maquassie. Mr. Hübner calls it a 'porphyritic granilite,' but I have rather adhered to the nomenclature of Dr. Atherstone and others. My thus finding the same underlying rock across the Vaal forms a connecting link between the mineral regions of this part of the country, the Transvaal, and the far interior.[1] Proceeded about 16 miles down the Vaal; formations the same as before."

Thus the Karoo strata continue not only up to the Vaal, but into and beyond the Transvaal, and form considerable portions of the region to the east, bordering on and forming part of Natal. In the diamond-districts they have been worn down to a low level, in some places, perhaps, to the lowest crystalline rocks, at all events down to the "Devonian" strata, which certainly come out to the hilly surface further to the north-east, where Dr. Carl Mauch found specimens of *Murchisonia* in Sekhomos and Mosilikatzes country, in the Transvaal Republic, in 1867.

Of the well-known "Karoo Formation" itself, we may say that it consists of an enormous series of shales and sandstones, rich at places with the wonderful remains of extinct Reptiles (*Dicynodon, Oudenodon, Micropholis, Galesaurus, Cynochampsa, Massospondylus, Pachyspondylus, Leptospondylus, Euskelesaurus, Orosaurus, Saurosternon, Pristerodon,* and others undescribed), and Palæoniscan Fishes, together with Coniferous Trees, Ferns, and other Plants (among which *Lepidodendron* has been noticed by Rubidge and Grey), and coal-beds also. These strata are crossed by frequent trap-dykes (doleritic?, dioritic, and syenitic) at different angles; and are often overlain by and intercalated with similar igneous rock. Being horizontally bedded and much denuded, this extensive series of strata constitutes table-lands and flat-topped hills, deeply divided by broad valleys. A remarkable feature in this great series of probably lacustrine deposits is its basement-bed of angular and rounded blocks of trap, granite, etc., massed together in a dense cement, which in some places appears to be felspathic, but elsewhere argillaceous. Hence this great persistent band has been variously termed "claystone-porphyry" (Bain), "trappean conglomerate" (Wyley), "a species of trachyte" (Sutherland), and "Boulder-clay" (Sutherland and Griesbach). The late Dr. Rubidge thought that, on

[1] This "granilite" may possibly also be the same as Bain's binary granite of the Paarl and near Bain's Kloof, not far from Cape Town. Geol. Trans., 2nd series, vol. vii., p. 179.

the flanks of the Zuurberg (near Grahamstown), this great trap-breccia had received its felspathic character from metamorphic influences (Quart. Journ. Geol. Soc., vol. xv., p. 198).

The Karoo beds have been enormously denuded in the great catchment area of the Orange and the Vaal, on a scale proportionate to the vast destruction these strata have been subjected to throughout their extent, as indicated by Bain[1] and Rubidge,[2] and more elaborately described, in the case of the Eastern Province, by Mr. Stow.[3]

To the north-east of Cronstadt, the Vaal Valley comes into the sandstone district (continuous with, and a part of, the Karoo series), from off the old quartzites and gneiss of the Transvaal. These are broken through by volcanic rocks (with craters to the south-west of the Gats Rand, Transvaal), and associated with marble, and dyked with granite, on that watershed of some of the northern tributaries of the Vaal (Higson). The great Draakenberg or Quathlamba range supplies the other head waters of this diamond-sanded river. The Draakenberg consists of Karoo beds, intercalated and surmounted with trap-rocks (Sutherland and Griesbach).

The Wittebergen, also composed of Karoo strata and volcanic rocks, branch off westward from this great range, at about 29° S. Lat., and divide the head waters of the northern tributaries of the Vaal from those of the Caledon and Orange Rivers, which, rising in the Mont-aux-Sources or Bouta Bouta (about 10,000 feet above the sea), at the divergence of these mountains, run over the Karoo strata of Basutu Land, Smithfield, Colesberg, etc., to the neighbourhood of Hopetown, where our remarks began.

Alluvium of the Vaal and Orange Rivers, and possible sources of the Diamonds.—The superficial deposits of the Vaal Valley (we are told) consist, in some places, of a ferruginous unctuous soil, with or without sand and pebbles; at other places, of calcareous tufa, with or without pebbles; and elsewhere of drifting sand, or of clay of various colours. These lie either over gravel or on tufa, or on the basalt,[4] conglomerate, or other bottom-rock. Superficial outspreads of pebbly gravel are frequent, with or without any of the foregoing. Ridges of shingle also occur; and sometimes angular quartzose gravel[5] appears to predominate. Of what the stratified conglomerate (mentioned above as a bed-rock) consists is not stated; but the shingly deposits on the surface, whether loose or cemented with iron-oxide, are mainly composed of more or less rolled frag-

[1] Geol. Trans., 2nd ser., vol. vii., p. 57; 1845.

[2] Geol. Mag., Vol. III., p. 88, etc.

[3] In a paper lately read before the Geological Society of London.

[4] The basalt is said by some to be a very different igneous rock from the abundant greenstone of the country to the south and south-west.

[5] Dr. J. Shaw remarks that the angular quartz gravel is said to be bad groun for diamonds; and that the pebbly alluvium is better for the finders.

ments of chalcedony (agate and carnelian), with both rolled and fresh crystals of quartz, and with much broken garnet and peridot. A rusty coating of iron-oxide frequently obtains. Basalt, conglomerate, and sandstone, are among the coarser débris of the valley,[1] which is in some places "strewn with fragments of rock" (Cooper). The diamonds are found in the gravel and in the sandy soil above it; and occasionally in the tufa here and there associated with the gravel. The gravel or shingle occurs not only on the flats, but on the hills and hillocks called "kopjes" (over 100 feet high). Some at least of these seem to be protrusions of basalt, or outliers of strata and dykes, of limited extent, with rifts ("kloofs") and hollows on them. They are coated with sand and gravel, and the latter is said to be particularly diamantiferous.[2]

Mr. Gilfillan, in the "Grahamstown Journal," July, 1870, states that, "from the fact of the stratification being horizontal, and the diamonds being exposed after heavy rains, and so many of them having been found at intervals over a large surface (along the course of the Vaal River), and the surface having very little incline, I came to the conclusion that the South-African diamond deposits must extend over an immense tract of country, more or less immediately at the surface, along the valley of the Vaal, and that where the appearances are favourable, such as spots where there is little or no vegetation, with quantities of pebbles of quartz variously coloured (green and rose-coloured more particularly), and black and red and ribbon jaspers, and rolled fragments of iron-ore, scattered over the surface on a ferruginous soil, with conglomerate rock in the vicinity, diamonds will be found both on the surface and a few inches below it."

Opportunities of examining parcels of the Vaal River gravel (mostly sorted) have been afforded me by Messrs. Atherstone, Ochs, Grey, and others; and Prof. Tennant has kindly aided me in drawing up the following list of minerals from these diamond gravels, both by adding from his own parcels, and by determining some that were doubtful:—Chalcedony, Agate, red and white Carnelian, Mochastone, Semiopal; subangular and rounded. Quartz, pellucid, smoky, milky, opaque; both perfect and waterworn crystals. Amethyst. Jasper and Lydite, waterworn. Calcite, fragments. Selenite, crystals. Garnet (Pyrope) and Cinnamonstone:[3] fragments of garnet very plentiful, perfect crystals rare. Chlorite. Natrolite and Mesotype, crystals and fragments. Olivine (Peridot), fragments plentiful. Diopside, fragments. Tourmaline, perfect and broken. Hepatic Py-

[1] Dr. J. Shaw writes of the materials of the alluvium thus:—"The pebbles of sandstone, quartzite, crystalline sandstone, granite, clayslate, agate, tourmaline, iron-pyrites, garnet, garnet-spinel [?], etc., which compose this alluvium, are all roundedly polished and waterworn, and are imbedded at Klipdrift in a brownish fatty earth."—*Nature*, Nov. 3, 1870.

[2] All philologists must protest against the mongrel word "diamondiferous," partly English and partly Latin, that the Colonists have adopted instead of "diamond-bearing" or "diamantiferous."

[3] Some of these have been quoted as "Rubies."

rites, perfect. Specular Iron-ore, Pea-iron-ore, and other Oxides of iron. Ilmenite, waterworn fragments.

Professor Tennant[1] has also received a large piece of greenstone-amygdaloid, having its cavities mostly filled with Calcite, a few with Chalcedony, and still fewer with Greenearth and Olivine.

If not denuded everywhere down to the underlying palæozoic rocks, possibly the Karoo basement-bed of "trap-breccia" or boulder-deposit (if it ever reached thus far)[2] may have been left exposed somewhere along this great valley, and yielded its granitic, trappean, and other blocks, which elsewhere along the outcrop of this remarkable band, in Natal and across the Cape Colony, are often of massive proportions.

Not only this great breccia, but other strata of the Karoo series contain granitic material;[3] and some of even the highest of them are composed of it, some of the sandstones being quartzose with a little mica, and much decomposed felspar. Hence any simple minerals once in the granite or old schists may have been liberated, unaltered and unworn, on the further and perhaps recent degradation of old granitic débris. A perfect and delicately thin crystal of tourmaline, from the Vaal, now in Dr. Atherstone's possession, indicates this, as well as numerous perfect crystals of quartz, hepatic pyrites, etc. Many of the minerals in the gravel seem to be traceable to igneous (amygdaloid) rocks, and some to palæozoic rocks, *in place* not far off.[4] Mr. Bain long ago observed[5] that the Orange River, to the west of Aliwal, has "pebbles of serpentine, steatite, asbestos, agate, and amygdaloid, both of black and white colour; these minerals being entirely different from those which form the materials of the pebbles occurring in the river-beds within the Colony." Certainly for such soft minerals and rocks as some of those here mentioned, and for pieces of asbestos (tremolite) veins picked up on the Vaal (Grey), there must be such neighbouring sources as outcropping masses of metamorphic rocks would afford, like the "Asbestos Mountains" lower down the Orange River. Asbestos, serpentine, and steatite are elsewhere associated with metamorphic rocks, as they are on the Orange River and the Upper Vaal. The quartz and amethyst crystals might be derived either from amygdaloidal geodes (Gregory),

[1] See also Prof. Tennant's lecture on South-African Diamonds, Journal Soc. Arts, Nov. 25, 1870, p. 15, etc. Reported in the Geol. Mag. for January last, p. 35.

[2] The palæozoic rocks of the Transvaal having been at least a shoal, overlapped, if not wholly covered, by the Karoo formation, it is highly probable that the latter commenced with the boulder-bed here as elsewhere. It is possible, however, that the latest beds only of the Karoo formation reached thus far; and hence the enigma of Palæozoic coal-plants in the same section with the Mesozoic fossils in the Stormberg.

[3] See also Dr. Sutherland's observations on the blocks of porphyritic granite in the arkose, or granitic sand, of the Karoo beds in Natal, as well as in the breccia (which in 1855 he thought to be of volcanic origin). Quart. Journ. Geol. Soc., vol. xii., pp. 466 and 467.

[4] There is selenite (small sagittate macles; Grey) of local origin, which may have resulted from decomposition of pyrites in the drift, and reactions with the tufa.

[5] Trans. Geol. Soc., 2nd ser., vol. vii., p. 58, 1845.

or from quartz-veins in Karoo beds,[1] in old schists,[2] or in granite. The abundant peridot or chrysolite of the alluvium, however, is referable perhaps to the amygdaloids of the Karoo beds, if not to the volcanic rocks of the Gats Rand, though it may have come from metamorphic rocks;[3] whilst garnet is found in both igneous and metamorphic rocks.[4] Diopside occurs in crystalline rocks. Ilmenite and hepatic marcasite are known only in metamorphic rocks.

The great abundance of agate in the river-alluvium necessarily points to the amygdaloidal lavas of the Karoo formation as the source whence the Orange, the Vaal, and their tributaries, have obtained a large proportion of their gravel (Rubidge, Quart. Journ. Geol. Soc., vol. xi., p. 7; and Atherstone, Geol. Mag., Vol. VI., p. 212). There must be much amygdaloid *in sitû*, or imbedded, judging from the unworn crystals of natrolite, peridot, etc. Agate gravel[5] is traceable up the higher streams; but whether or no these

[1] Dr. Rubidge showed me a crystal of topaz in a piece of one of the Karoo auriferous quartz-dykes near Smithfield, described in the Quart. Journ. Geol. Soc., vol. xi., p. 4, and vol. xii., p. 237. Should some of the gold-bearing quartz-veins, such as occur on the Kraai River and near Smithfield, be continued northward to the Vaal, they would be probable sources of rock-crystal, topaz, and gold; but as the yield is very poor at the places named, we cannot reckon on the supply being great elsewhere. Dr. Muskett (in a letter read at a meeting of the Port-Elizabeth Nat. Hist. Society, October 29, 1868) expressed an opinion that the diamonds may have been "set free by the disintegration of the highly ferruginous trap-rocks that abound near the spot where they have been found." We learn from Mr. Higson (quoted above at p. 52), that both trap-dykes and quartz-dykes of the Karoo series traverse the Vaal.

[2] Dr. Grey has sent to England tremolite, amethyst, quartz with galena, a workable variety of steatite, and massive prehnite, from the valley of the Vaal. (Exhibited before the Geological Society, November, 1870.)

[3] Chrysolite is common in the Brazilian diamond-drift, though only metamorphic rocks appear to have yielded the débris.

[4] The garnet-sand, washed for pyrope, near Bilin, in Bohemia, has been found to contain diamonds. Bull. Geol. Com. Italy, 1870, p. 175 (this fact, however, is doubted in Poggendorf's Annalen); and Geol. Mag., 1870, Vol. VII., p. 348.

[5] Agate pebbles are known in the upper part of the Caledon River; and pebbles of amygdaloid rock and rolled agates on the north-eastern branch of the Orange River, and in the Kraai. In 1856 Dr. Rubidge remarked that "the amygdaloid rock which supplies the agate-gravel of the Orange, Caledon, Kraai, and Vaal Rivers appears to exist in the 'Mont-aux-Sources' (Giant's Castle), in the Draakenberg, as an unworn specimen was found in the Eland River (a tributary of the Vaal), not more than twelve miles from its source."—Quart. Journ. Geol. Soc., vol. xii., p. 237.

In a footnote at p. 223, Trans. Geol. Soc., Second Series, vol. vii., 1858, mention is made of some drifted ossicles of Encrinites, picked up, when Sir G. Cathcart returned from his unsuccessful attack on Moshesh, by a soldier, near the most easterly branch [Kraai ?] of the Orange River, where they were associated with ferruginous casts of small turreted shells [*Murchisonia* ?], with fragments of agate, quartz, and fossil wood, and with crystals of mundic. The occurrence of Devonian strata at the base of the Draakenberg is indicated in all probability by the fossils referred to; and, whilst the quartz and mundic may be referable to veins in such rocks, or to altered schists of the same or greater age, the agate and fossil wood are sure local signs of the Karoo beds.

So also the river-gravel from near the mouth of the Orange River, referred to in the same footnote, with its Encrinital joints, rolled amygdaloid, waterworn agate, carnelian, cream-coloured chert, and greenstone, and fragments of micaceous shale and copper-ore, points to the Metamorphic, Devonian, and Karoo strata, through which the river runs, in escaping from the interior of South Africa on the western torrents have, in relatively late times, supplied much of the agate that now coats the flats of the great valley, or if an old alluvium[1] has been re-sifted and reduced to lower levels, or if the degradation of the rocks in place during immense periods of time has left the agate gravel of the Free State, are open questions.[2] Again, has this degradation been due to atmospheric and pluvial action (Rubidge, etc.), or mainly to glacial action, as recently advocated by Mr. G. W. Stow? In either case, whether the diamonds and other minerals have come out of granite, palæozoic schists, or Karoo beds, even if they have been brought from some distance, they may have come without damage in the glaciers and the river-ice, or they may have been freed from their travelled matrix by subsequent degradation.

But what was their original matrix, and where is it to be sought for? If it be granite, that rock is still to be found, perhaps in local outcrops, and certainly not far up the Vaal, above Potscherfstroom; although the old granite shores bounding the Karoo formation have long since been worn down to lower levels even than those of the deposits once formed of and within them. Plentiful wrecks, however, of the old granite are contained in the Karoo beds, and often exposed, as before said.

If among gneissic, micaceous, talcose, argillaceous, or other schists the matrix of diamond is to be looked for, we are not without indications of the existence of such old altered rocks, together with marble, in and about this region; for they are not wanting on the north side of the Vaal and Orange basin; and they are all usually associated with granite more or less intimately.[3]

That some old schistose rocks contain diamonds in Brazil is well known, especially the granular quartzose rock, called "itacolumite" (sometimes flexible[4]), and certain argillaceous, micaceous, chloritic,

side of the continent. As diamonds are associated with the ruins of such rocks in the upper part of this great river's course, possibly they may be found among the detritus of the same rocks crossed by it near its mouth. As Dr. Sutherland has shown that old crystalline palæozoic, and Karoo rocks are all denuded together in Natal, probably among their ruins diamonds are to be found in that country also.

[1] For Dr. Rubidge's views respecting the eastern source of the agates, and of the old high-level flats and terraces of agate gravel, see Geol. Mag., Vol. III., p. 89.

[2] Dr. John Shaw ("Nature," Nov. 3, 1870) thinks that "a series of metamorphic and sedimentary rocks which lay above the present rock-system of the region," have been slowly worn down; the shifted and reduced débris, and a few local remnants of the series, being all that remain of these old rocks, which he thinks may have been the original seat of the diamonds. Dr. W. G. Atherstone says (Geol. Mag., No. 59, p. 212):—"From the great distance of the finding-places apart, and their propinquity to the several river-beds, which all proceed from the Quathlamba or Draakenberg sandstone ranges, I have little doubt that, on careful exploration, the real source of the diamond deposits will be found far to the eastward."

[3] The finding of diamonds at Bloemhof, near Potscherfstroom, if well substantiated, is of great importance in our inquiry; for it shows that the presence of the Karoo beds is not necessary for their occurrence; since the Karoo formation does not reach so far, according to Mr. Higson's observations ("Natal Herald," August 8, 1867). In this case they must have come from the metamorphic or the granitic rocks of the Transvaal, as the drainage of the Magaliesberg, with its Karoo beds, goes northward.

[4] The flexible itacolumite (or sandstone of quartz and rotten felspar), associated with diamond-fields in India, is found beyond the Draakenberg, in Natal; and there it is accompanied with a kind of jade, as in Siberia.

talcose, and hornblendic schists, associated with it. (See the memoir by MM. Heusser, Clarez, and G. Rose, "Annales des Mines," vol. xlvii., 1860; translated in the Geologist, vol. iv., p. 168, etc., 1861.) This granular quartzose schist, and the other schists with which it alternates,[1] are extensively decomposed and readily washed away in Brazil. They yield, besides the diamond, the minerals of metamorphic rocks and their vein-stones, such as:—Quartz and Amethyst; Sulphur; Euclase; Kyanite and transparent Andalusite; Felspar; Topaz; Chrysolite; Chrysoberyl; Tourmaline, black, green, and transparent; Amphibole; Hornblende; Garnet; Calcite and Arragonite; Specular Iron-ore and Hæmatites; Magnetic and Arsenical Pyrites; Copper-pyrites; Rutile, Anatase, and Brookite; Ores of Tellurium; Ores of Manganese; Chromate of Lead; Gold and Platinum.

In South Africa the abundance of agate in the gravel, leads us, as above said, to see if the Karoo beds might be the original matrix of the diamond there. The late Dr. R. N. Rubidge long since suggested[2] that the influence of the many veins of volcanic rock, traversing the plant-beds and coal of this formation, may have been a cause of the reduction of the hydro-carbons to pure carbon; and, though he could advance no arguments in support, he could point to the change of coal in the Stormberg into anthracite by that agency, and to the existence of South-African graphite, possibly due to a further change of the carbon in these rocks.[3]

Drs. Muskett and Atherstone, and perhaps Dr. Shaw and Mr. Higson, seem to think, with Dr. Rubidge, that the Karoo beds, or their dykes, are to be credited with the diamonds. But this origin for the gem is left unsupported, except by Rubidge's supposition that, given *coal altered to graphite by heat,* we may also have coal altered into diamond; and by the associated abundance of the Karoo agates and the prevalence of the débris of Karoo strata in the Vaal Valley (Griesbach).

After all, as above intimated, the diamonds may either have been native to the rocks out of which the Karoo deposits were largely formed; or, more probably, they may have been derived from the old rocks of the north-east, and from local outcrops of such rocks in the Orange River Free State itself. In this case agate and carnelian are not the chief signs to be looked for in diamond-yielding gravel, but an assortment of the minerals known to abound in metamorphic rocks.

[1] Limestone also occurs with these schists, which are thought by Agassiz and Hartt to be probably Silurian rocks, highly altered. See also the Rev. G. J. Nicolay's paper in the British Association Report, 1868 (Trans. Sect. p. 74), for an account of one of the Brazilian diamond-fields.

[2] Quarterly Journ. Geol. Soc., vol. xi., p. 7; 1855.

[3] In the "Academy" for December, 1870, is an imperfect report of a discussion at the Geological Society of London, wherein it is intimated that Prof. Morris expressed an opinion that, as the Bamboo produces *tabasheer*, so the Conifers of the Karoo formation may have produced a resin that has since been converted into pure carbon. We must wait for the elucidation of this hypothesis. See also Prof. Morris's "Lecture on Diamonds," etc., *Mining Journal*, Dec. 17, 1870, p. 1063.

APPENDIX.—As bearing on the foregoing, I add the following translation of M. Chancourtois's remarks on the probable origin of diamonds, from "Silliman's American Journal of Science and Arts," 2nd ser., vol. xlii., p. 271:—

"E. B. de Chancourtois has presented the view that the diamond has been formed from hydrocarburetted emanations, as sulphur is formed from hydrosulphuretted emanations, and that its origin is thus connected with the previous existence of petroleum-bearing or bituminous schists. In the oxydation of sulphuretted hydrogen in solfataras, all the hydrogen is oxydized, but only a part of the sulphur passes to the state of sulphurous acid in this humid process of combustion. So, in an analogous manner, the diamond was probably formed; that is, in the course of the humid combustion of a carburetted hydrogen, in which all the hydrogen was oxydized, but only a part of the carbon was transformed into carbonic acid. This view accords with the occurrence of the diamond in arenaceous rocks, or itacolumites, which are mostly metamorphic rocks of palæozoic age, and which may have once been bituminous, either by original formation or by emanations from lower rocks.

"M. Chancourtois supposes that the crystal would have formed only where there were fissures for the passage of the vapours of the carburetted hydrogen, and where the process could go on with extreme slowness." *Les Mondes*, July 19, 1866, p. 438.

The Editor of the *American Journal* adds:—"The author does not appear to connect the process of formation with that of the metamorphism to which the diamond-bearing rocks have undoubtedly been subjected, and which may have been essential to the result."

The Carboniferous strata of the United States, which in Pennsylvania yield anthracite instead of coal, have in Massachussetts been so much further metamorphosed that they consist of gneiss, quartzite, bands of plumbaginous anthracite, pyritiferous clay-slate, mica-schist with garnets and veins of asbestos, and graphitic schists (Hitchcock and Lyell). At places where further metamorphism may have affected such granitiferous and graphitic schists, diamonds may of course be looked for, in association with garnets, etc., in the local drift.

II.—NOTES ON FOSSIL OSTRACODA FROM THE POST-TERTIARY DEPOSITS OF CANADA AND NEW ENGLAND.

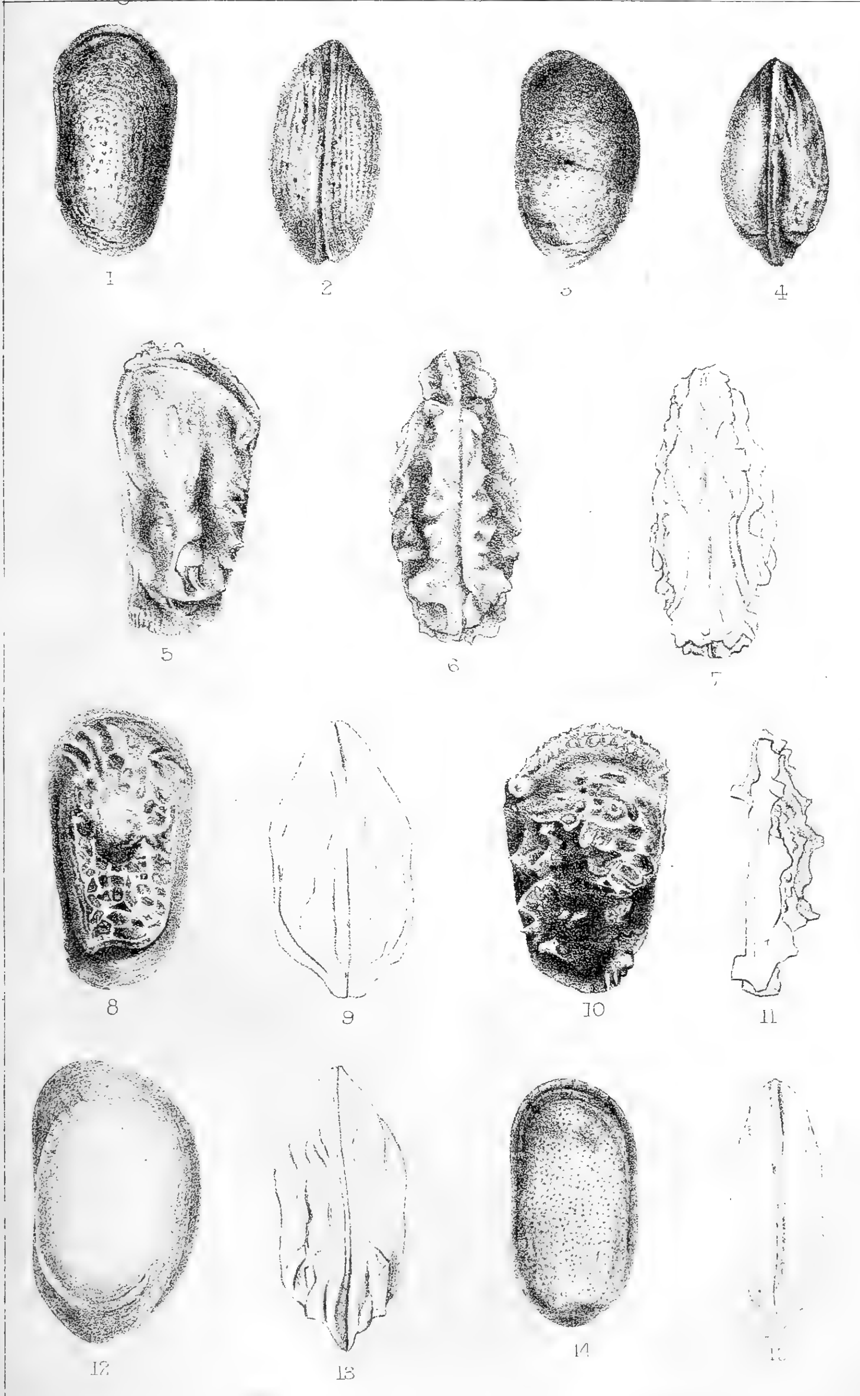
By GEORGE STEWARDSON BRADY, C.M.Z.S., and H. W. CROSSKEY, F.G.S.

PLATE II.

WE are indebted for the material from which the following notes have been compiled to Principal Dawson, of Montreal, and to the Secretary of the Portland Society of Natural History, to whom our best thanks are due for the opportunity thus afforded us of comparing the fossils of the North American Clay Beds with those of our own country. By carefully washing the clays kindly forwarded to us, we have obtained many specimens in excellent condition for examination.

Of the thirty-three species here noticed, twenty-three are well known to us as occurring in the Scottish Glacial Clays, twenty-five are living inhabitants of the British Seas, while six (*Cythere cuspidata, C. MacChesneyi, C. Logani, Cytherura granulosa, C. cristata, Cytheropteron complanatum*) are new to science, being here for the first time described.

We know too little of the recent American Ostracoda to institute any very precise comparison between them and the fossil fauna represented by the following list of species; but when compared with British collections, we find the contents of the Canadian fossiliferous



G. H. Ford. Mintern Bros. imp.

Post-Tertiary Ostracoda from North America.

clays to resemble very closely those of some similar formations in Scotland, and less closely those of dredgings obtained in the seas around the Hebrides and Shetland.

The character of the Mollusca with which the Ostracoda are associated justifies the same observation. About two-thirds of the Mollusca collected from the Scotch glacial clays are also found in the corresponding beds of Canada; and the difference between the glacial fossil fauna of Canada and that now existing in the Gulf of St. Lawrence is far less marked than the difference between the glacial fauna of the Clyde beds and that now existing in the Firth. The fossil fauna of Canada is slightly more arctic than that of the Gulf, but does not contrast with it so broadly as the fauna of the Scotch glacial clays with the Mollusca still living in the neighbouring waters. The resemblance between the fossil glacial Ostracoda of America and the Ostracoda of Scotch glacial clays, being closer than the resemblance between the glacial and the living Ostracoda of Scotland, renders the determination of their relationship to living American Ostracoda of considerable geological importance. It may be useful to geologists to enumerate the Ostracoda found in the various clays we have examined, and indicate at the same time the general character of the groups of Mollusca with which they are associated.

PORTLAND.—Out of 31 species of Mollusca catalogued, 18 occur fossil in Scotch glacial clays, including such characteristic forms as *Pecten Groenlandicus; Pecten Islandicus; Leda pygmæa; Tellina calcarea (proxima); Natica affinis (clausa); Buccinum Groenlandicum.* The associated Ostracoda are:

Cythere emarginata (Sars).
„ *concinna* (Jones).
„ *Dawsoni* (Brady).
„ *limicola* (Norman).
„ *dunelmensis* (Norman).
Cytheridea papillosa (Bosquet).
„ *Sorbyana* (Jones).
Loxoconcha granulata (Sars).
Xestoleberis depressa (Sars).
Cytherura nigrescens (Baird).
Cytherura Sarsii (Brady).
„ *cristata*, nov. sp.
„ *striata* (Sars).
„ *granulosa*, nov. sp.
„ *undata*, var.
Cytheropteron latissimum (Norman).
„ *nodosum* (Brady).
Sclerochilus contortus (Norman).
Paradoxostoma variabile (Baird).

Saco (Maine).—On the banks of the Saco river, about ten miles from its mouth, 15 species of Mollusca are catalogued, of which only five occur in the Scotch clays, viz.: *Leda pygmæa; Leda arctica; Nucula inflata; Menestho albula; Natica affinis—M. albula,* however, being rather doubtful and very young. The great abundance of *Leda arctica* constitutes a remarkable analogy between this bed and the clay at Errol near Dundee, and at Moss in Christianiafjörd. The associated Ostracoda are:

Cythere leioderma (Norman).
„ *lutea* (Müller).
„ *MacChesneyi*, nov. sp.
„ *emarginata* (Sars).
„ *limicola* (Norman).
„ *cuspidata*, nov. sp.
„ *dunelmensis* (Norman).
Cytheridea papillosa (Bosquet).
„ *cornea* (Brady and Robertson).
„ *Sorbyana* (Jones).
„ *Williamsoniana ?* (Bosquet).
Cytheropteron latissimum (Norman).
„ *complanatum*, nov. sp.

Lewiston, 110 feet above the sea. Only two species of Mollusca can we find yet determined from near this place, viz.: *Mya arenaria* and *Leda truncata,* both also Scotch fossils. The associated Ostracoda are:

Cythere emarginata (Sars).
Cytheridea Sorbyana (Jones).
Cytheropteron inflatum (B., C., and R., MS.).
Sclerochilus contortus (Norman).

Montreal.—Upon examining catalogues given by Dr. Dawson in the Canadian Naturalist, it appears that out of 20 species of *Lamellibranchiata,* 15 occur fossil in Scotland, and 17 out of 27 species of *Gasteropoda.* The beds contain nearly all the most characteristic Scotch glacial fossils. The associated Ostracoda are:

Cythere MacChesneyi, nov. sp.
„ *Dawsoni* (Brady).
„ *globulifera* (Brady).
„ *Logani,* nov. sp.
Cytheridea papillosa (Bosquet).
„ *punctillata* (Brady).
Cytheridea Sorbyana (Jones).
Cytherura Robertsoni (Brady).
Cytheropteron complanatum, nov. sp.
„ *inflatum* (B., C., and R., MS.).
„ *angulatum* (B., C., and R., MS.)
Eucythere argus.

There is no doubt both that many more species of Ostracoda will be discovered upon examination of larger quantities of material than we have yet obtained, and that the number of Mollusca will be increased by every fresh exposure of the clays; but these lists have been given, merely tentatively to indicate general relationships, which, when further developed, may prove of geological value in classifying the various deposits of the Glacial epoch.

One of the writers of this paper (Mr. Brady) has described 29 species of recent Ostracoda from the Gulf of St. Lawrence, dredged in depths varying from 10 to 50 fathoms, but in one case 250 fathoms (Annals and Mag. Nat. Hist., Dec., 1870). Of these 29 species, 13 are found in our list of fossils from the American glacial clays, viz.:

Cythere leioderma.
„ *lutea.*
„ *emarginata.*
„ *concinna.*
„ *dunelmensis.*
„ *Dawsoni.*
Cytheridea papillosa.
„ *punctillata.*
Eucythere argus.
Xestoleberis depressa.
Cytherura undata
Cytheropteron nodosum.

Although, as Mr. Brady remarks, it is unwise to generalize hastily, yet we cannot help noticing that the general facies of the recent Ostracoda from the Gulf of St. Lawrence much more nearly approaches to that of the Shetland seas or of the Scottish glacial clays, than it does to that of England, while it has scarcely anything in common with that of the Mediterranean,—a fact which has an important connexion with the suggestions we have made in this paper.

LIST OF SPECIES.

. x *Cythere leioderma* (Norman), Saco, Maine.
. x „ *lutea* (Müller), Saco, Maine.
„ *MacChesneyi,* nov. sp., Saco; Saxicava Sand, Montreal; Dr. D.
. x „ *emarginata* (Sars), Portland, Lewiston, Saco.
. x „ *concinna* (Jones), Portland. Rare.
„ *Dawsoni* (Brady), Montreal, Portland. Rare.

.	x	*Cythere limicola* (Norman), Portland, Saco.
.	x	„ *globulifera* (Brady), Saxicava Sand, Montreal.
		„ *Logani*, nov. sp., Montreal; Dr. D.
		„ *cuspidata*, nov. sp., Saco, Maine. Rare.
.	x	„ *dunelmensis* (Norman), Saco, Portland.
.	x	*Cytheridea papillosa* (Bosquet), Portland; Saco; Saxicava Sand, Montreal; Dr. D.
.	x	„ *punctillata* (Brady), Saxicava Sand, Montreal.
	x	„ *cornea* (Brady and Robertson), Saco. Rare.
.	x	„ *Sorbyana* (Jones), Saco; Portland; Saxicava Sand, Montreal. Abundant.
		„ *Williamsoniana ?* (Bosquet), Saco. Rare.
.	x	*Eucythere argus* (Sars), Dr. D. Rare.
	x	*Loxoconcha granulata* (Sars), Portland.
.	x	*Xestoleberis depressa* (Sars), Portland. Rare.
.	x	*Cytherura nigrescens* (Baird), Portland. Rare.
.	x	„ *Sarsii* (Brady), Portland. Rare.
		„ *cristata*, nov. sp., Portland.
.	x	„ *striata* (Sars), Portland. Rare.
		„ *granulosa*, nov. sp., Portland. Rare.
.	x	„ *undata*, var., Portland.
.	x	„ *Robertsoni* (Brady), Saxicava Sand, Montreal; Dr. D.
.	x	*Cytheropteron latissimum* (Norman), Portland, Saco.
		„ *complanatum*, nov. sp., Montreal, Saco.
.	x	„ *inflatum* (B., C., and R., MS.), Montreal, Lewiston. Rare.
.	x	„ *angulatum* (B., C., and R., MS.), Montreal. Rare.
.	x	„ *nodosum* (Brady), Portland. Rare.
.	x	*Sclerochilus contortus* (Norman), Portland, Lewiston.
.	x	*Paradoxostoma variabile* (Baird), Portland.

x Species marked thus occur living in the British seas.
. Species marked thus occur in British Post-Tertiary Clays.

Cythere MacChesneyi, nov. sp., Plate II., Figs. 1, 2.—Carapace as seen from the side compressed, subreniform, higher in front than behind, greatest height situated much in front of the middle, and equal to about half the length; anterior extremity boldly and evenly rounded, posterior much narrower and obliquely rounded; superior margins straight, sloping from before backwards and obtusely angular at each extremity; inferior deeply sinuated in the middle; seen from above, ovate, widest in the middle, width rather less than the height, sides subparallel, subacuminate in front, rounded behind. Shell rather thin and fragile; surface of the valves closely set with small pitted impressions which have a sub-concentric arrangement, and on the ventral surface coalesce into longitudinal furrows. Length, 1-50th of an inch.

This is unlike every other published species with which we are acquainted, and has something of the general aspect of a *Loxoconcha*, from which it is, however, quite distinct. We have pleasure in inscribing it to our esteemed friend Professor MacChesney, of the University of Chicago. Several specimens of this species occurred in gatherings from Montreal and Saco.

Cythere Logani, nov. sp., Plate II., Figs 8, 9.—Carapace tumid; seen from the side subquadrate, greatest height situated in front, and equal to rather more than half the length; anterior extremity well rounded, posterior obliquely subtruncate, emarginate in the middle, superior margin straight sloping backwards, angulated in front, rounded off behind, inferior nearly straight; seen from above subhexagonal with subparallel sides; anterior extremity obtusely pointed, posterior broadly and obtusely mucronate, width equalling the height. Shell robust, surface of the valves marked near the middle by a large rounded tubercle, and a little within the inferior and posterior borders by a sharply cut precipitous ridge (nearly straight below, but forming a sigmoid curve behind), which marks off the sculptured portion of the shell; surface-sculpture consisting of irregularly angulated pits, which are comparatively small and well defined behind the central tubercle, but larger and vaguely impressed in front. Length, 1-40th of an inch.

A fine and well-marked species, which we dedicate to Sir William Logan, the excellent Director-General of the Geological Survey of Canada. *Cythere macropora*, Bosquet, seems to approach this species somewhat closely, but is altogether less tumid, especially behind the middle, and is distinctly dentate at the postero-inferior angle. We noticed several examples of *C. Logani* in various stages of growth among the Montreal specimens.

Cythere Dawsoni, Brady, Plate II., Figs 5, 6, 7.—We here give figures of a specimen which appears to belong to the male of *C. Dawsoni*. The original figures in the "Annals and Magazine of Natural History," for December, 1870, were imperfect, owing to the accidental loss of the shell, which appears to have been that of a female.

Cythere cuspidata, nov. sp., Plate II., Figs. 10, 11.—Valves seen from the side oblong, subquadrangular, greatest height in front, and equalling nearly two-thirds of the length; anterior extremity well rounded and finely toothed throughout; posterior obliquely subtruncate; superior margin sloping backwards, nearly straight; inferior, almost straight, curving upwards behind; seen from above the outline is compressed, excessively broken and irregularly spinous. Surface of the valves very irregularly pitted and spinous, beset, especially towards the dorsal margin, with triangular spines of variable size, and within the anterior margin bearing a regular row of about fourteen small rounded tubercles; hinge-tubercle large and prominent. Length, 1-28th of an inch.

One valve only of this fine and very distinct species has occurred to us.

Cytherura undata, var. This variety, figured in the "Annals and Magazine of Natural History," *loc. cit.*, from a single recent specimen, occurs more abundantly and in precisely the same condition, in the Post-Tertiary Clay of Portland.

Cytherura granulosa, nov. sp., Plate II., Figs. 14, 15—Carapace elongated, compressed; seen from the side subquadrangular, of almost equal height throughout; height equal to fully one-half of the length; anterior extremity well rounded; posterior produced in the middle into a very broad obtusely truncate beak; superior margin scarcely at all arched, inferior almost straight; seen from above cuneiform, widest near the posterior extremity, thence tapering gently to the front, which is obtusely pointed, posterior extremity tapering very abruptly to the central beak; greatest width much less than half the length. Surface of the shell smooth, minutely and closely punctate, and marked on the posterior half with a few faint longitudinal striæ. Length, 1-60th of an inch.

Cytherura cristata, nov. sp., Plate II., Figs. 12, 13.—Shell seen laterally approaching closely *C. similis* in shape; greatest height situated in the middle, and exceeding half the length; anterior extremity rather obliquely rounded, posterior produced in the middle into a broad obtusely rounded beak; superior margin boldly arched, somewhat flattened in the middle; inferior slightly sinuated in the middle; seen from above, elongated, hexagonal, with nearly parallel sides, and equally tapering mucronate extremities; width barely equal to half the length. Shell-surface perfectly smooth, except on the ventral surface, which is somewhat waved and rugged, bearing within the inferior border a slightly elevated crescentiform ridge, which is extended partly round the posterior margin. Length, 1-55th of an inch.

Cytheropteron complanatum, nov. sp., Plate II., Figs. 3, 4.—Shell seen laterally sub-semicircular, highest in the middle, height equal to nearly two-thirds of the length; anterior extremity rounded; posterior produced into a subacute central beak; superior margin very boldly arched; inferior, slightly convex, sinuated in front of the middle; seen from above ovate, acuminate in front, mucronate behind; twice as long as broad; greatest width situated near the middle. Surface of the valves covered with closely set, moderately large circular pits, and having an imperfectly defined transverse sulcus near the middle of the ventral margin; lateral alæ obsolete. Length, 1-50th of an inch.

This is one of the more abundant species in the Montreal beds.

EXPLANATION OF PLATE II.

Fig. 1.	*Cythere MacChesneyi*,	seen from	left side	} × 60 (Figs. 1–9)
2.	,, ,,	,,	above	
3.	*Cytheropteron complanatum*,	,,	left side	
4.	,, ,,	,,	above	
5.	*Cythere Dawsoni*,	,,	left side	
6.	,,	,,	above	
7.	,,	,,	below	
8.	*Cythere Logani*,	,,	left side	
9.	,,	,,	above	
10.	*Cythere cuspidata*, right valve			} × 40 (Figs. 10–11)
11.	,, ,,	seen from	above	
12.	*Cytherura cristata*,	,,	left side	} × 84 (Figs. 12–15)
13.	,, ,,	,,	above	
14.	*Cytherura granulosa*,	,,	left side	
15.	,, ,,	,,	above	

III.—On Phenomena connected with Denudation, observed in the so-called Coprolite Pits near Haslingfield, Cambridgeshire.

By the Rev. O. Fisher, M.A., F.G.S.

THE upper portion of the sections in these pits usually exhibits from a foot to a foot and a half of soil, which I call, after Mr.

Trimmer, "Warp."[1] In this district it is unusually full of land-shells of recent species. Nevertheless, the assemblage is not exactly what one meets with living on the spot. The most common *Helix* of the warp is *H. arbustorum.* This species occurs alive in the neighbourhood, but it can scarcely be called common. *Helix nemoralis* is common in the warp and also alive. *Helix aspersa* is by no means common in the warp, but it is common alive. *Cyclostoma elegans* is very common in the warp, but I have not seen it alive in this neighbourhood. It is exceedingly likely that drainage and cultivation may have been sufficient to have wrought these changes. At the base of the warp I have found an oyster-shell, which looks as if it had been broken at the edge to get it open.

Below the warp we have what the workmen term "mixed clay." This is sometimes little else than disturbed clunch or "white clay." But in other places it contains patches of clayey gravel and sand. Sometimes the gravel contains so many phosphatic nodules, that it is extracted and picked over for them. Among its contents are pebbles of hard rocks, generally well rounded. Sometimes these attain a considerable size—a foot or more in diameter. This deposit is often closely compacted, and the workmen will describe it as "proper hard old stuff." It is what I have elsewhere called "trail."

Here, as elsewhere where I have examined it, this "trail" contains no organic fossils of its own. Although in this neighbourhood shells are abundant in the warp, yet they nowhere, that I have seen, descend into the trail. It has the character of being a mixture of the deposits of the immediate neighbourhood, but it is not stratified. The matrix of white clay, forming its bulk, is derived from the lower chalk or clunch. The flints are similar to those of the gravels of the neighbourhood, and probably are derived from the Boulder-clay. The pebbles and larger stones are clearly from the same source; and the phosphatic nodules must have come from the outcrop of the Greensand. The question then is, What agent has brought these materials together as we see them?

The agencies of rivers and of rain have a prescribed right to be first considered.

But when we compare the deposit in question with an admitted river-gravel, like the neighbouring one of Barnwell, the difference of character is at once apparent. Moreover, we meet with the trail in places where rivers have never run, as in the bottoms of dry valleys; for instance, in a coprolite pit now in work below the limekiln at Eversden. It is conceivable that a river, now running at the bottom of a valley, may formerly have meandered over every portion of that valley included within its main features, and, while at work for ages in excavating the valley, may have left traces of its former wanderings. But it is not conceivable that it can have departed from the main valley, so as to have excavated the tributary valleys which descend into it from among the hills. Consequently, when we find no traces of streams in these tributary valleys, we must attribute their forma-

[1] See the author's paper on the "Warp" of Mr. Trimmer. Journ. Geol. Soc., vol. xxii., p. 553.

tion and the superficial deposits in them to some other cause than the river.

There is, therefore, much more reason to consider the trail as due to rain-wash. If any bare surface of ground is subjected for some length of time to the action of rain, it soon begins to exhibit in miniature a contour not unlike that of the ordinary landscape. This seems to prove that rain is capable of moulding the surface to such inclinations as usually occur. Moreover, the mixtures of clay, sand, and gravel, which are accumulated in some spots by torrents of rain-water, even when the torrents are quite small, exhibit a structure not unlike that of trail.

But I have already, in former papers on this subject, brought together arguments for doubting whether rain can have produced all the observed effects, and I do not wish on the present occasion to reiterate them. Nevertheless, I am free to acknowledge that I have frequently been greatly staggered in my conclusions, and have been led to doubt whether after all rain has not been the agent in producing the trail and moulding the landscape which it envelopes. But on consideration I have always reverted to the contrary opinion.

I will now mention some of my observations in coprolite pits which have confirmed me in believing rain incompetent to explain some of the phenomena.

In the first place, if rain be the agent, why should the trail be separated by a surface of demarcation from the superficial soil or warp? The surface soil has undoubtedly been formed under the action of rain, and if the trail were also so formed, the two ought not to differ in character; or, at the least, they ought to graduate into each other. And wherefore should the demarcation between the two be the limit below which organic remains do not descend? These facts prove, at any rate, that if rain was the agent which produced the trail, it must have done so under conditions certainly differing from those which exist at present.

The occurrence of large stones in the trail is also to my mind a difficulty. They are found hereabouts most abundantly under the hills which are capped with Boulder-clay. There is no doubt where they come from. But if the clay has been washed away by rain, ought not all the large stones to be left behind, and not a few here and there, say one or two cart-loads to the acre?

Again, if rain-wash be the source of the trail, it seems that it ought to have been washed down by the shortest route from higher ground. But I have found coprolites in it where there is no outcrop of the Greensand above, but where they must have come by a route parallel to the direction of the hill; the outcrop at the locality being at a lower level than the place where they occur, though they crop out at a higher level further up the valley.

But the most remarkable phenomenon, and indeed that which has led me to offer these remarks, is the evidence of lateral thrust which I have noticed, and which in at least two instances has produced a reduplication of the coprolite bed. In one case the accompanying section appeared in the face of the pit. The locality was a field on the south of the road between Haslingfield and Harlton, just under the hill.

I can scarcely doubt that the manner in which the trail descends below its normal depth, at the place where the squeezing has occurred, is an index of the pressure by which the effect has been produced in the beds below.

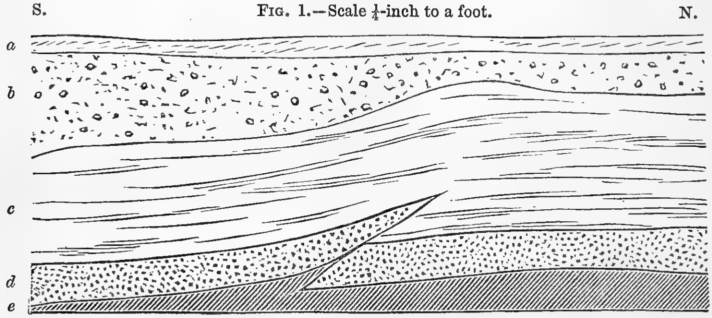


FIG. 1.—Scale ¼-inch to a foot.

(*a*) Warp. (*b*) Trail. (*c*) "White-clay." (*d*). Phosphatic nodule bed. (*e*) Gault.

The other instance of reduplication of the coprolite bed which has come under my notice, occurred in a pit about a furlong distant, north-west, from the last, and the section, when I first saw it, was as shown below.

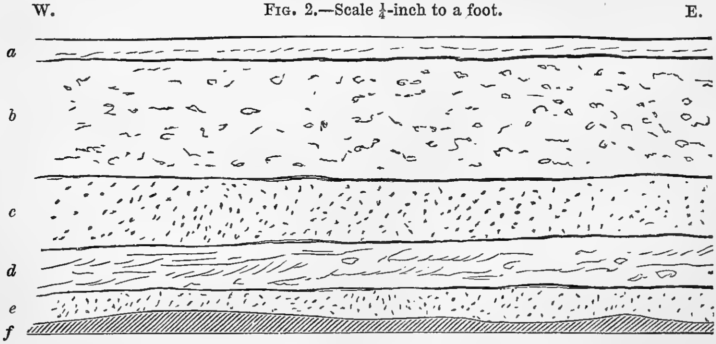


FIG. 2.—Scale ¼-inch to a foot.

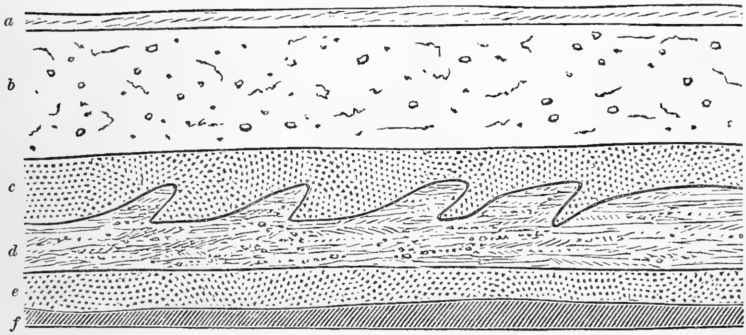
(*a*) Warp. (*b*) Trail. (*c*) False Phosphatic nodule bed. (*d*) "White Clay" and Sandy Gravel passing into Gault. (*e*) Phosphatic nodule bed in its normal position. (*f*) Gault with uneven surface.

After a time the white clay intervening between the coprolite bed became intermingled with Gault. I was not able to learn with certainty from the workmen whether there was any definite order of superposition between the two, some of them affirming that the Gault was above, and others the white clay; but my belief is, that there was no definite order of superposition between the two, and I saw portions of white clay entangled in the Gault, after it prevailed.

This doubling of the bed of coprolites occupied an area of about twenty-five yards in length by five yards in breadth at the widest part, and tapering at each end. The longer axis was nearly at right-angles to the axis of the hill, lying south by west and north by east.

The section at right-angles to the one given in the diagram, Fig. 2, and at a place near the centre of the patch, and nearly in the direction of its length, showed a remarkable serrated line of junction between the upper bed of coprolites and the intervening clay, thus:

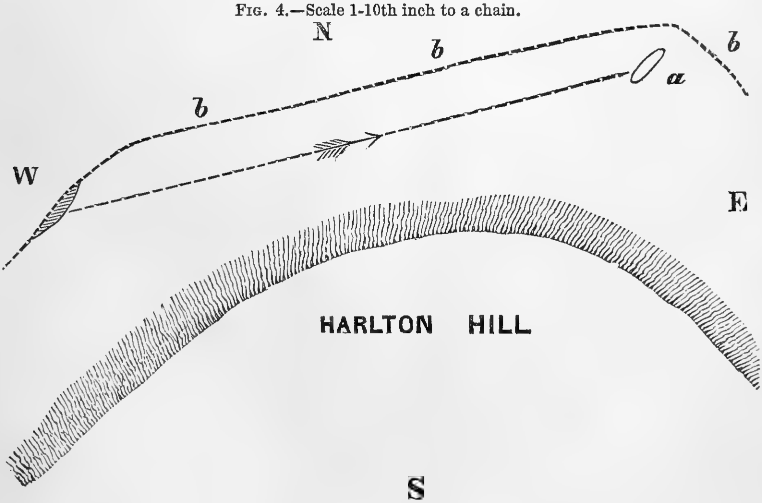
S. FIG. 3.—Scale ¼-inch to a foot. N.



Section seen at right-angles to the last. The letters refer to the same beds as before.

I can conceive no other way in which the phenomenon I have described can have happened, than by a piece of the edge of the coprolite bed at its outcrop, along with some of the Gault on which it rested, having been broken off and pushed along bodily over the undisturbed portion, in the direction of the valley, somewhat in the manner indicated in the annexed figure. The hill is the spur between the words "Clunch" and "Offal" in the Ordnance Map.

FIG. 4.—Scale 1-10th inch to a chain.



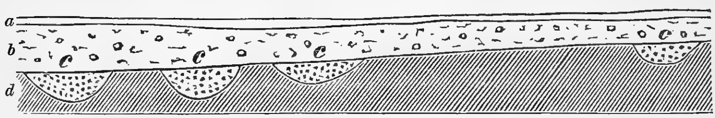
(*a*) The patch of travelled Phosphatic nodules. (*b*, *b*, *b*) The outcrop of the Phosphatic nodule bed. The arrow shows the direction in which it is presumed that (*a*) may have travelled.

Neither rain-wash nor river-action, even if a river were at hand, could have effected this.

It almost always occurs in this neighbourhood that, when the coprolites are near the surface (say at a depth less than three feet), they undulate rapidly, the depressed parts of the bed being thickened. When they get so near the surface that the crests of the undulations are cut off by the trail, and the depressions alone remain, they are said to be "pocketty," and the pockets seem to contain almost the entire store of coprolites, as if the whole of the stratum had been accumulated in the depressions.

The following section was taken in the same pit as the two former.

Fig. 5.—Scale ¼-inch to a yard.
Section showing Pockets.



(*a*) Warp. (*b*) Trail. (*c, c, c, c*) Pockets containing Phosphatic Nodules respectively 2 ft., 2 ft., 1½ ft., and 1 ft. deep. (*d*) Gault.

It must not, however, be supposed that the undulations are long troughs, though I think it may be asserted that there is a general parallelism about them. They are rather, as they are termed, "pockets," although I think they are usually longer in one dimension, and that in the same direction for all. Here I think we have another consequence of lateral pressure.

I have one more instance of the transference of material in an unscattered state to mention. It occurs near Lords Bridge Station. A ditch was dug some time ago upon my glebe, and I observed beneath the gravel covering, and resting upon the Gault, a portion of the coprolite bed, with a little of the white clay above it. I thought, upon seeing it, that I had discovered a bed of coprolites which might be worked; but, upon examination, it turned out to be an isolated patch of a very few yards in length, forming a portion of the trail. It is evident it must have travelled in a mass to its present position.

I have published my opinion that land-ice may have been instrumental in producing the condition of the surface[1] which I have described; and I have given reasons for supposing that the climate of these latitudes may have been sufficiently rigorous for that result about 100,000 years ago.[2] It appears to me that a sheet of ice, moving over the surface, would disturb it to a depth depending partly upon the pressure and partly upon the nature of the material. Between the ice and the solid earth there would be a layer of material of a certain thickness interposed, which had been entirely detached from the rock, constituting what is called a *moraine profonde*.

I conceive the trail to be a remnant of it, thinned off by subsequent atmospheric denudation, which has derived the warp from it.

[1] Geological Magazine, Vol. III., p. 483. [2] *Ibid.*, Vol. IV., p. 193.

While the ice was moving forwards, pushing this *moraine profonde* beneath it, it must have occurred that the passage of the moraine over the surface was checked at some points more than others, owing to its being more stony there, or by other causes locally increasing the friction. At such points, the portions behind pressing forward would cause accumulations, which would indent the material into the ground beneath more deeply at those spots, causing those depressions which are so characteristic of the lower surface of the trail.

The general effect of this action upon the surface of the rock, which had not as yet been actually rubbed off and denuded, would be to drag forward a superficial portion, disturbing it and reducing its thickness; this effect diminishing downwards, until it disappeared at a depth depending upon local conditions.

Now when, in this district, the coprolite bed (about a foot or less in average thickness) happened to be near enough to the surface to come within the limit of the disturbed material, on account of its peculiar constitution of small nodules in a soft matrix, it would yield readily to the forward pressure, even more so than the Gault beneath; but, owing to the nodules, it would be liable to get checked at some points more than at others, and wherever that happened, there accumulations would be formed, which would be depressed into the Gault below, and form the pockets which I have described. I may add, that the ridges of Gault between the pockets show surfaces of slickenslide within them, and have small portions of Greensand and phosphatic nodules occasionally impacted into them.

IV.—Note on a New British Cystidean.

By the Editor.

In the Geological Magazine, Vol. VII., p. 260, Pl. VII., Figs. 2–5, we published a description, by Prof. de Koninck, of a new British Cystidean, which the author named *Placocystites Forbesianus*. We called attention in a footnote (op. cit., p. 261) to the probability of Prof. de Koninck's Cystidean being the same as Mr. Billings's *Ateleocystites Huxleyi;* but as we had not seen the Canadian specimen upon which the genus was founded, we abstained from speaking very positively as to their identity. We, however, prepared a sketch of *Placocystites*, which we forwarded by Sir William Logan, who kindly undertook to submit it to Mr. Billings, in order to obtain his opinion thereon. We have been favoured with the subjoined letter, which has, however, been accidentally mislaid, and so for a time delayed in publication, for which we beg to apologize.

Sir,—Sir W. E. Logan gave me your sketch of *Placocystites*, and I have this morning re-examined all of our specimens, and also compared Prof. de Koninck's figures and descriptions in the article in the Geol. Mag. to which you refer. *Placocystites* and *Ateleocystites* are undoubtedly the same, as suggested by you.

Anomalocystites, Hall, Pal. N.Y., vol. iii., p. 134, pl. 7a and 88, is also the same genus. The number of plates is different in the English, Canadian, and New York species, but this does not matter in such a genus of Cystideans as this. Since my Decade was published, we have collected several additional specimens of *A. Huxleyi*, but, unfortunately, none of them give any new information. They are all imbedded in the rock, and all show the same, the concave, side. The four species—*Ateleocystites Huxleyi*, Billings, Lower Sil.; *Placocystites Forbesianus*, De Koninck, Upper Sil.; *Anomalocystites cornutus*, Hall, Upper Sil.; *Anomalocystites disparilis*, Hall, Devonian—are all composed of a limited number of plates, not arranged in regular series, their bodies convex on one side and concave on the other. The first three have the plates transversely striated in a peculiar manner, and most probably good specimens of the fourth would show the same surface character. This striation is of the same kind in all, and differs in aspect from that of any other Cystidean genus known.[1] It is so peculiar that it appears to be near a sort of a *group character*, so to speak, like the scale-markings of some of the Crustacea. These points of agreement are of such a nature that, although none of the species have been as yet described on good specimens, they seem quite sufficient to prove that they are congeneric. E. Billings.

Montreal.

We subjoin figures of the upper and under sides of this remarkable Cystidean, for the elucidation of which we now possess a very fine series of specimens, many of which have been collected by C. Ketley, Esq. The original of Fig. 1 was obtained by J. Gray, Esq., of Hagley.

Ateleocystites Huxleyi, Billings = *Placocystites Forbesianus*, De Koninck.

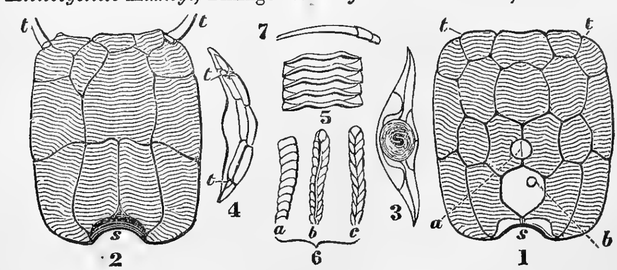


Fig. 1. Convex side, showing the so-called "anal plate" (*a*), and the ovarian pore (*b*), the base of the tentacles (*t*, *t*), and the point of attachment for the stem (*s*).
" 2. Concave side, showing the tentacles (*t*, *t*).
" 3. View of the lower extremity of the body, showing the attachment of the stem (*s*).
" 4. View of the top of the body, showing the points of attachment for the arms or tentacles (*t*, *t*).
" 5. Portion of stem near the body: drawn from a specimen having a portion of the stem still remaining attached.
" 6. *a*, *b*, *c*. Three views of a small tapering stem, found detached, but having the same characteristic sculpture visible upon its joints observed in *Ateleocystites*. Probably the lower extremity of the stem.
" 7. One of the arms, or tentacles, drawn from a specimen, having the arm still attached to the body.

(All the above specimens are in the British Museum, and were obtained from the Wenlock Limestone, Wren's Nest, Dudley.)

[1] Compare the ornamentation of *Ateleocystites* with the plates of *Turrilepas*

NOTICES OF MEMOIRS.

I.—THE GEOLOGY OF THE CARBONIFEROUS ROCKS NORTH AND EAST OF LEEDS, AND THE PERMIAN AND TRIASSIC ROCKS ABOUT TADCASTER. By W. T. AVELINE, A. H. GREEN, M.A., J. R. DAKYNS, M.A., J. C. WARD, and R. RUSSELL. 1870. 8vo. pp. 14. (London: Longmans & Co.)

THIS little work is an explanation of quarter-sheet 93 S.W., of the one-inch Geological Survey Map of England, portions of which area have, we presume, been surveyed by each of the authors therein mentioned. They give a brief sketch of the leading geological and physical features of the country, reserving all details for a promised memoir on the Yorkshire Coal-field.

The strata represented are the Millstone Grit, the Lower Coal Measures or Ganister Beds, the Middle Coal Measures, Magnesian Limestones and Marls of Permian age, and the Bunter Sandstone. Glacial deposits in the shape of Boulder-clay, Gravel and Sand lie here and there, and River and Estuary deposits likewise occur in places.

The authors furnish a table of the Carboniferous rocks shown in the area, marking the maximum, minimum, and average thicknesses of the different beds, with the local names under which they are known. They point out those which are applied to economic purposes, in this, as well as in the other series of rocks to which they refer.

II.—ON THE BORING OF THE PHOLADIDÆ.

The following notice on the Boring of the Pholadidæ, by the late Alexander Bryson, Esq., President of the Royal Physical Society, extracted from the Edinburgh Philosophical Transactions (1859, p. 321), will be read with interest as bearing upon the Pholas-origin of certain perforated Limestones.

In this communication the author referred to the various theories advanced to account for the boring of the Pholadidæ in rocks.

The first hypothesis, which supposes that the molluscs perforate by means of the rotation of the valves acting as augers, he disproved by exhibiting old individuals of the *Pholas crispata* with the dentated costæ on the shells as sharp as in any young specimen. That these animals bore by siliceous particles secreted by the foot, as suggested by Mr. Hancock, has been disproved by microscopic observation; and that currents of water set in motion by vibratile cilia seemed also insufficient to account for the phenomenon.

Another theory supposes that an acid is secreted by the foot, capable of dissolving the rock.

Wrightii (also from the Wenlock-shale and Limestone, Dudley), figured and described by H. Woodward in the Quart. Journ. Geol. Soc., vol. xxi., pl. xiv., figs. 1*a* to 1*i*. See also the GEOL. MAG., Vol II., 1865, p. 470 (Woodcut). Can it be possible that any actual relationship exists between these two remarkable and aberrant forms?—H.W.

This the author showed was not tenable, as the strongest Nordhausen sulphuric acid fails to dissolve aluminous shales and Silurian slates; and also that any such acid secretion would act more readily on the valves themselves. From many experiments on the cutting of hard siliceous substances, the author found that the softer the substance was in which the cutting material was impacted, the greater the amount of the work done. He was thus led to the conclusion that the Pholadidæ bore with the strong muscular foot alone, and that they obtain the minute particles of silica from the waves or the arenaceous rocks in which they are found; and hence there is no necessity for either an acid or silicious secretion. That the foot was the boring apparatus, and not the valves, he proved from a specimen of a Pholas-hole in shale, where the pedal depression of the animal was distinctly seen.

He also exhibited a piece of glass bored to the depth of 1·50 of an inch, by means of the point of the finger and emery alone.

III.—The Terraces of Norway.—By Prof. Kjerulf, of Christiania.

[Translated from the Norsk, by Marshall Hall, Esq. Reprinted from "Scientific Opinion" of Feb. 23, March 2, and March 9, 1870.]

THE terrace-like steps, which it is the object of this paper to describe, are remarkable features of the Norwegian valleys. These valleys are filled with various deposits of clay, sand, and gravel, but the floor of each valley does not slope evenly from its commencement to the lower end of the valley, where it opens into the sea, but it rises thence by steps, from lower to higher plains, irrespective of the river which traverses it along an inclined plane. These steps, the surfaces of which are apparently horizontal, have a gentle slope at the upper portion, and usually terminate below in a steep slope of about 30°. These are the Terraces.

It seems most reasonable to suppose (says the author) that these valley terraces were caused by a water-surface on a level with them. If the sea be the agent, marine remains ought to occur from the highest terrace far up the valley to the lowest, at the present sea-shore, and at the same time a certain uniformity might be expected in the nature of the materials filling up the valley. But marine remains are only to be found at the lower altitudes, under 500 to 600 feet. At about the same altitude the nature of the bottom of the valley is evidently different. From 500 to 600 feet is, therefore, the highest beach-mark, and it will be presumed that steps found lower than this are marks of the sea-level, whilst for the other steps higher up some different cause must be assigned.

With respect to their situation, the steps may be classed into two large groups: (1) Those that occur in a completely open situation; (2) Those comparatively closed in, and partially supported by the damming produced by the mountains on both sides approaching each other.

The maritime steps proper are all open. The inland steps are almost all distinctly closed.

Since 1858, when he began a series of observations on these terraces, Prof. Kjerulf has pointed out three causes to which these terraces may have been due.

1. The former position of the sea, which left its highest marks on the land at 600 feet above the present level. 2. Ancient bottom moraines, which obstructed the valley at a time subsequent to the Glacial period, creating dams, so that a basin could be formed in the water-course. 3. Obstruction by a mountain which might create a basin so long as the water-course in the valley did not erode still deeper into the dam.

In his opinion the ultimate causes of the steps of the water-courses are not different, but there was one main cause, namely, the presence of a water surface, which caused the materials washed down by the streams to be heaped up everywhere to the height marked out.

Where the watercourse joined the sea without any obstruction, the materials brought down through the valley might be piled to a considerable height at this level and below it. Where, however, a bottom moraine obstructs the passage, a basin may be formed inside this wall, and the material of the water-courses piled as high as the sill. A similar case is the obstruction caused by the spur of a mountain. Then supposing the sea-level to be lowered, the dam broken through, or the mountain obstruction opened, at each of those spots some portion of the piled-up materials will remain at the sides of the passage, subsequently to be dug out by the water, or else the terraces will show the former water-level.

The steps of the water-courses are directly connected with the question of upheaval, and the author confidently adheres to the belief that the land has only risen 600 feet since the Glacial epoch. Lyell's theory of a sinking and rising of 6,000 feet is shown to be unsupported by facts; and in regard to the question of time, that whereas this theory would require a period of 480,000 years, it is hereby reduced to 24,000.

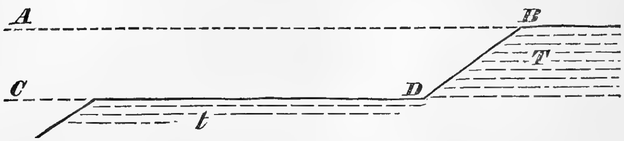
The terraces or water-courses throw light upon the uniformity of rate of the motion of the land.

The terraces above the highest beach-mark can almost always be attributed to dams and other obstructions. The case is, however, different as regards terraces lying below this mark; for these lie entirely open to the mouth of the valley, and they are unsupported by dam or obstruction of any kind.

The formation of the terraces has been generally attributed entirely to the sea. But, Prof. Kjerulf remarks, the sea alone could never form a terrace, as may be plainly seen by any one sailing round the coast of Norway, for he will observe that the shores are not surrounded by terraces, but that they occur in few places only—in those, namely, where a water-course opens out. The chief work of these latter consists in transporting gravel and mud down to the nearest water-basin. The terrace is formed by the joint labour of the stream and the sea. Now if the sea sank equally and slowly, there is no cause at hand for the formation of high, distinct, regular, and open terraces, one below another. On the contrary, for the formation of a plurality of terraces, it is requisite that the sea-level shall remain for some time and then rapidly change, therefore suggesting not a regular, but an irregular or periodical movement.

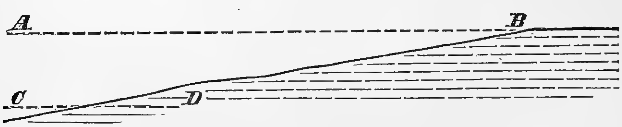
In illustration of this, the following woodcuts are given. If the water level A B (Fig. 1) sinks suddenly to C D, and then comes to

Fig. 1.



a state of comparative quiet, the terrace T will be laid dry, and the formation of the lower terrace *t* begins at the lower level. If, on the contrary, the water at the level A B sinks gradually and slowly to C D, and continues to sink, the materials of the water-course will be heaped up to the water-level of each year, and high and low tide will affect the detritus at the same time, and a slope will be formed from B to C, but no distinct steps (Fig. 2).

Fig. 2.



These facts lead the author to conclude that the motion occurred with several shocks, with intervals of comparatively slow motion, if not of rest. And it follows from this that any computations of time derived from such motion cannot be very accurate.

REVIEWS.

I.—The Truth of the Bible: Evidence from the Mosaic and other records of Creation; the Origin and Antiquity of Man; the Science of Scripture; and from the Archæology of different Nations of the Earth. By the Rev. Bourchier Wrey Savile, M.A. 8vo., pp. 325. London: Longmans, Green, & Co., 1871.

THE number of books treating of Science and Religion, which have been and continue to be issued, is astonishing, and, so far as we are aware, few, if any, solid results are gained by their publication. Indeed, this is so manifest, that we are led to inquire whether after all there is any direct relation between the subjects. Most of these authors, it seems to us, start with a misunderstanding, and it is because of this misconception that so many of these Geo-theological books continue to be written. First, they are under the impression that the Bible was given to teach us Natural Science, which is (we should have thought) capable of refutation by the merest tyro.

Secondly, if the Bible was given us (as we believe it was) not to teach us natural science, but our moral and religious duties, we cannot see the necessity of a concordance being arrived at where no connection exists.

Religion is based upon matters of Faith, and deals with man's moral and spiritual nature, and is incapable of being reduced to proof.

Natural Science is a systematic record of facts derived from a study of the phenomena of nature, upon which its deductions are based, and it only claims so far to be indisputable as it is capable of being reduced to proof.

Religion and Natural Science may be compared to two parallel lines which, prolonged to infinity, can never touch, but there is no discord between them, save such as is due to the obliquity of vision on the part of the authors of these very useless and ill-conceived books.

To arrive at the truth is doubtless the object of most of these writers, as it is of all thoughtful men; but as a rule they display a most lamentable ignorance of science, and are remarkably devoid of judgment in the selection of the authors to whom they refer for information.

In one of the chapters of his book, the Rev. B. W. Savile invites attention "to some of the *Variations in Science* (under the respective heads of Astronomy, Geology, Anthropology, Egyptology, and Theology), which are known to exist amongst the learned of the present day, and which seem sufficient to prove the truth of the saying, that the science of one age is the nonsense of the next, on account of its endless changes." In illustration of this, he points out the diversity of opinion regarding the nature of the earth's interior, the period of its existence, and of geological chronology in general; questions which, from the nature of the evidence, we can scarcely hope ever to see definitely settled. Mr. Savile's ideas of physical geology seem to be of a decidedly *Uniformitarian* character.

Lyell considers that the earth's crust is known to a depth of perhaps ten miles, "but how he obtains this knowledge is [to the Reverend author] a mystery, for the deepest mine on record is less than half a mile in depth." !!! Can he have read any of Lyell's books?

Again, on the question of the length of time required for the formation of different deposits, he seems to wonder that estimates of the rate of formation of peat and of alluvial deposits made in different areas should vary.

Further on he affirms that "although five in every seven *genera* are the same in the Human as in the Tertiary period, there is not a single *species* common to the two periods." (!)

One more quotation will probably suffice to show what little reliance can be placed upon Mr. Savile's conclusions, at any rate so far as his geology is concerned, for although he refers in many instances to the best authorities, it is as frequently that he misinterprets their meaning. He mentions that "the conclusion of an eminent man of science [Mr. Prestwich] only five years ago shows that it is very doubtful whether the extinct animals, such as those modelled in the gardens of the Crystal Palace, are of the great antiquity hitherto assigned to them." (!)

We cannot see that Mr. Savile has done much good by the slurs he casts upon geological deductions, nor will contempt for the teachings of the leaders in "the boasting philosophy of the present age" (as he terms it) call forth more than a smile from any candid reader.

Geology, so far from rendering its sincere students "boastful," is fully as well calculated as its sister-science Astronomy to induce a humble frame of mind; and those who, like the author, entertain so unjust a view of its devotees, would do well to imitate our leading geological writers, who never mix up religious dogmas with geological facts.

II.—The Devonshire Association for the Advancement of Science.

HAVING received a number of separate copies of papers read during the past year before the Devonshire Association, and which have been published in the Transactions of this Society, we will briefly notice the subjects which are treated in them. They are:—

1. *The Modern and Ancient Beaches of Portland.* By W. Pengelly, F.R.S., F.G.S.

The author first refers to the Chesil Bank, notes descriptive of which he has compiled from the well-known paper of Mr. Coode, C.E. He remarks upon the abundance of pebbles derived from the Budleigh Salterton conglomerate, which he noticed in company with Mr. Vicary, in the course of observations made upon the bank. He however adds little to what is already known upon the subject, merely concluding that the direction of transportation is from west to east, in the direction of the prevalent winds. Turning his attention next to the raised beach at Portland,[1] he adduces facts to show that the so-called raised beach is really a consequence and proof of an elevation of the coast to the extent of not less than 50 feet, and that, during the "Raised-Beach era," the direction of transportation was, as it is now, from west to east. This latter conclusion comes into collision with the opinion of Mr. Godwin-Austen, who, in describing the raised beaches of Devon and Cornwall,[2] regarded the presence in them of numerous chalk flints as indicating that the transportation of the materials at this time was from east to west. Mr. Pengelly, however, in 1867, suggested that the flints were possibly derived from submarine outliers of gravel at no great distance, and he mentions that recently he has been informed of the

[1] Described by Mr. Whitaker in the Geological Magazine, Vol. VI., p. 438.
[2] Quart. Journ. Geol. Soc., vol. vi., p. 87, 1849.

abundance of flint-shingle in the bed of the sea around Lundy Island, and in a bank off the Dodman Point, in Cornwall. He concludes by asking, "Is it too much to hope that ere long it will be a part of the duty of the officers of the Geological Survey of Great Britain to survey and map the bottom of the British Seas and Channels?"

2. *The Ash Hole and Bench Bone-caverns at Brixham, South Devon.* By W. Pengelly, F.R.S., F.G.S.

In this paper Mr. Pengelly has collected all the information that has been published respecting these caverns. The Ash Hole Cavern, which was partially explored about thirty years ago by the Rev. H. F. Lyte, is referred to by Prof. Owen,[1] under the name of the "Berry Head Cavern," and he mentions the occurrence in it of remains of the badger, polecat, stoat, watervole, rabbit, and reindeer. The Bench Cavern was discovered in 1861; it has yielded remains of *Hyæna spelœa, Canis lupus, C. vulpes,* and *C. isatis,* etc.

3. *The Literature of the Caverns near Yealmpton, South Devon.* By W. Pengelly, F.R.S., F.G.S.

The only descriptions of these caves appear to be those given, between the years 1835 and 1839, by Mr. J. C. Bellamy and the late Colonel Mudge, and the present communication by Mr. Pengelly consists in the main of a transcription of the papers by these gentlemen in chronological order.

4. *Crustacea Podophthalmata, and the Histology of their Shells.* By Edward Parfitt.

The Stalk-eyed Crustacea (or *Podothalmata,* as they are accidentally misspelt throughout this paper) possess considerable interest to the geologist, from the distant period to which they date back,—a shrimp-like form appearing as early as the Carboniferous period. In the seas surrounding the British Isles there are found no less than 110 species belonging to this group, and of this number 70 species inhabit the coasts of Devonshire.

The paper is illustrated with a plate showing the microscopical structure of the Crustacean shells, to give an account of which is the author's principal object. He moreover furnishes a valuable catalogue of the Stalk-eyed Crustacea of Devonshire, accompanied by notes on their habitats, etc.

5. *Fossil Sponge Spicules in the Greensand of Haldon and Blackdown.* By Edward Parfitt.

Mr. Parfitt describes a number of forms of sponge spicules, figured in a plate, which he identifies with genera of sponges now living, and having a wide geographical distribution.

Sponges must have been very abundant during the deposition of the cherty deposits called greensand on Haldon and Blackdown. Bands of spicula, varying in thickness from a foot to a mere trace, are mentioned by the author as occurring in these beds, and the erosive action, to which attention has been called by Dr. Bowerbank, is very conspicuous on many of the spicula. Their surfaces appear

[1] British Fossil Mammals and Birds.

sometimes to be eaten away, so as to leave a sort of reticulated surface standing up above the body of the spiculum, and in some of the larger specimens the surfaces are dotted with minute punctures, around which Mr. Parfitt has noticed a series of annulations in the form of Beekite.[1]

6. *List of Works on the Geology, Mineralogy, and Palæontology of Devonshire.* By William Whitaker, B.A., F.G.S.

This list contains no less than 300 papers relating to the geology of Devonshire, which must be of great service, not only to the members of the Devonshire Association, most of whom, away from libraries, would be ill able to hunt up the literature of their county, but to all geologists in any way interested in it. Those only who have had occasion to find out the different works written upon a particular subject can estimate the amount of labour which this list by Mr Whitaker must have necessitated.

III.—The Royal Geological Commission of Italy, Bulletin, No. 1–10 (in seven). 8vo. Florence, 1870.

[R. Comitato Geologico d'Italia. Bolletino, No.1–10.]

THIS Commission was ordered by a royal decree of December 15, 1867, for the purpose of providing Italy with a geological map of the country (on a scale of $\frac{1}{50000}$), and accurate sections of the strata, and to insure high-class teaching in mineralogy, geology, and mining. For this end, a national institution (under the Minister of Agriculture, Industry, and Commerce), with its president and officers, record-office, library, and museum, together with an examining board, have been set a-foot; and it will be perfected as soon as the State can afford the means for carrying out in full the purposes of this useful and well-promising Royal Commission. The members at the end of 1869 were:—Igino Cocchi, Professor of Geology in the Royal Upper Institute at Florence, President; Bartolommeo Gastaldi, Professor of Mineralogy in the School of Applied Engineering at Turin; Felice Giordano, Engineer, Inspector of the Royal Mining Corps; Guiseppe Meneghini, Professor of Geology in the University of Pisa; Lodovico Pasini, Senator (since dead). By the enthusiasm and good sense of devoted geologists, desirous of making their favourite science useful to the State, this Geological Survey has been brought under the notice of the Government, and is now fairly set going, just as in other countries fellow-workers had already got King, Kaiser, and Republic to recognize and advance their labours in working out the structure and developing the resources of their native lands. May the progress of the Italian Survey be steady and rapid, insured by Italy's new-found peace and unity! And certainly the experience of foreign Surveyors, the advanced views of modern geology, and the vast accumulation of facts and theories in the

[1] Mr. W. H. Bensted long ago called attention to the occurrence of bands of spicula in the Kentish Ragstone Quarries at Maidstone. The workmen suffered with inflammation in their hands, which Mr. Bensted discovered to be due to the irritation caused by these fossil-sponge spicules penetrating the skin.

world-wide publications of to-day, are all at the service of the new Commission, and will doubtless be turned to good account.

In the mean time the Commission[1] publish their "Memoirs" (4to.) and "Bulletin" (8vo.)—the former devoted to larger communications on and results of work in Italian geology, the latter with shorter notices and current information, such as the constitution and rules of this Commission; its library-catalogue, with bibliographical notices, etc. Zittel on the Central Apennines (with inverted strata); Cocchi on Elba; Negri and Spreafico on the Lago di Lugano; Manzoni on some Miocene Fossils; Theobald on the Valtellina; Grattarola Momo and Alessandri on Road-sections of the Hills in Florence (on a scale of $\frac{1}{2000}$); Maggi on the Conglomerate of the Adda; Grattarola and Alessandri on the Post-Pliocene Beds in the Valleys east of Florence; Suess on the Rothliegende of the Val Trompia; Wolf on a Sulphur Deposit near Naples; Caruel on the Fossil Cycadeous *Raumeria*, and a new species, *R. Cocchiana* (with photographs); Abdullah Bey on the Devonian Limestone of the Bosphorus; Gerlach on the Geology of the Southern Pennine Alps; Suess on the representatives of the Carboniferous and Permian Formations in the Alps; Cocchi on the Granite of the Val di Magra, and on a Tithonian Band in that valley; Curioni on the Val Trompia; and Pirona on the Sedimentary Strata of the Euganean Hills, are the observers and subjects (some illustrated with woodcuts) as far as geology is concerned; whilst numerous mineralogical and short geological notices give much that is new of Italy, and bring together correlative information from all parts of the world.

Thus the State Committee of Geologists, associated for the advancement of their science in Italy, and its application to the improvement of mines, quarries, lands, and roads, have fairly begun their systematic work in a field where many have already laboured, with varying success, in searching out nature's truths and seeking for the treasures of the earth, for noble or ignoble ends. This royally commissioned Survey, however, has for its only aim the increase of knowledge and the improvement of Italy's well-being. The hammer, the plough, and the pickaxe will work the surer and the faster with their guidance; and the capitalist, the thinker, and the philanthropist will each find a clearer path for his thoughts and actions —helping, raising, and enlightening himself and his fellow men.

With honest purpose, and with "science and industry" for their adopted motto, this small and trusty band of native geologists will before long make Italy truly and fully known to their countrymen by a map whereon the divisions will not be drawn by sword and sceptre, nor coloured by hate and bigotry, but pencilled out according to compass and clinometer, for the mutual benefit of agriculturist and miner, shepherd and vine-grower, noble and peasant, according to the outcrop of bare rock and the broad spread of fruitful strata.

T. Rupert Jones.

[1] The Office of the Commission is *Corso Vittorio Emanuele*, No. 17, Florence.

REPORTS AND PROCEEDINGS.

I. Geological Society of London.—December 7, 1870. — Joseph Prestwich, Esq., F.R.S., President, in the chair. The following communications were read:—1. "On Fossils from Cradock and elsewhere in South Africa." By Dr. George Grey. Communicated by Prof. T. Rupert Jones, F.G.S.

From the Karoo-beds, Dicynodont fossils and the jaw of a reptile, *Estheriæ*, and some coal and coal-plants (*Lepidodendron, Sigillaria*, etc.), were the chief specimens noticed by the author. Some *Stigmariæ* from the old Coal of Lower Albany, and gravel and miscellaneous minerals from the Diamond Fields, formed part of the collection.

2. "On some points in South-African Geology."—Part II. By G. W. Stow, Esq. Communicated by Prof. T. Rupert Jones, F.G.S.

This paper commenced with a detailed account of the Forest zones, coal, and other strata of the Karoo formation, as seen in sections in the Winterberg and Stormberg. The author particularly pointed out the position of the Fern-beds at Dordrecht, of the Reptilian remains found on the Upper Zwartkei, and of the Coal on the Klaas Smits River. He next referred to the climatal changes of South Africa, as indicated by its geology and fossils, particularly the Karoo-beds, the *Enon* conglomerate, the *Trigonia*-beds, the several Post-Tertiary shell-beds, and especially the present surface conditions, which he regarded as due to ice-action, as evidence of which he adduces *roches moutonneés*, moraines, basins, and striæ, both north and south of the Stormberg, in British Kaffraria, and even in Lower Albany. He concluded with remarks on the probable succession of periods, and on the former existence of a great southern continent.

Discussion.—Prof. Ramsay expressed a hope that the author at some future time would discuss the numerous subjects of which he treated at greater length and under separate heads. He was not surprised at the finding of Carboniferous plants in the Dicynodon beds, which appeared to be of Triassic age, inasmuch as the same was the case to some extent in our own later beds of Oolitic date. He agreed in the view of the probability of a vast continent having formerly existed in the southern part of the world, and considered that the denudation of Southern Africa had been so great, that it was no wonder the boundaries of the old freshwater lakes were no longer easy to find. It was also by no means surprising to him that a recurrence of glacial phenomena should be found in Southern Africa, as it had been in Europe. He did not, however, think it necessary to call in the action of ice for the excavation of valleys such as some of those described, as rain and running water appeared to him sufficiently powerful for the purpose. At the same time he would not deny the possibility of ice having been the agent in these cases.

Mr. R. Tate had seen evidence of similar effects being produced by aqueous force to those resulting from glacial action, and cited instances of moraine-like deposits having been formed by running streams in Central and Southern America.

Mr. Henry Woodward suggested that it would be desirable to wait for further particulars of the sections before assuming the actual association of *Sigillaria*, *Alethopteris*, and other accepted Coal-measure plants, with plants of doubtful Carboniferous age, such as *Palæozamia* and *Glossopteris*. He added that the *Stigmaria* lately said to have been obtained from the Kimmeridge Clay, had really come originally from Newcastle.

Prof. T. Rupert Jones remarked that Mr. Stow, like other South-African geologists, had had ample experience of the effects of violent rain. With regard to the mixture of Palæozoic plants, such as the *Lepidodendron*, etc., sent by Dr. Grey, with *Palæozamia* and *Pecopteris*, he thought it somewhat analogous to the mixture of Palæozoic and Mesozoic fossils in Australia.

3. "On the Geology of Natal, in South Africa." By C. L. Griesbach, Esq., Corr. Memb. of the K. K. Geologischen Reichsanstalt, and of the K. K. Geographischen Gesellschaft, Vienna. Communicated by Henry Woodward, Esq., F.G.S.

The author commenced by describing the physical geography of Natal, and then indicated the characters and distribution of the rocks which occur in that country. He stated that the granitic and gneissic rocks do not form the most prominent elevations, but they appear chiefly in the lower parts of river-valleys, and sometimes in small hills. Mica-schists and slates are found associated with the granites. The great plateaux consist of an undisturbed sandstone, which the author identifies with the Table-mountain Sandstone, and which lies horizontally upon the granites and old slates. The tops of many of the table-mountains in Natal are crowned by beds of dark basaltic greenstone. The Karoo formation, which lies in part upon the Table-mountain Sandstone, consists of a vast series of sandstones and shales, some of the latter containing beds of coal. The author agreed with Mr. Tate in regarding these beds as of Triassic age. At the base of the Karoo formation the author described a boulder-bed, which he was inclined to identify with the rock described by Mr. Bain as "Claystone porphyry," and through this greenstone has forced its way. On and near the coast of the southern part of Natal some sandy marls and sandstones belonging to the Cretaceous series were said to occur; the author gave lists of fossils obtained from these deposits, which he identified with the Trichinopoly series of India. Several of the fossils were described as new species. The author considered that the evidence adduced indicated that, after the development of the Table-mountain Sandstone, Africa and India formed parts of one continuous continent, afterwards covered by the Cretaceous sea. The area now covered by the Indian Ocean was the basin of a large series of lakes; and this condition persisted through a long period of tranquillity, lasting through the Triassic to the Upper Jurassic age. The greater part of this continent was then depressed and covered by the shallow Cretaceous sea. The economic mineral products of Natal were mentioned by the author, who referred to the occurrence of graphite, coal, gold, and copper.

Discussion.—Prof. T. Rupert Jones commented on the importance of the paper as throwing so complete a light on the geology of Natal, and proving the geological sequence to be similar there to that in other parts of Southern Africa. He remarked that the author had done special service by the great increase of information furnished by him regarding the Cretaceous rocks of Natal, and their equivalence to those of India. He also pointed out that Mr. Griesbach had proved that the Karoo formation was continuous to the other side of the great dividing range, and formed the floor of the Orange and Vaal Valleys, and that as Mr. Stow had indicated glacial action on the south side of the Orange Valley, it was quite possible that the gravels containing the diamonds were of local origin, as Dr. Grey had suggested.

4. "On the Diamond-districts of the Cape of Good Hope." By

G. Gilfillan, Esq. Communicated by W. W. Smyth, Esq., F.R.S., F.G.S.

Mr. Gilfillan described his going through Colesberg to Hopetown, and thence across the Orange River to Backhouse; and then, after crossing the Vaal, up its right bank as far as Lekatlong. He noticed such diamonds as he saw or heard of, and described the locality as being thickly coated with sand, diamond-bearing gravel, and tufa, hard blue shales occurring here and there in protruding hills.

Discussion.—Prof. Tennant stated that he had lately seen as many as 500 diamonds from the South-African fields in the possession of one person, some weighing as much as 50 carats. He had seen another fragment of a stone which must have originally been at least as large as the Koh-i-noor.

II. December 21, 1870.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. "On Lower Tertiary Deposits recently exposed at Portsmouth." By C. J. A. Meyer, Esq., F.G.S.

The author described some exposures of Lower Tertiary deposits made during excavations for the "Dockyard Extension Works" in Portsmouth Harbour. The thickness exposed, exclusive of alluvial deposits, amounted in all to 127 feet. The beds dip S.S.W., or nearly south, $2\frac{1}{2}$ to 3 degrees. The author grouped them under the four following divisions, in ascending order:—

1. Clays and sands with pyrites	36 feet
2. Argillaceous sands with *Dentalium*	25 ,,
3. Sands with *Lingula*	8 ,,
4. Clays with *Cyprina* and sandy clays	55 ,,

The author indicated the fossils contained in each of these divisions, remarking upon the range of some of the species, and upon the apparent mixture of London clay forms with others usually regarded as characteristic of higher or lower beds, which occurs especially in the "*Lingula*-sands." He suggested that, as the species found here present some slight differences from those occurring in other deposits, the difficulty might be got over on Darwinian principles. The author considered that the fossils did not furnish any satisfactory evidence of the true position of these beds; but, from stratigraphical evidence, he regarded them as being included in group 3 and part of group 4 of Mr. Prestwich's section of the Whitecliff strata in the Isle of Wight. He concluded with some remarks on the superficial deposits consisting of gravel and old and recent mud overlying the Tertiary beds in the section described by him.

Discussion.—Prof. Ramsay called attention to the value attaching to such observations as those of the author on the nature of the superficial deposits as distinct from the older rocks on which they repose.

Mr. Etheridge observed that the presence of the *Lingula* determined the position of the Bognor beds in the series, though there appeared great difficulty in fixing it stratigraphically. The commingling of species exhibited in this instance of shells hitherto supposed to be peculiar to certain horizons, he regarded as very remarkable.

Prof. Morris observed that the section seemed to show, not only the order of the beds, but their manner of deposition, the whole having formed part of a tranquil sea-bottom. He remarked on the difficulty of separating the more recent mud deposits from the beds of more ancient date. He pointed out the method of formation of septaria apparently by segregation, as they sometimes included undisturbed parts of the beds. The number of bivalves bored by carnivorous mollusks was remarkable, as was also the absence of *Pectunculus*.

Mr. Gwyn Jeffreys observed on the habits of *Lingula*, which had been by some regarded as an annelid, and not as a mollusk. It afforded a curious instance of the persistence of species, as there was no distinction that could be established between those of the Crag and of Silurian times. It lived at the present time between high- and low-water mark, and the *Panopæa* at a slightly lower level, and probably had done so in Tertiary times.

Mr. Evans inquired whether the upper gravel, like that on the shore of Southampton Water, contained any flint implements.

Mr. Meyer replied that he had not examined the gravels with that view.

2. "Note on some new Crustaceans from the Lower Eocene of Portsmouth, collected by C. J. A. Meyer, Esq., F.G.S." By Henry Woodward, Esq., F.G.S., F.Z.S.

Mr. Woodward drew attention to the occurrence in the fossil state of pelagic forms of Crustacea armed with long spines on the latero-anterior angles of the carapace.

Two Eocene forms had been described by Dr. Alphonse Milne-Edwards, namely, *Enoplonotus armatus*, and *Psammocarcinus Hericartii*.

Two new forms, differing generically from the above, but probably referable to the same family (the *Portunidæ*), were described, under the names of *Rhachisoma* (gen. nov.), *R. echinata*, and *R. bispinosa*.

A third form, belonging to the *Corystidæ*, was then noticed. This family, represented in the fossil state by the genus *Palæocorystes*, is well known in the Gault and Upper Greensand of Folkestone and Cambridge, one species ranging up as high as the Maestricht beds. The occurrence of *Palæocorystes* in the Lower Eocene is of great interest. Mr. Woodward named this new *Palæocorystes*, *P. glabra*.

3. "On the Chalk of the Cliffs from Seaford to Eastbourne, Sussex." By W. Whitaker, Esq., B.A., F.G.S.

The author compared the chalk of the Sussex coast with that of the Kentish coast, and stated that it consisted of the following divisions in descending order:—

1. Chalk with flints of great thickness.
2. Chalk with flints and nodular layers, weathering rough.
3. Chalk without flints, but with nodular layers, weathering rough.
4. Thick-bedded massive chalk without flints.
5. More thinly-bedded chalk without flints, but with marly beds.
6. Chalk-marl, 50 or 60 feet.

The highest of these divisions stretches as far eastwards as Beachy Head, and forms the whole of the cliffs to within a short distance of that point.

4. "On the Chalk of the southern part of Dorset and Devon." By W. Whitaker, Esq., B.A., F.G.S.

The divisions of the Chalk were traced by the author westward from cliffs on the north side of Swanage Bay to beyond Beer Head in Devonshire. At first the succession of the beds was shown to be as in the Isle of Wight, namely:—

1. Chalk with flints, very thick.
2. Chalk with few flints.
3. Chalk-rock, very thinly developed.
4. Chalk without flints.
5. Chalk-marl.

It was shown that the lower beds became thinner westward, until, at one part of the Beer Head section, the chalk with flints rested at once on the Upper Greensand; and the following general conclusions were drawn:—

That the chalk-marl thins westward, and its bottom part becomes marked by the presence of quartz-grains, showing perhaps signs of a less deep-sea character than usual.

That the Chalk without flints thins westward (from about 200 feet in the Isle of Wight), until, in Devonshire, it is but 30 feet thick, or even less.

The consequent nearness of the Chalk with flints to the Greensand helps to explain the deposits of flints on some of the Devonshire hills.

Discussion.—Mr. Etheridge pointed out the resemblance between the series described by the author and that of the Chalk of Antrim. He thought it probable that the Cretaceous beds had originally extended over the whole of Western England. He called attention to the Blackdown-beds, which had been regarded as Upper Greensand, but certainly were not so, though probably Cretaceous, as well worthy of examination.

Mr. Hull hoped that some Fellows of the Geological Society would extend their examination of the Chalk into Ireland, and visit the Antrim district. It was the case there that the Chalk with flints rested immediately on the Upper Greensand, though there was an intermediate band known as the Mulatto-bed, which might possibly represent the Chalk-rock.

Prof. Morris thought the paper afforded evidence in favour of the Chalk having been deposited in a sinking area, and during the process various alterations in the conditions took place.

Mr. D. Forbes inquired as to the character of the nodules mentioned, and whether they were siliceous or not.

Mr. Meyer mentioned that near Branscombe there occurred a band within 8 feet of the Red Marl, containing fossils apparently the same as those of Blackdown.

Mr. Whitaker had purposely avoided characterizing the greater part of the Greensand-beds as either Upper or Lower. He thought the Cherty-beds of the west were stratigraphically higher than those of the Isle of Wight. The nodules inquired about were not siliceous, though probably containing some silica, but were rather phosphatic.

Royal Geological Society of Ireland (Jan. 11).—A paper was read by Edward Hull, Esq., F.R.S., Director of the Geological Survey of Ireland, "On the Geological Age of the Ballycastle Coal-field, and its relation to the Carboniferous Rocks of the West of Scotland."

The object of the paper was to prove that the Coal-field of Ballycastle, County Antrim, was referable to the type of the Lower Coal-field of Scotland, and consequently of the age of the Lower Carboniferous series; in other words, of the Mountain Limestone.

The Carboniferous series of Ballycastle, which had been described in 1829 by Sir R. Griffith, F.R.S.,[1] was shown to consist of three divisions in descending order.

1. *The Upper.*—Consisting of massive sandstones, shales with beds of coal, black-band and clay-band, ironstones, etc. (*Lingula squamiformis*).

[1] "Report on the Coal Districts of Tyrone and Antrim" to the Royal Dublin Society, 1829.

2. *The Middle.*—Consisting of a thin bed of Limestone lying between shales, with Carboniferous limestone genera and species of shells, crinoids, and corals.
3. *The Lower.*—Consisting of massive reddish grits and conglomerate with thin beds of shale.

The author showed that the Carboniferous limestone of Ireland undergoes in its extension northwards changes similar to those of the same formation in Britain, when traced from Derbyshire into Northumberland and Scotland. The calcareous member thins away and is replaced by sedimentary strata of sandstone and shale, showing approximately terrestrial conditions, productive of coal and ironstone. It was thus that in the case of the Glasgow coal-field the limestone of Derbyshire, several thousand feet in thickness, was represented by only thin bands of earthy limestone, interstratified with a thick series of grits, shales, etc., with ironstone and coal. In a similar manner, the Ballycastle coal-field, with only a few feet of limestone shown in the cliffs of the bay, was the representative of the Carboniferous limestone of the centre of Ireland, nearly 3,000 feet in thickness.

Mr. Hull regarded the Lower division (No. 3) of the Ballycastle beds (as above described) as undoubtedly the representative of the "Calciferous Sandstone Series" of the Geological Survey which lies at the base of the Carboniferous rocks of the West of Scotland, and that the Middle and Upper divisions (Nos. 2 and 1) correspond to the Carboniferous limestone series, or lower coal-field of that country.

As regards the palæontological evidence, it was in favour of this view, as far as it had been studied. Out of 33 species observed in the limestone band of Ballycastle Bay, 50 per cent. had been described in the Lower Carboniferous rocks of the West of Scotland,[1] and one of the uppermost seams of coal lying above the limestone had yielded *Lingula squamiformis*, a form characteristic of the limestone series in the North of England, as also in Scotland and Ireland. Mr. W. H. Baily, F.G.S., concurred in the view of the age of these beds, on palæontological grounds.

The author concluded by pointing out several features of similarity between the Ballycastle beds and the Lower Coal series of the West of Scotland, such as the occurrence of several beds of "Black-band" ironstone; the hydraulic and earthy character of the limestone of Ballycastle Bay exactly resembling the "Arden" and "Cowglen" bands of Glasgow. Some uncertainty still remained whether there were any beds in the Ballycastle district as high in the geological series as the Millstone grit, or true Coal-measures; but until more light could be brought to bear on this question by further exploration, and a complete investigation by the Government Surveyors, the author meanwhile regarded the whole series as Lower Carboniferous.

[1] Trans. Geol. Soc. of Glasgow.

Geological Society of Glasgow.—December 1st, 1870.—Mr. John Young, Vice-President, in the chair.

Bituminous Striped Sandstone.—The Chairman exhibited a block of Carboniferous sandstone from Gilmorehill quarry, about nine inches in thickness, showing in that space thirty-two well-defined alternate white and dark-brown stripes, which gave the specimen a beautifully stratified appearance. Mr. Young stated that the brown stripes were due to the particles of sand having become mixed with bituminous matter previous to their deposition. It was perhaps not easy to explain the alternation, so oft repeated, of these white and coloured bands, but he thought the stripes could not have been so clear and distinct if the sand had been impregnated with the colouring matter *after* deposition. The layers of white and brown sand had evidently been deposited as such, at irregular intervals, over the area in which this striped sandstone is found, and which, he might mention, is of very limited extent in the quarry he had named. He then referred to other bituminous sandstones found in the coal-measures near Glasgow, and said he believed the bitumen by which they had become impregnated had been driven off by heat from other bituminous strata in their neighbourhood, and in some cases had been mixed with the sand during the deposition of the bed; in others, had been carried into it at a later period by infiltration. As regarded the specimen before them, the former, as he had already indicated, was the more probable hypothesis. All these bituminous sandstones, on being burnt, lose their bitumen, and return to their normal colour.

Carboniferous Fossils.—Mr. Thomas Naismyth exhibited several drawers of fish remains, principally from the coal-fields around Glasgow, upon which Mr. Young offered a few remarks illustrative of their generic characters and their range in the Carboniferous strata. The collection contained a number of fine large teeth of *Rhizodus Hibberti*, from the ironstone pits at Possil; jaws, scales, and teeth of *Megalichthys Hibberti* and *Megalichthys rugosus*, besides a number of fin-spines and other fragments of fishes, from the Airdrie coal-field. Among the specimens were also to be noticed a few fragments of reptilian remains, consisting of portions of crania, vertebræ, etc., which had been found near Airdrie, and at Quarter, near Hamilton.

Mr. James Thomson, F.G.S., said the specimens exhibited by Mr. Naismyth were of considerable interest, especially the reptilian. These belonged to two new species of *Labyrinthodon*, of which he had already found remains in strata of the same geological horizon.

Oil Shale.—Mr. D. C. Glen, C.E., laid before the meeting several slabs of oil shale from near Collingwood, on Lake Huron, Canada; and also some samples of the petroleum distilled from it. The slabs were from the Silurian formation, which is of great extent in North America, and remarkable for the regular succession of its strata. When examined, these blocks of shale were found to be stratified horizontally with layers of Trilobites, Entomostraca, and other marine organisms. The oil shown was distilled from the shale in the usual manner, by heated retorts. The pure, clear spirit is taken from the oil, leaving a thick residuum, which is used for tarring outside work, and also for burning in steam-boiler and other furnaces. Another sample of oil on the table was pumped up from a bored well at Bothwell, C.W., where the oil occurs at a depth of from 100 to 500 feet from the surface. When pumped out, it is mixed with three or four times its bulk of salt water. It is then allowed to settle in large tanks, and when the water is drawn off from below it leaves the oil in very much the same state as that distilled from the shale. In all probability, therefore, this oil is derived from a similar stratum, impregnated with organic animal matter.

CORRESPONDENCE.

SPORE-COAL; FLINT, AND PROTOZOA.

Sir,—I am an elderly amateur of Geology, and have suffered many disappointments, on finding that what my scientific guides had, at one time or another, told me to accept as the definite cause and explanation for this or that fact or problem, on which I sought their opinion, was rotten or could not hold water. Indeed, I scarcely hesitate to disbelieve in a new theory, and to discredit an asserted discovery, unless the former holds good through several editions of a manual, and the latter survives the discordant statements of opposite parties for the term of at least three sessions, exclusive of the British Association Meeting when it was first promulgated. I shall not, however, have time to believe in any of the advanced facts and notions of to-day if these rules of mine remain unbroken. Will you be pleased, Mr. Editor, to serve as strainer to my curds and whey, and tell me what is the cheese, when I shall have put the collected matter of my reading before you?

Now you must know that I like to read about *coal*, as well as burn it this cold season; and I have read very many curious things about it. Of course, when I was a boy, coal, I was told, was the accumulated vegetable refuse of the Mosaic deluge, whilst the fossils of the Lias country, which constituted my world at that time, were the defunct Mosaic sea animals. Once I heard a lecture on the origin of coal from pitch-lakes; but whether they were such as those of Trinidad, described by G. P. Wall, or rather like those elsewhere, so well described by A. Dante, J. Milton, and others, I had my doubts. Then I read that coal was the drift timber of pre-historic Mississippis and Orinocos. Then I was informed it was the successive jungles of unknown trees on sinking islands in the former world. Then I learned from Goeppert and others that these trees and herbs could be satisfactorily separated and recognized, even in the coal itself, as well as in the clay-beds among which it lies; and Unger drew Martinesque forests of Sigillarias, Stigmarias, etc., and I presumed all was known. Then Quekett and other histological microscopists (you see I know some hard words) showed the structure of various coals; and their long and short, shaped and shapeless, coloured and discoloured, particles were very interesting; but I could not satisfy myself which way the slices were cut for the microscope, nor which was the top and which the bottom of the piece of coal. Then Dr. Dawson taught me more clearly about the order of the bright and the dull black layers, and explained everything so nicely that I thought we knew the history of the coal, its forests, and all its antecedents. Others had taught me of the spore-made "trubs," of the chemical changes of the hydro-carbons of woody matter, peat, lignite, coal, etc.; and I recognized the difference between the native charcoal, or black touchwood, of the streaky coal, and the anthracite, or coal changed into carbon by loss of its hydrogen, and so on. But, Mr. Editor, now begins my trouble. I have just read Mr. Dawkins's "Science Lecture on Coal" (8vo. pamphlet; Heywood, Manchester), and I find that "bituminous coal" is so called, not because it is mostly convertible into bitumen by heat, but because it *contains bitumen;* and I learn that all this "bitumen" is nothing but sporangia and spores! And that to prove this, none have laboured so successfully as "Professor Morris, Mr. Carruthers, and last, though not least, Professor Huxley"! Of course, I have heard of these spores and spore-cases before; but this seems to me to be a case of sporimania on the lecturer's part. It may be so with other people too. I cannot think it is with Prof. Huxley, for the lecture on coal given by him at Bradford, December 28, 1869, as reported in "Scientific Opinion," is one of the best lectures I ever read,—unpretending, clear, simple, comprehensive, and indeed perfect; and, however full of information on coal and coal-spores it may be, it does not break out into any wild notion of universal spore-coal, nor supply any jack-o-lantern lights of false science. Nor do I see any symptoms of this spore-madness in Messrs. Morris and Carruthers, if I have read their writings aright. They and their fellow-workers have long ago told us what kind of plants bore the spores that are found here and there in the coal; and they must indeed feel glad to find that the lecturer assures us that he thinks it is not at all difficult to trace some analogy of the extinct Lycopods with a living order of vegetation!

Do tell me, Mr. Editor, how far I may go in for the coal-bitumen and the coal-spore doctrines in my geological conversations next year, when, as usual, I intend to turn over a new leaf; indeed, I think, quite a new branch of anthracology!

Mr. Dawkins has given us the spores of his new theory; but he cuts away the roots of Lepidodendron and the leaves of Sigillaria. Am I to lay aside the teachings of Dawson and others, and, after reading Dr. Hooker's memoirs of 1848, omit everything till I come to Mr. Carruthers's late excellent papers, and Prof. Huxley's and Dawkins's lectures, with the chapter on coal in Lyell's "Elements" for my *entremets?* If so, I fear I may get the spore-fever too!

Dear Mr. Editor, there are other geological troubles in my mind-life. What am I to do about flints? I will not make a *résumé* of my "Phases of Faith" in Silicification. They might be as heterodox as other people's "Phases." Let me say, however, that I did not heartily believe in Ehrenberg's dissolution of Diatoms for the making of flint. I thought that the decomposed felspars and the many mineral springs would do as well; and I did not believe that the silex ever stuck round a sponge like glue on an apprentice's fingers. I did think there had been a pseudomorphism of silex after carbonate of lime in every limestone, even on the sides of joints in chalk; and I hoped for some good experiments to back up my fancy. But now I am driven back to the dissolution of diatoms and siliceous spicules, with regenerated silex, where never a diatom nor sponge need have been, just because the zoologists have found plenty of diatoms, polycystines, and siliceous sponges in what they are pleased to call the "Chalk-mud" of the deep Atlantic! Further, I am told to believe that Toulmin Smith's membranous Ventriculites were once siliceous, but gave up their hypothetical silica in the muddy chalk, to suit, I suppose, the last new idea that zoologists, thinking to benefit geology, have brought up with the sounding-lead! What a uniform consentaneous sacrifice the Ventriculites must have made; as neatly plundered of their supposititious silica as the French villas are cleared of lamps and pianos by the Prussians.

The diatom-mania has led us before now through Salpas and Whales' coprolites, to full-grown flints! And with this warning before me I shall eschew them, and even encourage a Spongiphobia in the matter of silicification, until, Mr. Editor, I am directed to the true light, though it be but a spark, that zoologist, mineralogist, and geologist together have to get out of flint.

My next trouble—no—you shall not be bored with that. It is like the others—the result of enthusiastic savants running wild with the one new idea that has, I fear, deluded them, and others before them, with the hope of throwing a flood of light on that obscure but interesting subject which circumstances have led them to take up as a study, or as the text for a lecture. "The intelligent foreigner" that we know of once found, in the lake of Mexico, petrified Notonecta eggs so like *oolite* that, being a geologist, he immediately discovered that all oolites are petrified insect eggs! So with the spores;—all flaming coal is spores! So with flint; it is all jelly of diatom-broth and sponge-spicule-soup! And now, dear Sir, please tell me, are these the curds and whey from which genuine cheese is made?—Yours, etc.,

COALHOUSE, FLINTSHIRE,
Christmas Day, 1870.

RUSTICUS EXPECTANS.

POSTSCRIPT.—I am troubled too by what seems to be a Rhizopodal madness among palæontologists, upsetting my old notions, and offering such new ones that a course of reading in the existing manuals does not enable me to digest. In fact, nearly every obscure little thing, and many big things once safely registered among corals and such like, become foraminiferal now-a-days. Indeed, geologists, especially the new ones, have had the Globigerina-fever ever since Mr. Sorby explained that some chalk is nearly made up of Globigerina shells. The Atlantic mud, in some places, was next found to consist of Foraminifers and Polycystines; and if anything else was wanted in its protozoal character, it was soon supplied with Coccoliths and the pervading but almost intangible Bathybius, which has permeated ocean-beds and men's minds after the fashion of Huns and Tatars, Saracens and Prussians, invading broad lands and occupying history until a change comes o'er the spirit of earth's dream once more. I suppose these Rhizopodal truths are more or less genuine. But are we to admit of sub-Alpine flanks and sub-Himalayan buttresses made of Nummulites, and that the Turco-Persian frontiers are marked out by gigantic Foraminiferal Loftusias? Are there whole beds of Parkerias; and are wide sea-floors coated thickly with siliceous casts of small Forams? Are we to suppose that nearly all the fine-grained limestones belong to the protozoists, and are sealed as theirs by visible Alveolines, Fusulines, etc., and by microzoa innumerable, known only to the experts? This seems enough for us to believe; but let me ask—did really the big Stromatopora enter as a Foraminifer in the race of life? And did the Eozoon, known only to the upper ten of palæo-zoology, play as important a part before Canada was, as it has (in books) since Canada became a Dominion? We are overwhelmed with Rhizopods: to say nothing of Sponges, old and new, and other Protozans.

Can you, Mr. Editor, tell me when the Rhizopodists will cease to trouble us with such multitudes of these low things? We poor amateurs seem to be so many Pharoahs—to be afflicted in all our quarters with protozoan creatures enough for all four of Egypt's animated plagues!—R. EX.

MR. CROLL'S HYPOTHESIS OF THE FORMATION OF THE YORKSHIRE BOULDER-CLAY.

Sir,—I submit that Mr. Croll's hypothesis of the formation of the Yorkshire Boulder-clay by a sheet of land-ice, without any intervention of the sea, is at once negatived by the abundant beds of sand and gravel intercalated in it, in one of which occur shells perfect, unrolled, and sometimes double; and that his explanation of the absence of chalk from the purple clay by one arm of his ice-sheet having passed north of, and so escaped, the Wold is equally negatived by the fact of this clay overlying and passing gradually down (through clay with more and more chalk) into the chalky clay along the Holderness coast, viz., at Dimlington cliff, and at the cliff south of Mappleton; for besides this gradual transition, these places could not by any possibility be reached from the direction of Shap without the chalk being crossed.

From the way in which Mr. Croll uses the quotation from a paper of mine as to the origin of the chalk in Boulder-clay, the reader might suppose that, like Mr. Croll, I regarded such Boulder-clay as a *deposit* of land-ice without intervention of the sea; and I am anxious not to be misunderstood in this respect: for though I regard the material making up the chalky clay, and indeed most of that making up all glacial clay, as the *product* of land glaciation, yet the evidence seems to me unanswerable that such clay, wholly unstratified as it is, has been deposited under the sea; and that moreover to all appearance as tranquilly as many sedimentary deposits.

Were your pages less engrossed with Glacial topics, I should like to discuss with Mr. Croll the evidence bearing upon this subject, as well as upon the hypothesis of an ice-sheet 2,000 feet and more in thickness, which he and Mr. Jamieson insist has passed, regardless of hill and vale, over the higher mountains of Scotland, such as Schiehallion, and the filling up of the North Sea with ice; but until opportunity offers, I must content myself with demurring to all these propositions.

I may mention that Mr. Rome thinks that the Shap blocks are confined to the upper part of the purple clay, and that he ascertained the exact spot (about 15 feet from the top of the cliff) near Saltburn whence one of these boulders had come. Supposing this to be confirmed, it would show that the glacial period had nearly terminated when these erratics came over; and the period arrived when the glacier ice having been lifted out of the straths and valleys, the mountain regions had become an archipelago filled with ice-floes, to the agency of which (and not to that of bergs) both Prof. Harkness and myself refer the transport of the blocks in question—the period, in fact, to which I would refer all the glacial accumulations of the Scottish highlands.

SEARLES V. WOOD, Jun.

GLACIATION OF THE LAKE-DISTRICT.

Sir,—In your last number Mr. Mackintosh, in his reply to the letters of my colleague, Mr. Wollaston, and myself, states, with reference to my letter in your number for last December, that any want of theoretical agreement between us consists to a great extent in the application of terms. He also says that I have not substantiated any charge of inaccuracy of observation in his paper published in your number for last October. Mr. Mackintosh there stated that in the valley of Kentmere "no traces of moraines, except perched and scattered blocks, are to be found."

In my letter I stated my belief that "the old lake, represented by the alluvium of Kentmere, originated partly from damming by a moraine;" and I also pointed out the occurrence of scratched stones in this valley. The want of theoretical agreement indicated by these two passages does not seem to hinge upon any different "application of terms."

Mr. Mackintosh calls the mounds which occur in the Kentmere valley "an upland extension of the boulder-drift of the plains." On this I make no comment. Boulders do occur in the valley, together with large numbers of scattered blocks, the latter derived from the immediate vicinity. I still, however, retain my belief that these mounds are the remains of moraines. The position of the mounds, the scratched stones, the alluvial flat, and the gravels at the mouth of the valley, all tend to confirm me in this belief. I do not hold the view about the two great valley-ignoring ice-streams at different periods, with which Mr. Mackintosh credits me. I believe the striæ transverse to the axes of the valleys were made when the ice was disappearing from the low ground, and that the ice on the fells, being no longer forced to pass in the direction of valley axes by adjacent valleys full of ice, simply gravitated towards the lower ground, probably obliterating in its passage much previously formed striation, and leaving in its stead these later finishing touches, in the same way that a few strokes of a file will obliterate previous file marks made in a contrary direction.

If Mr. Mackintosh does not believe in the existence of moraine stones on the fells in the neighbourhood of Skeggles Water—What then are the scratched stones which are so numerous there? They in every respect resemble ordinary moraine stones, and I feel bound to regard them as such until their markings can be satisfactorily accounted for by some other hypothesis. In conclusion, I may add that it has not been my intention to look for faults in Mr. Mackintosh's paper, but simply to uphold my observations when the statements of Mr. Mackintosh seemed to contradict or ignore them; and I trust that his researches among the northern cliffs may lead him to useful and interesting results.

Frank Rutley.

H. M. Geological Survey,
January 14, 1871.

MR. CROLL ON THE DISPERSION OF BOULDERS.

Sir,—It is with reluctance that I crave space for a few remarks on Mr. Croll's article, but I think it desirable that some of the difficulties with which his theory seems to be beset should be stated without unnecessary delay.

Difficulties connected with Physical Geography.—The ground W.S.W. of Wasdale Crag does not rise to a sufficient height to have enabled it to generate or give a direction to an ice-stream capable of carrying blocks from Wasdale Crag over the Pennine chain. In the case of an ice-stream assailing the Lake District from an external source, the questions arise—How was it propelled across the ridges and valleys intervening between the Irish Sea and Wasdale Crag? Where was the originating high ground situated? Or, if the stream came from a Polar ice-cap in a southerly direction, how was it diverted towards the E.N.E.? These difficulties Mr. Croll may be able to explain, but I cannot see how his theory can be reconciled with the following facts.

Prevailing Direction of Glaciation.—As Mr. Croll surmises, many instances of glaciated rock-surfaces showing the passage of ice across the N. of England in an E.N.E. direction may possibly yet be found at high levels, but the fact ought not to be overlooked that most of the high-level instances hitherto discovered do not trend in the above direction, but nearly at right angles to it, or in approximately opposite directions (instances—Gaythorn Tileworks, N. and S.; watershed between Kentmere and Long Sleddale, N. and S.;[1] many *roches moutonnées* north-east of Windermere, glaciated from N.N.W.; Coniston Old Man, near Copper Works, N. and N.N.W.; south of Pudding Cove, nearly N.; entrance of Low Water Cwm, glaciated from between E. and N.E., at a height of nearly 2,000 feet above the sea). At lower levels, between Kentmere and the Irish Sea, the glaciation in nearly every instance I have yet seen has come from points of the compass between N. and N.W. (see article, Geol. Mag. for October, 1870); in a very few instances *from* between N. and E.N.E., rather than *towards* these points. What seems to be the original glaciation, indicated by small parallel undulations, has generally come from between N. and N.N.W., instead of trending in the direction of Mr. Croll's supposed ice-sheet.

Direction of Drift-carriage.—Between Wasdale Crag and the Pennine chain, the direction in which the drift has been carried varies from N. round by E. to S., though the part of the drift which found its way over Stainmoor travelled E.N.E. Between Wasdale Crag and the Irish Sea, the direction is generally from N. to S., or from points between N.W. and N.E. In many instances the drift-carriage has crossed the striæ at greater or less angles. The Eskdale granitic drift, in a matrix of Boulder-clay, crosses the most splendid specimen of glaciated rock-surface I have yet anywhere seen. On the coast adjacent to Blackcombe, the granite, from the N., is found in the *three drifts* (lower Boulder-clay, middle sand, and upper Boulder-clay), and these three drifts would appear to represent the main part of the glacial period in the Lake District, so as to render it highly improbable that any land ice-stream from the Irish Sea could ever have flowed E.N.E. to Wasdale Crag. On the supposition that the Eskdale drift, and the nearly parallel Criffell drift,[2] were carried by a stream of land-ice, the channel of the Irish Sea must have been partly or wholly filled up to a great height by this stream, as Mr. Eccleston has found blocks of Eskdale-fell granite more than 1,000 feet above the sea on the west side of Blackcombe, and this stream must have carried the granite as far south at least as Bridgenorth and Wolverhampton. On the Pennine hills, and in the Yorkshire valleys, south of the latitude of Wasdale Crag, the drift-carriage has either approximately followed the valleys, or come chiefly from the N.W. or N.N.W.,[3] if we except chalk-flints, which may possibly have come from Ireland. Fragments of Wasdale Crag granite are found in the brown Boulder-clay west of Ripon, and, according to Mr. Green, F.G.S., a boulder of this granite may be seen at Royston, near Barnsley.

Connection between the Direction of Drift-carriage and Altitude.—Though the Granite in the Wasdale area rises to a height of about 1,600 feet above the sea on

[1] Mr. Rutley has found striæ near Skeggles Water, running nearly E. and W. (Geol. Mag. for December, 1870).

[2] Mr. Croll's theory, to be satisfactory, ought to embrace an explanation of the dispersion of Criffell granite as far at least as Cliburn (near Penrith), and nearly the whole way uphill, or in opposition to the drainage of the country.

[3] On the north side of Rombald's Moor, however, Millstone-grit has been beautifully smoothed and striated W. and E. at a height of about 900 feet above the sea.

high ground separated from Wasdale Crag by a watershed, Wasdale Crag (or rather Wasdale hill), from which, I believe, most of the boulders were dispersed, is only 1,479 feet above the sea-level. An ice-stream, such as that supposed by Mr. Croll, with a surface low enough to have received fallen blocks of granite, could scarcely have been 100 feet thick on Stainmoor pass. Could such a thin layer of ice have persisted in moving over the pass, so as to keep the ice-stream on the other side supplied with blocks? and in what way did the eastern ice-stream receive or acquire a motion sufficient to enable it to ignore not only minor or subordinate ridges, but hills in E. Yorkshire more than 1,000 feet in height?[1] If we suppose Mr. Croll's ice-stream to have pushed the blocks from Wasdale Crag along its bed (a theory which, of the two, would best accord with the fact that many of the blocks are more or less rounded, and often imbedded in drift), the question arises, how could the supposed ice-stream have acquired a power of shoving so many large boulders up a steep slope nearly 1,000 feet in vertical height?[2]

Dispersion in different Directions.—Mr. Croll has justly remarked that ice-streams may have varied their directions as their surfaces stood at different levels; but a stream of land-ice impinging on Wasdale Crag at a level which would have given it a direction towards Tebay would certainly have sent it along the valley of the Lune, in which valley no blocks of granite have been found. No one, I suppose, would presume that a local ice-stream could have flowed up this valley so as to check the glacier from Wasdale Crag. The existing configuration of the ground is likewise inconsistent with the idea of local ice-streams flowing north and north-east from Wasdale Crag. But the main difficulty in the way of accepting Mr. Croll's theory is to be found in the fact that Wasdale Crag boulders have been carried *south* in the direction of Kendal over a pass traversed by the Kendal road, which approaches Stainmoor pass in altitude. To the north of Kendal they are found in considerable numbers, imbedded in drift as well as appearing at the surface. During what stage in the lowering of the 2,000 feet ice-sheet were these boulders carried southwards?

Mr. Croll seems to think that radiating dispersion can be more easily explained by land-ice than by floating-ice. That land-ice could have dispersed boulders in various and often opposite directions from detached or semi-detached hills of moderate elevation appears to me almost impossible. The advantages possessed by the floating sea-ice (not iceberg) theory, over the land-ice theory, consist in the fact, that coast-ice may be dispersed by variously-directed winds blowing off the land; by drift-currents arising from these winds; and by ebb-tidal currents. Through these mediums it may find its way into the courses of great tidal and other currents, and these may change their directions with changes in the form of the shore or sea-bottom, produced by the sinking or rising of the land, and by denudation.

D. Mackintosh.

THE BLUE CLAY IN THE WEST OF ENGLAND.

Sir,—Allow me through your pages to convey to Mr. De Rance my sincere regret for having erroneously attributed the authorship of his paper "On the Glacial Phenomena of Lancashire and Cheshire," to Prof. Hull. I never met with the paper in full, aud therefore avoided quoting its views. With regard to the thickness of the blue clay near Llandudno, the reference is to a paper in your November number, by Mr. H. F. Hall (not Mr. Hull, as by a misprint it appears in your correspondent's letter). My impression, on reading the statement, was that it was excessive, but I would not

[1] The land-ice theory is rendered still more improbable by the facts, that Wasdale Crag granite has found its way as far as the mouth of the Humber; that from a narrow neck on Stainmoor it has expanded over an area forty miles in breadth (from Ripon and York to the sea-coast); and that Liassic drift from the N. Yorkshire hills (over which the granite must have passed) has been dispersed over the plain of York. *Gryphæa incurva* have been found in Boulder-clay as far west as Keighley.

[2] Blocks of Permian breccia have been moved up a neighbouring slope to a vertical extent of 1,000 feet, and this, I think, can be sufficiently explained by the progressively upward movement of coast-ice during a subsidence of the land.

oppose a mere unsupported recollection to an opinion formed upon the spot by, probably, a more competent judge. I therefore gave Mr. Hall's figures, stating that the thickness assigned was "unusual."

I think these are the only points in Mr. De Rance's communication requiring a reply. The rest of his letter appears to refer to the paper regarding the authorship of which I have made so unfortunate a mistake. CHARLOTTE EYTON.

BIDDULPH, CONGLETON, January 5th, 1871.

ON THE SUPPOSED PHOLAS-BORINGS IN MILLLER'S DALE.

Notwithstanding the statement we inserted in our last number (p. 40), that Mr. Bonney had submitted to us his specimen from Miller's Dale, which is *beyond doubt limestone*, and perforated in the way described, we have received another letter from Mr. Edwin Brown on the subject. He is still firm in the belief that no such borings exist in the limestone where indicated in Mr. Bonney's diagram, and he states that the roadway in question has been cut in a bed of *toadstone*, and at so recent a date as not to be laid down in the Ordnance Maps. He invites geologists to visit the spot and to judge for themselves. We think it will be better not to discuss this subject further. The specimen is still in our possession, and those who feel interested may examine it at any time. The locality described is of course equally open to those who may have the opportunity of visiting Miller's Dale (see Mr. Bonney's paper, GEOL. MAG., Vol. VII., 1870, p. 267).—EDIT. GEOL. MAG.

A NEW LOCALITY FOR *LEAIA*.

SIR,—At page 219 of No. 71 of the GEOL. MAG. are some notes on the little bivalved Entomostracan *Leaia*, and its distribution, South Wales having then (May, 1870) yielded numerous individuals of this rare genus to the researches of Mr. Wm. Adams, F.G.S.

Thanks to Mr. C. W. Peach, the veteran geologist, of Edinburgh, I am enabled to add another locality, and the most northern yet known, for this genus, as I have had the opportunity of examining an easily determined, though somewhat crushed, pair of valves in a piece of ironstone from near Edinburgh. They do not offer any new specific characters. Like the others already met with (excepting a Lower Permian form from Neunkirchen, in Germany), Mr. Peach's specimen is from the Carboniferous formation.

Mr. Peach tells me that "the clay-ironstone nodule containing this *Leaia* is from the Lower Carboniferous Shales of Wardie, on the Forth, near Edinburgh. The nodules from these shales (flattish in shape, with rounded outlines) contain coprolites, fishes, plants, etc. The shales also contain similar organisms; in fact, they are very rich indeed, and have been a famed hunting-ground for palæontologists. Agassiz long ago described six species of fish from these beds; and since then others have been discovered. Full particulars may be found in the Memoirs of the Geological Survey of Great Britain: the Geology of Edinburgh; Map 32 of Scotland, 1861, pages 30 and 31." T. RUPERT JONES.

THE

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ORIGINAL ARTICLES.

I.—On a Method of Determining the Mean Thickness of the Sedimentary Rocks of the Globe.

By James Croll, of the Geological Survey of Scotland.

VARIOUS attempts have been made to measure the positive length of geological periods. Some geologists have sought to determine, roughly, the age of the stratified rocks by calculations based upon their probable thickness and the rate at which they may have been deposited. This method, however, is worthless, because the rates which have been adopted are purely arbitrary. One geologist will take the rate of deposit at a foot in a hundred years, while another will assume it to be a foot in a thousand or perhaps ten thousand years; and, for any reasons that have been assigned, the one rate is just as likely to be correct as the other: for if we examine what is taking place in the ocean bed at the present day, we shall find in some places a foot of sediment laid down in a year, while in other places a foot may not be deposited in a thousand years. The stratified rocks were evidently formed at all possible rates. When we speak of the rate of their formation, we must of course refer to the *mean rate;* and it is perfectly true that if we knew the thickness of these rocks and the mean rate at which they were deposited, we should have a ready means of determining their positive age. But there appears to be nearly as great uncertainty regarding the thickness of the sedimentary rocks as regarding the rate at which they were formed. No doubt we can roughly estimate their probable maximum thickness; for instance, Professor Ramsay has found, from actual measurement, that the sedimentary formations of Great Britain have a maximum thickness of upwards of 72,000 feet; but all such measurements give us no idea of their mean thickness. What is the mean thickness of the sedimentary rocks of the globe? On this point geology does not afford a definite answer. Whatever the present mean thickness of the sedimentary rocks of our globe may be, it must be small in comparison to the mean thickness of all the sedimentary rocks which have been formed. This is obvious from the fact that the sedimentary rocks of one age are partly formed from the destruction of the sedimentary rocks of former ages. From the Laurentian age down to the present day, the stratified rocks have been undergoing constant denudation.

Unless we take into consideration the quantity of rock removed during past ages by denudation, we cannot—even though we knew the actual mean thickness of the existing sedimentary rocks of the globe and the rate at which they were formed—arrive at an estimate regarding the length of time represented by these rocks. For if we are to determine the age of the stratified rocks from the rate at which they were formed, we must have, not the present quantity of sedimentary rocks, but the present plus the quantity which has been denuded during past ages. In other words, we must have the absolute quantity formed. In many places the missing beds must have been of enormous thickness. The time represented by beds which have disappeared is doubtless, as already remarked, much greater than that represented by the beds which now remain. The greater mass of the sedimentary rocks has been formed out of previously existing sedimentary rocks, and these again out of sedimentary rocks still older. As the materials composing our stratified beds may have passed through many cycles of destruction and re-formation, the time required to have deposited at a given rate the present existing mass of sedimentary rocks may be but a fraction of the time required to have deposited at the same rate the total mass that has actually been formed. To measure the age of the sedimentary rocks by the present existing rocks, assumed to be formed at some given rate, even supposing the rate to be correct, is a method wholly fallacious.

"The aggregate of sedimentary strata in the earth's crust," says Sir Charles Lyell, "can never exceed in volume the amount of solid matter which has been ground down and washed away by rivers, waves, and currents. How vast then must be the spaces which this abstraction of matter has left vacant! How far exceeding in dimensions all the valleys, however numerous, and the hollows, however vast, which we can prove to have been cleared out by aqueous erosion!"[1]

I presume there are few geologists but would admit that if all the rocks which have in past ages been removed by denudation were restored, the mean thickness of the sedimentary rocks of the globe would be at least equal to their present maximum thickness, which we may take at 72,000 feet.

There are three elements in the question; if two of them are known, the third is known in terms of the other two. If we have the mean thickness of all the sedimentary rocks which have been formed and the mean rate of formation, then we have the time which elapsed during the formation; or, having the thickness and the time, we have the rate; or, having the rate and the time, we have the thickness.

One of these three, namely, the rate, can, however, be determined with tolerable accuracy if we are simply allowed to assume—what is very probable, as will be shown—that the present rate at which the sedimentary deposits are being formed may be taken as the mean rate for past ages. If we know the rate at which the land is being

[1] "Principles," vol. i. p. 107 (tenth edition).

denuded, then we know with perfect accuracy the rate at which the sedimentary deposits are being formed in the ocean. This is obvious, because all the materials denuded from the land are deposited in the sea; and what is deposited in the sea is just what comes off the land, with the exception of the small proportion of calcareous matter which may not have been derived from the land, and which in our rough estimate may be left out of account.

But how are we to determine the rate of sub-aërial denudation? This rate can be determined by a method advanced a few years ago.[1] It is this: the rate at which the land is being lowered by denudation is measured by the amount of sediment carried down to the sea by the river systems. The rate, for example, at which the basin of a river is being denuded is determined with perfect accuracy by the quantity of sediment carried into the sea by the river.

Unfortunately—except in the case of the Mississippi—no very accurate determination has as yet been made of the quantity of sediment carried down to the ocean by rivers. The annual amount conveyed into the ocean by the Mississippi has been accurately measured by Messrs. Humphreys and Abbot. Taking their estimate of the amount of sediment and area of drainage of the Mississippi, it is found, by the method above referred to, that its basin is being lowered at the rate of one foot in 6,000 years.

Sir Charles Lyell has shown clearly that in regard to the amount of sediment carried down into the sea, there is perhaps no river which may more safely be taken as a fair representative of rivers in general; and in the mean time we may be warranted in taking one foot in 6,000 years as representing the mean rate at which the land is being abraded.

Taking the proportion of land to that of water at 576 to 1,390, then one foot taken off the land and spread over the sea-bottom would form a layer five inches thick. Consequently, if one foot in 6,000 years represents the mean rate at which the land is being denuded, one foot in 14,400 years represents the mean rate at which the sedimentary rocks are being formed.

Assuming, as before, that 72,000 feet would represent the mean thickness of all the sedimentary rocks which have ever been formed, this, at the rate of one foot in 14,400 years, gives 1,036,800,000 as the age of the stratified rocks.

Professor Huxley, in his endeavour to show that 100,000,000 years is a period sufficiently long for all the demands of geologists, takes the thickness of the stratified rocks at 100,000 feet, and the rate of deposit at a foot in 1,000 years. One foot of rock per 1,000 years gives, it is true, 100,000 feet in 100,000,000 years. But what about the rocks which have disappeared? If it takes a hundred millions of years to produce a mass of rock equal to that which now exists, how many hundreds of millions of years will it require to produce a mass equal to what has actually been produced?

[1] Philosophical Magazine for February, 1867, p. 130, and May, 1868, p. 379; see also Mr. Geikie's Memoir "On Modern Denudation," Trans. of Glasgow Geol. Soc. for 1868.

Professor Huxley adds, "I do not know that any one is prepared to maintain that the stratified rocks may not have been formed on the average at the rate of $\frac{1}{83}$ of an inch per annum." When the rate, however, is accurately determined, it is found to be, not $\frac{1}{83}$ of an inch per annum, but only $\frac{1}{1200}$ of an inch, so that the 100,000 feet of rock must have taken 1,440,000,000 years in its formation—a conclusion which, according to the results of modern physics, is wholly inadmissible.

Either the thickness of the sedimentary rocks has been over-estimated, or the rate of their formation has been under-estimated, or both. If it be maintained that a foot in 14,400 years is too slow a rate of deposit, then it must be maintained that the land must have been denuded at a greater rate than one foot in 6,000 years. But most geologists, I presume, felt surprised when the announcement was first made, that at this rate of denudation the whole existing land of the globe would be brought under the ocean in 6,000,000 of years.

The error no doubt consists in over-estimating the thickness of the sedimentary rocks. Assuming, for physical reasons stated on a former occasion,[1] that 100,000,000 years limits the age of the stratified rocks, and that the proportion of land to that of water and the rate of denudation to have been on the average the same as at present, the mean thickness of sedimentary rocks formed in the 100,000,000 years amounts to only 7,000 feet.

But be it observed that this is the mean thickness on an area equal to that of the ocean. Over the area of the globe it amounts to only 5,000 feet; and this, let it be observed also, is the total mean thickness formed, without taking into account what has been removed by denudation. If we want to ascertain what is actually the present mean thickness, we must deduct from this 5,000 feet an amount of rock equal to all the sedimentary rocks which have been denuded during the 100,000,000 years; for the 5,000 feet is not the present mean thickness, but the total mean thickness formed during the whole of the 100,000,000 years. If we assume, what no doubt most geologists would be willing to grant, that the quantity of sedimentary rocks now remaining is not over one-half of what has been actually deposited during the history of the globe, then the actual mean thickness of the stratified rocks of the globe is not over 2,500 feet. This startling result would almost necessitate us to suspect that the rate of sub-aërial denudation is probably greater than one foot in 6,000 years. But be this as it may, we are apt, in estimating the mean thickness of the stratified rocks of the globe, from their ascertained maximum thickness, to arrive at erroneous conclusions. There are considerations which show that the mean thickness of these rocks must be small in proportion to their maximum thickness. The stratified rocks are formed from the sediment carried down by rivers and streamlets and deposited in the sea. It is obvious that the greater quantity of this sediment is deposited

[1] Phil. Mag. for May, 1868, p. 371.

near the mouths of rivers and along a narrow margin extending to no great distance from the land. Did the land consist of numerous small islands equally distributed over the globe, the sediment carried off from these islands would be spread pretty equally over the sea-bottom. But the greater part of the land-surface consists of two immense continents. Consequently the materials removed by denudation are not spread over the ocean-bottom, but on a narrow fringe surrounding those two continents. Were the materials spread over the entire ocean-bed, a foot removed off the general surface of the land would form a layer of rock only five inches thick. But in the way in which the materials are at present deposited, the foot removed from the land would form a layer of rock many feet in thickness. The greater part of the sediment is deposited within a few miles of the shore.

The entire coast-line of the globe is about 116,500 miles. I should think that the quantity of sediment deposited beyond, say, a hundred miles from this coast-line is not very great. No doubt several of the large rivers carry sediment to a much greater distance from their mouths than a hundred miles, and ocean currents may in some cases carry mud and other materials also to great distances. But it must be borne in mind that at many places within the hundred miles of this immense coast-line little or no sediment is deposited, so that the actual area over which the sediment carried off the land is deposited is probably not greater than the area of this belt —116,500 miles long and 100 miles broad. This area on which the sediment is deposited, on the above supposition, is therefore equal to about 11,650,000 square miles. The amount of land on the globe is about 57,600,000 square miles. Consequently one foot of rock, denuded from the surface of the land and deposited on this belt, would make a stratum of rock five feet in thickness; but were the sediment spread over the entire bed of the ocean, it would form, as has already been stated, a stratum of rock of only five inches in thickness.

Suppose that no subsidence of the land should take place for a period of, say, three millions of years. During that period 500 feet would be removed by denudation, on an average, off the land. This would make a formation 2,500 feet thick, which some future geologist might call the Post-Tertiary formation. But this, be it observed, would be only the mean thickness of the formation; its maximum thickness would evidently be much greater, perhaps twice, thrice, or even four times that thickness. A geologist in the future measuring the actual thickness of the formation might find it in some places 10,000 feet in thickness or perhaps far more. But had the materials been spread over the entire ocean bed, the formation would have a mean thickness of little more than 200 feet; and spread over the entire surface of the globe, would form a stratum of scarcely 150 feet in thickness. Therefore, in estimating the mean thickness of the stratified rocks of the globe, a formation with a maximum thickness of 10,000 feet may not represent more than 150 feet. A formation with a *mean* thickness of 10,000 feet represents only 600 feet.

It may be objected that in taking the present rate at which the sedimentary deposits are being formed as the mean rate for all ages, we probably under-estimate the total amount of rock formed, because during the many Glacial periods which must have occurred in past ages the amount of materials ground off the rocky surface of the land in a given period would be far greater than at present. But in reply it must be remembered that although the destruction in ice-covered regions would be greater during these periods than at present, yet the quantity of materials carried down by rivers into the sea would be less than at present. At the present day the greater part of the materials carried down by our rivers is not what is being removed off the rocky face of the country, but the Boulder-clay, sand, and other materials which were ground off during the Glacial epoch. It is therefore possible, on this account, that the rate of deposit may have been less during the Glacial epoch than at present.

When any particular formation is wanting in a given area, the inference generally drawn is, that either the formation has been denuded off the area, or the area was a land-surface during the period when that formation was being deposited. From the foregoing it will be seen that this inference is not legitimate; for, supposing that the area had been under water, the chances that materials should have been deposited on that area are far less than are the chances that there should not. There are sixteen chances against one that no formation ever existed in the area.

II.—On *Euphoberia Brownii*, H. Woodw., a New Species of Myriapod from the Coal-measures of the West of Scotland.

By Henry Woodward, F.G.S., F.Z.S.,
of the British Museum.

(PLATE III., Fig. 6.)

I HAD the honour in 1866[1] to describe the first specimen of a fossil Myriapod from the Coal-measures met with in this country. It was discovered by the late Mr. Thomas Brown, of Glasgow, an indefatigable geologist and an ardent collector of fossils, who obtained it in a nodule of Clay-ironstone from Kilmaurs.

I determined it to be identical with the *Xylobius sigillariæ*, described by Dr. Dawson from the South Joggins Coal-formation of Nova Scotia.[2]

Other remains of *Xylobius* have also been obtained in Clay-ironstone-nodules, from the Coal-measures near Huddersfield, by Mr. Joseph Tindall of that town, which were referred by me to the same species, and figured in the plate with the Kilmaurs example.

Having been in 1869 entrusted by my friend Mr. James Armstrong, at that time the Honorary Secretary of the Glasgow Geological Society, with another and much larger form of Myriapod from

[1] Trans. Glasgow Geol. Soc., 1866, vol. ii. p. 234, pl. iii.
[2] Quart. Journ. Geol. Soc., Lond., 1859, vol. xvi., p. 268.

Kilmaurs (also collected by the late Mr. Thomas Brown), I propose now to describe and figure it.

The specimen (figured of the natural size in Plate III., Fig. 6), preserved in the round, is four inches in length, and nearly a quarter of an inch in breadth, is contained in an Ironstone-nodule (like those previously discovered), both sides of which are well preserved. Thirty-six raised body rings, separated by an equal number of intermediate depressions, can be counted between the head and the last segment, each ring having two pairs of appendages. There are indications of pores, and also of the bases of tubercles or spines, along the dorsal line, but the latter are less perfectly preserved.

In their great work on the Geological Survey of Illinois, 1868, vol. iii., p. 556, figs. A–D, etc., Messrs. Meek and Worthen have described and figured two new forms of Myriapod under the generic name of *Euphoberia*, namely, *E. armigera*, and *E. ? major*.

The former of these, which equals in size the Kilmaurs specimen, we reproduce in the accompanying Plate III., Fig. 7.

From Messrs. Meek and Worthen's description of *E. armigera* we extract the following (p. 557):—"From all its characters, we can scarcely doubt that it is a Myriapod. One of these more complete specimens seems to be nearly entire, and shows a semicircular head, as wide as any part of the long slender body. It is not in a condition to show the eyes, nor are any remains of mandibles, antennæ, or other appendages preserved. The entire length of this specimen is 3·90 inches, and its breadth about 0·20 inches. It tapers very little from the anterior to the posterior end, which seems to terminate rather abruptly. In the whole length, as many as about seventy-five or seventy-six segments may be counted. But it is worthy of note that there are only half this number on the dorsal side, where each one corresponds to two below. As seen in a side view (the specimens being flattened by pressure), the downward curved ends of the dorsal scutes, or dorsal half of the segments, are apparently more or less rounded, while each of these pieces supports three or four small pointed spines, curved a little backward, and arranged so as to form as many rows along the back of the animal. Some of these spines are seen to give off a small, very short, branch, generally on the anterior side.

"On the under side of the body there are, as already explained, two segments to each of the dorsal scutes, and these segments, of course, are scarcely half the size of those above, though each bears a pair of small slender-jointed legs, about 0·25 inch in length, in the specimen nearly four inches long, of the typical species *E. armigera*. So far as can be made out, these legs show at least five gradually tapering joints. In some of the specimens, the smaller lower segments show some appearances of openings, like spiracles.

"These, however, appear to exist in each one of the lower parts of each segment. A still larger and more rounded opening or pit, is also seen just below each of the latter, and may be the point of attachment of the legs. In the specimens represented, it will be observed there are also round pits or perforations in the larger dorsal scutes. These are cavities left in the matrix by spines. In order to understand this, however, it is necessary to bear in mind that the specimens are altogether mere impressions left in the matrix. On comparing the figures, it will be observed that there are more of these pits in one than in the other, besides other differences that might seem to indicate that they belong to very different species, These differences, however, we are rather inclined to believe due to the different manner in which the specimens have been crushed, and the fact that the specimen figured is pressed nearly flat, while the other retained more of its natural convexity, and likewise shows more of the dorsal side and less of the smaller ventral segments.

"Under a magnifier, the surface of all the specimens shows a minutely granular appearance. As these granules are seen on the surface of moulds or impressions left in the matrix, they indicate the presence of a minutely pitted marking on the fossil itself.

"Locality and position: Lower part of true Coal-measures, Mazon creek, Grundy county, Illinois, United States, North America."

The indications of dorsal spines observable both on the American and Scotch specimens (a character not known in any existing Myriapod), together with their equally large size, agreeing as they also do closely in the number of their segments; they may, with propriety, be referred to the same genus.

But as the dorsal scutes observed in the Illinois examples appear to be absent in the Kilmaurs example, the segments of which are more strongly corrugated than are those of its American congener, it will perhaps be better to give it a distinctive specific appellation.

I therefore propose to name this fine English Myriapod *Euphoberia Brownii*, after its discoverer, the late Mr. Thomas Brown, whose indefatigable labours in seeking fossils in these deposits deserves to be had in remembrance.

EXPLANATION OF FIGS. 6 AND 7, PLATE III.

FIG. 6. *Euphoberia Brownii*, H. Woodw., in an Ironstone-nodule from the Coal-measures, Kilmaurs, near Glasgow (figured of the natural size).

6*a*. Four of the segments enlarged, showing the bases of the dorsal spines and the feet.

6*b*. One of the feet much enlarged.

7. *Euphoberia armigera*, Meek and Worthen, natural size. Ironstone; Coal-measures; Grundy Co., Illinois, U.S.

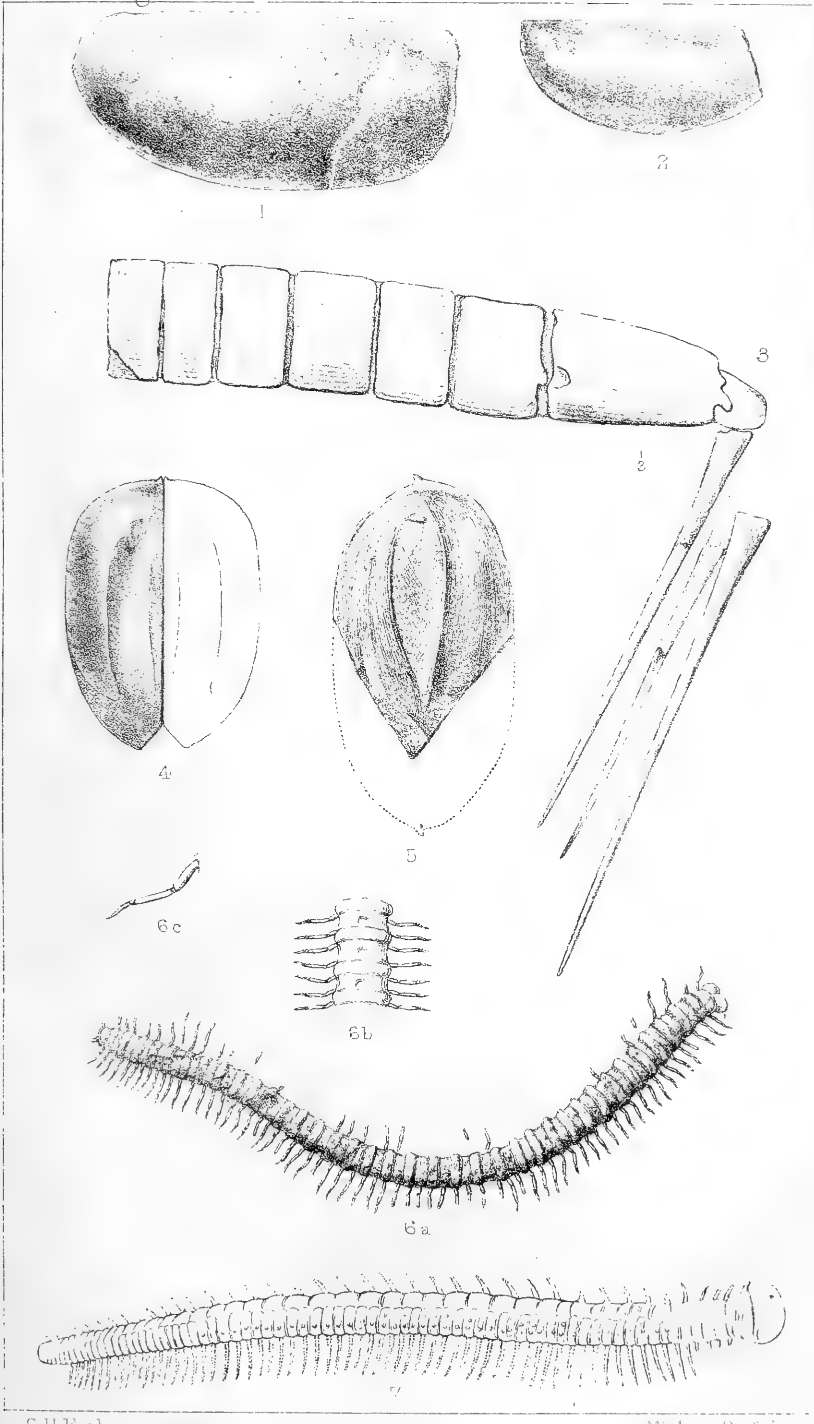
III.—ON SOME NEW PHYLLOPODOUS CRUSTACEANS FROM THE PALÆOZOIC ROCKS.

By HENRY WOODWARD, F.G.S., F.Z.S.

(PLATE III., Figs. 1–5.)

1. *Ceratiocaris Ludensis*, H. Woodw., Plate III., Fig. 3 ($\frac{1}{3}$ nat. size).

DURING last summer I visited the interesting and ancient town of Ludlow, where, under the guidance of Mr. Robert Lightbody, F.G.S., I had the opportunity of seeing the admirable Public Museum, belonging to the Ludlow Natural History Society, and also the rich private collection of Mr. Lightbody and that of Mr. Humphrey Salwey. In the Society's Museum, my attention was



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New British Fossil Myriapod & New Phyllopodous Crustaceæ.

directed by Mr. Lightbody to a truly remarkable fossil from the collection of Mr. Henry Pardoe, and obtained by him from the Lower Ludlow, Church Hill, Leintwardine. It consists of seven body-segments and three caudal spines, of the largest example of *Ceratiocaris* I have ever seen; exceeding in size the *C. Bohemicus* of Barrande, or *C. Murchisoni* from the Upper Ludlow Rock, Ludlow and Wenlock Shale, Dudley, figured and described by me in the Geological Magazine, 1866, Vol. III., Pl. X., Fig. 8, pp. 203–205. The figure (taken from a sketch made at the time) given on Plate III., Fig. 3, being only one-third the size of the fossil, conveys but a very inadequate idea of this interesting Crustacean remain. The seven body segments together measure eight and a half inches in length, and nearly two inches in breadth; they are nearly quadrangular, and are covered with fine and delicate parallel slightly waved striæ. The first segment is three-quarters of an inch long; the second, half an inch; the third, three-quarters of an inch; the fourth, fifth, and sixth, one inch each in length; and the seventh, two and three-quarter inches long. Their articular faces do not overlap, and are nearly straight, save the sixth, which has a small rounded articular process fitting into a corresponding depression in the seventh segment, which at its distal extremity is also furnished with an articular process, to which the tail-spines are united. The tail-spines are not pitted, but are very robust, and are six and a half to seven inches in length, and nearly half an inch broad at their proximal end. Unfortunately, the carapace of this giant Phyllopod is wanting; but taking the comparative proportions of *C. papilio* from Lesmahagow as our guide, it could not have measured less than eight inches in length, by four and a half inches in breadth.

I propose to name this new species *Ceratiocaris Ludensis.*

2. *Ceratiocaris Oretonensis*, H. Woodw., Plate III. Fig. 1 (nat. size).

Among the large series of fossils acquired by the British Museum from the collection of the late Mr. Edward Baugh, of Bewdley, are two new forms of *Ceratiocaris,* which were obtained from the Yellow Carboniferous Limestone of Oreton and Farlow, Worcestershire. (See Plate III., Figs. 1 and 2, figured of the natural size).

They agree closely in form with certain Upper Silurian species found at Benson's Knot, Westmoreland; but are destitute of the beautiful and delicate striated ornamentation observable upon the carapaces of those species.

The larger form (Plate III., Fig. 1) measures two inches in length by seven-eighths of an inch in depth; the dorsal line is nearly straight, the anterior end is rounded, the posterior slightly produced and truncated; the ventral margin is rounded, and has a slightly raised border for about three-fourths of its length; the valves of the carapace are tumid, and when perfect appear to have been smooth and free from ornamentation, like the valves of *Leperditia:* the eye-spot is not very distinct, but forms a slightly raised prominence near the anterior end of the carapace. I propose to name this new and large Carboniferous species *Ceratiocaris Oretonensis.*

3. *Ceratiocaris truncatus,* H. Woodw., Plate III., Fig. 2 (nat. size).

The second and smaller form (Plate III., Fig. 2) measures fourteen lines in length and seven lines in depth ; the dorsal line is straight; the anterior end is truncated at its extremity, and the ventral margin is strongly curved and terminates in an obliquely-truncated posterior border (not well shown in the figure, which conveys the idea of a broken edge). No eye-spot or ornamentation has been observed in this species. The valves are tumid, particularly at the anterior end. I propose to name this species *Ceratiocaris truncatus.*

4. *Dithyrocaris tenuistriatus,* M'Coy, Pl. III., Fig. 4 (nat. size).

Some time since the British Museum acquired from Mr. J. H. Burrow, formerly of Settle, Yorkshire, a small series of Carboniferous limestone fossils, among which is the valve of *Dithyrocaris,* figured on Plate III., Fig. 4, of the natural size.

It agrees closely if it is not identical with the *Dithyrocaris tenuistriatus* of M'Coy (see Synopsis Carboniferous Fossils of Ireland. Dublin, 1844, 4to. p. 164, pl. 23, fig. 3), but it is one third larger. It is probably also the same as Prof. de Koninck's *Avicula paradoxides* (see De Koninck's Description des Animaux Fossiles, etc. Liège, 1842, 4to., pl. vi., fig. 6, p. 139).

The valve measures 1 inch and 5 lines in length, and half an inch in breadth ; it is broadest at the anterior end, contracting slightly towards the posterior border, which appears to terminate in an obtuse central point. The border of the carapace, for a breadth of three lines, is separated from the median portion by a strongly-raised keel, which follows the contour of the margin, dying out at the interior and posterior ends of the valve. Near the anterior end, this keel intersects the eye, which forms a raised narrow ridge one line in length, nearly parallel with the mesial line, and about 2 lines distant from it. Another less prominent ridge runs nearly parallel with the mesial line occupying a space intermediate between it and the cheek-border, but nearer the former.

When examined with a high power, in a good light, the surface, especially the border, is seen to be covered with very fine wavy striæ.

It is exceedingly difficult to decide whether this form had its valves expanded widely, as in the recent *Apus,* and probably in the fossil *Dithyrocaris Scouleri;* or whether, as in *Nebalia* and *Ceratiocaris,* they were folded down upon the sides of the animal's body. The distinction seems an important one, but the frequent occurrence of the united expanded valves of *Ceratiocaris* in the Upper Silurian Shales of Lesmahagow, often renders it difficult to decide as to the actual and normal degree of expansion or folding down of the lateral borders of these crustacean shields during the lifetime of the animal.

5. *Dithyrocaris Belli,* H. Woodw., Plate III., Fig. 5 (nat. size).

Amongst a series of Crustacean remains, from the collection of Prof. Bell, of Canada, obtained in the Middle Devonian of Gaspé, and left with me for examination by the kindness of Principal Dawson, F.R.S., of McGill's College, Montreal, is the portion of a valve of *Dithyrocaris ?* most beautifully sculptured, which we have figured on Plate III., Fig. 5, of the natural size. The specimen is eleven lines in breadth, and probably measured, when entire, nearly two inches in length. The dorsal border is rounded in a corresponding degree with the ventral border; a small rostrum is observable at the anterior end, from which two prominent ridges also take their rise and pass over the side, one arching towards the dorsal, the other bending towards the ventral line, but uniting again on the centre of the valve at one inch from the anterior end. The fine striæ above and below these prominent ridges are parallel, but those inclosed in the central elliptical space cross one another so as to form a finely reticulated pattern on its surface. The eye-spot is distinct and prominent at the anterior end, near the intersection of the two curved ridges. Other slight, scarcely visible, folds traverse the carapace parallel to the ventral and dorsal border, indicating that the original shell was of extreme tenuity, like that of the recent *Apus* and *Estheria*.

Should the discovery of other and more perfect specimens prove this to be a true *Dithyrocaris*, it will be the first specimen of this genus met with in rocks of Devonian age.

I had proposed to call this form *D. striatus*,[1] but as there is already a *D. tenuistriatus*, it will be better not to give it so indistinct a name. I therefore beg to name it *Dithyrocaris ? Belli*, after its discoverer.

IV.—On the Two Glaciations of the Lake District.[2]

By C. E. de Rance, F.G.S., of the Geological Survey of England and Wales.

It has always been difficult to account for the fact that, while Moraine Drifts occur at such low levels in the Lake District, Marine Drifts are found at such high elevations in the surrounding district. Mr. Mackintosh's new facts throw some light on this phenomena, but do not entirely explain it, owing to his having given, in my opinion, far too little importance to the second Glaciation experienced by the Lake District after its emergence from the Glacial Sea.

His discovery of Boulder-clay and Laminated Sand at several points in the Lake District, though invaluable as proving the submergence of the mountains, are in themselves only fringes, patches, or terraces, the remains of masses of Marine Drift which once filled up the valleys to considerable heights, which, with the exception of these fragmentary portions, have been entirely scooped out by the glaciers of the second age, which left their marks and their moraines not only in highland valleys, as admitted by Mr. Mackintosh, but in such lowland valleys as the Liza, Windermere, and Langdale, often in the actual space cleared out of the Marine Drift and the still older Lower Moraine Drift beneath.

I have elsewhere[3] endeavoured to show that two distinct Lower

[1] British Association Reports, Section C., Liverpool, 1870.
[2] I have merely visited the district as a tourist.
[3] "Glac. Phen. of Lan. and Ches." Quart. Journ. Geol. Soc., Dec. 1870.

Boulder-clays occur both in Lancashire and in North Wales, the one precisely resembling the Upper Clay in composition, colour, and character of included fragments; the other being a tough, hard, blue or black coloured clay, invariably occurring at levels above 300 feet; while the ordinary red Lower Till is hardly ever found above 50. The low-level Clay appears to have been formed under marine conditions, the pebbles and boulders being brought on floating ice from the ice-foot surrounding the Lake District, while the high-level Clay is evidently the result of a small ice-sheet of comparatively local origin, no foreign erratics occurring in it.

In the railway cutting between Penrith and Keswick two Boulder-clays are seen, the one red, the other blue; the former precisely resembles the Upper Till of Lancashire and Cheshire, while the latter would appear to be the representative of the "land-ice Lower Till" of Lancashire and Carnarvonshire.

In some places Mr. Mackintosh calls his Clay "2" by the Furness name, "pinel," and to this division he assigns the reddish clay of the Penrith cutting; and as there can be no doubt that his division "3" is the true "Middle Drift" of Prof. Hull, it follows that his divisions "1" and "2" are the representatives of the two Lower Tills described above.

In Carnarvonshire the two Lower Tills may be seen, the one resting on the other; the red lying on an eroded and sea-worn surface of the blue or black clay below, which fact would tend to prove, as I had inferred before visiting North Wales, that the formation of the land-ice Lower Till commenced universally in the north-west of England, before the commencement of the deposition of the Marine Lower Till; at the same time, it is not impossible that, after the subsidence commenced, glaciers reached and even entered the sea, whose moraines were swept off the surface of the ice, and carried by tidal currents southwards, and deposited in the silt there forming, producing the Marine Lower Till: thus simultaneously land-ice Lower Till might be forming beneath the submarine glaciers, and Marine Lower Boulder above it; and after a time, towards the Middle Drift age, when the climate ameliorated, the ice melted and the Marine Clay sank down in some places quicker than in others, giving rise to those twistings and oblique laminations so often observable in that clay.

The mounds of drift, associated with rôches moutonnées at Grange Bridge, below Derwentwater, appear to have been formed by one of the later glaciers, and once to have extended entirely across the valley below Grange Fells, damming up a lake behind, until the river cut a passage through. The Rev. Mr. Bonney has referred to the fine rôche moutonnée on the left bank of the stream at Grange, which has certainly not been touched by the sea, which would be the case if the mounds were formed by it, as suggested by Mr. Mackintosh.[1] Below Rosthwaite the Derwent receives Stonethwaite Beck, which, a little above that hamlet, is formed by the junction

[1] Geol. Mag., 1866, p. 292.

of two streams, Longstrath Beck and that of Greenup Gill. The former takes its source from the Col between Angle and Sprinkling Tarns (at an elevation of 2,500 feet); from this point radiate, as from a centre, streams that flow into Eskdale, Wasdale, Borrodale, Longstrath, and Mickleden; and in the Glacial period this must necessarily have been a centre from which ice would flow in these various directions, both in the first and in the second Glaciations.[1]

Rosthwaite to Stye-head Pass.—Following the Derwent, it is found to receive a beck flowing down Horse Gill at the village of Seatoller; from thence it flows through an alluvial plain, formed of re-arranged moraine mounds, rising from 338 to 450 feet, bounded on either side by rather steep cliffs, the edges of hills rising to an elevation of more than 2,000 feet. Between Seathwaite and the junction of the river with the brook which flows from Sprinkling and through Stye-head Tarns, occur moraine mounds from 30 to 40 feet in height, through one of which the river has cut a channel. A little above the point where the footpath crosses the river the water has cut a very narrow channel through the rock, which is here exposed, the surface of which is rounded by glaciation. On the slope of Base Brown there is a little loose Drift, stained very red with iron or copper, especially above the spot where the brook is precipitated over the rocks forming a waterfall, which is cut in a rather steep glaciated and drift-covered slope intervening between the upland gorge above and the valley of the Derwent below, and over which a glacier flowed from the one to the other, supplied in great measure by one that took its source in the valley of Sprinkling Tarn between Great End and Seathwaite Fell. The base of the steep ascent below the fall is 600 feet above the Ordnance datum line, the top being about 1,250 feet, from which point the slope is very gradual up to Stye-head Pass. Many blocks of rock from this upland valley are found upon the steep slope below; the surface, indeed, is strewn with masses of rock, often of very large size, but not indicating many signs of glaciers; the waterfall only in part represents the slope, sufficient time not having elapsed for it to have cut back to the highest part. In the whole of the Stye-head Valley, up to the summit level of the Pass at 1,560 feet, there are slight traces of glaciation, patches of Moraine Drift, perched blocks, and rounded masses; but I failed to find any on the slope of the Great Gable above. But as rock-basins occur at elevations of nearly 2,000 feet, it is probable that an ice-stream, fed by the peaks of Sca Fell and Allen Crags, flowed over the sites of Sprinkling and Angle Tarns into Stye-head Valley, and that glaciers lingered in it in the period of re-emergence from the sea, one of their moraines, left in the gradual retreat of the ice, filling up the valley and damming up the water, producing Stye-head Tarn. Upon the opposite side of the Pass fragments of Moraine Drift are seen

[1] In the Col between Longstrath and Mickleden, the highest elevation is 1,581 feet, and between them and Eskdale 2,490 feet; the small conical hill, called Allen Crags, 2,572 feet, rises in the centre, and is joined to Glaramara by a slightly elevated ridge, forming the north and south water-shed, between the water flowing east and then south into Morecambe Bay, and that flowing west into the Irish Sea.

like fringes here and there on the hill-side up to a great elevation; they are probably left by glaciers which flowed when the level of the rock bottom of the Lingmell Beck gorge was higher than at present, the remainder having been scooped out by later glaciers, which have also helped to deepen the bottom of the valley, the slope of which is far more rapid than that of the head of Borrodale. Moraine matter, sand, and tumultuous heaps of gravel occur on the right bank of Lingmell Beck, under Wasdale Fell, some of them being 50 and 60 feet in height, left by the later glaciers, which do not appear to have reached the lake Wast Water, which lies in a gigantic rock-basin, bounded to the west and north by high sloping mountains, and to the east by steep cliffs, called the Screes, 1,774 feet in height, which have every appearance of descending at the same angle beneath the water, which is known to reach a depth of 270 feet, or about 80 feet below Trinity high-water mark, the level of the surface of the water being 204 feet above the Ordnance datum line. The surfaces of the Screes are covered with a vast quantity of loose material, the result of the weathering of the cliff, the fragments varying in size from a foot to the eighth of an inch; it especially occurs near the base dipping under the water, with only a slightly altered angle of repose; occasionally, at a height of about 350 feet, a ledge of rock crops out, stopping the fall of detritus from above; at points where the continuity of the ledge is broken, the débris has flowed through the opening, as through a funnel, spreading out into a fan-shaped mass below, marked with curious curves, showing the direction of motion, being first obliquely northwards, then downwards, then at a small angle curving southwards. Taking into consideration that the deepest side of the lake is the eastern, under the Screes Cliff, it appears probable that the ice that scooped out the lake was not only derived from the valleys at its head, but was in part, from an icy stream that poured over the Screes themselves, derived from the undulating ground surrounding the various peaks of Sca Fell, Greenhow, and Eskdale Fell, during the first glaciation. Looking at the general trend of the ground, though valleys occur between Sca Fell and Illgill Head, there is reason to believe that a small ice-sheet would flow west in the direction of Wast Water, and, meeting with the cliffs, would flow over them, adding its immense weight to the glacier already occupying the gorge, derived from the Mosedale and Lingmell valleys, would cause it to exercise an enormous grinding power on that point, causing the central eastern side of the lake to be, as we now find it, the deepest.

But in the second glaciation the ice does not appear to have moved over the shoulders of the hills from Sca Fell, but to have flowed south into the valleys of Eskdale and the River Mite; while in the first period, here and elsewhere in the Lake-District, the ice appears to have gathered on all the strips of upland undulating plain surrounding the various peaks, and separating the different valleys, and thence to have radiated in all directions, pouring over cliffs and valley-sides into the gorges and vales below, wherever an indentation or fall in the ground facilitated its flow over the edge, making rock basins in the upland district, smoothing the rocks of the cliff, and grinding and deepening those of the valleys.

Wast Water to Buttermere.—Leaving Wasdale Head by Mosedale, that valley is seen to be entirely shut in by the steep rocky hills of Red Pike, the Pillar, Looking Stead, and Kirk Fell. Through this ridge runs the east and west water-shed, separating the brooks that flow north into Ennerdale from those that flow south into Wasdale. One of the latter forms a spring in the Black Sale Pass; in this Col, and all along the course of the stream, patches of moraine matter occur, and at the point where the path from Wasdale crosses the stream, the rock is slightly rounded; and this indeed is the case with the hill Looking Stead itself, over whose summit the ice appears to have fairly passed during the first glaciation. But the rounding in the brook-course, and in that of Black Sale, would appear to have been caused by small glaciers in the period succeeding submergence, which, uniting at the bottom of Mosedale, scooped out the old moraines and the possible Marine Drift with which they were covered; and in their retreat left their own small moraines at the bottom of the valley, which have since been much denuded away by stream-action, before the commencement of which they appear to have extended across the valley, damming up the water, and forming a small lake behind.

Looking up the Liza Valley from the hill Looking Stead (2,058 feet) two brooks are seen to join a little above the point where the footpath to Scarf Gap crosses the Liza, together forming that stream. In the fork between these brooks a sloping hill comes down from Green Gable; the surface of this slope especially near its lower end, is covered by numerous conical moraine mounds, resembling, when viewed from this height, a series of gigantic ant-hills. They also occur below the base of the slope; on both sides of the Liza, especially on the north bank, east of the point where the footpath to Scarf Gap cuts the 900 feet Ordnance contour line, occurring on the slope at least as high as 1,250 feet, being formed by a gradually retreating glacier in the last glaciation. At a similar level traces of glacial rubbish occur immediately below the Gap, formed probably by a small glacier, which, fed by ice flowing off High Crag and Warnscale, passed over the pass in two directions, towards the Liza and towards Buttermere. Some of the moraine heaps in the former valley, especially on the south bank, just behind the Sheep-pens, are elongated ridges rather than conical mounds, with long axes, running in a W.N.W. direction, with a sharp dividing edge, like the ridge of a gable roof; the slope to the right and left (angle of repose?) being 38°, those of the ridge being as shown in the following sketch, Fig. 1.

The south bank of Buttermere, below High Stile and High Crag, shows traces of a double glaciation, the rocks being rounded and scored in a primary direction from S.E. to N.W., or in the line of the valley; and in a secondary, from S.W. to N.E., wherever the small glaciers of the second period came down the indentations in the hill's side now occupied by brooks, one of which flows through

Bleaberry Tarn. The great Crummock Water and Buttermere Glacier appears to have filled up the valley to a height of nearly 700 feet above the present level of the lakes, scooping out their basins in its course, or rather basin, for the two lakes are merely separated from each other by the alluvium of Sail Beck, as has been pointed out by my colleague, Mr. J. Clifton Ward, F.G.S.

Fig. 1. Sketch of Moraine Mound, in the Valley of the Liza, Cumberland.

a. Moraine Mound, or ridge.
b. The river Liza, with scattered blocks of glaciated rock, derived from the Moraines.
c. Alluvial plain of the Liza.

Buttermere to Honnister Pass.—A little above Buttermere village is a rounded and smoothed mass of rock, partially covered by Moraine Drift, which more or less covers the bottom of the slope of Buttermere Fell above Gatesgarth, where some erratic masses of rock occur, the moraine matter being much covered with rain-wash, and partly re-sorted by river-action; higher up, near Honnister Pass, the brook flows through a deep narrow channel, sometimes through Drift, sometimes between the Drift and the rock; this Drift appears to be partly moraine stuff and partly matter that has fallen from the crags on either side. The glacier of the second period that occupied this valley, flowing westward, would pass down into the Buttermere Lake gorge, and thus its terminal moraine is beneath the present water-level of the lake, which has also been filled at its upper end by alluvium.

Honnister Pass to Rosthwaite.—From the top of the Pass a long smooth slope is seen to trend down towards Seatoller from the Hanse, margined or limited on its upper portion by cliffs formed by Seatoller Fell to the north and Grey Knotts to the south. Ice would appear to have gathered round the upland heights and to have poured over these cliffs upon the long inclined plain below, which has been worn into a gigantic rôche moutonnée. Near the top of this slope a brook rises, crossing the path below the Hanse, at which point its channel is only a few inches deep; but, like all streams flowing over a curved surface to a plain (on to the sea) below, it has cut a gorge, the bottom of which is a chord, to the curve, extending from the source of the stream to the plain: thus, in the present instance, the gorge gradually goes on increasing in depth until the point is reached where the curve is strongest, after which it diminishes as the curve of the surface descends. The level of the brook where it crosses the path is 1,000 feet; at the point where the curve is strongest the level is 500 feet, the bottom of the gorge being nearly 40 feet beneath; at the bottom, where it flows into the Derwent alluvium, it is about 350 feet, the slope of the stream having exceeded the slope of the ground by less than one degree. To produce this small gorge vertical denudations of the bed and longitudinal denudation of the banks has alone taken place, sufficient time not having elapsed for horizontal denudation of the banks, producing an alluvial plain, as has been the case with the valley of the Derwent; it is therefore probable that this gorge, unlike that of Borrodale, had no pre-glacial existence, and has been entirely formed since the emergence of the country from the glacial sea, and after the slope in which it is cut had obtained its rounded contours, and probably even after the glaciers of the second period had disappeared, though no doubt a small glacier passed down Hanse Gill over the line of the present stream, and connected itself with the Borrodale glacier of the second period.

Rosthwaite to Stake Pass.—A little above the village of Stonethwaite, the Beck of that name receives a small brook, flowing out of Dock Tarn (1,322 feet) on Watendlath Fell. The cliffs on either side of the Beck are glaciated, and the ice appears to have nearly covered the Fell, and to have fallen bodily over the cliffs over which the Beck now finds its way. Between these Borrodale Fells and the Wythburn Fells to the east the surface of the ground is an undulating depression, with peaks rising here and there, divided by cols, none of which (between Borrodale and Wythburn) are more than from 1,550 to 1,600 feet in height. The ice during the first glaciation would appear to have occupied the whole of these Fells up to that level, and thence poured downwards into the above-mentioned valleys by the various small ravines, and occasionally, as in the present case, descending over the cliffs forming the limits of the great valleys, in the lower portions of which the ice would appear to have steadily flowed northwards in those valleys lying north of the circular watershed, and southwards in those lying on the south, as Windermere and Coniston Valleys, Eskdale and Wast Water Valley, scooping in many instances the great rock-basins, now occupied by lakes, at the points of greatest pressure. In the bottom of Stonethwaite Beck Valley traces of this glaciation are observable in the woods on the south bank, where the rocks are moutonnéed, and scored in the direction of Greenup Gill, down which a glacier flowed joining that from Longstrath Beck; the scored rocks are at an elevation of about 440 feet. At the point where the two latter Becks join, the rocks are rounded; and where a rude bridge crosses Longstrath Beck the rock is cut through, almost appearing as if a rocky barrier had stretched across the mouth of the valley, and that the rock bottom sloped upwards towards it, being a small rock-basin, once probably occupied by a lake. Following the lines of Longstrath, it is found to be an insignificant brook, wandering through a narrow alluvial plain, bounded on either side by steep cliffs. At the foot of these, but especially on the east side, there are sloping masses of Drift, partly the result of falls from above, but in great measure due to moraine matter left by the first glaciation, possibly re-arranged at the surface by marine action.

The glaciers of the second age, though not so often taking the form of a small ice-sheet as those of the first, would appear to have been both large and powerful, dwindling and retreating mile by mile as the climate ameliorated; the perpetual snow-line gradually rising and rising, until at last it left the highest peak of Sca Fell, and the last glacier melted away. In most of the valleys of the Lake District traces of these retreating glaciers may be seen, tier above tier of moraine mounds stretching across the valley, becoming smaller and more insignificant as the source of the valley is neared. Some of these mounds occur in that of Longstrath, commencing (in a distinct form) at a point a little above the spot where the Beck receives the second brook on the east bank (Ordnance one inch Map, 98, North-west), counting from the north; higher up in the valley, the mounds become very numerous, some of them being from 20 to 40 feet in height, others being cut in two by the stream between the third and fourth brook running into it. Below High White Stone (2,500 feet) there are two tiers of these mounds, one above the other, running in the direction of the valley, the higher reaching nearly to the 1,000 feet contour, or to a height of 300 feet above the Beck. Still higher up the valley, especially on the north side, numerous mounds also occur at the foot of the slope. At one point lower down, on the east side of the Beck, between the first and second brooks, at a height of 900 feet, the rock is rounded and scratched directly upwards (E.), which must have been produced by ice pouring over the edge from the comparative table-land above, which is a continuation of that high ground intervening between the gorges of Borrodale and Thirlmere, already alluded to as having been probably covered with ice during the first glaciation, and to a less extent during the second. This undulating ridge is continued through High White Stones, until it terminates in Langdale Pikes, the ground being sufficiently flat to have received a thick covering of peat during the cold, moist, continental period immediately succeeding the Glacial epoch. From this peat-covered undulating plain rise several eminences; amongst them, Sergeant Man (2,414 feet), in the side of which rises the brook that supplies Stickle Tarn (1,540 feet), which lake, as shown by Prof. Hull, F.R.S., in 1860,[1] is dammed up by a moraine, which must have been formed by a glacier flowing down the valley from Sergeant Man, which again points to the principal source of ice being in the upland plain. Indeed I found that the whole of the Col called the Stake Pass is covered with moraine heaps of small glaciers, left in the retreat toward the peaks, on the last amelioration of climate; many of these mounds are covered by nearly 20 feet of peat. The moraine of Stickle Tarn, as stated by Prof. Hull, has never been touched by the sea; and as I have strong reason to believe that these mounds were formed by the glaciers of the first period during their retreat, in consequence of the amelioration of climate which took place in the

[1] Edin. New. Phil. Journ., vol. xi., new series, 1860.

middle of the Glacial epoch, which ushered in the Middle Drift period, it is clear that the sea of that period never reached so high. This coincides with the fact that Middle Drift occurs at elevations always below that level; thus that at Macclesfield and at Moel Tryfaen reach but 1,200 and 1,350 feet respectively, and the new sections described by Mr. Mackintosh as discovered by himself and by Mr. Ward, at Coniston and at Trout Beck, reach but 1,000 feet. There is therefore little doubt but that during the greatest submergence of the Middle Drift period, the land in the north-west of England and north of Wales never sank more than 1,400 feet below its present level.

Stake Pass to Dungeon Gill.—At the head of Langdale Valley, below Stake Pass, a remarkably fine moraine occurs, which it is needless for me to describe, as Professor Hull has figured it in his paper "On the Vestiges of Extinct Glaciers in the Lake District of Cumberland and Westmoreland,"[1] with which paper I regret I was not acquainted when I wrote my "Notes on the Surface-Geology" of the district in 1869; for in it he describes in detail the old glaciers of Windermere, Grasmere, and Grisedale, alluded to in my own. He also describes in this paper Great and Little Langdale, Stockdale, and Patterdale, and gives the figure of the fine glaciated rock behind St. Mary's Church, which has been transferred to the pages of the "Antiquity of Man." He also gives it as his opinion that glaciers descended as low as 500 or 600 feet, after the retreat of the sea, and that the Drift sea ascended as high as 1,000 feet, a result which in the latter case further investigations have merely proved to be true. He also was, I think, the first to distinguish between the Moraine and the Marine Drifts of the Lake District, and to show why the former descend so low, and yet the latter ascend so high.

Below the great moraine at the foot of Rosset Gill, fragments of still larger moraines remain above Dungeon Gill, especially a large one on the north bank before reaching Middle Fell Place, which is covered with erratic perched Boulders, resembling on a small scale the great moraine mound at Blaen-y-nant, in the Pass of Llanberis, described by Prof. Ramsay, F.R.S.[2]

Dungeon Gill to Chapel Stile.—From the alluvial plain of Great Langdale Beck immediately below the hotel rise many fine examples of rôches moutonnées, the long axes being in the direction of the valley; another fine example occurs at Thrang, in a garden below Chapel Stile Church; the striations here are very distinct,[3] the primary scores pointing up the valley. Between these two points glacial rubbish is seen at several points, in one resting upon shattered slates.

Chapel Stile to Coniston.—In this district my opportunities of examination were small, but it would appear that the glaciers of the second epoch in this area exerted but little effect in scooping out

[1] Edin. New Phil. Journ. [2] "Ancient Glaciers of North Wales."

[3] Being nearly as good as those I observed on the east bank of the foot of Lyn Lydaw (N. Wales), near the bridge over the lake, which are certainly the freshest looking of any in that district, or in the Lake District.

the Marine Drift, the surface of the ground up to about 800 feet being much as it was left by the Upper Boulder-clay sea, to which age I refer the loamy stony drift below Arnside; lower a small glacier flowed west from Low Tarn to High Yewdale, where it joined a glacier which, both in the first and second glaciations, flowed down Yewdale Beck, from Tilberthwaite.

Coniston to Greenodd.—Coniston water, like all the great lakes of the district, lies in a rock-basin, the glacier which formed it (in the age preceding the submergence) reaching to a height of at least 150 feet above the present surface of the water.

Every small island, as in Windermere and Grasmere, is a rôche moutonnée, as is the rock at the foot of the lake on which the hotel is built, from the windows of which, a view of the entire lake is seen running along the exact centre measured from east to west; this rock was therefore the southern abutment of the Coniston Glacier, behind which the great scooping power was exerted, though to a certain extent this must have been exercised in the valley lower down, as the rock is rounded on the south side as well as on the north; but the traces of Moraine Drift in the valley of the Crake have been obliterated by marine action, which has overspread the country with a representative of the Upper Till of the south; this is particularly well seen at Lowick Green, and to a less extent on the slopes above Spark Green. The glacier of the second age, though it reached the head of Coniston lake, and probably shed its terminal moraine in the middle of it, evidently never reached the foot, and thus the Marine Drift of the valley of the river Crake is now undisturbed, though, possibly, detailed examination may discover the traces of small glaciers which have occupied its tributary becks.

Looking at the facts I have observed in the Lake District, Lancashire, and Cheshire, I think it probable—(1) That before the Glacial epoch the land stood further out of the sea; that denudation of cliffs took place, accompanied with subsidence. (2) That while this was going on the climate became colder, and the Glacial period commenced; the undulating strips of plain between the various valleys became covered with ice, which in time forced its way into them, which then more than half-filled them with an icy stream; this in course of time scooped out rock-basins in the valley floor beneath, in the manner shown to be the case in North Wales by Prof. Ramsay, F.R.S. (3) That while these gigantic glaciers filled the valleys of the Lake District, small ice-sheets covered the whole of Lancashire up to a height of 1,000 feet and down to the level of 50 feet, forming the Terrestrial Lower Boulder-clay, which contains only comparatively local boulders; that this clay is therefore synchronous with the Lower Moraine Drift of the Lake District; that below 50 feet the Lowlands of Lancashire and Cheshire were even then (at the close of this episode) under water; and that probably the feet of many of the great glaciers of the Lake District were also under the sea. That these glaciers brought down to the sea-level, on their surface, lateral moraines, derived from the inland valleys; which moraines, becoming entangled with the ice surrounding the coast, were lifted on it by the tides, and, to a certain extent, sea-worn; and that, as pieces of the ice-foot and coast-ice were detached and floated southwards, sub-angular scratched boulders were carried with them, being deposited in the loamy mud, derived from the Triassic plains, forming in the Lowlands of Lancashire and Cheshire. (4) That the climate commenced to ameliorate, the subsidence still continuing, clay was no longer brought down by glaciers to the Lancashire ice-foot, the formation of Marine Lower Boulder-clay ceased, and on its surface, the Middle Drift Sand, derived from the erosion of the cliffs by the sea and of the land by rivers, commenced to be deposited. (5) That subsidence did not cease until the whole country was submerged to a depth of 1,400 feet. (6) That a Glacial climate recommencing, the land rose; that a pause or fresh subsidence took place, the ice-foot again appearing, the Upper Till was thrown down. (7) The land rising, glaciers again occupied the valleys and scooped out the Marine Drift.

V.—On Faults in Drift at Stockport, Cheshire.

By John Aitken, F.G.S.

(With an Illustration.)

During the years 1866 and 1867 considerable discussion took place through the medium of this Journal on the question of the existence of dislocations, or faults, in Glacial Drift. As I believe no communication has appeared since the latter year in these columns on that subject, it may not be altogether uninteresting to your readers if I briefly refer to a clear and unmistakeable example of faulted drift which recently came under my observation at a ballast pit close to the Stockport Railway Station. At the time of my first visit, about three months ago, my object being to search for traces of marine shells in the sand, the several details of the section were exhibited with remarkable distinctness, the action of the weather having brought out the several lines of bedding and fracture as sharply as though they had been produced in a body of compact Sandstone; indeed, so exact was the resemblance in that respect that at a short distance it would have been difficult to believe that such was not the fact. Unfortunately, since that time, a quantity of sand has been removed from the face of the pit, thereby partially obliterating the details; the principal features, nevertheless, were easily discernible a few weeks ago, when I last visited the spot.

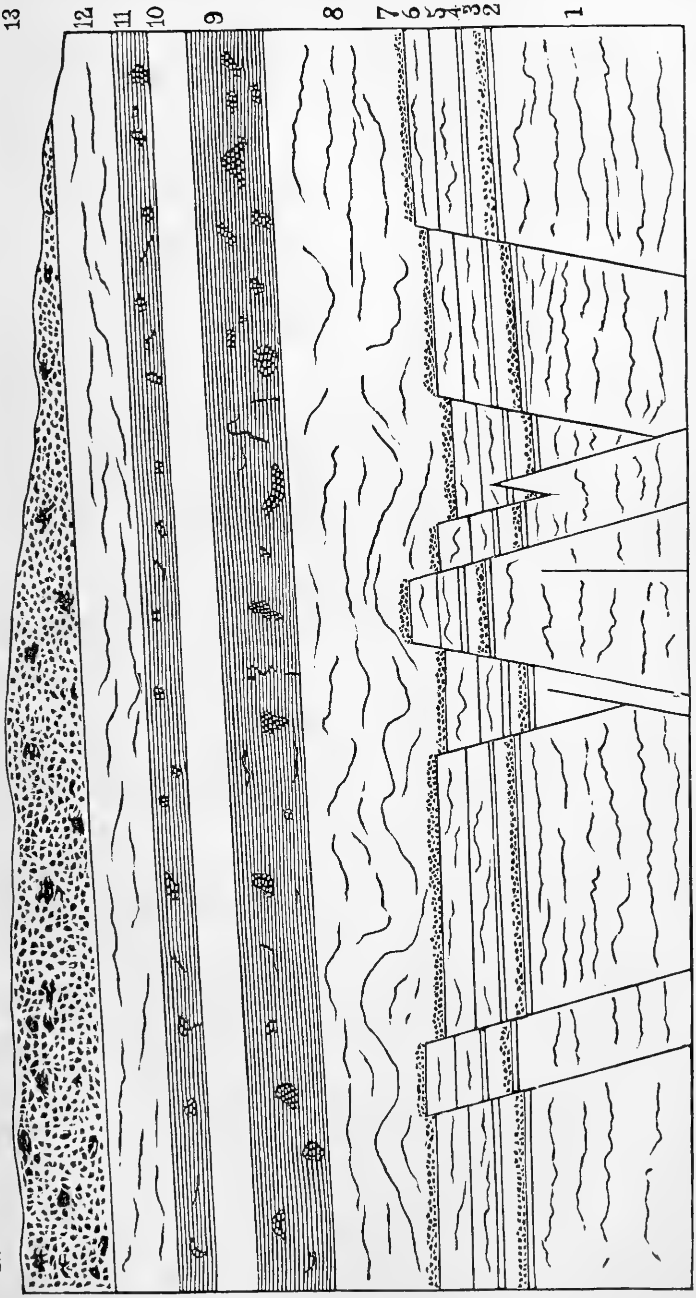
The section has a longitudinal extension of 45 feet, and a vertical depth of about 25 feet, 14 feet of the lower portion being almost entirely composed of fine, sharp, stratified red sand of (according to the classification adopted by Prof. Hull and Mr. Searles V. Wood, jun.) Middle Drift age, conforming very closely as to colour to the New Red Sandstone of the neighbourhood, upon which it rests, and from which it has evidently been derived, and in which are distributed, in considerable numbers, rounded and water-worn pieces of coal, in some places massed together in nests or pockets, and at others scattered about singly in the sand or gravel. The overlying beds, having an aggregate thickness of about 11 feet, are composed of brown and mottled clay, sand, and gravel. Running along the lines of bedding and faults are thin layers of argillaceous sand, about half or three-quarters of an inch in thickness, which, on account of possessing a greater power of resistance to sub-aerial degradation than the principal body of the sand, give a degree of sharpness and distinctness to the section but rarely witnessed in strata of this character. It is further noteworthy that the faults do not extend through the whole vertical depth of the exposed strata, but are confined to about 9 feet in thickness of the subordinate beds, the bed No. 8 presenting the appearance of arching, or curving, over the elevated conical portion near the centre of the section, as though that division had been forcibly thrust upwards, and partially forced into the overlying bed at a time when it had only recently been deposited, and when, for want of pressure, it had not become sufficiently consolidated to fracture like the rest, but was from that cause in a plastic and yielding state. The supposition that the superincumbent beds of clay, sand, and gravel were deposited at a period subsequent to the dislocation of the subordinate strata, not only fixes the time of its occurrence, but also accounts for the perfectly undisturbed character of these upper beds.

Most of the Drift faults described in the Geological Magazine occur in strata resting upon the Cretaceous formation, and it has, with some degree of probability, been suggested that, at least in some of the instances mentioned, the appearance of faulting may have resulted from subsidence of the superior beds into caverns, or hollows, produced in the calcareous beds beneath by the mechanical force of running water, or the chemical action of the acids contained therein. This suggestion, although worthy of the fullest and most favourable consideration, in those instances where the Drift immediately reposes upon chalk or other calcareous rock, easily operated upon by the agents referred to, loses its force when applied to those of an arenaceous character like those at Stockport, which, as is well known, are almost destitute of all calcareous ingredients in their composition.

Whether the dislocations here encountered extend to and also affect the subordinate Triassic rocks, it is impossible to say, as they are concealed from view by other and lower members of the Drift formation; but, if we may judge from analogy, no reasonable doubt can exist that such is the fact; indeed it is difficult, if not impossible, to conceive of any other way in which they can have been produced, under the circumstances here stated, than by a sympathetic action with the underlying rocks.

Whilst writing upon the subject of faults in Drift, I may be permitted to refer to the description of a section of this character given by Professor Hull, at p. 182, Vol IV. of this Magazine, which was exposed to view during the progress of the work in preparing the site for the New Town Hall at Rochdale; the origin of which

Section of Faults in Drift.—Stockport, Cheshire.



Length of Section, 45 Feet. Dip W.N.W. 6°.

Vertical depth of Section, 25 feet.

(although Professor Hull declines to offer a decided opinion upon the subject) may, I conceive, be satisfactorily accounted for on the following ground, without having recourse to the supposition of their having been caused by the disturbance of the subjacent Palæozoic strata, an hypothesis which the author seems inclined to favour.

During the time the section was exposed I had frequent opportunities of visiting the spot, when my attention was attracted to the disturbed condition of the beds, the nature of which was described in the notice referred to. The section occurred on the face of what was formerly a steep slippery bank of considerable elevation, at the foot of which the river Roach now runs, and at a place where that river formerly made a considerable bend to the south of its present course: thus giving rise to a sort of obtuse promontory, around two sides of which the water would then flow, and against which it would in times of flood be projected with considerable force, and that too at a time when it was not confined to a particular course by artificial means. Under these circumstances it is more than probable that the faults here observed are attributable to the undermining and destructive influence of the water at the base of the cliff, aided by the percolation of the surface water and the soft loamy and clayey character of some of the beds, causing a series of subsidences or land-slips to take place. The force of this supposition will be rendered more apparent by referring to the explanatory sketch accompanying Prof. Hull's paper, where the strata are represented as being let down by three successive steps in the direction of the river.

Whether this view be accepted or not, I trust it will be found deserving of careful consideration as offering a feasible and probable explanation of the phenomena.

The sketch of the section, given on page 119, although not drawn exactly to scale, is approximately correct.

EXPLANATION OF SECTION ON PAGE 119.

		ft.	in.
No. 1.	Red sand with indistinct wavy lines of bedding	5	0
2.	Argillaceous sand		3
3.	Sand with a thin layer of fine gravel at the bottom, resting on No. 2., containing water-worn bits of coal...	1	0
4.	Argillaceous sand		3
5. & 6.	Sand...	2	0
7.	Fine gravel...		3
8.	Fine sand with irregular discoloured lines running through it	5	6
9.	Stiff brown clay inclosing boulders and pebbles much mottled with green streaks and patches	3	0
10.	Sand, in places mixed with gravel	2	0
11.	Clay, with a few pebbles	1	0
12.	Sand	2	6
13.	Fine Gravel (say 2 to 3 feet thick)	2	6
	Total	25	3

VI.—On the Occurrence of Websterite at Brighton.

By S. G. Perceval, F.G.S.

On the 30th July last year I observed that a deposit of Websterite, subsulphate of alumina, had been cut into, in excavating for the new system of drainage in the Montpelier Road opposite the south end of Vernon Terrace. It occurs at a depth of 16 feet from the surface of the road, beneath a ferruginous deposit of varying depth, which overlies the chalk on the summit of the hill, consisting of ochreous clay with occasional flint-breccia and masses of hæmatite[1] iron ore in some instances mammillated and associated with crystals of selenite. The iron ore is occasionally friable and of a cindery appearance, containing in its cavities angular pieces of chalk and occasional groups of crystals of selenite. The deposit of Websterite is about three feet wide at its junction with the overlying ferruginous mass, narrowing as it descends, apparently occupying a fissure in the chalk, which has at some time been filled with clay, or has been formed by some decomposing action on the chalk, the chalk intruding occasionally into the vein of Websterite. The mineral varies much in colour and appearance, consisting in some places of a soft white powder, which, I am informed by Sir W. C. Trevelyan, he has observed in specimens at Newhaven, and which he has ascertained by the microscope to consist entirely of minute transparent crystals, the nature of which he believes has not yet been investigated; sometimes in masses of various size presenting the appearance of meerschaum, compact and structureless, or somewhat botryoidal in form, occasionally presenting a concentric structure, and rarely and only in a certain portion of the deposit exhibiting spherical concretions with a radiating structure. Specimens of these various forms I have presented to the British Museum. A mass of yellow clay with imbedded chalk flints divides the summit of the vein of Websterite, and near the clay the mineral assumes the character of allophane, having a yellow ivory-like appearance, towards the chalk forming the wall of the vein of Websterite. The wall of the vein is marked by a dark line caused by the association of a soft black substance, oxide of manganese, with the Websterite.

The deposit of Websterite which was exposed in the Montpelier Road was again met with at about the same depth in Clifton Hill, near its junction with the former. Here the mineral was associated with a hard white breccia apparently composed of a mixture of subsulphate of alumina, with gypsum, and with occasional imbedded chalk flints. The hæmatite or manganese was also developed in connexion with this formation.

A deposit of Websterite has also been met with opposite Powis Villas, at no great depth in the chalk, consisting of a horizontal layer about a foot thick, differing much in appearance from that in the Montpelier Road, having apparently been more uniformly crystallized and of a less heterogeneous character than the former, con-

[1] *Limonite?* Edit. Geol. Mag.

siderably harder, and of a milky colour. The exterior of the deposit was coated with a hard black rind, much resembling the charred bark of a tree. Black grains of the same substance in a soft powdery state permeated the mass, which had a cellular and towards the exterior a somewhat fibrous character. The general appearance of the mineral was highly suggestive of a vegetable origin. Pieces with the rind attached, and having a fibrous structure, much resembled portions of a gigantic cocoa nut. Two specimens were obtained from the same place, which have been secured for the Brighton Museum, which were mistaken for the stems of fossil trees, being in the form of a trunk, and described by Mr. J. Howell, of Brighton, as "six inches in diameter, the bark changed into lignite, and medullary rays diverging from the centre." The substance on the exterior of the specimens, which so much resembled lignite, has been examined by Dr. Flight, of the British Museum, and has been found to consist of manganese with a certain proportion of cobalt. Both opposite Vernon Terrace and at this locality a layer of chalk flints was continuous through the deposits of Websterite, proving that the original substance which has been replaced by the Websterite was contemporaneous with the chalk. A considerable number of specimens from the excavations in the Montpelier Road and Clifton Hill I have presented to the Museum of Practical Geology in Jermyn Street, and to the Brighton Museum. The discovery of the Websterite I communicated to Mr. T. W. Wonfor, of the Brighton and Sussex Natural History Society, and to Mr. J. Howell, of 7, Guildford Road, who have since investigated the deposits, and have brought a notice of it before the Brighton Society. The finest examples of this mineral which have been obtained from Newhaven, and which were collected by Mr. H. Catt, of Brighton, are in the Pavilion Museum, and are mentioned in "Merrifield's Natural History of Brighton."

No doubt many deposits of the mineral have been met with and overlooked in excavating for the foundation of houses in this part of Brighton.

NOTICES OF MEMOIRS.

I.—On some operculated Corals, Silurian and Recent.

By Dr. Gustaf Lindström, Wisby, Isle of Gotland.

During the spring and summer last year, I received two specimens of the very remarkable four-sided Rugose Coral *Goniophyllum pyramidale*, His.,[1] by which quite unexpected elucidations concerning the nature of the opercular apparatus of this coral were gained. These specimens are still provided with the operculum, almost complete, in its original position. Far from consisting of

[1] For figures and other details concerning it and some of its congeners, I may refer to a paper in "Ofversigt Vetenskaps-Akademiens Förhandlingar," 1865, p. 271, Pl. xxx. and xxxi., of which a translation is given in the Geological Magazine, 1866, Vol. III., page 356, Pl. XIV.

only one valve, as in the kindred genera *Calceola* and *Rhizophyllum*, it is composed of four valves, attached one to each side of the pyramid. These four valves form two pairs, as the opposite valves resemble each other. They meet with their apex in the centrum of the coral, and overlapping each other in a sort of spiral way, to be described further on, they completely close the calice of the coral. In the specimen I first received, all four valves are left in their place, and although two are sunk in the calice and somewhat crushed, their outline may still be seen. In the other specimen, only three valves are left behind. By this material, together with valves found detached, a sufficiently accurate opinion of the shape of this curious apparatus may be formed. Those valves that are attached to the bottom side (that on which the coral rests when in its natural position), and to the opposite or the uppermost side, have a trapezoidal shape (See Fig. 6, Pl. XIV., Geol. Mag., 1866). The valves of the left and the right side are both triangular. The lateral borders of all the valves are slightly curved, rarely straight. Along the middle of their outside a groove runs from the nucleus to the apex. It is broad and flat-bottomed in the trapezoidal valves, and its section forms only an obtuse angle in the triangular ones. The first and original part of the bottom valve, or what is called its nucleus, is circular; then it acquires a semicircular shape, and this is again surrounded by other lines of growth giving the final trapezoidal outline. The nuclei of the other valves are from their first origin already of the triangular or trapezoidal shape. Thus the successive changes in the shape of the opercular valves are, I think, clearly indicated. As the valves during their growth increase faster at the apical than at their basal part, the nucleus comes more closely to the basal line, and lies below the centrum (fig. 6, pl. xxx. in Ofversigt Vet. Ak. Förhandl., 1865). Excepting the lines of growth, no other sculpture is to be discerned. The dimensions of the different valves are in the most complete specimen as follows, viz:—

	Basal line.	*Length from Basal line to apex.*
Bottom valve	20 m.m.	somewhat more than 10 m.m.
Left-side valve	17 „	10 „
Uppermost valve	16 „	10 „
Right-side valve	15 „	9 „

Hence, the bottom valve is the largest, and the other valve decrease in size as they are remote from that in a direction towards left. The left-side valve covers with its right border the left border of the bottom valve, and it is itself in the same way covered by the left border of the uppermost valve, whilst the valve of the right side reposes with both its borders on the adjoining borders of the uppermost and the bottom valve. So that the last-mentioned valve is situated beneath the three others with its borders, and its truncated apex is hidden far below the apex of the opposite valve. I now suppose that the situation and the size of the different valves signify their different age and origin in such a way that the largest and deepest situated is the oldest, and for a time the only valve existing that was sufficient to cover the incipient coral. The shape of its nucleus, as described above, is in accordance with such a supposition, the nucleus being at first quite circular, as the calice of the coral itself was. The specimen, which is still covered by its operculum, is at its basis cylindrical, then acquires a semiconical shape, having one side flat—the bottom side—and one convex. First, at a distance of 9^{mm} from the basis, the whole length of the coral being 16^{mm}, it is quite four-sided. The bottom valve is the only one that is completely homologous, as to its interior surface, to the single-valved operculum of the genera *Calceola* and *Rhizophyllum*, as I endeavoured to point out in my former paper. Its median ridge is very faint, and it is at the basal or cardinal line above that ridge provided with a pit into which, just as in Calceola, no doubt the blunt edge of the corresponding calicular septum has been inserted. The uppermost valve, on the contrary (pl. xxx., fig. 8, in Ofversigt Vetenskaps-Akademiens Förhandlingar), has a very large median ridge, larger than in any of the other valves, and this large prominence corresponds with the deep septal groove in the calice. The triangular valves—those of the left and right side—are quite similar to each other, and resemble also the uppermost valve, although the median ridge is not so prominent. The valves are with their basal or hinge line so closely affixed to the borders of the calice, that no opening is seen, excepting in one of the crushed valves, which is a little lifted, so as to show how the teeth-like prominences on the valve are lodged in the interstices between the uppermost edges of the septa.

In the Proceedings of the Royal Academy of Sciences in Stockholm (Ofversigt Vet. Ak. Förhandlingar), 1868, page 421, pl. vi., fig. 4, 5, I described a new species, *Cystiphyllum prismaticum*, and I also then, as well as in my first paper on the Corals (Geol. Mag., 1866, page 411, Pl. XIV., Fig. 22, 23), gave a description of its operculum. This coral is formed as an obtusely four-sided prism, and has now been found in sufficient numbers to show not only that the animal shed its operculum, and formed a new one at intervals, some bearing two opercular valves above each other, affixed to the same side below the calicular rim, but also that its calice was closed by several valves on different sides, these being still attached to at least two sides in some specimens. But it cannot now be decided whether there were only four valves, as in *Goniophyllum*, in accordance with the four-sidedness of the coral, or more.

It is of great interest to find that these Palæozoic operculated corals have their counterparts among the recent corals. Prof. Koelliker in 1866, in his "Icones Histiologicæ," 2te Abtheil. 1 Hft. p. 135, described an operculum consisting of eight valves in some species of the genera *Primnoa* and *Paramuricea*. Such species, according to him, are *Primnoa lepadifera*, L., and *Param. placomus*, L. Through the great kindness and liberality of Prof. S. Lovén, I have been enabled to examine specimens of both these species, as well as of *Primnoa verticillaris*, L., and of an undescribed species of the genus *Calyptrophora*, J. E. Gray (Proceed. Zool. Soc., 1866, p. 25). In *Param. placomus* and *Primnoa verticillaris* these opercula are incomplete, being only composed of valves of two long and narrow sclerites, which do not close the mouth of the calice. *Primn. lepadifera* and the *Calyptrophora*, on the contrary, have a complete operculum, and they agree in several points with *Goniophyllum.* The valves in all these are triangular, and cover completely the top of the polypary, in such a way that some valves repose with their borders on those of the others. As is the case in *Goniophyllum* the median line of the outside of the valves is deepened, and to this channel or groove an elevated ridge corresponds on the interior surface. This ridge in the Primnoæ is a fulcrum to muscles from the basis of the tentacula. In other respects there is not much similarity between the Palæozoic and the recent species. The opercular valves of the Primnoæ have grown in a radial way, the calcareous bodies radiating towards all sides from a nucleus, or centrum, situated at the lower side of the operculum. In the Rugosa, again, the growth has been concentric, each new layer being added around the previous. Moreover, no traces of spiculæ or calcareous bodies are seen, the operculum and the coral are made up of homogeneous matter, and there is no reason to believe that the original structure has been obliterated by external metamorphosing agencies. Other fossils, Brachiopoda and Perforate Corals, in the same stratum, retain the most minute details of their characteristic microscopical structure unaltered, and metamorphosing agencies affect generally all fossils in the same stratum. The opercular valves of the Primnoæ are, in all probability, morphologically identical with the scales that cover the polyp all round, to which they bear a close resemblance, being entirely composed of the same sort of calcareous bodies, arranged in the same radial manner. If this scaly covering of the polyp is an ectodermic secretion, the calcareous spiculæ that are scattered so abundantly in the interior of the soft parts of the animal, and which are quite dissimilar to the spiculæ ("*Kalkkörper*," Koelliker) that compose the scales and the opercular valves, alone represent in the Primnoæ the sclerenchyma or the polyparium proper of other Anthozoa. I think there exists some sort of homology to these ectodermic scales of the Primnoæ amongst the Rugosa in *Cyathophyllum* (*Pholidophyllum*, n.g.), *Lovéni* Edw. and H.[1] Specimens of this very common and widely distributed fossil show, when in a good state of preservation, a thick covering of small ($\frac{1}{2}^{mm}$), very thin scales, tightly clustered together in longitudinal rows along the costæ. There are two rows of scales on each costa, this being indeed double or divided

[1] The authors of this species themselves doubt its belonging to the genus Cyathophyllum (Hist. Nat. Cor. III., p. 367, Brit. Foss. Corals, p. 280, pl. 66, fig. 2). In this they are quite right, as it does not in any way coincide with the species commonly considered as Cyathophylla. Its strange exothecal covering in scaly rows, its septa, its well-developed tabulæ, its double costæ, and the complete want of dissepimental structure between the septa, justify my forming a new genus out of it, which I propose to name *Pholidophyllum.* As it now stands, it contains only a single species, *Ph. Lovéni*, which is found most abundantly in Gotland, and also in Russia (Oesel), Norway (Christiania), England (Dudley and other localities), N. America (Lake Huron, St. Joseph's Island). It occurs also in the Drift of Northern Germany, from whence Ludwig, in Palæontographica, vol. xiv., pl. 47, fig. 3, and pl. 51, fig. 4, has obtained it and named it *Tæniocyathus* and *Tæniolepas spinosa.*

into two halves by a shallow furrow. Thus, each moiety of the costa is provided with its row of scales. The adjoining rows of the same costa meet in an obtuse angle, the point directed downwards. This position of the scales on the theca or epitheca of the coral gives them an exothecal character, and reminds one of the corresponding position of the many opercular valves left *on* the epitheca of *Cystiphyllum prismaticum,* as well as sometimes on that of *Goniophyllum pyramidale* (See Geol. Mag. 1866, Pl. XIV., Fig. 4 *o,* and Ofvers. Vet. Ak. Förh., 1868, pl. vi. fig. 4). I am therefore inclined to think that the opercula of the Rugose Corals, although much diversified, are secretions of an exothecal nature, homologous to the small scales of *Pholidophyllum Lovéni,* and perhaps also to the scales and opercular valves of the Primnoæ.

II.—The Geological Survey of India.

Memoirs of the Geological Survey of India. Vol. VII., Part 2. 1870.
Records of the Geological Survey of India. Vol. III., Part 4. 1870.

This Part of the Memoirs contains two reports by Mr. T. W. H. Hughes, F.G.S., etc.

1. *On the Kurhurbari Coal-field.*—This coal-field, situated in the district of Hazaribagh, although one of the smallest in the Indian empire, has for many years attracted public attention, owing partly to the superiority of its coals to those from any of the fields in the Damuda valley, and partly to its position as a source whence to supply the wants of the East Indian Railway and the larger towns west of Dinapore. It occupies an area of about eleven square miles, in which occur the Talchir and Damuda series, and also two inliers of crystalline or metamorphic rocks. The area is bounded by crystalline rocks. The distribution of these rocks is shown on a small geological map, drawn to the scale of one inch to the mile.

The Talchir series occupies but a small portion of the field; it consists of conglomerates, shales, and sandstones, without coal.

Of the Damuda series, only the lowest or Barakar group is represented. This group comprises pebbly-beds, grits, and sandstones, with beds of carbonaceous shale and seams of coal. The structure of the coal-field is, roughly, that of a basin. Trap-dykes occur in great frequency, and, of course, will have impaired the coal through which they pass.

There are not more than three, or at most four, workable beds of coal, and it is chiefly with a full description of these, at the different localities where they crop out, or have been already worked, that this Memoir is occupied.

The principal seams exhibit an irregularity which is characteristic of the Barakar group. Mr. Hughes estimates eighty millions of tons as being the probable amount of coal available in this field.

2. *On the Deoghur Coal-fields.*—The name Deoghur is applied generally to three outliers of coal-measures which occur in the neighbourhood of the Adjai River, to the east of the Kurhurbari

coal-fields. These outliers were so long ago as 1853 pointed out by the Geological Survey, but only recently the increased facility of communication with Calcutta and the provincial towns, afforded by the construction of a railway from Sitarampur to Lakki Serai, suggested the possibility of working the coal. A further examination of the rocks to determine this question shows, however, that, owing to the poor quality of the coal and the limited area over which it occurs, no successful competition with the Kurhurbari field could be carried on.

This Number of the Records contains two papers:—

1. *On the Geology of Mount Tilla in the Punjab*, by A. B. Wynne, F.G.S.

This hill, which rises to the height of 3,242 feet above the sea, is a very striking feature in the country, and mainly so through great dislocations of the stratified rocks of which it is composed, whereby beds of greater or less hardness are placed in abnormal contact with others possessing different degrees of resistance to disintegrating forces. The rocks include Tertiary (Sivalik) beds, Nummulitic limestone, and beneath them a considerable thickness of calcareous, shaly beds, and sandstones. The lofty portion of the ridge of Mount Tilla coincides with a fractured anticlinal curvature of the strata, while along its south-eastern side three, if not four, step-like faults repeat some portions of the strata. This interesting structure of Mount Tilla is illustrated by a Sketch-map and Section.

2. *Reports on the Copper Deposits of Dhalbhum and Singhbhum*, by V. Ball and Emil Stœhr.[1]

The copper ores occur for the most part in a zone of schists, situated near the base of the sub-metamorphic rocks. These ores have been repeatedly worked by the ancients, as numbers of old excavations testify, and Mr. Ball is of opinion that the earliest workers were an Aryan race called Seraks.

In regard to the mode of occurrence of the copper, it seems probable that in Singhbhum it occurs both in lodes and as a deposit disseminated through the rocks.

Two companies have of late years been formed to work the mines, and both have failed. Nevertheless, the authors think that copper-mining might be profitably carried out; but for that purpose such colossal companies as these were not suited. H. B. W.

III.—Geological Explorations in the Rocky Mountains, U.S.A.

PROFESSOR O. C. Marsh, of New Haven, Conn., U.S.A., has recently returned from an extensive tour in the Rocky Mountain region for palæontological purposes, and has enriched the shelves of the Geological Peabody Museum of Yale College with a crowd of magnificent specimens, besides adding largely to the list of American fossils. His party consisted of thirteen amateurs and students, besides numerous guides and an occasional military escort. They

[1] The Mining Geologist to the Singhbhum Copper Company.

were in the field more than five months, in Kansas, Nebraska, Colorado, and Utah. The Union Pacific Railroad formed their base of operations, from which they made excursions both to the north and south, one or two hundred miles. In the midst of wild beasts and still more dangerous savage Indians, their path was beset with difficulties and fraught with adventure. The scientific results of the expedition will be published as soon as possible.

The fossils obtained in Nebraska, Utah, and Colorado were chiefly from the "Loup River" Pliocene and the "Mauvais Terres" or the Miocene, both deposits formed beneath enormous fresh-water lakes, whose banks were tenanted by many of the peculiar Pachyderms of the Paris Basin. The number of American fossil horses—some of them contemporary with the earliest human tribes, but now entirely extinct—has been enlarged to eighteen. One of them is allied to the *Hipparion*, and another is a pigmy only two feet high. The well at "Antelope Station" (U.P.R.R.), an excavation ten feet in diameter and only eight feet deep, has furnished specimens of fifteen mammals! Four of these are horses, two rhinoceroses, an animal allied to the boar, two camels, and three large carnivores. The Miocene strata were found two hundred miles further south than they had been noticed previously. Much additional information was obtained about the *Titanotherium Proutti*; tending to show that it was only half as large as originally described.

The most important expedition of the summer was along the main tributaries of the Colorado River in Utah, a region hitherto unexplored by scientific men. It proved to be a Miocene country, formerly one of those enormous fresh-water lakes, abounding in crocodiles, serpents, turtles, and fishes. At one point of view eleven fossil turtles could be seen at once without turning the head. Rhinoceroses and various other mammals of the warmer regions seem to have frequented the shores of this ancient lake. Numerous specimens illustrating the anatomical structure of the Mosasauroid reptiles were exhumed in Kansas; after which the party disbanded and returned home. This Rocky Mountain region is wonderfully inviting with its stores of Pachyderms and fresh-water reptiles, and no industrious collector can fail to be liberally rewarded by a visit. Not a hundredth part of the region has yet been carefully explored.

C. H. H.

IV.—Report on the Testaceous Mollusca obtained during a Dredging Excursion in the Gulf of Suez, in the Months of February and March, 1869. By Robert M'Andrew.

[Annals and Magazine of Natural History, December, 1870.]

THE dissimilarity between the fauna of the Red Sea and that of the Mediterranean has attracted much attention from naturalists; and this fact, combined with the more or less distinct character of the deposits now forming over the bottoms of the two seas—that in the Red Sea being essentially calcareous, while at the mouth of the Nile the deposit is chiefly sand—has bearings of much importance to the geologist.

Having some time previously been struck with the novelty of species of Mollusca occurring on the shore of the Gulf of Suez, Mr. M'Andrew determined to go again and make some detailed observations on the marine fauna. Accordingly in 1869, accompanied by Mr. Edward Fielding, he proceeded to Suez, and devoted six weeks to dredging along the coast of the Sinai peninsula. The results of his investigations are communicated in the Report now before us. The total number of species of Mollusca obtained amounts to 818, of which 619 have been identified or described, the remaining 199 being still undetermined. 355 of the species have not been previously recorded as inhabiting the Red Sea; and of these, fifty-three, including three genera, are new to science, and have been described by Messrs. H. and A. Adams. Most of the undetermined species will, it is expected, prove to be new.

Professor Issel, of Genoa, in a recently-published work upon the shells of the Red Sea, enumerates but 640 species of recent Mollusca from the whole area—a fact which speaks well for the important results that have been obtained by Mr. M'Andrew; while, in addition to Mollusca, he lost no opportunity to collect specimens of Echinodermata, Crustacea, Corals, etc., accounts of which will probably be published.

Mr. M'Andrew observes that further researches only tend to confirm the distinction between the Red Sea and Mediterranean species of Mollusca, so that a barrier between the seas must have existed from very remote time. This, however, is quite consistent with Professor Issel's statement, that an examination of the geological conditions of the Isthmus leads to the conclusion that the two seas were united during the Eocene and Miocene periods.

What influence the Suez Canal may have in modifying the distribution of the forms of life, is at present a source of much interest.

H. B. W.

REVIEWS.

I.—Report on the Present Condition of the Geological Survey of the Colony of Victoria. (Melbourne, 1870.)

A SHORT time ago we had occasion to notice the termination of the Geological Survey of Victoria, which had for a long period been most ably conducted by Mr. A. R. C. Selwyn. The suddenness of the course taken by the Colonial Government created much surprise, and considerable regret was felt that the Survey of a Colony, so important in its economic bearings, should be left in an unfinished state.

We have just received a report, dated 23rd September, 1870, made by Mr. R. Brough Smyth to the Hon. Angus Mackay, M.P., Minister of Mines, in which the writer submits his plans for the completion of the Geological Survey of Victoria. He first points out the amount of work done by Mr. Selwyn and his staff of assistants. They surveyed an area of 3,510 square miles, which was published on maps, drawn to a scale of two inches to a mile. Mr.

Selwyn, moreover, in 1863 published a geological sketch-map of the whole colony, on the scale of eight miles to one inch, to which, as well as to the other publications of the Geological Survey of Victoria, attention was drawn in the Geological Magazine for May, 1866.

Mr. Smyth thinks that the late Geological Survey was carried on with less regard to the interests of the miner than it might have been—the great gold-fields of Ballarat and Sandhurst were not included in the area surveyed, and less than one-fourth of it embraces country which is interesting to the gold-miner. He proposes "that, instead of mapping with costly traverses the lines of the outcrop of non-productive formations (in the sense of not containing veins of ore or deposits of economic value), there should be surveyed, levelled, and mapped, all the more important gold-fields, carrying from one area to the other such necessary connexions as might serve the geologist and assist his investigations."

Most persons acquainted with field-geology would prefer Mr. Selwyn's plan of working steadily on, rather than that of working out in detail more or less isolated areas. By the former plan beds could be correlated, and more definite and satisfactory conclusions would undoubtedly be arrived at as to the geological structure of the country. There would be system and consistency,—and although the results obtained would not perhaps have the immediate money-value that would follow from special investigations and surveys of the different gold-fields, yet, in the end, we cannot help thinking that Mr. Selwyn's plan, if continued, would have the more lasting value.

Mr. Smyth remarks that, on his plan, "maintaining one party in the field, and providing also for the regular publication of maps and reports, the analyses of mineral specimens, and the examination of fossils, would not cost more than £1,500 per annum," whereas to continue the survey as it was formerly conducted, the expenses would probably be not less than £8,000 for the same period. It is true that he trusts to receive assistance from private individuals, by which means the labours of the field-geologist, he thinks, would be greatly reduced. But it is exceedingly questionable as to how much reliance could be placed upon observations and information derived from persons not connected with the Survey, and having, perhaps, but little knowledge of geological surveying. Many individuals, too, from personal interest in a district, would be apt to exaggerate the importance of its mineral wealth.

We should imagine that, although valuable information might be elicited from private sources, the whole country must be gone over by the officers of the Survey, and they would, in the localities to which attention had been directed, be better prepared as to what to expect, and would the more readily determine the mineral resources of the area.

We should, moreover, be inclined to doubt as to whether really valuable assistance could be gained with the offer of such low salaries as must necessarily follow from the very small amount for which Mr. Smyth applies, in order to carry on the Geological Survey.

Surely, if the work be worth doing at all, it should be done well and thoroughly, and we should be among the first to welcome any repentance on the part of the Colonial Government, that would be shown in the appointment of a fresh staff, equally efficient, and as well, if not better, paid, than the old Geological Survey of Victoria.

II.—Neues Jahrbuch für Mineralogie, Geologie und Palæontologie. Von G. Leonhard und H. B. Geinitz; 1869, Hefte 2–7; 1870, Hefte 1–5; and General Index for 1860–69.

EIGHTEEN months have slipped by since we noticed the current numbers of Leonhard and Geinitz's "Neues Jahrbuch," see Geol. Mag., Vol. VI., p. 272. The appended classified list of the original memoirs in the subsequent numbers, as far as they have reached us, shows that diversity of subject in the main branches of our science is well sustained; and the treatment of the subjects, and the names of the authors, together with those of the many correspondents to the "Neues Jahrbuch," testify to wide-spread and sound science among our German brothers in geology, who keep up their title to the upper places among Crystallographists and Mineralogists, and are second to none in Palæontology and general Geology. In fact, the following catalogue of subjects specially treated of will speak for itself; and when we remember that these are associated with an excellent bibliographical record of geological and mineralogical works, with letters on current news and late discoveries, and with careful digests of hundreds of books and memoirs, we feel bound again to call the earnest attention of our readers to this invaluable periodical, and to congratulate Germany on the industry, acumen, and good work of her geologists.

The granite and granite tors of Eibenstock in the Erzgebirge, 259, 1869; Volcanic eruptions of 1868, 686, 1869 (pl. viii.); Volcanic eruptions of 1869, 433, 1870; Etna in 1863–66, 257, 1870 (pl. i.); Microscopic structure of Vesuvian lavas, 169, 1869 (pl. ii.); Obsidian from Hecla, 529, 1870 (pl. v.); Volcanic rocks of Auvergne, 6, 1869; Trachyte of the Laacher See, 569, 1870; Diabasic rocks and minerals of Voigtland and the Frankenwald, 1, 1870; Lustre and dichroism of Hypersthene, 532, 1869 (cut); Hauyne, 329, 1869; Prehnite of Harzburg, 314, 1870 (cuts); Polyhalite, 325, 1869; Two new Phosphates, Isoclase and Collophane, 306, 1870; Pseudomorph of Bunter Sandstein after Calcite at Heidelberg, 714, 1869; Pseudomorph of Calcite and Asbestos after Apophyllite, 425, 1870; Macled Calcite, 542, 1870 (pl. vi.): Macled Chrysoberyl (Alexandrite), 548, 1869 (pl. vii.); The hexahedral crystal-system, 290, 1870; Formation of crystals, 183, 1870 (pl. iii.); New Galena crystal, 311, 1870; Glaucopyrites, 195, 1870; Crystals of Dimorphine, 537, 1870; Magnetite and Titanite, 513, 1869; The so-called silver-sand of Andreasberg, 445, 1869 (cuts); The Wenzelgang near Wolfbach, 290, 1869; Gold-deposits of California, 21 and 129, 1870 (pl. ii.).

Amiens gravel, 139, 1869 (cuts and pl. iv.); Eocene *Oolaster* from

Upper Austria, 451, 1869 (pl. vi.); Greensand fossils from near Osnabrück, 808, 1869 (pl. ix.); Upper Mesozoic strata near Eisenach, 385, 1870; Permian plant-remains from Val Trompia, 456, 1869 (pl. v.); Coal Insects (in the Dresden Museum, etc.), 158, 1869 (pl. iii.); Coal Insects of Thuringia, 282, 1870 (cuts); Ostracods and an Insect from the Saarbrück Coal, 286, 1870 (cuts); Coal plants from the Altai, 462, 1869 (pl. vi., figs. 4 and 5); Coal fossils (especially fruits) from Haute-Loire, 417, 1870 (pl. iv.); Devonian rocks of the Westerwald, 658, 1869; *Eozoon* in Sweden, 551, 1869; Geology of Guatemala and Salvador, 769, 1869; Geology of Norway, 385, 1869 (cut).

The decennial Index (*Allgemeines Repertorium*, etc.) for the "Jahrbuch," consists of world-wide and almost perfect lists of Authors, Subjects, and Places, having relations with Geology, Minerals, and Fossils, for the years it refers to. With its predecessors, for nearly fifty years, it forms a valuable series of catalogues for general and special reference. T. R. J.

III.—A Guide to the Western Alps. By John Ball, F.R.S., M.R.I.A., etc. New Edition. 8vo., pp. 378. (London, 1870. Longmans, Green, & Co.) Price 7*s.* 6*d.*

THE present volume is one of three, which together form "The Alpine Guide"; it is devoted to a consideration of the entire range that encircles the plain of Piedmont, from the Maritime Alps north of Nice to the Pass of the Simplon, along with the Dauphiné and Savoy Alps, and the portions of Switzerland connected with the Pennine range. In addition to the ordinary subjects treated of in a guide-book, and which Mr. Ball's extensive acquaintance with the country has rendered very complete, we are also glad to notice that in this work attention is prominently drawn to the Natural History of the Alps, in a series of articles on the Climate and Vegetation, the Zoology, Meteorology and Hypsometry, the Glacial Phenomena, and, lastly, on the Geology. Our object in noticing this book is particularly to direct attention to an article on the Geology of the Alps, by M. Desor, of Neuchâtel, which has been translated by Mr. Ball. This essay brings together all the important facts known of the geology of the district; and it is satisfactory to learn that the views expressed by its author coincide in the main with those held by Professor Studer and other leading Swiss geologists.

The general structure of the Alps has been shown by Professor Studer to consist of groups or mountain masses, characterized by a crystalline centre and an outer coating of sedimentary rocks. He distinguished nineteen of these groups between the Ligurian Alps and the Adige; and M. Desor, in extending this classification to the entire range of the Alps, increases the number to thirty-three, which he severally describes.

The highest peaks of the Alps are formed of crystalline rocks, although many prominent peaks are formed of Secondary deposits. Among the crystalline rocks are reckoned the several varieties of granite, gneiss, and some mica-schists. Their probable metamorphic origin is pointed out, but M. Desor observes that, so far as regards the connexion between the orography of the Alps and their geological structure, it is of little importance whether we consider the crystalline centres as originating in the eruption of igneous rocks, or in the metamorphism of old sedimentary deposits.

The intervals or "troughs" between the higher masses are, as a rule, occupied by stratified rocks of softer and less-resisting nature; they consist generally of Palæozoic or of older Secondary strata. The disturbances to which these beds have been subjected prove of great intensity. During elevation the crystalline rocks which underlie these beds, when lifted to a sufficient height and delivered from lateral pressure, seem to have expanded in the direction of least resistance, and thus has been produced the *fan-structure* so characteristic of the central region of the Alps.

The Alpine geologist has many difficulties to contend with in the repeated folding of the strata and in the actual reversion of their original order of superposition; he has, moveover, to deal with deposits which scarcely ever retain the characters that are elsewhere familiar to him—the rocks are remarkably altered, and fossils are extremely scarce. M. Desor remarks that it is upon the outer slopes of the Alps, and at a distance from the crystalline groups, that the sedimentary rocks can be studied to the best advantage. Here, he adds, it is sometimes possible to observe the entire series, from the Palæozoic to the Miocene deposits, following each other in their natural order, and so much the better displayed as they are remote from the centres of disturbance.

The author gives a brief description of the different sedimentary deposits, and we should mention that this volume is accompanied by a coloured geological map of the Western Alps, on a scale of about five and a half miles to the inch.

A short space is devoted to the relations between the Geology and Orography of the Alps, and, in conclusion, a sketch is given of the Geological History of the Alpine Regions.

The first distinct evidence of a land-surface in the Alpine region occurs in the Coal period. From the Coal period to the Lias the sea probably again covered nearly the entire area. There is reason to believe that the latter epoch was preceded and accompanied by considerable oscillations of level, and that thence we may date the commencement of a continuous barrier of dry land, separating the seas that flowed on its north and south sides.

The Secondary period was, on the whole, marked by elevation; in the Eocene period considerable changes of level occurred; while in Miocene times the plain of Switzerland was submerged to a depth which permitted the accumulation of vast masses of Conglomerate and of Molasse, and in some places the sea appears to have reached districts which it had not touched since the Palæozoic epoch. The final upheaval, commencing after the deposition of the Miocene strata, is that which gave to the Alpine chain its existing form.

Mr. Ball gives copious lists of works relating to the topography and Natural History of the Alps, and he remarks that it may be a satisfaction to future travellers if he expresses his conviction that, in spite of all that has yet been done, no portion of the Alps can, in a topographical and still less in a scientific sense, be said to be thoroughly explored. In districts supposed to be well known, an active mountaineer will constantly find scope for new expeditions; and, if he has cultivated the habit of observation, he may at the same time make these subservient to the increase of knowledge.

REPORTS AND PROCEEDINGS.

I. January 11, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—1. "On the older Metamorphic Rocks and Granite of Banffshire." By T. F. Jamieson, Esq., F.G.S.

The author indicated three divisions in the metamorphic strata of Banffshire:—At bottom a great thickness of arenaceous beds, more or less altered into quartz-rock, gneiss, and mica-schist; next a series of fine-grained clay-slates, in the midst of which is a bed of limestones; and then again an upper group of arenaceous strata. The author stated that the arrangement of the rocks is very similar to that occurring in Bute and Argyleshire. He remarked that the general texture of the beds is fine-grained, and considered that they were probably deposited in the depths of the sea, off the mouth of a great river, the deposition of the argillaceous strata having taken place during a period of increased depression. The deposition of the beds was said to have probably taken place after the formation of the (Cambrian) Red Sandstone and Conglomerate of the North-west Highlands, or in Lower Silurian times, the river by which the sediment was brought down being supposed to have drained the great Laurentian region to the north-west. After their accumulation the author supposed that "a glow of heat from beneath" approached them, causing expansion and the wrinkling of the mass into folds running from S.W. to N.E. The granites were considered by the author to owe their origin to the fusion and recrystallization of the arenaceous beds.

Discussion.—Prof. Ramsay observed that the general section wonderfully corresponded with that given many years ago by Sir Roderick Murchison of the Silurian and Laurentian rocks at Cape Wrath, and it seemed to him that the large views originally propounded by Sir Roderick were confirmed by the author. He was glad that the metamorphic origin of granite was supported by Mr. Jamieson, as he had held that view for several years, and he was pleased to find that opinions which had formerly met with so many opponents were constantly gaining acceptance. The fusion of these sedimentary rocks by metamorphic action was not identical with the fusion of lava, but their fluidity might be the same; and if that were the case, there could be no difficulty in accepting the possibility of the injection of such fused rocks into crevices and fissures. The crumpling of the beds, however, was due to more extensive causes than those contemplated by the author. The proportion of igneous rock injected into contorted rocks, like those of North Wales, was almost infinitesimal, and the crumpling could hardly be due to mere local causes.

Prof. Ansted referred to what he had observed in the north-west part of Corsica, where about 40 feet of granite were distinctly interstratified between perfectly un-metamorphosed beds of sandstone and limestone, without any alteration at the points of contact, such as would be produced by an igneous rock. He also cited the crumpled strata in the Maritime Alps, in which the granites were parallel with the other beds, and seemed to form part of them.

Mr. Carruthers mentioned that the late Prof. Fleming, twenty years ago, had taught the same doctrine as to the nature of granite as that held by the last speakers.

Mr. David Forbes agreed that the crumpling of the strata was not due to the intrusion of any eruptive rock. He completely disagreed with Prof. Ramsay and the author as to the origin of granite, and maintained that, in the sedimentary rocks traversed by the granite, the requisite ingredients for the formation of granite did not exist. The proportion of felspar in quartzose rocks was infinitesimally small, as compared with that entering into the composition of granite. He could not accept the notion of the heat from the interior approaching gradually to some portion of the surface.

Prof. Ramsay, in reply to Mr. Forbes, maintained that some of the slaty rocks of Wales, by extreme metamorphism, would pass into some kinds of granite. As to the conditions of metamorphism of the rocks, this process must have gone on at a time when these older rocks were overlain by a great thickness of more recent beds which have since been removed by denudation.

2. "On the connexion of Volcanic action with changes of Level." By Joseph John Murphy, Esq., F.G.S.

The author commenced by discussing the chemical theory of volcanic action, which he considered he had disproved. He remarked on the coincidence of volcanic action with elevation of the surface, but stated his opinion that the elevation of one part of the earth's surface, and the depression of another, are the results of a movement of subsidence in the following manner:—The interior of the earth is constantly cooling, and as it cools it must contract. But the cold strata of the surface cannot contract in the same proportion; and as they must remain in contact with the core, they are compelled to form folds and ridges. The breaking out of volcanoes is due to the breaking of part of the earth's crust by these foldings. According to the author, "volcanic action is not the cause, but the effect of secular changes of level; and secular changes of level are due to the subsidence of the surface on the interior, as the interior contracts in cooling."

3. "On some Points in the Geology of the neighbourhood of Malaga." By Don M. de Orueba. Communicated by Sir R. I. Murchison, F.R.S., F.G.S.

After referring to the writings of previous authors upon the geology of the south of Spain, the author noticed a mountain-chain near Antequera, one branch of which, known as the "Torcal," he described as presenting a very singular appearance, from the huge blocks of stone of which it is composed. The division of the rock into separate blocks, often of the most fantastic shapes, was attributed by the author to denudation by water. The "Torcal" consists of a compact limestone, generally of a red colour, resting conformably on the east upon a fine-grained white oolitic marble of considerable thickness. At the divisional line between the two formations many Ammonites were said to occur, and three of these were doubtfully identified with *A. giganteus, biplex,* and *annulatus.* These species would indicate the deposit to be probably of Portlandian age.

The plain of Antequera was considered by the author to consist of Tertiary formations. One of these, at the south of the city, he regarded as analogous to the "Calcaire grossier." He mentioned indications of the presence in the vicinity of a Miliolitic marble, and of a limestone containing Nummulites. Between Atequera and the Torcal, he noticed a small calcareous deposit containing many forms of *Gryphæa*. The paper was illustrated by photographs of two scenes on the Torcal, and of several species of Ammonites.

Discussion:—Prof. Ansted remarked that the condition of the Torcal was similar to that prevailing in many other limestone districts, and was probably due to subaerial denudation.

Mr. W. W. Smyth mentioned that he had lately had an opportunity of examining, at Cadiz, a collection of fossils formed by Mr. Macpherson in that district, which also contained specimens of Ammonites. There were large tracts in which the rocks appeared almost destitute of fossils, which rendered their classification extremely difficult; and great credit was due to the author for his exertions in a country where unfortunately so little interest was taken in geology. He mentioned that some of these unfossiliferous rocks had been classified as Silurian by some French geologists; but for this there was not the slightest evidence. It appeared far more probable that they were of Jurassic age. Some red beds, which had been called Triassic, were also in all probability Tertiary.

Mr. Gwyn Jeffreys, who had examined several collections in Spain and Portugal, stated that he had been much struck with the absence of newer Tertiary fossils, the latest being of Miocene age. These latter presented a tropical aspect, and differed from the mollusca now inhabiting the neighbouring seas.

Mr. Blake was not satisfied with the determination of the Ammonites, which appeared to him rather of Cretaceous than Jurassic forms.

Mr. Tate observed that the French geologists had determined the existence in Spain of the whole Jurassic series, from the Lower Lias to the Portlandian beds; and, judging from the photographs, he should consider the Ammonites to be Jurassic.

Mr. Boyd Dawkins cited the remains of *Rhinoceros etruscus*, procured by the late Dr. Falconer, at Malaga, as affording evidence of the presence of beds of Pliocene age in that district.

Prof. Duncan mentioned that he had found corals of the genus *Flabellum*, such as were found in the Tejares clays in recent deep-sea dredgings in the Atlantic, and among specimens brought from Japan.

Geological Society of London.—II. January 25, 1871. Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Physical Relations of the New Red Marl, Rhætic beds, and Lower Lias." By Prof. A. C. Ramsay, LL.D., F.R.S., F.G.S.

The author commenced by stating that there is a perfect physical gradation between the New Red Marl and the Rhætic beds. He considered that the New Red Sandstone and Marl were formed in inland waters, the latter in a salt lake, and regarded the abundance of oxide of iron in them as favourable to this view. The fossil footprints occurring in them were evidence that there was no tide in the water. The author maintained that the new Red Marl is more closely related to the Rhætic, and even to the Lias, than to the Bunter; and in support of this opinion he cited both stratigraphical and palæontological evidence. He described what he regarded as the sequence of events during the accumulation of the later Triassic deposits and the passage through the Rhætic to the Lias, and intimated that the same reasoning would apply to other British strata, especially some of those coloured red by oxide of iron, including the Permian, the Old Red Sandstone, and a part of the Cambrian.

Discussion.—Mr. Etheridge thought the question of the nature of the Rhætic beds was to a great extent Palæontological. The main point in connexion with them was as to how the British beds were to be connected with the Lombardic and Middle European areas. It certainly seemed probable that in this part of the world the conditions of life were different, the deposits being much less in thickness, and the fauna much diminished; and where represented at all, the shells occurred in a dwarfed and stunted form. The exact horizon and nature of the Sutton beds had still to be determined.

Mr. Godwin-Austen believed that every mass of Red Sandstone would ultimately be referred to either a brackish or freshwater origin. A comparison of the ancient and present area of the Caspian Sea would tend to remove any doubt that might remain on the mind of geologists, as to the possibility of the existence of such vast internal seas as those which had to be called in to account for these formations. He regretted that former observers had not attached more importance to the duration and extent of those freshwater conditions which were found so commonly to have prevailed between the periods of deposit of the great marine formations. There was another fact to be borne in mind, that even in existing lakes, the water at the one end was sometimes completely fresh, and at the other end salt, each of course with a different fauna.

Prof. Rupert Jones said that although there were good grounds for the lake-theory, something might be said for shallow seas. He remarked that sulphate of lime was deposited from sea-water before salt, that oxide of iron might originate from chloride of iron diffused in water, whether of lakes or seas, and that the hæmatites of Permian age were probably deposited in the sea. He considered that Foraminifera required great caution when used as criteria, as the varietal forms giving the facies were of more importance than the genera and species. The *Estheriæ* were never marine, although often occurring in plenty in temporary freshwater pools on the sea-shore. In his monograph of *Estheria*, he had said much to substantiate the notion that freshwater conditions often prevailed during the formation of the Keuper. Both in the Old Red Sandstone of the Baltic provinces, and in the Lettenkohle and Keuper of Germany, when *Estheria* comes in, *Lingula* dies out. The *repeated* set of formations in the Permian and the Trias precludes their contemporaneity, as supposed by Messrs. Godwin-Austen and Marcou.

Mr. Bauerman remarked that the Hallstatt beds which had been cited as marine, contained large deposits of rock-salt.

M. Marcou thought that the difficulties in regarding these beds as of freshwater origin were greater than the author supposed. The absence of fossils in gypsum, though almost universal, was not total. He had himself seen three specimens of *Trigonia* in gypsum from Stuttgart.

Mr. Tate mentioned the discovery by Mr. Burton, of marine fossils in the Red Marl, in one instance in combination with vegetable remains. He commented on the sharp demarcation observable in Ireland between the Rhætic beds and the Marl below, whereas it was almost impossible to separate them from the Lias above. He doubted, however, whether the true relations of the Rhætic beds were to be worked out in this country. As to the fossils of the Sutton Stone, they were all purely Liassic.

Mr. Burton stated that the fossils from the Red Marl came from a spot about five miles from Retford, in the direction of Gainsborough, but he had not seen them *in situ*. There are, however, no Rhætic beds within some miles.

Rev. Mr. Winwood, in the absence of Mr. C. Moore, from ill health, inquired whether the author regarded the White Lias as Rhætic or Liassic.

Professor Ramsay, in reply, was quite willing to accept marine fossils as coming from the Red Marl. The fact of *Estheria*, a brackish or freshwater form, occurring in certain bands, was in favour of his views, as he considered that at intervals the freshness of the water in such a lake as he had suggested must have varied. He could not accept the probability of oxide of iron having been deposited in a large sea area to such an extent as to colour the sands. All rocks that could be proved to be of marine origin, even when they contained iron, were not stained red unless by infiltration from above. He pointed out that the old area of the Caspian was far larger than the lake in which he had suggested that the New Red Marl had been deposited. If, as was more than probable, there had been during all geological time continental areas somewhat in the same positions as those of the present day, there must have been large areas of inland drainage in which some such deposits as those in question must of necessity have been formed.

2. "Note on a large Reptilian Skull from Brooke, Isle of Wight, probably Dinosaurian, and referable to the genus *Iguanodon.*" By J. W. Hulke, Esq., F.R.S., F.G.S.

The author stated that the skull described by him was obtained from a Wealden deposit at Brooke, in the Isle of Wight, from which many remains of Dinosauria have been obtained. He described its characters in detail, and remarked that its most striking peculiarities were:—the completeness of the bony brain-case; the obliteration of the sutures, especially those of the basicranial axis; the massiveness of the skull; and the great downward extension of the basisphenoid, with the attendant upward slant of the lower border of the basi-presphenoidal rod. The first of these characters occurs elsewhere among reptiles only in *Dicynodon;* and the first and second characters combined, were regarded by the author as approximating the skull to the ornithic type. The reference of this skull to *Iguanodon* was founded chiefly on the place from which it was obtained, which has furnished abundant remains of that genus, and on the obliteration of the sutures, which the author stated to be a character of the mandibles of *Iguanodon.*

Discussion.—Prof. Huxley congratulated the Society on the progress being made in our knowledge of this interesting group of reptiles and of their ornithic affinities.

Mr. Seeley remarked on the similarity of the internal cavity of the skull to that of *Ichthyosaurus.* Some of the external characteristics differed much from what he was acquainted with in other Dinosaurian skulls, which more closely resembled those of ordinary lizards. He considered that the affinities of *Dinosaurs* were in the direction of *Teleosaurus,* from which the position of what were supposed to be the optic nerves in this skull materially differed. On the whole, he was not at once prepared to accept this skull as that of an Iguanodon.

Mr. Hulke briefly replied, and observed that he had limited his speculations to those which legitimately arose from the facts before him.

III. Geological Society of London.—February 8, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—1. "On the Punfield Formation." By John W. Judd, Esq., F.G.S., of the Geological Survey of England and Wales.

Those formations which have been deposited under *fluvio-marine* conditions, and which yield at the same time marine, freshwater, and terrestrial fossils, are of especial interest to the geologist, as they furnish him with a means of correlating the great freshwater systems of strata with those of marine origin.

At the bottom of the Wealden we have one such fluvio-marine series, the well-known Purbeck formation; at its summit is another, less known, but not less important, for which the name of "Punfield Formation" is now suggested. Some of the fossils of the latter were first brought under the notice of geologists by Mr. Godwin-Austen in 1850; and their peculiarities have since been the subject of remark by Prof. E. Forbes, Sir C. Lyell, and others.

The typical section of the beds is at Punfield Cove, in the Isle of Purbeck, where they are about 160 feet thick, and include several bands with marine shells. The lowest and most remarkable of these yields about forty well-defined species, many of which, as well as one of the genera, are quite new to this country. A section somewhat similar to that of Punfield is seen at Worborrow Bay.

In the Isle of Wight, at Compton, Brixton, and Sandown Bays, similar fluvio-marine beds are found at the top of the Wealden, and attain to a thickness of 230 feet. The marine bands here, however, yield but a very scanty fauna. Indications of the existence of beds of the same character and in a similar position are found in the district of the Weald.

While the Purbeck formation exhibits the gradual passage of the marine Portlandian into the freshwater Wealden, the Punfield formation shows the transition of the latter into the marine Upper Neocomian (Lower Greensand). Thus we are led to conclude that the epoch of the English Wealden commenced before the close of the Jurassic period, lasted through the whole of the Tithonian and of the Lower and Middle Neocomian, and only came to a close at the commencement of the Upper Neocomian.

In tracing the Cretaceous strata proper from east to west, they are found to undergo great modification; while the Neocomian and Wealden, which they overlap through unconformity, besides being greatly changed in character, thin out very rapidly.

On stratigraphical and palæontological evidence, the Punfield formation is clearly referable to the upper part of the Middle Neocomian. Its fauna has remarkably close analogies with that of the great coal-bearing formation of Eastern Spain, which is of vast thickness and great economic value.

The claim of the Punfield beds, equally with the similarly situated Purbeck series, to rank as a distinct formation, is founded on the distinctness of their mineralogical characters, their great thickness, the fact of their yielding a considerable and very well characterized fauna, and of their being the equivalent of a highly important foreign series.

Discussion.—The President remarked that the limited amount of freshwater formations in this country was an obstacle to their correlation, and stated that Constant Prevost had endeavoured to correlate the Secondary freshwater and marine formations.

Mr. Godwin-Austen remarked upon the thinning out of the Lower Greensand, especially in France; upon the imperfection of our knowledge of the great Cretaceous formation, and upon the probability of the intercalation of freshwater conditions in the Lower Greensand. The formation at Punfield seemed to present an intercalation of marine between purely freshwater conditions. He indicated how a slight change of level might have intercalated marine conditions in the Wealden. The deposition of the White Chalk and Oolite occupied enormous periods (in both cases purely marine), during which the northern hemisphere was a great northern ocean; and as the distribution of land and water was due to the operation of great cosmical laws, the duration of terrestrial and of the intermediate freshwater conditions was probably of equal length.

Mr. Etheridge observed that out of sixty or seventy species from the deposits in Eastern Spain, we have thirty-nine or forty in Britain. The fauna was, indeed, precisely the same. He referred to several of the species, and intimated his intention of describing and figuring those forms which have not been detected in the Spanish deposits.

Mr. Seeley stated that he could not agree with Mr. Judd in his conclusions, and that he objected to the method adopted by him. He had examined all the sections, and was convinced that the strata at Swanage were all superior to those seen in the section in the Isle of Wight. He regarded the shell noticed as a *Vicarya*, as a Greensand form. There was nothing in the fossils to indicate a separation from the Lower Greensand, of which he regarded these beds as forming a part. Each division was to be traced westwards continuously, but changing in mineral character. Mr. Seeley objected to the correlation of these deposits with others occurring in Spain or any other distant locality, and considered the community of fossils not sufficient to establish such a correlation. He objected also to the introduction of a new term into geological nomenclature.

Mr. Jenkins remarked on the value of Mr. Judd's description of the sections, even if his deductions were to be rejected. He regarded the establishment of a Punfield formation as unnecessary, and cited the Purbeck and Portland beds as examples of analogous freshwater and marine deposits. He indicated that the Weald may be regarded as the freshwater equivalent of the Lower Neocomian. He doubted whether the shell referred to *Vicarya* really belonged to that genus. *Ammonites Deshayesii* was said to have a restricted range in time. Mr. Jenkins remarked that it was very widely diffused, and therefore should have a wide range in time, which would invalidate the argument founded on it.

The Rev. O. Fisher stated that in 1853 he had observed a fault cutting off the Gault from the Punfield Beds, and that its position might account for the disappearance of a great mass of Lower Greensand.

Mr. Judd, in reply, said he did not propose the term "Punfield Formation" as a definitive term, but only as a matter of convenience. He believed that strata could be positively identified by the organic remains contained in them, although the method may have been grossly abused. Physical investigations *alone* led to nothing but confusion, as might be seen by the stratigraphical attempts of the predecessors of William Smith. The name *Vicarya* for the shell which had been referred to was only provisionally adopted, on the authority of De Verneuil and other writers.

2. "Some remarks on the Denudation of the Oolites of the Bath district, with a theory on the Denudation of Oolites generally." By W. Stephen Mitchell, Esq., M.A., F.G.S., of Gonville and Caius College, Cambridge.

The author briefly referred to the theory according to which Oolitic deposits were supposed to have been originally spread out in continuous sheets over the country which they occupy, and to owe their division into separate hills to the action of denudation after their original deposition and consolidation. He suggested, as an equally probable hypothesis, that whilst the marls and clays of Oolitic areas were probably originally deposited in continuous beds, the limestones in many cases may never have extended beyond the areas now occupied by them. He described the beds of limestone in the Oolitic hills as thinning out towards the valleys on all sides, maintained that the limestones owed their origin to coral reefs, and cited several descriptions of coral islands by the late Prof. Jukes, to show the agreement in their structure with that which he ascribed to the Oolitic hills. He assumed that in the event of a coral-area becoming one of sedimentary deposition, the sedimentary deposit would preserve intact the contour of the coral islands, and inferred that this has been the case in the Bath district, so that the Great Oolite cappings of the hills of that area may represent the original contours of coral islands, exposed by the denudation of the Bradford clay. The amount of denudation undergone by the Great Oolite limestone he considered to be very small. The Inferior Oolite, on the contrary, he believed to have suffered denudation, and he considered that the course of the valleys formed by this agent was dependent on the form of the limestones capping the hills.

Discussion.—Prof. Morris did not consider that the author's views as to the Oolitic masses round Bath being originally isolated coral banks with clay-beds, although suggestive, were quite satisfactory. He pointed out that the strata on each side of the valleys were similar in structure, mineral character, and fossil contents, and were once continuous; and the present intervening deep valleys were rather due to the movements which the area had undergone in producing lines of weak resistance, subsequently assisted by the erosive action of percolating and running water, both in excavating and undermining the harder rocks, so as to cause them to bend towards the hill-sides, or fall in larger or smaller masses on their slopes.

Mr. Seeley thought that Mr. Mitchell was justified in applying considerations drawn from the formation of coral islands to the elucidation of the phenomena under discussion. He maintained that limestones must always occur in isolated masses with intervening masses of clay, and that the clay would be washed out, leaving the limestone as hills.

Mr. Whitaker held that when like beds cropped out on the tops or flanks of opposing hills it was a logical inference that the said beds had once spread across the space between; that there was no need to call in the agency of supposed coral islands to explain the occurrence of isolated masses of limestone, which were perfectly accounted for by denudation, an agency which involved no supposition, and was quite equal to the work.

Mr. Etheridge remarked that the Mollusca of the outliers of the Oolites in the Severn Valley were constant in beds of the same relative level. He also referred to the sliding of the Oolitic strata of the Cotteswolds upon the subjacent clays as accounting for the dip towards the valleys mentioned by the author. He considered that the valleys had been scooped out by denudation.

The President inquired whether the author was provided with any sections showing the thinning out of the beds.

Mr. Mitchell, in reply, stated that he had seen both sides of what he regarded as coral reefs. He remarked that his hypothesis was arrived at by deduction, by inferring from observations on existing coral reefs that those of the Oolites must have been covered up as islands. He remarked that if the Oolitic beds had slipped, as described, upon the underlying clays, they could hardly range on opposite sides of the valleys. He noticed that the action of water in covering the blocks of Oolite with crystallized carbonate of lime would be protective, and remarked that the surface of the reefs was virtually a sea-bottom on which Mollusca lived, so that their occurrence at corresponding levels in different hills was not to be wondered at.

The following specimens were exhibited to the Meeting:—

Fossils from the Punfield Formation; exhibited by J. W. Judd, Esq., in illustration of his paper.

Specimens of Gold; exhibited by Prof. Tennant, F.G.S.

A Flint and Bone Implement from the Gravel of Cambridgeshire; exhibited by the Rev. Osmond Fisher, F.G.S.

Geologists' Association.—The Annual General Meeting of this useful and flourishing Society was held at University College, on Friday, the 3rd of February last, the retiring President, Professor Morris, in the chair. The annual report having been read and adopted, the officers for the ensuing year were elected. Thomas Davidson, Esq., F.R.S., F.G.S., etc., who has just completed his great work on the British Fossil Brachiopoda, and Charles Moore, Esq., F.G.S., the indefatigable and highly-successful explorer of Lower Jurassic strata, were unanimously elected honorary members of the Association. A vote of thanks to John Cumming, Esq., F.G.S., who has retired from the office of honorary secretary, which he has ably filled during several years; and to Professor Morris, who has presided over the Association with so much honour to himself and advantage to the members for the past three years, was warmly supported by several speakers, and heartily accorded by the meeting. Professor Morris and Mr. Cumming returned thanks in their usual felicitous manner. The newly-elected President, the Rev. Thomas Wiltshire, M.A., F.G.S., F.R.A.S., etc., having taken the chair, which had been vacated by Professor Morris, Caleb Evans, Esq., F.G.S., read the second part of a very able and interesting paper "On the Geology of the Neighbourhood of Portsmouth and Ryde." The first part of this paper, read at a previous meeting, gave the results of an exploration of the beds of Lower Eocene Age, recently exposed by the excavations for the docks now in course of construction at Her Majesty's Dockyard, Portsmouth. The second part of the paper, which was very long, dwelt more particularly on the Middle and Upper Eocene Formations of Hampshire and the Isle of Wight, and gave a clear and succinct description of the interesting Fluvio-marine deposits, which are found only in this part of Great Britain. A fine collection of fossils from the localities mentioned in the paper, which had all been collected by the author, was exhibited. In the course of the long and interesting discussion which followed the reading of the paper, Professor Morris directed attention to the fallacy so prevalent amongst young geologists of regarding formations containing different assemblages of fossils as necessarily of different epochs, and strongly urged extreme caution in determining the relative ages of formation in different localities, since dissimilar local conditions may have had so great an influence on the life of the period of deposition, as to change very considerably the character of the fauna of two synchronous formations. We strongly recommend those wishing to obtain a practical acquaintance with the geological features of the South of England, to seek admission to the Geologists' Association, as visits to several localities of interest will be paid by the Association during the present year.

J. Logan Lobley, Hon. Sec.

CORRESPONDENCE.

Sir,—Will you allow me to correct a slight inaccuracy in a very interesting paper by Mr. C. E. de Rance on "The Glacial Phenomena of West Lancashire and Cheshire," published in No. 105 of the Quarterly Journal of the Geological Society. Referring to a paper of mine, published more than ten years ago, on the Glacial Phenomena of the Lake District, he states, incorrectly, that it is to be found in the pages of the "Edinburgh Philosophical Magazine." The correct reference is the "Edinburgh New Phil. Jour.," vol. xi. (1860.)

It is from this paper that the illustration of the *rôche moutonnée* in the valley of the Rotha, near Ambleside, given in Lyell's "Antiquity of Man," p. 269, is copied, accompanied by a correct reference.

As much is now being written on the glacial phenomena of this part of England, perhaps some of the authors of these communications may feel inclined to refer to the observations I have recorded; and I only regret that all my spare copies have long since been used up.

GEOLOGICAL SURVEY OFFICE, DUBLIN, EDWARD HULL.
16*th February*, 1871.

GLACIATION OF THE LAKE-DISTRICT.

SIR,—Allow me to make a few more remarks on the question of the glaciation of these dales—I think they will be my last.

Let not Mr. Mackintosh suppose that Mr. Rutley and I have combined to make out a case of "The Queen *v.* Mackintosh." I differ from them both. A friend of mine, accustomed to the aiguilles and horns of the Alps, remarked that our hills looked like great heaps of rubbish shot out of a cart; and "a distinguished personage" once said to me with characteristic vehemence—"The whole of Cumberland is one vast *rôche moutonnée.*"

Is not this the result we should expect from a thick sheet of ice moving across the whole country, leaving its marks in boulders and glaciated rocks near the Tarns of Busco at a height of 2,300 feet, in scratches across the water-shed between Grasmere and Loughrigg Tarn, in boulders on Silver How, in scratches across the water-sheds of Kentmere and Long Sleddale, and finally, as Mr. Croll suggests, in the erratics of Stainmoor?

If, as the climate grew warmer, this sheet of ice shrank into glaciers of the Alpine type, should we not then have such scratchings and roundings as we find in the bottoms and along the sides of the dales?

These scratches in the valleys would then be more recent than those across the water-sheds.

I do not understand how the want of parallelism in some of the scratches is any bar to our supposing them to be the product of land-ice. When two ice-currents meet, the stronger will deflect the course of the weaker; and if its strength vary ever so little, according to the season, so also will the direction of the scratches.

Let not Mr. Mackintosh say:

"Proveniebant oratores novi, stulti adolescentuli."

I speak only of what I have seen in the last three years in the valleys reaching from Little Langdale to Long Sleddale, and in the Green Slate area. The rest of his paper I leave to those who know the country he treats of.

GEOLOGICAL SURVEY, GRASMERE, GEO. HYDE WOLLASTON.
16*th February*, 1861.

THE SUPPOSED THERMAL SPRINGS IN CAMBRIDGESHIRE.

SIR,—The explanation which the Rev. O. Fisher suggests as to the cause of the heated water in the fen wells, to which I called attention at Liverpool, is that which, when I first heard of the circumstance, occurred to my own mind.

I am quite disposed to accept it, if it can be made to square with the facts, as I confess I am unable satisfactorily to explain the matter, but it did not seem to me at the time to do so, nor does it now, for the following reasons:—

Well No. 1 appears to have been sunk through 5 or 6 feet of peat, then 1½ foot of clay; the water coming from a seam of sand beneath the clay; the heat of the water being 69° on March 14th last, while that of the air was 39°.

At the adjoining farmyard, half a mile distant, Well No. 2 is supplied from the surface water, and this showed on my visit no such abnormal temperature; but at the next farm, half a mile beyond, where Well No. 3 pierces the clay, I found again the water to be heated.

If the heat were caused by the decomposition of manure (or of the peat), one would suppose that the water nearest the surface would show the highest temperature—the contrary being the case.

At another farmyard, Well No. 4 shows water of only about 50° Far., but I was informed by the proprietor that a short time since an Abyssinian tube-well was put down temporarily, and at a few feet greater depth it brought up heated water.

Well No. 5, the water from which I found to be of 71½° of temperature on March 14th, and 79¾° on June 2nd, that of the air being at the same time 39° and 70° respectively, is sunk through gravel, and the water from it is so pure that it is used for drinking purposes.

Beside this, I am informed that the phenomenon has been observed continuously for years, not only in winter, when the yards are full of stock, but in summer, when they are unoccupied.

Several samples of water have been analyzed by Mr. Francis Sutton, F.C.S., and he can find nothing whatever to support the hypothesis that the heat results from chemical decomposition.

I feel with Mr. Fisher the difficulties of any other than a chemical explanation, but I have called attention to the phenomenon because I think there is a *primâ facie* case for further investigation.

Heigham Grove, Norwich,
February 15*th*, 1871.

F. W. Harmer.

MISCELLANEOUS.

Student's Elements of Geology. By Sir Charles Lyell, Bart., F.R.S., 8vo. pp. 624. 1871. (London: John Murray.)

It may be of use to the readers of this work to learn that owing to a "shift in printing," which happened during the production of the copies first issued, certain passages in pages 452 to 454, are rendered difficult of comprehension. The bottom line of p. 452 should be at the top of p. 451; the bottom line of p. 453 at the top of p. 452; the top line of p. 454 at the top of p. 453. This error is corrected in the later copies, and those who possess the faulty volume can obtain the four pages properly corrected on application to Mr. Murray, 50, Albemarle-street. They can also procure at the same time a short list of errata, which have been lately printed, and in which the most important correction is the substitution of the word "magnesia" for that of "lime" in the last line but one of p. 485.

Thos Davidson F.R.S.

Engraved by J. Brown, from a Photograph by Mayall.

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GEOLOGICAL MAGAZINE.

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EMINENT LIVING GEOLOGISTS.

Sketch of the Scientific Life of Thomas Davidson, F.R.S.

(With a Portrait.)

THERE are but few men who, having passed many of the best years of their lives in almost constant retirement, have achieved so vast an amount of solid and lasting work, have attained to so high a position amongst their fellow-workers, and the award of whose numerous and well-merited honours has caused greater satisfaction among his scientific brethren than Thomas Davidson, Esq., of Muirhouse, F.R.S., F.G.S., Vice-President of the Palæontographical Society; Member of the Geological Societies of France, Edinburgh, and Glasgow; Member étranger de l'Institut des Provinces, France, and Linnean Society of Normandy; Imperial Mineralogical Society of St. Petersburg and of the Imperial Society of Naturalists of Moscow; Royal Academies of Belgium and of Bavaria; Société Royale Hollandaise des Sciences, Haarlem; Royal Society of Liège; Academy of St. Louis; American Philosophical Society, Philadelphia; Zoological Society of Vienna; Palæontological Society of Belgium; Hon. Member of the Geologists' Association, the Dudley and Midland Geological and Scientific Society, etc.

He was born in Edinburgh 17th of May, 1817, and his parents possessed considerable landed property in the county of Midlothian.

At six years of age he was taken to the Continent, and with the exception of occasional visits to Scotland was entirely educated in France, Switzerland, and Italy, under the direction of French and Italian tutors.

At eleven years of age (it would appear) he had already evinced a marked predilection for the study of Natural History, as well as for that of the fine arts, and consequently every effort was made by his parents in order to secure for him the great advantages which Paris affords to the scientific and artistic student. During five or six years young Davidson followed the classes of Cordier, Elie de Beaumont, Constant Prevost, Dufrenoy, Geoffroy Saint Hilaire, Dumeril, Valenciennes, de Blainville, Milne Edwards, Audouin, Brongniart, Pouillet, Baron Thénard, and other great masters in science; these admirable lectures being delivered free of charge to those who attend them, at the Sorbonne, Jardin des Plantes, E'cole des Mines, and College de France, the French Government defraying all expenses.

In 1832 the study of Sir Charles Lyell's "Principles of Geology," as well as the intimacy which had sprung up between Constant Prevost and Davidson, led the latter to bestow greater attention upon the sciences of geology and palæontology, so much so that at fifteen years of age he had already, under the guidance of Constant Prevost, explored the larger portion of the Basin of Paris, and formed a remarkably good collection of its rocks and fossils.

In 1835 Davidson matriculated at the University of Edinburgh, followed the lectures of Prof. Jamieson, and the chemical class of Dr. Reed; he also accompanied and assisted Mr. R. Cunninghame in his geological survey of the three Lothians.

In the winter of 1836 he returned to the Continent, and, hammer in hand, and chiefly on foot, explored a large portion of France, Belgium, Switzerland, Germany and Italy.

Soon after 1837 Mr. Davidson became acquainted with Baron von Buch, and was strongly urged by that distinguished Prussian geologist to undertake a minute and searching study of the recent and fossil Brachiopoda, and especially so as that important division of the Invertebrata was then very little understood. He likewise pointed out to him the great advantages geology might reap from a successful elaboration of the class. Davidson therefore set to work in good earnest, and gradually assembled all that might tend to elucidate their characters, classification, history, and their geological and geographical distribution. From 1837 to 1870 he has devoted all his powers (and without any pecuniary reward) to advance that portion of palæontology, as well as to stimulate researches upon the same subject by others.

Mr. Davidson also indulged to a considerable extent his taste for the fine arts, and was during four years an attentive and favoured pupil of Paul Delaroche. He exhibited a cartoon at Westminster Hall, and pictures at different exhibitions. He studied also for two years at the École des Beaux Arts, and there received instruction from Horace Vernet and other distinguished French Academicians. Indeed, he was urgently solicited by Paul Delaroche and others to abandon the pursuit of science, and to give himself up entirely to the art of painting, and with that intention spent the winter of 1841 in Rome; but the early implanted love for scientific researches at last predominated, and he subsequently made use of his knowledge of drawing as a most important auxiliary to his scientific labours.

In 1846 and 1847 Mr. Davidson devoted much time to a careful examination of a large portion of Sir R. Murchison's Silurian District, and after a short sojourn in Paris in 1848 (having been present at the Revolutions of 1830 and 1848) he was requested by Professors E. Forbes, J. Morris, S. P. Woodward, and Dr. Bowerbank to prepare a monograph of British fossil Brachiopoda for the Palæontographical Society. The publication of the first portion of that monograph was commenced in 1850, and terminated in 1870. The work is composed of three thick quarto volumes, and is illustrated with 171 plates, drawn upon stone by his own hands. The labour in connexion with this work has been enormous, necessitating much field as well as cabinet labour, but the undertaking was so favourably viewed, both at home and abroad, that he received every possible encouragement and assistance from every person to whom he had occasion to apply, so that the number of specimens that passed through his hands for examination during the last thirty or more years has been perfectly surprising. It became necessary in 1853 that he should propose a new classification for the entire group, and this part of the work soon went through a French and German edition. His general introduction was revised by himself, and translated into French and German by M. E. Deslongchamps and his son, and by Dr. Suess and Count Marshall, of Vienna; Prof. Owen, Dr. Carpenter, and Sir R. Murchison likewise kindly contributed chapters to the book.

During the period employed in the preparation of his English work Davidson's attention was continually directed to the study of the recent and of foreign fossil species, as it was necessary to institute a comparison between those found in other parts of the world and those that occur in Great Britain, and likewise to ascertain what was the geological and geographical distribution of the whole group. The study of the soft parts of the animal was also carefully prosecuted. Some of the results of these investigations have been contributed to the Quarterly Journal of the Geological Society, the Bulletin de la Société Geologique de France, the Annals and Mag. of Nat. Hist., the Geologist and GEOLOGICAL MAGAZINE, the London Geological Journal, Proc. of Linnean Soc. of Normandy, Zool. Soc. of London, Transactions of the Geological Society of Glasgow and Royal Society of Liège, etc.

In 1858 Mr. Davidson was elected one of the Honorary Secretaries of the Geological Society of London.

On the 17th of February, 1865, Mr. Davidson received from the Council of the Geological Society the Wollaston Gold Medal, and on the 25th of September, 1868, Sir R. Murchison presented him with a Silurian Medal (Survey) for his "Illustrations and History of Silurian Life."

In December, 1870, Mr. Davidson was awarded the Gold Medal of the Royal Society in recognition of his valuable contributions to Palæontology.

At the Anniversary Meeting of the Palæontographical Society (March 31st) this year, the Council of that Society presented to Mr. Davidson a copy of his magnificent work on British Fossil Brachiopoda, handsomely bound, as a small expression of their high estimation of his valuable and protracted labours for the promotion of the objects of the Society.

List of Mr. Davidson's published works.

1. British Fossil Brachiopoda. 3 volumes in quarto. 1258 pages. 171 plates. 1850–1871.
2. Remarks on some Species of Brachiopoda. London Geol. Journal, 1847. 8 pages. 1 plate.

3. Observations on some Wenlock Limestone Brachiopoda, with descriptions of several New species. London Geol. Journal, 1847. 14 pages. 2 plates.
4. Plate representing four specimens of *Hypanthocrinites granulosus* (Lewis). London Geol. Journal, 1847. 1 plate.
5. Descriptions of some Species of Brachiopoda (in conjunction with Prof. Morris). Annals and Mag. of Nat. Hist. 2nd series. 1847. 9 pages. 2 plates.
6. Mémoire sur les Brachiopodes du Système Silurien Supérieur de l'Angleterre. Bull. Soc. Geol. de France. vol. v., 2nd series, 1848. 30 pages. 2 plates.
7. Réponse aux observations faites par M. Deshayes dans la Seance du 8 May, 1848. 5 pages.
8. Note sur le *Magas pumilus* (Sow.), in conjunction with Mr. Bouchard. Bull. Soc. Geol. de France. vol. v., 2nd series. 1848. 8 pages. 1 plate.
9. Observations sur quelques Brachiopodes Siluriens. Bull. Soc. Geol. de France. vol. vi., 2nd series, 1849. 4 pages.
10. Note sur quelques éspèces de *Leptæna* du Lias et du Marlstone de France et d'Angleterre. Bull. Soc. Geol. de France. 2nd series, vol. vi., 1849. 4 pages.
11. Mémoire sur quleques Brachiopodes Nouveaux ou peu connus. Bull. Soc. Geol. de France. vol. viii., p. 62, 1849. 13 pages. 1 plate.
12. Notes on an Examination of Lamarck's Species of Fossil Terebratulæ, and on the Internal Structure of *T. pectunculoides*, etc. Annals and Mag. of Nat. Hist. 2nd series, vol. v., 1850. 22 pages. 3 plates.
13. Notes and descriptions of a few Brachiopoda, including a Monograph of French Liassic Spirifers. Annals and Mag. of Nat. Hist. 2nd series, vol. ix., 1852. 19 pages. 3 plates.
14. Sketch of a Classification of recent Brachiopoda, based upon internal organisation. Annals and Mag. of Nat. Hist. 2nd series, vol. ix., 1852. 17 pages, and numerous woodcuts.
15. On some recent species of Brachiopoda. Proc. of the Zool. Soc. of London, 1852. 9 pages. 1 plate.
16. Lettre sur la Classification des Brachiopodes. Bull. Soc. Geol. de France. 2nd series, vol. x., 1853. 4 pages.
17. Sur les *Obolus* Anglais. Bull. Soc. Geol. de France. vol. x., 1853. 2 pages.
18. On some Fossil Brachiopoda of the Devonian Age from China. Quarterly Journal Geol. Soc., vol. ix. 1853. 7 pages. 1 plate.
19. Observations on the *Chonetes comoides*. Quarterly Journal Geol. Soc., vol. x., p. 202. 1854. 5 pages. 1 quarto plate.
20. Lettre sur la distribution Géologique des Brachiopodes vivants, Tertiaires, Crétacées et Jurassiques des Iles Britanniques. Bull. Soc. Geol. de France. 2nd series. vol. xi. 1854. 14 pages.
21. A few remarks on the Brachiopoda, etc. Annals and Mag. of Nat. Hist. 1855. 17 pages. 1 plate.
22. Revised French Edition of his General Introduction (translated by M. Deslongchamps). 200 pages. 9 quarto plates. 1856.
23. Revised German Edition of his General Introduction (translated by Dr. Suess and Count Marshall). Vienna, 1856. 160 pages. 5 plates. Quarto.
24. Notes sur les genres *Athyris*, *Camarophoria*, *Orthesina* et *Strophomena*, des terrains Permiens de l'Angleterre. Bull. Soc. Linn., of Normandy, vol. ii. 1857. 12 pages. 2 plates.
25. On the genera and sub-genera of Brachiopoda that are provided with spiral appendages, etc. 23 pages. 1 folio plate. The Geologist, 1858. This paper was translated into French by D. L. de Koninck, and published in the Proc. of the Royal Soc. of Liège for 1859.
26. On the families Strophomenidæ and Productidæ. The Geologist, 1859. 21 pages. 2 quarto plates.
27. On *Spirifer convolutus* (Phil.). The Geologist, 1859. 3 pages. 1 woodcut.
28. A Monograph of Scottish Carboniferous Brachiopoda. The Geologist for 1859 and 1860. 80 pages. 5 quarto plates.
29. On British Carboniferous Brachiopoda. The Geologist, 1861. 19 pages.
30. On Recent Brachiopoda. Annals and Mag. of Nat. Hist., 1861. 16 pages.
31. Carboniferous Brachiopoda of the Punjaub. Quarterly Journa Geol. Soc., 1861. 11 pages. 2 quarto plates.
32. Palæontological Notes on Scottish Jurassic and Cretaceous Brachiopoda. 1862. 5 pages. 1 plate.

33. Résumé du Tom. 2 de mon Ouvrage sur les Brachiopodes des Iles Britanniques. Bull. Soc. Geol. de France. 2nd series, vol. xix., 1862. 18 pages.
34. On the Lower Carboniferous Brachiopoda of Nova Scotia. Quarterly Journal Geol. Soc., 1863. 16 pages. 1 plate.
35. On recent and Tertiary Species of the genus *Thecidium*. Geol. Mag., 1864. 10 pages. 2 plates.
36. On Maltese Tertiary Brachiopoda. Annals and Mag. of Nat. Hist., 1864. 10 pages. 1 plate.
37. Notes on the Carboniferous and Jurassic Brachiopoda collected in the North-Western Himalayas, Thibet, and Cashmere. Quarterly Journal Geol. Soc., vol. xxii. 1866. 10 pages. 2 plates.
38. On the Brachiopoda from the Carboniferous Limestone and Shales of the County of Cork, in the Museum of the Geological Survey of Ireland. Description of sheet 192 of the Map of Ireland. 1866. 4 pages.
39. Notes on recent Brachiopoda from Jamaica, etc. Proc. Zool. Soc., 1866. 3 pages. 1 plate.
40. On the Genus *Syringothyris*. Geol. Mag., 1867. 5 pages. 1 plate.
41. On *Terebratula venosa*. Annals and Mag. of Nat. Hist., 1867. 3 pages, and woodcut.
42. On the Earliest Forms of British Palæozoic Brachiopoda. Geol. Mag., 1868. 14 pages. 2 plates.
43. On the Upper Silurian Brachiopoda from the Pentland Hills, etc. Trans. Geol. Soc. of Glasgow. Pal. series. 1868. 21 pages. 3 quarto plates.
44. Notes on Continental Geology. Geol. Mag. for April, May, June, and July, 1869. 38 pages.
45. Note on the Age of the Rocks containing *Ter. viator* or *Diphya*. Quart. Journ. Geol. Soc., vol. xxv. 1869. 3 pages.
46. Notes on Recent Mediterranean Brachiopoda. Annals and Mag. of Nat. Hist., 1869. 3 pages.
47. Notes on the Brachiopoda hitherto obtained from the Pebble Bed of Budleigh-Salterton. Abstract printed in Proc. of the Brit. Assoc. for 1869. The entire paper in the Quarterly Journal Geol. Soc., vol. xxvi., 1870. 19 pages. 3 plates.
48. On Italian Tertiary Brachiopoda. Geol. Mag., 1870. 27 pages. 5 plates.
49. On Japanese recent Brachiopoda (ready for press), with 2 plates. 1871.

Note.—So that he has published up to this date some 2220 pages and 244 plates!

ORIGINAL ARTICLES.

I.—Remarks upon Inversions of Carboniferous Strata in Somersetshire.

By Horace B. Woodward, F.G.S., of the Geological Survey of England.

During the past few years Mr. Charles Moore and Mr. J. McMurtrie[1] have called attention to a remarkable inversion of strata, which was indicated by the working of coal under the Mountain Limestone near Vobster, on the north of the Mendip Hills. And this fact renders necessary an important modification in the geological sections of the district.

This inverted structure seems generally to be attributed to a

[1] C. Moore, Geol. Mag. for July, 1866, p. 331, and Quart. Journ. Geol. Soc., vol. xxiii., 1867, p. 453. In the latter publication, referring to his interesting discovery of a trap dyke, near Stoke Lane, on the Mendip Hills, Mr. Moore remarks that, by its protrusion, the Old Red Sandstone and Carboniferous rocks have been carried forward in a northerly direction, and are not only left standing vertically, but

folding-over of the main ridge or anticlinal of the Mendip range, but no one, so far as I am aware, has been bold enough to represent the idea in diagram.

The subject is to a great extent theoretical,—the facts connected with it are not sufficient to render possible a definite solution of it,—but the strata are so remarkably disturbed, that it could hardly be otherwise. I have for some time been puzzled to draw a section that would satisfactorily account for the phenomena, and being led to differ from the prevalent notion, I venture to publish one, which I think will explain the general structure of the district. Or, perhaps, by exciting discussion, it may be the means of eliciting further information, and of thus obtaining more correct information upon the subject.

At Luckington and Vobster, near Coleford, three patches of Mountain Limestone appear in the midst of the Coal-measures. When originally mapped by the officers of the Geological Survey,[1] they were considered to be due to upheaval, bosses of the rock being represented in their Horizontal Sections as thrust up through the Coal-measures.[2] With the facts then observed, this was the safest theory to adopt, but now that coal has been worked beneath the Limestone a different theory is necessary to account for their position, and an inversion of some sort must be the correct explanation.

Inversions of strata are by no means new features in this district. In 1824 Messrs. Buckland and Conybeare pointed out that in the Nettlebridge Valley the coal-strata are sometimes in a vertical position, for at Pitcot a shaft was sunk in one bed of coal to a depth of eighty fathoms, while towards Mells they noticed the strata to be actually inverted, and occasionally so disturbed that at Vobster the same bed of coal was thrice passed through in a shaft.[3]

In reference to this subject, by far the most important contributions are those of Mr. McMurtrie.

In his paper on the "Faults and Contortions of the Somersetshire Coal-field," he mentions the folded and contorted strata of the Nettlebridge Valley, and he remarks that the amount of confusion

are in some instances folded over upon themselves. In illustration of this he mentions the working of coal beneath the Mountain Limestone of Luckington.

J. McMurtrie, "Faults and Contortions of the Somersetshire Coal-field," a paper read before the Bath Nat. Hist. and Antiq. Field Club, 24th Feb., 1869.

Mr. S. W. Brice, in his "Essay on the Coal-field of North Somersetshire," 1867, mentions that at Vobster branches have been driven right under the Mountain Limestone in search of coal. And he suggests that when the Mendip range was considerably higher than it is now, masses of the Limestone might easily have been dislocated from their parent rock, and have rolled down a species of inclined plane into the positions they now occupy.

[1] Two of these, the one at Luckington and the other at Upper Vobster, were laid down on the Geological Survey Map, sheet 19. During a re-survey of the ground, Mr. W. A. E. Ussher has carefully traced out the boundaries of the three. They were very accurately laid down by Mr. W. Sanders, F.R.S., in his "Map of the Bristol Coal Fields, and country adjacent," 1864.

[2] A similar section was given by Buckland and Conybeare. Trans. Geol. Soc., series 2, vol. i.

[3] Trans. Geol. Soc., series 2, vol. i., p. 255. See also Conybeare and Phillips, "Geology of England and Wales," 1822, p. 428.

which the Coal-strata present is such as to baffle description.[1] From Holcombe to Mells the beds are inverted, and dip to the south at various angles, and he states that "at Nettlebridge every yard of the ground has been proved, and the gradation traced from the point at which the true northern inclination exists to where the abnormal southern inclination shows itself." From this he infers that the same disturbance which folded the Coal-measures back upon themselves carried with them masses of Limestone, of which the patches in question are traces.

He does not, however, attempt to explain this in the section he gives, merely drawing a patch of Limestone resting unconformably upon the inverted Coal-measures.

In attempting to account for these vestiges of Limestone, two theories suggest themselves. One, to which allusion has been made, is that the Mendip anticlinal was so folded over to the north as to bring the Mountain Limestone above the Coal-measures. But a serious difficulty at once presents itself. What has become of the Millstone Grit, which should occur between the two? No trace of this has been observed around any one of the three patches of Limestone.[2] The Grit is present in its regular position, but a mile off, thoroughly conformable, as there is a gradual passage between it and the Mountain Limestone below, and between it and the Coal-measures above.[3] The thought occurs that it might have thinned out. That probably the area in which it was deposited was shallowing, and that this is not to be accounted for by increase of sediment alone, but must have been aided by elevation. That the elevation being of unequal intensity over the whole area, the Mountain Limestone might be raised above the sea-level in places, leaving the Grit to be deposited in patches. Afterwards the Coal-measures would entirely cover it, and overlap in places so as to rest directly upon the Mountain Limestone.[4]

But this is not a happy thought; there is no evidence whatever to support a notion that any portion of the Mendip area was above water whilst the Millstone Grit was in process of formation. Again, the Millstone Grit near Coleford has been estimated (by Mr. McMurtrie) to have a thickness of 500 feet; therefore, it could not well have thinned out in so short a distance. And it is no doubt persistent along the Mendip Hills, although the greater portion of it is concealed by the Keuper Marls and Conglomerates. It is

[1] It has been remarked that the disturbances in the Somersetshire Coal-field furnish "our nearest approach in Great Britain to the abrupt foldings which are so remarkable in the Coal-field of Belgium." (W. W. Smyth, etc.)

[2] And Mr. McMurtrie kindly informed me in a letter dated March 8th, 1870, that so far as he was aware the Millstone Grit has never been detected between the Limestone and the Coal-measures at Luckington and Vobster.

[3] This gradual passage is clearly shown in Vertical Sections (sheets 11 and 12) published by the Geological Survey of England. Indeed, it is well known that from the Old Red Sandstone to the Coal-measures in this area, there is no physical break whatever.

[4] On this subject, see also the remarks of Professor Ramsay, Mem. Geol. Survey, vol. i., p. 312.

exposed from Mells to near Ashwick; it was probably reached in a boring at Chewton Mendip;[1] Mr. Sanders has noticed a trace of it near Compton Martin;[2] and in the summer of 1869, I mapped traces of it near Wells, on the southern slope of the Mendips, where, however, it had previously been observed by Mr. Williams, of the Geological Survey. Being unaware of this at the time, I was much pleased to find my work corroborated.[3]

Having come to the conclusion that the Millstone Grit has not died out, we have still to account for its absence, and the aid of faults must be invoked in order to get rid of it.

But are there any facts to show that the main ridge of Mendip was folded over? Now, although the Coal-strata present every variety of disturbance, this is decidedly not the case with the Mountain Limestone and Old Red Sandstone. On the northern side of the Mendips they attain a much higher general inclination than on the southern side, and in one locality (near Stoke Lane) Mr. Sanders has observed the Limestone in a vertical position. But never, so far as I am aware, has it been noticed to be inverted along the borders of the Nettlebridge Valley, the average dip being between 60° and 70° in a northerly direction.[4]

The Coal-measures must not be taken as affording a type of the amount of disturbance which the district has suffered—the whole series of rocks would be bent and folded, but whilst under pressure the Mountain Limestone and Old Red Sandstone would be hard and unyielding, the coal-shales would be squeezed up and contorted in all manner of ways, as, indeed, they are now found.[5]

Mr. McMurtrie remarks that the "New Rock series," being chiefly composed of strong sandstones, does not present so much distortion as the other beds in the Coal-measures.

There seems to be no evidence in favour of the theory that the Mendip anticlinal was folded over, and the facts observed are against such a notion.

By introducing a fold further to the north, and by calling faults to our assistance, the position of these Limestone masses may, I think, be satisfactorily accounted for—and without resorting to any form of structure which is not already known in the Mendip area.

The accompanying section shows my attempt to explain the general structure.

[1] McMurtrie—Lecture on the Carboniferous Strata of Somersetshire, 1868, p. 14.

[2] Map of the Bristol Coal Fields, etc.

[3] De la Beche, Mem. Geol. Survey, vol. i., 1846, p. 413.

[4] *Vide* Sanders' Map. The only locality where anything like an inversion has been observed, is by the road-side at Churchill Batch, at the western edge of the Mendip range. Proceeding along the high road in a northerly direction, the Mountain Limestone is seen dipping at a high angle to the north, then it becomes vertical, and a little further on the beds dip to the south. The whole is seen clearly in one section, and it forms an excellent example of "fan-shaped" structure. This was originally noticed by Buckland and Conybeare, who regarded it as a sharp synclinal. Mr. McMurtrie admits that the Mountain Limestone has not as a rule been folded back, regarding the Vobster patches as exceptions.

[5] I find that the same idea is expressed by Conybeare and Phillips, *op. cit.*, pp. 347 and 360.

DIAGRAM-SECTION TO ILLUSTRATE MR. HORACE B. WOODWARD'S PAPER ON THE INVERSION OF CARBONIFEROUS STRATA, SOMERSETSHIRE.

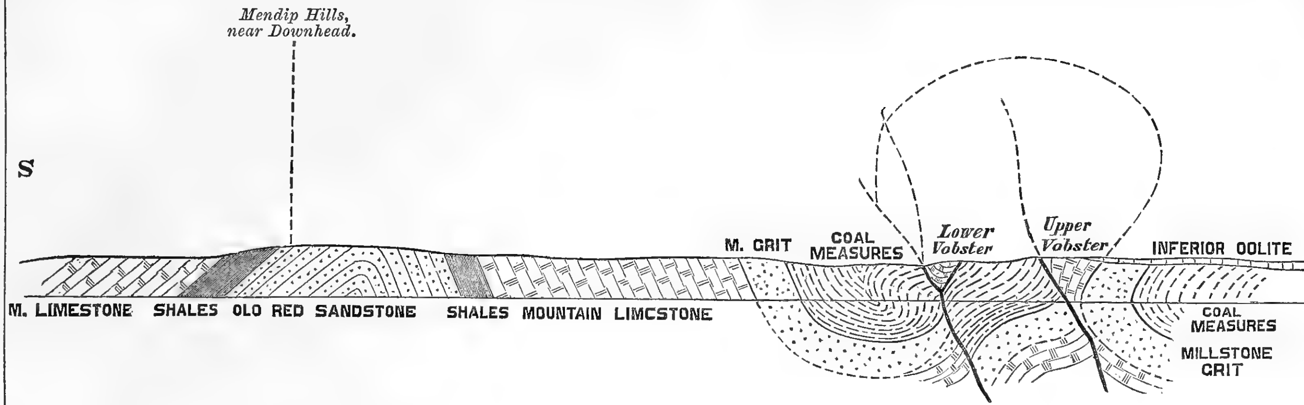


DIAGRAM-SECTION TO EXPLAIN THE OCCURRENCE OF MOUNTAIN LIMESTONE AT UPPER AND LOWER VOBSTER, SOMERSET.

Scale about two inches to one mile.

The relative thicknesses of the formations, and their general dip, have of course received attention.

The fan-shaped anticlinal would have exerted sufficient force to produce any amount of contortion in the Coal-measure shales; the twisted beds to the south and the inverted strata on the north are well accounted for. The beds of course would not have stretched across the entire distance represented by the dotted line; great rents and fractures must have occurred, and while the beds, as is well known, were very much faulted, there is not much difficulty in imagining the little patch of Limestone at Lower Vobster to be the relic of a mass faulted into such a position—along with the Coal-measures which have been let down between the masses of Limestone.[1]

In regard to the origin of the Limestone at Luckington, a similar and probable continuation of the same disturbance would account for it. As "reversed" faulting has been introduced, it should be mentioned that cases of this are not uncommon in the Mendip area. In the last volume of the Geological Magazine attention was re-directed to a reversed fault at Uphill, near Weston-super-Mare, while in the Radstock Coal-field there are numerous "overlap faults," as they are termed, where seams of coal have been forced over one another, so that pits sunk on the spot pass twice through the same seams.[2]

The Millstone Grit has been inserted conformable to the Mountain Limestone on its northern side at Upper Vobster. This is purely hypothetical, for the surface is obscured by a covering of Inferior Oolite. As the beds are known to be inverted to the north, the Grit might very well come in between the Coal-measures and the Mountain Limestone. The explanation at any rate is as satisfactory as one that would cut it off again with the aid of another fault.

And now as regards the plan: two at least of the patches must be surrounded by faults. But considering the great disturbances to which the beds have been subjected, the dislocations must have been very numerous. Faults are known to be common; on the original theory the bosses of Limestone were surrounded by faults; therefore one need not be scrupulous about retaining them.

Of several varieties of structure I have drawn, the one now given appears to me the most satisfactory. The problem is as full of difficulty as it is of interest. It seems to me that the isolated patches of Limestone could not have been thrown over from the main anticlinal; the explanation I have drawn seems to accord with the known facts. And here I leave it, in the hopes that it may tend, in some degree, to the elucidation of the phenomena.

[1] This is the kind of structure so characteristic of the Alps—as noticed by Studer, Desor, Lory, and others.

[2] G. C. Greenwell, "Notes on the Coal-field of East Somerset." Trans. North of England Inst. of Mining Engineers, vol. ii., 1854, p. 255.

Greenwell and McMurtrie, "On the Radstock portion of the Somersetshire Coal-field." 1864. p. 17.

McMurtrie, "Faults and Contortions," etc.

The faults in the Somersetshire Coal-field are worthy of much study from their variety and remarkable characters. Mr. McMurtrie mentions an instance of beds thinning out towards a fault, a fact that may sometimes be noticed in the Lias where it is similarly affected.

II.—Æolian Drift or Blowing Sand, Ireland.

By G. H. Kinahan, M.R.I.A., etc., etc.

In many parts of the world large accumulations of blowing sand exist, either on the sea-board or inland. When inland it usually is composed for the most part of silicious particles; but when in the neighbourhood of the sea, it is more or less mixed with shells, corals, etc.; moreover, it may merge into *shell-sand,* a highly calcareous Drift, formed of the débris of shells, coral, madrepore, and other marine organic remains.

Accumulations of Æolian Drift, such as the sands of the Sahara, seem to be of marine origin, being old sea basins, while others may be due to meteoric abrasion, frost, heat, wind, etc. disintegrating finely arenaceous and other rocks, and thereby forming sands;[1] nevertheless other accumulations seem to be glacier-formed. These quartziferous Æolian sands in Ireland are locally known as *Blowing sand* or *Rabbit sand,* and large deposits occur in various places, being most conspicuous when found near the sea, where they form dreary, undulating, ever-changing wastes.

On a casual examination, these sands would appear to be of recent formation, containing as they do numerous recent land and marine shells, and as is often the case in places overlying recent peat-bogs. These facts, nevertheless, may not prove their age, and undoubtedly not their origin. The wind, more especially in exposed situations, drifts them, on account of their loose and frail nature, hither and thither, by which means they may submerge peat-bogs, and as they are a favourite resort for all kinds of land snails, every gust of wind must bury hundreds of the latter. Moreover, if they are on the sea-board, during low water thousands of marine shells will be blown up among them, as may be seen by any observer who, braving the cutting shower of sand, traverses them during a gale of wind.

As they are ever changing their position, it is evident that they have only recently assumed the forms we now find; however, their origin may not be so very recent, and that they are as old as the *Moraine drift* would seem to be suggested by the position in which they are found.[2] They seem only to occur at or in the vicinity of the mouths of valleys, and the larger and more extensive the valley the greater the accumulation. Moreover, in all these valleys there appear to have been at one time systems of glacier. Thus on the west coast they occur north of the mouth of the Killaries, the fiord that divides the Counties of Mayo and Galway; also a little south of the Killaries at the mouth of the valley of the Culfin river; on Omey Island and the mainland thereabouts, being immediately north and south of the mouth of the fiord called Streamstown Bay; further southward, north and south of the mouth of Mannin Bay. There are large deposits in the neighbourhood of Slyne Head, on the Aran Islands,

[1] Agassiz and others have noted vast thicknesses of Meteoric Drift in parts of Brazil.

[2] Only localities of which the writer has personal knowledge are mentioned in these notes.

and a little south of Black Head, which places are respectively north, opposite and south of the mouth of Galway Bay; south of the mouth of the Shannon; also towards the east end of Dingle Bay, in the neighbourhood of Castlemaine Harbour, at the mouth of the Larne River; at Valentia Harbour, on Beginish and the mainland, at the mouth of the valley of the Cahersiveen River; also at Ballinskelligs Bay, north of the mouth of the valley of the River Inny. The foregoing localities are on the sea-board, but deposits will also occur inland, as, for instance, large accumulations of "Rabbit sand" are found banked against the south slopes of the Clare hills, that lie north-west of the town of Limerick, being north of the mouth of the valley of the Shannon; also in the neighbourhood of Killonan, a station on the Limerick and Waterford Railway, opposite Glencoloo, the valley that separates Slieve Kimalta from the Silvermines hill; and in the neighbourhood of Birdhill and Kilmastulla, opposite the valley that divides the Silvermines hill form the Arra mountains.

As all these deposits of Æolian Drift occur near the mouth of some valley, is it not possible, if not probable, that their original formation had some connexion with the different valleys? That glaciers once flowed respectively down each of these valleys would seem to be suggested by the ice etching, grooving and polishing, which have been observed in nearly all of them,[1] and as rivers flowing from glaciers are described by various observers as being "turbid and white," from the silt in suspension, or, to quote Principal Dawson, "The glaciers are mills for grinding and triturating rocks. . . . The fine material which has been produced, the flour of the mill, so to speak, becomes diffused in the water which is constantly flowing from beneath the glacier, and for this reason all the streams flowing from glaciers are turbid with whitish sand and mud." From this might not a solution of the problem be found for the formation of all these large *Blowing sand* deposits? As they may possibly be the "flour of the mill," or in plain words the glacier-formed silt, at or in the neighbourhood of the mouths of the valleys down which glacial rivers once flowed.

Against this suggestion it may be urged, that the silt carried down by a river ought to have been carried out to form a deep sea deposit. This may be true to a certain extent, and from personal experience I cannot say what occurs at the mouths of the present glacial rivers; a nearly similar action however is at present at work on the Allihies River that empties itself into Ballydonegan Bay, County Cork, and from the facts there to be studied, it would appear that some at least of the sand will remain at or near the mouths of such rivers. On the Allihies River are situated the stamps, dressing floors, etc., of the Bearhaven Copper Mines, and its waters night and day are white and turbid with the washings from the floors and mills; where goes on artificially a similar grinding process to that which naturally exists

[1] The tracks of ancient glaciers are quite conspicuous in the valleys in Yar-connaught, and those of Kerry mentioned above. Of the other valleys the author cannot speak personally.

in a glacier. Here the silt, instead of being carried out to sea, has been heaped on the beach, changing what formerly was a coarse shingle into a deep fine sand. Moreover, if report speaks true, when the crafts for shipping the ore first frequented the bay, it had a rocky bottom devoid of anchorage, while now it is sandy; and hereafter, if perchance the sea-bottom were elevated, there would be a deposit of blowing sand, liable to be carried hither and thither by the winds, and formed into sand-dunes and hillocks, the characteristic features of these sand deposits.

Off the east coast of Ireland, in various places, are large sand banks. Two of them occur near the mouth of the River Liffey, and are called the north and south Bulls, and others will be found off the coast between Dublin and Wexford, the largest being the Kish and Arklow Banks. The valley of the Liffey must have received the waters from all the glaciers that occupied the valleys on the north and north-west slopes of the Dublin and Wicklow hills, while the several sand-banks off the coast of Wicklow and Wexford[1] seem to be connected with the different valleys on the east and south of those mountains. Thus the Kish Bank is partly opposite the Liffey valley and partly opposite the valley of the Bray River; while the banks between Bray and Wicklow seem each to be connected with small river valleys, the largest being the valley of the Vartry, that empties itself into the sea at the town of Wicklow. The Arklow Bank is opposite to the valley of the Avoca River, which extends northward from Arklow by Rathdrum into the heart of the Wicklow mountains; while the banks and sand-hills in the neighbourhood of Wexford Harbour, are in the vicinity of the mouth of the valley of the River Slaney.

The writer of these notes, when he had completed the examination of the country north of the mouth of the Shannon, believed that the large accumulation of Æolian Drift, banked against the south slopes of the hills there situated, was of recent origin, being at the present day in course of formation. To this belief he was led by those hills, for the most part, being composed of a friable sandstone that apparently disintegrated freely. Therefore he considered that the rain-wash had been, and still was, carrying the sand from the hill-tops to the south slopes, quite forgetting that the sand would not stop there, but be carried on to the plain below. Since then additional experience has proved to him that his reasonings were unstable, more especially when on the slopes of similarly circumstanced hills, such as those of Slieve Aughta, at the junction of the Counties Clare and Galway, which for the most part are composed of exactly similar rocks, he found no banks of these peculiar sands.[2] Moreover, he observed that similar sands seem only to occur at, or opposite to, or in the vicinity of the mouths of valleys, and the larger and more extensive the valley the greater the accumulation. From these circumstances

[1] There are sand deposits on the sea-board, but as the writer is not thoroughly acquainted with them, they are not mentioned in these notes.

[2] I do not mean to assert that none of the sand was formed recently by meteoric action, but I now believe the mass of it is glacier-formed.

he was led to believe he must look to other causes besides the present meteoric abrasion. Since accumulations of sand occur at or in the vicinity of all the valleys of Yar-connaught that open towards the west; and as in each of them there is palpable evidence that glaciers once flowed down them towards the west, he cannot but be inclined to believe that these sands originally owed their origin to glaciers. That similar accumulations do not always exist at or near the mouths of the valleys in that country which open eastward—seems due to their glaciers being feeders of the glacier of the Lough Corrib valley, which itself was a branch of the glacier that flowed down the valley now occupied by the waters of Galway Bay; however, at the mouth of some of these valleys they do exist, and are described in the Memoirs of the Geological Survey of Ireland (sheets 95 and 105). Furthermore, his belief is strengthened when he considers that all the accumulations of this kind of sand in Ireland, with which he is intimately acquainted, both at or near the sea-board, and inland, have similar relations to valleys in which, if he has not observed the traces of glaciers, yet it is not only possible but also highly probable, that they once existed. Since the glacial period, on account of the loose and frail nature of the Æolian sand, they have been a prey to the caprice of the wind or other moving forces, and have been drifted hither and thither, and their real relations to the more recent deposits obliterated.[1]

III.—On the Pre-Glacial Geography of Northern Cheshire.

By C. E. de Rance, F.G.S., of the Geological Survey of England and Wales.

BETWEEN the mountains of North Wales and the sea, occur two terraces, an upper composed of Boulder-clay sloping towards the sea, and a lower, consisting of peat and alluvium, but little removed above high-water mark, running far inland, where broad valleys like the Vale of Clwyd breach the coast, and where rocky headlands jut into the sea, as the Great and Little Ormes Heads. The two terraces are almost entirely denuded away, but often the lower one has alone suffered, as between Penmaen Bach and Penmaen Mawr, where a bay in the rocks, so to speak, is filled up with Upper Boulder-clay. It is quite evident that before denudation of the coast took place, the peat plain had a far greater extension than at present, which is proved by the fact of the occurrence of peat and a submarine forest at Rhyl, in borings in the Dee, and around the whole coasts of Cheshire, Lancashire, and southern Cumberland. It is also evident that considerable denudation of Glacial beds had taken place before the period of the old forests, and that the seaward prolongations of these beds, which themselves rested on an old sea-bottom, had been denuded away, and that a great plain, or series of plains, formed much of what is now the Irish Sea, before the forests came into existence; the lower terrace now fringing the coasts

[1] These supposed glacier-formed sands must not be confounded with the accumulations of *shell sand* that are found in many places on the Irish sea-board, and often contain from 70 to 90 per cent. of calcareous matters.

being the landward edge of this plain. It is nowhere better seen than in the Birket plain, forming the northern portion of the Hundred of Wirral, in North Cheshire. It is bounded to the south by an old pre-Glacial cliff, which abruptly terminates the northerly prolongation of all the numerous longitudinal valleys running with the strike of the Triassic rocks, of which this district is composed, each valley having a steep escarpment facing the west, as described by Professor Hull[1] and myself.[2] To the east the continuity of this plain with the Mersey and with that surrounding Lancashire further to the north, is broken by a comparatively high tract of Triassic sandstones, rising like an island between the Mersey and the plain; to the north this tract is bounded by the sea, which is forming cliffs, and to the south its continuity is broken by a transverse gorge running across the strike of the strata, at the bottom of which flows to the east the tributary of the Mersey called Wallasey Pool. The western margin of the tract is above the plain, consisting of a natural escarpment, a continuation of that forming the eastern slope of a valley south of the Pool. On the side of the Mersey the eastern face of the tract is concealed by a bed of Glacial Drift, nearly seventy feet in thickness, forming a cliff of about that height; these deposits also fill up the bottom of Wallasey Pool gorge, and cover to a great extent the undulating plains stretching away from Liverpool towards Ormskirk, on the opposite side of the Mersey. The banks of the latter, on the north side, are sometimes composed of about twenty feet of rock, capped by Boulder-clay, but more often the latter comes down to high-water mark, and occasionally even far below, proving that the deepest line of the pre-Glacial valley did not precisely correspond in position to the present channel of the river. This, taken in conjunction with the fact that the bottom of the Wallasey gorge, as well as the rock floor of the Birket plain, is excavated far below high-water mark, the space being filled in with Boulder-clay, leaves little doubt that in pre-Glacial times the land stood at least thirty feet higher than at present. The breadth of the actual stream of the Mersey is inconsiderable compared with the present extent of its estuary, which is produced by the bottom of the old valley being submerged beneath the tidal level, but not until the Boulder Drifts had been re-excavated out by post-Glacial denudation, which, in the case of the Mersey, was chiefly fluviatile, but in the Birket plain was marine, the sea wearing back the Boulder-clay up to the old pre-Glacial east and west cliff, and also slightly cliffing the base of the natural escarpment, forming the western margin of what may be called the "Wallasey island." This Wallasey escarpment exhibits fine sections of the unconformable junction of the Keuper with the upper mottled sandstone, and was once continuous with that of Flaybrick Hill. These two form the eastern slope of an old longitudinal valley before the formation of the gorge, the western slope of which has been removed by that denudation which produced the Birket plain, and also destroyed the seaward prolongations of all the existing north and south valleys further to

[1] Explanation of Hor. Sec., Sheet 68. [2] Quar. Journ. Geol. Soc., Feb. 1871.

the westward towards the Dee, now abruptly cut short by the cliff forming the southern margin of the Birket plain and Wallasey Gorge. Before the formation of the former plain, and before the north and south valleys were deepened to their present extent, it is clear that the Mersey flowed westward over a plain, the level of which coincided with, or was but little above, that of the various escarpments occurring between the valleys. For when it first commenced to flow they were not in existence, and the streams which afterwards flowed in them could only deepen them in regard to the gradually decreasing level of the transverse gorge, which regulated the height of the outfall. Therefore, it is not improbable that when the river flowed over this old plain, that it extended far to the westward, until it abutted against the mountains of Wales, and that the hard and soft beds composing it were alike level—longitudinal valleys not being yet scooped out of the latter. For in all districts where these phenomena are observable the slope of the soft beds composing a longitudinal valley is towards the brook or stream, which runs at right angles to an escarpment, forming the landward side of it, and which, in cutting through escarpments lower down, forms transverse gorges, the upper termination of the slope corresponding to the level of the base of the escarpment. It is therefore clear that before the latter was formed these longitudinal slopes could have had no existence, and that their angle increased exactly in proportion to the height gained by the escarpment, or in other words to the descent of the level of the base. Therefore, there is reason to believe, that the various valleys south of the old high-level course of the Mersey did not extend indefinitely northwards, but fell into that river at points, opposite which entered similar streams, flowing from the north. The continuity of the old plain westwards was broken by the River Dee, which must have formed a broad valley, receiving the waters of the Mersey as a tributary, at a point opposite Mostyn; from thence, flowing northwards, far out into what is now the Irish Sea, and receiving the waters of the Clwyd. As the Mersey deepened its course, longitudinal valleys began to be formed by the wash of rain on the soft sandstone, and after a time the hard beds began to be left as escarpments, through which the river always cut a channel *before the soft beds behind* were removed by lateral wash, which could never work lower than the level of the outfall, the key to which was the transverse stream. Subsidence taking place, marine denudation went on, and the sea gradually approached the district, the valleys and hills to the west were shaved across, and the Birket low-level plain came into existence, at a level but slighly below that to which the longitudinal valleys had worn themselves; the Mersey flowed at the bottom of the Wallasey Pool gorge, and fell directly into the sea.

In historic times the Wallasey Pool was a main outlet of the Mersey, but at present it enters the sea by a broad valley between Liverpool and Egremont; but it would appear probable, as this is a longitudinal valley, with a fault at the bottom, lying north of the Wallasay Gorge, that in pre-Glacial times the stream that occupied it flowed south into the Mersey, and that on the deepening of the valleys, and the subsidence of the land, its seaward margin was exposed to marine denudation at the period of the formation of the Birket plain.

It therefore appears probable that in pre-Glacial times a plain of marine denudation composed of hard and soft beds of New Red Sandstone existed from the borders of Wales to south-western Lancashire,[1] unbroken by valleys, over which flowed the Dee to the north, receiving as a tributary from the east the Mersey, which gradually cut for itself a transverse gorge across the strike of the rocks; at the same time, longitudinal valleys to the north and to the south, gradually came into existence. Those to the north were afterwards entirely destroyed by Marine denudation, which formed a lower plain. The subsidence continuing and the climate becoming glacial, the district was submerged beneath the waters of the Glacial Sea, and the Gorge, or transverse valley, as well as the longitudinal valleys, were filled up with Glacial deposits. Afterwards, on the re-elevation of the country, these were excavated out, partly by running water, and partly perhaps by small glaciers which, as I have attempted to show elsewhere, undoubtedly held their ground, at the close of the Glacial epoch, in the valleys of the Lake-district. The entire valley of the Mersey, including its termination through the Wallasey Gorge, would be equally filled up with Drift; over this surface of Drift the river must have flowed, widening and deepening its channel as it ran, here making great cliffs of overhanging Boulder-clay, and there cutting through the Drift, down to the bare rock, and in some instances cutting its bed wider and deeper in the rock than it was before the Glacial submergence.

In the cliffs on the south side of the Mersey, near Eastham, the base of the Glacial Drift, resting on the rock, is more than twenty feet above the present base of the cliff, which is slightly below high-water mark. The river is now wearing this cliff back and back into the gradual slope of the old pre-Glacial valley, which appears to have had its deepest hollow near the opposite bank on the Lancashire side of the river; near the Otter's Pool the base of the Drift is rather below high-water mark, the rock only forming the strand between tide-marks. The rock-surface is also below high-water mark on the west coast of the peninsula, where the banks of the Dee are formed of Boulder-clay, more or less from Hoylake to Parkgate and Neston. Near Hoylake a submarine ridge of rocks occur, Bunter pebble-beds thrown up by a fault, culminating in Hilbre Island. Between the ridge and the Cheshire coast there is a channel, and from the ridge to the opposite coast of Wales the rock surface descends to a great depth, and the Glacial beds are much denuded, and are covered up by an immense thickness of alluvial silt resting on peat, the silt reaching, I believe, a thickness of 60 or 70 feet. It has been penetrated in boring for coal, which has been found to lie under the western side of the estuary of the Dee.

The bed of the Mersey from Runcorn Gap to the sea is excavated

[1] And of course much further, but in the above notes the country around the mouth of the Mersey is alone considered.

partly by tidal action, in the bottom of one of the old north and south longitudinal valleys, mentioned as occurring so frequently in Cheshire; on the emergence of the country it was re-excavated by the Mersey, which cut for itself a fresh channel in the Drift, in addition to excavating out the Wallasey Gorge, and cutting its present course between Egremont and Liverpool, which is daily becoming wider and wider, under the horizontal denuding power of tidal waters.

NOTICES OF MEMOIRS.

On the Nature of the Earth's Interior.[1]

By David Forbes, F.R.S., etc.

IN a previous discourse on Volcanos, Geological Magazine, 1870, Vol. VII., p. 314, attention was directed to the phenomena of volcanic action, specially considered in relation to the part which such igneous or internal forces have played in determining the grand features of the external configuration of the sphere upon which we live.

If, now, we follow up this subject still further, it will naturally lead to an inquiry into the nature of the internal substance of the globe itself, within which the foci of such agencies must be situated; but quite independent of this, there can be little doubt but that most intelligent persons have at some time or other already asked themselves the question as to what the central mass of the earth beneath them consisted of.

The answer which in the first instance would be most likely to suggest itself to the mind would be, that it consisted of solid stony matter, such as is seen forming the body of its mountains, the foundation of its continents, and the rock basins which contain its seas. The belief in such an hypothesis would, however, be rudely shaken by the first personal experience of the shock of an earthquake, the sight of a volcano in eruption, or the consideration of the immense faults which, in many places have disturbed and dislocated the solid land; whilst, so far from disposing us to regard the ground under us as entitled to the appellation of *terra firma* commonly employed by the ancients, the study of such phenomena could not but suggest grave doubts in our minds as to whether the earth, after all, could be anything like so solid and stable as at first sight we might have felt inclined to suppose it.

But very little inquiry into this subject is necessary, however, to convince any one of the great difficulties in the way of obtaining a satisfactory answer to this question, and to prove that in the present state of science we have not at our command sufficient data or evidence to enable us to arrive at any thoroughly conclusive solution of this most interesting problem.

As the rapid advances made by the natural sciences in all directions are, however, daily adding to our information bearing upon this subject, and thereby enabling previous deductions to be

[1] A lecture delivered in St. George's Hall, January 29, 1871.

modified or corrected, so as to lead to the formation of a more and more trustworthy opinion on the nature of those parts of our globe which, from their position, must always remain inaccessible to our powers of direct observation, it is imagined that a concise sketch of the present actual state of our knowledge concerning the probable constitution of the interior of the earth may prove interesting and instructive.

In treating this subject, we must first take into consideration what has already been done in the way of direct examination of the earth's substance in depth; yet, when it is remembered that the mean diameter of our planet is some 7912 miles, whilst the greatest depth hitherto attained by man's direct exploration has not even yet reached one mile from the surface downwards, the disproportion appears so enormous as to render it self-evident in the pursuit of this inquiry, especially as regards the more central portions of the earth, that we must in the main rely upon the less direct evidence furnished by calling in the assistance of the natural sciences.

The direct examination of the exterior of the earth, even when restricted to this depth, has, nevertheless, furnished us with many important data which can serve as a starting-point for this to a great degree speculative inquiry, and to some of these attention will now be directed.

It must in the first place be remembered that all the rocks which we encounter, and which compose so much of the solid exterior of our globe as is actually known to us, may be arranged under two principal heads, viz. the volcanic or endogenous, *i.e.*, those formed within the body of the earth itself, and the sedimentary or exogenous, *i.e.*, those rocks formed, or rather reconstructed, upon its surface out of the débris of previously existing rocks, arranged in beds or strata by the mechanical action of water.

It was until lately taken for granted by geologists, that the lowest sedimentary strata, in their normal, or in a more or less altered condition, rested directly upon granite, which was for a very long time regarded as the rock foundation upon which they, in the first instance, were deposited; this rock being then looked upon as the oldest of all, and even as representing the primeval or original surface covering of the earth. Later researches have, however, proved this hypothesis to be untenable, which is self-evident, since no instance of a granite has yet been met with in nature which, if followed up, does not at some point or other break through or disturb and alter, more or less, the stratified rocks in immediate contact with it, so that it naturally follows that such stratified rocks must have pre-existed on the spot, or in other words, that they must be older in geological chronology than the granite which came to disturb them.

In the present state of geological science, it is utterly impossible for us to point out any variety of rock whatever as the one which may have served as a foundation upon which the oldest sedimentary beds were originally deposited; in point of fact, the oldest rocks which we know at present are sedimentary rocks, mostly in an altered condition, belonging to the Laurentian series of Canada, and as yet geologists have not been able to discover what these sedimentary beds may in their turn rest upon, *i.e.*, what is actually beneath them.

Since we therefore have not as yet been able to reach down to examine directly any rocks lower in the geological series than those pertaining to the Laurentian formation, we will now turn to the Volcanos, in order to examine the mineral products which they bring up for our consideration, from depths vastly lower than those which we can ever hope to reach directly. What Volcanos teach us with regard to the nature of the Earth's interior at the depth from which they derive their supply of molten mineral matter, may be summarized as follows:—That at this depth, the earth's substance exists in a state of molten liquidity, forming as it were a sea of melted rock or lava, analogous in character to the eruptive rocks which have in former ages broken through the earth's crust; secondly, that the mineral products ejected by volcanos are very similar in chemical and mineral constitution, no matter from what part of the globe they may emanate; and lastly, that from the same volcanic orifice, and during the same eruption, lavas of two totally different classes may be emitted, viz. the light acid or trachytic lava, analogous to the granites, felsites, etc., of the oldest periods, and the heavy basic pyroxenic lava, all but identical with the dark basaltic or trappean rocks commonly met with, as dykes, etc., intersecting and disturbing most of the different sedimentary formations.

Besides these, another deduction from the study of volcanic phenomena, indicating that at a certain depth below the surface the volcanic vents must be in connexion with a continuous sea of molten lava, is based upon the influence which the moon appears to have on volcanic eruptions, an opinion which seems to have been confirmed by the observations by Professor Palmieri made during the last outburst of Vesuvius, on which occasion he reported that distinct tidal phenomena could be recognized, thereby indicating that the moon's attraction occasioned tides in the internal zone of molten lava similar to those it causes in the ocean. A further corroboration of this view is seen in the results of an examination of the records of some 7000 earthquake shocks which occurred in the first half of the present century, compiled by Perry, and which, according to him, demonstrate that earthquakes are more frequent in the conjunction and opposition of the moon than at other times; more so when the moon is near the earth than when it is distant, and also more frequent in the hour of its passage through the meridian.

Returning now to the more direct examination of the superficial parts of the earth, we find that the results of mining operations have also thrown considerable light, not only on the mineral nature of the rocks encountered in depth, but also upon some of their physical conditions. A numerous set of experiments made in deep mines in various parts of the world, far distant from one another, have most conclusively proved that the temperature of the earth, at least as deep down from the surface as has yet been explored by man, increases in direct ratio as we descend towards its centre. Other observations on the temperature of the water from deep-seated and hot springs, and from Artesian wells, fully confirm the experiments made in mines, and show that the temperature of the water furnished by them also becomes more elevated in proportion to the depth of the source from which it is derived.

As might naturally be expected, the interference of local circumstances renders it a matter of considerable difficulty to determine the true mean rate of such increase in temperature of the earth's substance downwards; still, in the main, observers all agree in placing it at somewhere between $1\frac{1}{2}°$ and $2\frac{1}{2}°$ Farenheit for every hundred feet in depth downwards, so that we shall not be far wrong if for our present object we estimate it at 2° Farenheit for every hundred feet, a rate which will be equivalent to 121° for each geographical mile nearer the earth's centre. Since no facts are at the present time known which can in any way invalidate the supposition that this or a somewhat similar rate of increase in temperature holds good at still greater depths, it appears to be perfectly correct and justifiable reasoning to assume that such is actually the case; whence it follows by a very simple calculation that, at a depth of about twenty-five geographical miles from the surface downwards, a temperature of about 3000° Farenheit should be attained, which would represent a heat at which iron melts, or one which is sufficient to keep lava in a state of perfect fusion at the surface of the earth. As it must be remembered, however, that at this depth the substance of the earth would be exposed to the pressure of the superincumbent mass, and as it has been demonstrated by experiment that many substances become more refractory, *i.e.*, require a greater heat to melt them or keep them in the molten state when exposed to pressure, the above calculation will have to be modified considerably in order to meet this condition of things. Unfortunately, we have not as yet sufficient data at command to enable us to settle the true ratio in which the melting points of rocks would become elevated by increased pressure; yet we may safely take it for granted, after allowing far more than the maximum rate of increase found in the experiments of Bunsen and Hopkins, that we should not require a distance as deep again in order to reach an internal temperature fully sufficient to keep such substances in a state of fusion, or in other words, to necessitate the inference that the solid rock crust of our earth cannot, at the utmost, be more than fifty miles in thickness.

If now we reason from the above data as our premises, it will follow as a natural consequence, that our globe must in reality be a sphere of molten matter surrounded by an external shell or crust of solid matter of very insignificant thickness when compared to the diameter of the entire globe itself, and that in point of fact this deduction represents exactly such a state of things as would be brought about in the event of a sphere of molten matter becoming consolidated on its exterior by the cooling action of the surrounding atmosphere; and the figure of the earth itself, which is an ellipsoid of revolution, *i.e.*, a sphere somewhat flattened at the poles, but bulging out at the equator, being that which a plastic mass revolving round its own axis would assume, is generally regarded by natural philosophers as all but conclusive evidence that the earth, at an early period of its history, must have been in a fluid condition.

Although the doctrine that the earth is a molten sphere surrounded by a thin crust of solid matter, was all but universally taught by geologists, there have of late years been brought forward several arguments to the contrary, which are apparently more in favour of its being a solid, or nearly solid mass throughout, and these arguments are fully entitled to our mature consideration. As our object is not to defend any particular theory, but to arrive as nearly as we can at the truth, we shall in the first place proceed to scrutinize all which has been brought forward in opposition to the older hypothesis of the earth's internal fluidity, and then to consider whether any other explanation as yet advanced may be more in accordance with the facts of the case.

First of all we have to answer the question as to whether it is possible for such a thin crust to remain solid, and not to become at once melted up and absorbed into the much greater mass of the molten matter beneath it. This would doubtless be the case if the central fluid mass had any means in itself of keeping up its high temperature independently of the amount of heat which it actually possessed when it originally assumed the form of an igneous globe. This question, however, in reality, answers itself in the negative, since it is self-evident that no crust could even commence to form upon the surface, unless the sphere itself was at the moment actually giving off more of its heat from its outer surface to the surrounding atmosphere than it could supply from its more central parts in order to keep the whole in a perfectly fluid condition, so that once such a crust, however thin, had formed upon the surface, it is self-evident that it could not again become melted up or re-absorbed into the fluid mass below.

The process of solidification due to external refrigeration would then continue going on, from the outside, inwards, until a thickness of crust had been attained sufficient to arrest or neutralize (owing to its bad conductibility of heat) both the cooling action of the surrounding air and the loss of more heat from the molten mass within, and thus a stage would soon be arrived at, where both these actions would so counterbalance one another, that the further cooling down of the earth would be all but arrested, a condition apparently ruling at the present time, since the surface of the earth at this moment, so far from receiving any or more than a minute amount of heat from the interior, appears to depend entirely, as regards its temperature, upon the heat which it receives from the sun's rays.

We have next to consider the argument, that if the earth's exterior was in reality only such a thin covering or crust like the shell of an egg, to which it has often been compared, that such a thickness would be altogether insufficient to give to it that stability which we know it to possess, and that it consequently could never sustain the enormous weight of its mountain ranges, such as, for example, the

Himalayas of Asia, or the Andes of America, which are, as it were, masses of heavy matter piled up high above its mean surface-level. At first sight this style of reasoning not only appears plausible, but even seems threatening to upset the entire hypothesis altogether; it requires, however, but little serious consideration to prove it to be more, so to say, sensational than actually founded upon the facts of the case; since it is only requisite for us to be able to form in our mind some tangible idea as to the relative proportions which the size of even the highest mountain bears to that of the entire globe, to convince us thoroughly, that if such a crust could once form and support itself, that it could with ease support the weight of the mountains also. This will be at once seen by a glance at the diagram before you, which represents, upon a scale of 200 miles to the inch, an imaginary section through the centre of the earth, whose mean diameter is taken at 7912 miles. The thickness of the earth's crust, supposing it to be, as before estimated, about 50 miles, is on this scale denoted by the black outer line or zone, only a $\frac{1}{4}$ of an inch in width, whilst on the top of this again are placed (coloured bright red) some little markings, scarcely amounting to more than a slight roughness on the outline of the circle, and which is quite impossible for any one to see, except upon very close inspection, since they at the highest part do not project more than $\frac{1}{35}$ of an inch above the circle itself; these markings, however, do upon this scale represent the actual comparative size of the great Himalaya chain of mountains, which rise to a maximum altitude of 31,860 feet, or six miles above the mean level of the sea. From this it will be readily perceived that if the earth could be seen reduced in scale down to about the size of an orange, that to all practical intents and purposes it would resemble to the eye an almost smooth ball, since even the highest mountains and deepest valleys upon its surface would not present to the eye greater inequalities in outline than the little pimples and hollows on the outside of the skin of an ordinary orange. A mere glance at such a diagram will therefore, I think, fully convince us that if this thin crust can support itself, it is not at all likely to be crushed in by the comparatively speaking insignificant weight of even our very highest mountain chains; in fact it would be quite as unreasonable to maintain such a supposition as to declare that the shell of a hen's egg would be crushed in by simply laying a peice of a similar eggshell upon its outside.

That a very thin spheroidal crust or shell, inclosing a body of liquid matter, such as an ordinary fowl's egg, does possess in itself an enormous degree of stability, and power to sustain pressure from without, is easily demonstrated experimentally, by merely loading a small portion of its surface with weights, as long as it does not give way under them. Even when placed upon its side (or least strong position), it was found that a portion of the shell of a fowl's egg, only one quarter of an inch square, could sustain several pounds' weight, without showing any symptoms of either cracking or crushing, or, in other words, this simple experiment indicates that if the external crust of the earth was only but as thick and strong in proportion as an eggshell, that it would be fully capable of sustaining masses of rock equal in size and weight to many Himalayas, piled up one atop of another, without any danger whatever to its stability.

For the sake of comparison, another diagram was prepared, which shows the actual proportions of the cross section of a fowl's egg, enlarged to the same size as the ideal section of the earth's mass previously alluded to; now as in this instance the crust of the earth was assumed to be some 50 miles thick, which is in the ratio of $\frac{1}{158}$ part of its entire diameter, it naturally follows that the crust would comparatively be considerably stronger in proportion than the shell of the egg in question, since this was found only to possess a thickness of $\frac{1}{200}$ part of its mean diameter (two inches), or in other words, if the earth's crust were proportionately as thick as the eggshell, it would be only 40 miles in thickness, which is one-fifth less than previously assumed.

The next argument which has been advanced against the probability of the major part of the earth's substance being in a fluid condition, is one based altogether upon astronomical considerations. It having been demonstrated that when two clocks are set agoing, the pendulums of which are similar to one another in all respects, except that whilst the bob of the one is solid, that of the other is hollow and filled with mercury, that the latter will swing somewhat faster, and consequently this clock gain time upon the former.

The late Mr. Hopkins, of Cambridge, applied this observation to the consideration of the movements of the earth in space, and by a very elaborate course of mathematical reasoning and calculation, demonstrated that the earth, if not quite solid, must be nearly so, since, according to his results, if the earth was merely a comparatively thin shell, filled with liquid matter, the ratio of certain of its movements (precession and nutation) would differ considerably from what they are actually known to be, and these conclusions appeared to be confirmed by the subsequent calculations of Sir William Thomson and Archdeacon Pratt.

Although grave doubts suggested themselves as to the correctness of the values used in these calculations for two of their most important elements, viz. the condensing action of pressure, and the expanding action of the very high temperatures within the globe itself, neither of which have as yet been determined with any certainty;—and although it might also be surmised that the conditions of a pendulum bob of polished glass filled with heavy slippery mercury swinging at the end of a rod must be very different from those of a nearly spherical globe filled with viscid sticky lava revolving on its own axis;—still geologists felt themselves quite unable to answer the arguments of the astronomers and mathematicians, and since none of them appeared to be sufficiently versed in either astronomy or mathematics as to be able to submit either the mode of reasoning or the calculations themselves to any strict scrutiny, they felt themselves, reluctantly no doubt, compelled to bow to the decision of such eminent authorities.

So stood the matter until the summer of 1868, when, fortunately for the advance of this inquiry, M. Delaunay, now Director of the Observatory of Paris, an authority equally eminent as a mathematician and astronomer, was induced to undertake the reconsideration of this problem; a labour which has not only resulted in his having altogether reversed the above decision by demonstrating the complete fallacy of the premises upon which so much elaborate reasoning had been based, but which proved conclusively by experiment that a sphere filled with liquid matter would, under circumstances such as are present in the case of the earth, behave in precisely the same manner as an entirely solid one, and consequently that the fact of the earth being either solid or liquid in its interior could neither have any influence whatsoever upon the rates of precession and nutation, nor be of any use as a means of deciding as to the real or approximate thickness of the earth's crust.

It may be remarked, however, that the conclusions arrived at by Mr. Hopkins, even when supported by Sir William Thomson and Archdeacon Pratt, were not universally acquiesced in; the celebrated German physicist Helmholtz for example, amongst others, was not satisfied as to their correctness; and in direct opposition to the deduction of Sir William Thomson that the earth's crust must be some 1000 miles in thickness, we have the conclusions of Mr. Henessy, whose calculations show that it cannot be more than 600 miles or less than 18 miles in thickness. We may conclude, therefore, that all the objections as yet advanced from an astronomical point of view against the theory of the fluid condition of the interior of our planet have been invalidated or explained away.

The only other argument in favour of internal solidity is one which bases itself upon the law announced, from purely theoretical considerations, by Professor Thomson in 1849, that the fusing points of bodies become more elevated when subjected to pressure, or in other words, that under the influence of pressure, bodies will require more heat to melt them or keep them in the molten state.

Starting from this, Bunsen argued that the earth could not be other than solid to the core, since, according to him, the enormous pressure accumulated at its centre would render its internal substance so infusible that it could not possibly remain in a molten state. To a certain extent this law was corroborated by the experimental researches of Bunsen and Hopkins made upon some of the very easily fusible substances, such as wax, spermaceti, parrafine, and sulphur; but later experiments did not appear to confirm it in the case of metallic substances, nor did it appear to hold true in other than the more compressible bodies.

In the case of the earth, therefore, the conclusions of Bunsen cannot be warranted or accepted, since we have to deal with materials to which this law has not as yet been even proved to apply; still, assuming, as seems most probable, that the materials composing the earth's mass do become to a certain extent more and more infusible, according as they approach nearer to its centre, it must on the other hand be remembered that this effect would be at the same time more or less neutralized by the expansion which these substances would undergo from the action of the earth's internal heat, since incontrovertible evidence has been produced to prove that the temperature of the earth increases in direct proportion to the depth; so that it seems most probable that the combined effects of expansion and heat would more than counteract any tendency to solidification due to the influence of pressure.

Having now taken into consideration the various objections which have at various times been urged against the theory of the earth's internal fluidity, as well as devoted some consideration to the opposing view of its solidity, it will be noticed, if we pass in review the more distinctive features of the two hypotheses, that the former theory is a legitimate deduction from the data afforded by the direct study of the earth itself, whereas the latter, on the contrary, instead of making the explanation of the earth's phenomena its starting-point, devotes itself all but exclusively to the task of proving that it could not be fluid. Thus, how is it possible, if the earth's mass be solid throughout, to account for the great upheavals and sinkings down of large portions of the rock formations which compose its external surface; do not these phenomena lead to the direct inference that the external crust cannot by any possibility rest in depth upon any unyielding mass of matter in a solid condition, but that it must necessarily be superposed upon some more or less fluid substance, which by its mobility can, when some one portion of the crust above it sinks down, become displaced, and so make room for it by elevating or as it were floating up some other part of the same?

In like manner the hypothesis that the earth is essentially solid necessitated that the phenomena of Volcanos should be explained upon the supposition that they had their sources in numerous small isolated basins of molten lava scattered over the surface of the globe, a view which is totally inconsistent with the results of chemical and mineralogical investigation, which proves that the ejected products are identical in constitution, even if taken from volcanic vents the most distant from one another; nor does such a theory attempt in any way to explain the tidal phenomena of volcanic outbursts and earthquakes previously referred to.

So far, therefore, as we have gone into this subject, we may regard the balance of evidence as indicating that at a depth of about fifty miles, or less, from the surface, there exists a continuous zone of molten rock or lava, such as is brought up to the surface in volcanic eruptions. Let us now consider how deep this zone or stratum of molten matter is likely to extend, and also what forms the more central mass of the earth below it.

In order to answer these questions, we must look for information to other than direct evidence, and first of all may inquire as to whether the consideration of the mean density, *i.e.*, expressed in other words, the actual weight of the entire earth itself, can throw any light upon these abstruse points. The consideration of the attraction which bodies exert upon one another in the ratio of their respective magnitudes has enabled the physicist to effect the at first thought apparently impracticable task of weighing the entire earth itself; it is, however, out of our province on the present occasion to describe the mode of doing so, and therefore we must content ourselves with accepting as facts the results of such investigations, which prove that the total weight of our planet is approximately five and a half times the weight of a similar globe of pure water.

Knowing thus that the mean density (or specific gravity, as it is also called) of the earth is $5\frac{1}{2}$, and also from direct experiment that the mean density of the entire solid matter or rocks forming its external crust, cannot be higher than about $2\frac{1}{2}$, or less than half that of the entire sphere, it naturally follows that the central parts must be infinitely more heavy than the surface, in order to account for so high a mean figure as $5\frac{1}{2}$; indeed, it has been calculated that if we suppose the earth is composed of three concentric portions, of equal thickness, and respectively increasing in density towards the centre in arithmetical progression, that we should have an outer crust of specific gravity of $2\frac{1}{2}$, like our ordinary rocks; an intermediate zone of specific gravity 12, or as heavy as quicksilver, and a central nucleus of about twenty times the density of water, or as heavy as gold.

This admitted increase in density has sometimes been erroneously represented as entirely due to the effects of the enormous pressure of the superincumbent mass, a supposition which is, however, quite untenable, since the tendency of all the numerous experiments made in this direction has been to prove that no substances exist which can be compressed or condensed to an indefinite extent, since what may be termed their approximative maximum density is soon obtained, beyond which point the effects of pressure become so much smaller in proportion to the extra force applied, that at last the further condensation effected by still greater pressure becomes all but inappreciable. Besides this, it must not be forgotten that the crust of the earth is a species of dome, like the shell of an egg, which can support itself without resting or floating upon its fluid contents, and further that the earth's high internal heat, by causing the materials which compose it to expand, must also counteract the effects of the superincumbent pressure; so that when all these facts are taken into due consideration, it appears evident that the materials which actually form the mass of the interior must be infinitely denser than any of the rock matter met with at the surface, and that they must also be of a metallic nature, since no other bodies are known which could at all fulfil these conditions of high density.

If, now, we imagine that the earth's interior be composed of a series of concentric zones or layers, made up of substances which are of more and more dense nature in proportion as they are situated nearer the centre, and also take for granted that the external one is rock of a density of $2\frac{1}{2}$, a calculation will show that the centre or nucleus will then be about specific gravity 10, or about as heavy as silver. Supposing now that the zone of molten lava, which we have already been led to conclude as existing at a depth of some 50 miles from the surface, has a density of 3, or say even 4, in order to make the fullest allowance for the condensing effects of superincumbent pressure, we should then find by calculation that this zone could not extend deeper than 400 miles, since below this depth the matter would be so heavy that its density can only be explained upon the supposition that it consists of metallic compounds, and as the density of the lower zones would still go on increasing up to the centre of the earth, the natural inference would be that the whole of the great central mass of our planet, situated at a distance of some 450 miles, or less, below the surface, is in reality formed of metals and their compounds.

Whether this great central metallic nucleus is solid or fluid may next be inquired into. According to Bunsen's theory previously alluded to, it ought to be solid, for, owing to the enormous pressure to which it would be exposed, the solidification of the molten sphere should first commence at the centre. This view would, no doubt, be quite correct if the earth were known to be composed of highly compressible non-metallic materials; but since this is not the case, and since, as before alluded to, the experimental data already obtained indicate that neither the metallic nor the less compressible substances become more refractory in proportion to the increase of pressure, we are at present, at least, more justified in assuming that this central nucleus must also be in a fluid condition, and the more so, not only because it is known that, as a rule, metallic compounds are much more fusible than rock silicates, but also as the well-known high temperature of the earth's interior would also, by its expanding action, tend to counteract the effects of the pressure.

In summing up the results of this inquiry, the balance of evidence appears to me to be decidedly in favour of the hypothesis that the interior of our earth is a mass of molten matter arranged in concentric zones according to their respective densities, and the whole inclosed within a comparatively thin external crust or shell, and that our globe consists of (1st) an external solid crust not exceeding fifty miles in thickness—the upper third or more of which consists chiefly of stratified sedimentary rocks which rest upon some, to us at present unknown, species of igneous rock, which at one period had formed the lower part of the primeval crust; (2ndly) below this again a zone or sheet of molten rock extending all round the sphere, and reaching to a depth not exceeding 400 miles below the solid crust; and (3rdly) a dense metallic nucleus, the outer part of which consists of the compounds of the metals with sulphur, arsenic, etc., whilst in the very centre we should expect metals in an uncombined condition, or alloyed with one another, to predominate.

Having now completed the task of giving a concise exposition of the present state of our knowledge respecting the nature of the interior of our planet, a few words may be added in conclusion by way of apology for introducing a scientific subject of so extremely speculative a nature. Although the first thing in science is to collect as many facts, *i.e. truths*, as possible, it is nevertheless absolutely necessary, in order to utilize these truths and not allow them to degenerate into a mere chaos of disconnected facts, to from time to time attempt their arrangement under some system or theory. If we could insure our possessing every single fact of the case, such a theory or system could not be other than the true one; for knowing all the facts, we should be able to correct it and test its accuracy. So long, however, as we have not arrived at such a desirable consummation, it must nevertheless be admitted that science may be benefitted by occasionally attempting—as in the present instance—to bring all the facts already obtained under some systematic hypothesis, even if this be regarded as but a temporary arrangement and subsequently found to require much modification in order to accommodate itself to the advances of our knowledge of the subject.

REVIEWS.

I.—SUN PICTURES OF ROCKY MOUNTAIN SCENERY; with a Description of the Geographical and Geological Features, and some account of the resources of the Great West; containing Thirty Photographic Views along the Line of the Pacific Railroad, from Omaha to Sacramento. By F. V. HAYDEN, M.D., U.S. Geologist, Professor of Mineralogy and Geology in the University of Pennsylvania. Quarto, pp. 158, with 30 full-page Photographs. (London: Trübner & Co., 8 and 60, Paternoster Row.)

THE construction of the Pacific Railroad led to the production of a series of fine photographic views by Mr. A. J. Russell, of New York, who spent more than two years along the line of road in the employ of the Union Pacific Railroad Company. From these photographs thirty have been chosen, mainly with a view to the illustration of some special feature of physical geography and geology, to which Dr. F. V. Hayden has contributed 158 pages of excellent descriptive text.

The district chosen for illustration in these sun pictures commences with the first range of mountains west of Cheyenne, and continues thence to Salt Lake City, thus serving as an illustrated guide to those who may desire to study those grand geological features which the Pacific Railroad opens to enterprising tourists.

Prior to the travels of Lewis and Clark in 1803 and 1804, it was supposed that the Rocky Mountains formed a single ridge, extending from north to south; or at least of one main range, with a few minor ranges. We now know that this name includes an almost limitless series of ranges of every variety of form. From the eastern slope westwards, we pass over range after range for a thousand miles or more, until we descend the western slope of the Coast Range to the Pacific Ocean.

Dr. Hayden shows us how the features of the country have been as it were developed. He points out that in proceeding westward from the Missouri or Mississippi rivers there is a gradual ascent. At first not more than one foot per mile, but steadily increasing until we reach the base of the mountains, where the ascent is fifty to 100 feet per mile. General G. M. Dodge, Engineer of the Union Pacific Railroad, has constructed a profile of the line, which well illustrates this point. Thus: From Omaha to Columbus, ninety-one miles to the west, we rise 488 feet, or more than five feet per mile. At Cheyenne, 426 miles from Columbus, we are 4,617 feet higher, having ascended a gradient of more than ten feet. In the succeeding thirty-three miles further west we have an ascending gradient of seventy feet to the mile.

The entire country west of the Mississippi may be divided into mountain and prairie. There are no large forests and very little timber, save that which skirts the small streams. Cotton wood, a few low oaks, with here and there an elm or ash, and belts of firs in the higher regions, alone relieve the monotony of undulating ridges and hills rising as far as the eye can see, like the waves of the sea after a storm. This combination of mountain and prairie may be said to comprise what is generally known as the Rocky Mountain region.

In this charming series of pictures we have all the highest merits of photography, and we also see how much more could be made of some of these wondrous scenes, by the addition of a little colour. Will the Sun ever be persuaded to paint his own pictures we wonder, perhaps he may some day, who knows?

Taking the photographs as they come, we find they divide themselves readily into—firstly: twelve superb geological studies, unequalled, so far as we are aware, for their grandeur. They are, plate ii., "Granite Rocks, Buford Station, Laramie Mountains." Here the granite is seen to be parted by a series of vertical and transverse joints, which, aided by weathering, has converted the mass into a series of gigantic tors, like those of Dartmoor and Cornwall. Plate iii., "Skull Rock (Granite) Sherman Station, Laramie Mountains," is like a cairn of rounded granitic blocks, each one as big as a cottage, suggesting the idea of some old giant's sepulchre. Plate v., "The Dial Rocks, Red Buttes, Laramie Plains," shows the effects of atmospheric weathering on rock masses composed of beds of unequal hardness, producing rock-columns, such as may be seen on the beach at Teignmouth; in this case, however, the agents employed have been the slow eating away of rain, frost, and wind. Plate ix. takes us in memory to the Sinaitic Peninsula, with its long flat-topped hills, its waterless valleys, bordered by eroded vertical cliffs with a vast talus of disintegrated rocks beneath, desolate and drear in the extreme. "Citadel Rock" and "Castle Rock," "Green River Valley," are magnificent outliers of rock, with perfectly horizontal bedding.

The "Conglomerate Peaks of Echo," the "Sentinel Rock Echo Cañon," and the "Hanging Rocks, Echo City," deserve more than a passing glance. Here we see beds of variegated sandstones and conglomerates, like our own Devonian Pebble and Boulder-beds, cemented together so compactly that frequently the softer underlying beds are weathered back, leaving the conglomerate to form a vast overhanging rock, as at Echo City.

Two striking photographs on the Weber River exhibit views of some remarkably weathered-out vertical beds of slaty limestones and marls, the former of which, at one point called the Devil's Slide, become massive beds, and, having resisted weathering more persistently than their neighbours, they now stand out on the hill-side like the huge ramparts of some old Cyclopean fortress.

Secondly: Artistic studies of mountain scenery. Under this head we would place "Moore's Lake (pl. i.), Head of Bear River, Uintah Mountains," a beautiful and wild little lake-scene, with borders of dark pines. Pl. vi., "Laramie Valley—from Sheephead Mountains," which, with its fertile tract bordering the stream, and its distant and desolate hills, might pass well for a view on the Jordan. Pl. vii., "Snow and Timber Line, Medicine Bow Mountains," is a fine piece of pine-forest with bare mountains beyond, very wild and lonesome to linger in. Pl. xiv., "Lake at the Head of Bear River, Uintah Mountains," is another wild and weird spot, unrelieved by a trace of humanity. Perhaps if we should choose the most exquisite photograph—that which a lover of mountain scenery and an artist might agree to admire for its beauty of composition and perfect harmoniousness of arrangement is pl. xxv., "The Wasatch Range of Rocky Mountains—from Brigham Young's Woollen Mills, Salt Lake Valley." Turning over these plates many times, we come back always to this exquisite piece of composition, which certainly deserves the first place of merit in the whole work.

We should like to make copious extracts from Dr. Hayden's admirable descriptions, and to speak of the engineering photographs and the sensation ones, such as the "thousand mile tree," etc., but space does not permit. We therefore heartily commend the book to the English public. Its novelty is not confined to its excellent illustrations of a country upon which but very few human eyes have yet looked; the text is nearly all published now for the first time, and written in a most pleasing and instructive manner. No library, aiming at securing the best books of the year, should be without it; and those who cannot individually afford to indulge in so grand a work for themselves, should recommend it for the public libraries to which they subscribe. We cannot but look upon Dr. Hayden's work as a great success.

II.—Palæontographical Society. Vol. XXIV.[1] Issued for 1870. January, 1871.

THIS volume, which well sustains the high character of the publications of this Society, contains:—

1. The Flora of the Carboniferous Strata. Part II. By E. W. Binney, F.R.S., F.G.S. pp. 33–62. Six plates.
2. The Cretaceous Echinodermata. Vol. I., Part IV. By Thomas Wright, M.D., F.R.S.E., F.G.S. pp. 137–160. Ten plates.
3. The British Fossil Brachiopoda. Part VII., No. IV. By Thomas Davidson, F.R.S., F.G.S., etc. pp. 249–397. Thirteen plates.
4. The Eocene Mollusca. Part IV., No. 3 (Bivalves). By S. V. Wood, F.G.S. pp. 137–182. Five plates.

[1] We noticed vol. xxiii. (issued for 1869) in the Geo. Mag., 1870, Vol. VII., pp. 97–100.

5. The Fossil Mammalia of the Mesozoic Formations. By Professor Owen, F.R.S., D.C.L., etc. pp. 115. Four plates.

1. In Part I. of the Flora of the Carboniferous Strata the author figured and described various stems belonging to the genus *Calamodendron* = *Calamites*.[1] "Before proceeding to describe the structure of more stems, it has been considered desirable," says Mr. Binney, "to bring before the public some specimens showing Organs of Fructification." In the present part, Mr. Binney figures and describes fruits of *Lepidodendron Harcourti*, *L. vasculare*; *Lepidostrobus Russellianus*, *L. dubius*, *L. tenuis*, *L. levidensis*, *L. Hibbertianus*, *L. ambiguus*, *L. Wuenschianus*, *L. latus*, and *Bowmanites Cambrensis*; this last-named form is evidently the same genus as the Calamite-fruit from the spathic iron-ore near Hattigen on the Ruhr, described by Rudolph Ludwig, and figured by us in the Geological Magazine, 1865, Vol. II., pp. 545 (compare also the figure on pl. 12 with the woodcut given in Geological Magazine, 1869, Vol. VI., pp. 294-5).

In his concluding remarks Mr. Binney says, "This Monograph no doubt the reader will have perceived was intended to be of a descriptive character, rather than an attempt to trace the analogy of those plants, the remains of which have formed our valuable beds of coal, with living vegetables. My endeavours have been to collect materials and give them to the public for botanists to work upon" (p. 60).

Notwithstanding this ingenuous statement, we cannot but regret that such a beautiful series of plates, as Mr. Binney has contributed, should be unaccompanied by carefully prepared botanical descriptions, based upon an acquaintance with living vegetable structures, feeling well assured that if palæozoic animal remains are capable of successful comparison with living forms, certainly vegetable structures may be so treated and with equal success.

2. Dr. Wright contributes descriptions of the remaining forms of *Cyphosoma*, and then proceeds with the family *Salenidæ* and the genus *Peltastes*. The ten plates by Mr. C. R. Bone, which illustrate Dr. Wright's Monograph, are fine specimens of this artist's work.

3. We heartily congratulate Mr. Davidson upon the completion of his labour of more than twenty years in illustrating and describing the species of British Fossil Brachiopoda for the Palæontographical Society. It is rarely that a scientific man is master of his own time, even should he be possessed of the other important requisites, of ability and perseverance, to carry on to its successful conclusion a labour so extensive. We cannot suppress a feeling almost akin to envy when we contemplate these three grand volumes of Brachiopoda now completed, as we ask ourselves the question, "Shall we have as goodly a book to show after twenty years?"

[1] See our remarks on *Calamodendron*, *Calamites*, etc. (Review Mon. Pal. Soc., vol. xxi.), Geol. Mag., 1868, Vol. V., p. 426.

In the Conclusion to his Silurian Monograph we find the following passage, which is well worthy to be recorded as evidencing the spirit in which this work has been carried on :—

"I should desire my readers," says Mr. Davidson, "to look upon this, as well as upon the whole series of my Monographs, as a bold outline sketch, and not as a finished picture, and as still demanding much labour and research, from many experienced hands, before it can be regarded by the scientific public as in any way approaching a complete work" (p. 345).

We can only hope that other authors may be able to write "Finis" to their Monographs with as clear a conscience on the score of completeness as our friend Mr. Davidson!

It is pleasant to know that we are not to lose his company in the future volumes of this Society, for he promises us, if his health permits, to add supplements to the Cretaceous and Jurassic Brachiopoda, for which a considerable quantity of materials has accumulated.

We should be very unmindful of our great obligations to the Honorary Secretary, the Rev. Thomas Wiltshire, M.A., F.G.S., did we omit to call attention to the fact that there is an admirable index to the Three Volumes of Brachiopoda, occupying forty-three pages, most carefully prepared by him, and giving, not only the page to each species, but a cross reference to every synonym referred to in the text of the entire work.

4. Mr. Searles V. Wood adds a third part to the Eocene Bivalves. Recollecting that the Palæontographical Society took its rise in the "London Clay Club," and that Mr. Searles Wood was one of its members, we cannot but rejoice to see so venerable an officer of the Society still actively contributing to its publications. The present Part contains figures and descriptions of the following genera, namely, *Verticordia, Cardita, Astarte, Woodia, Crassatella,* and *Chama.*

5. Professor Owen concludes this volume with a Monograph on the Fossil Mammals of the Mesozoic Rocks, the materials for which he has long been accmulating and the interest in which has by no means abated.

The first pages of this work are devoted to a consideration of the Rhætic Mammals of the genus *Microlestes,* in which the author places the detached tooth of *Hypsiprimnopsis rhæticus* discovered by Mr. Boyd-Dawkins at Watchet, Somerset, and also the remarkably rich series of detached teeth discovered by Mr. Charles Moore, F.G.S., of Bath, in a fissure of the Mountain Limestone at Holwell, Frome, Somersetshire. Then follow the Mammalia from the Stonesfield Slate of the genera *Amphitherium, Phascolotherium,* and *Stereognathus,* comprising four species.

The remainder of the work is occupied by the consideration and description of the Purbeck Mammalia, which (with the exception of *Spalacotheriuum tricuspidens,* Owen, discovered, in 1854, by Messrs. Wilcox and Brodie, of Swanage) were all brought to light through explorations carried on with characteristic ardour, and at much cost and personal risk, by Samuel H. Beckles, Esq., F.R.S. They occupy (with woodcuts) ninety-three pages of letter-press and nearly the whole of four plates. The descriptions of these early types of small Marsupial Mammals are founded almost entirely upon the evidence afforded by lower jaws, not more than half a dozen specimens being found in which the upper dental series are preserved, and no crania are as yet known. Above ten genera and twenty-five species have been determined from the Purbeck beds, Durdlestone Bay, Dorsetshire, and described by Professor Owen. The plates have been most carefully and successfully drawn by Mr. Alfred T. Hollick.

AMERICAN GEOLOGICAL SURVEYS.

III.—First Annual Report of the Geological Survey of Indiana, made during the year 1869, by E. T. Cox, State Geologist, assisted by Professor Frank H. Bradley, Dr. Rufus Haymond, and Dr. G. M. Levette. 8vo. pp. 240. Three maps and one sheet of sections. (Indianopolis, 1869.)

Although the result of little more than one year's work, this first report of Professor Cox contains a great amount of valuable information, and shows a zeal and earnestness of purpose that augurs well for the future.

The present volume contains reports upon Clay and Greene Counties, and the results of a reconnaissance made of Parke, Fountain, Warren, and Owen Counties by Professor Cox; and a report of Vermilion County, by Professor Bradley, etc.

As the Geological Survey is intended to include the entire State, attention is not confined to those counties in which coal and metalliferous ores are found, and those less favoured with mineral wealth are not neglected; one of these, Franklin County, has been surveyed and reported on by Dr. Haymond, and contains an account of the Physical Geology, the General Geology (including a description of the rock formations), Economic Geology (including the ores, building stones, and all the useful minerals), timber, mineral springs, Palæontology, water power, ancient earthworks, bones of Mastodon, and the soil and agriculture of the county.

In addition to the purely Geological Surveys and Reports, a great deal of valuable information on the Natural History of the State has been collected by Dr. G. M. Levette, who gives an interesting account of the various Mammals and Birds found in Franklin County at the present time.

The Report is accompanied by separate maps of Greene County, Clay County, and Vermilion County, upon which are clearly shown the outcrops of coals, the sites of actual workings, as well as where coal has been struck in borings or in well-sinkings; the positions of iron-ore, iron furnaces, stone quarries, etc. There is also a coloured section of the geological formations from Green Castle to Terre Haute constructed from outcrops and borings along the line of the Terre Haute and Indianopolis Railroad, upon which are shown the positions of the various coals (five in number) and strata, the latter comprising the Coal-measures, Millstone-grit, Sub-Carboniferous Limestone, Shale, and Sandstone; the Marcellus Shale, and Devonian and Upper Silurian Rocks, and also the levels at which springs of oil or of fresh, salt, and sulphur waters have been proved to occur.

The first object on commencing the Survey of the State was to acquire a more extended knowledge of the Brazil, or Iron-smelting Coal, about which much misconception appeared to prevail; the general impression being that this peculiar variety of coal, familiarly known as "Block Coal," or "Brazil Coal," was confined to a small basin, isolated from the great bituminous Coal-fields of Indiana and Illinois, and limited to an area of a few square miles. The Survey of Clay and Greene Counties, though confessedly not made so complete as desirable, has established the fact that splint or block coal has been traced from the southern limits of Greene County to Warren County on the north; and, also, that the area of the Indiana Coal-field may be stated at 6,500 square miles, or one-fifth the area of the entire State. According to Professor Cox, his investigations tend to prove that it is only around the edge or margin of the western Coal-basin that thick beds of Coal are to be looked for. Towards the central part of the basin, the Coal-beds which surround it are either altogether absent, or have dwindled down to seams that are only a few inches thick, their places being occupied by a preponderance of Argillaceous Shale, some Sandstone, and an occasional stratum of Limestone.

The great depository of limonite Iron-ore is at the base of the Millstone-grit, not only in Indiana, but likewise in Ohio, Kentucky, Tennessee, Illinois, Missouri, Arkansas, and the territory of New Mexico. In Clay county more or less Iron-ore is met with in the Shales all along the outcrop of the Millstone-grit, but as yet it has not been found in sufficient quantity to supply a blast furnace. The common horizon of Iron-ore in Greene County, as in most of the Western States of America, lies at the junction of the Conglomerate with the Sub-Carboniferous Limestone, filling pockets of various dimensions.

The duties of the State Geologist are sufficiently onerous, for besides conducting the purely Geological Survey, to make known the mineral resources of the State, the law places the State Geologist at the head of a geological and scientific department, for the purpose of collecting information designed to promote the interests of Agriculture, the Arts, Manufactures, and Mining. The State Geologist is also required to establish a laboratory at Indianopolis, fitted up with all necessary appliances for the analysis of such ores and substances as may be considered likely to be useful to the State; also, to form Geological and Natural History Collections, and to publish the results of his labours in the Annual Reports of the Indiana State Board of Agriculture. The analyses of Coals, Iron-ores and Slag, filling two pages (136 and 137), show that this part of the subject has not been neglected.

Although so recently instituted, the Survey has been attended by practical results, by drawing the attention of capitalists to the resources of the State, inducing large investments in Coal-lands, and the taking of decided steps for the erection of several new blast furnaces for smelting iron; also for the building of glass-works at Indianapolis, sand suitable for the manufacture of glass having been discovered by the Geological Department in various localities of the State.

From the information which has been furnished in this way to manufacturers, it is believed that the State has already been benefited more than ten-fold the cost of maintaining the Geological Survey.

(*To be continued in our next.*) H. W. B.

IV.—Geology.—By Professor John Morris, F.G.S., and Professor T. Rupert Jones, F.G.S. First Series. By Professor T. R. Jones, F.G.S. 8vo., pp. 84. (London: John Van Voorst.)

A FIRST instalment of this work, for which, by-the-bye, we have anxiously waited for a long time, was published at the close of last year. It is the work of Prof. Rupert Jones, and consists of Heads and Synopses of Lectures on Geology, Mineralogy, and Practical Geology, given at the Royal Military Staff and Cadet Colleges, Sandhurst.

The chief part of the little volume (pp. 58) is occupied by the Heads of Lectures delivered at the Royal Military College, between 1866-1870. There are three Synopses of Lectures occupying twelve pages, might not these have been amalgamated with advantage?

The volume is rather a Table of Contents to the forthcoming volumes, where, no doubt, each subject mentioned will be fully dwelt upon.

Teachers will find this book very handy in the arrangement of their lectures. There is much also that the student will find useful in preparing for an examination. Geological terms, the physical characters of rocks and minerals, are briefly explained. The chief points connected with Physical Geography and Palæontology are indicated, and the Table of the Geological Formations in the British Islands will be found very useful. The copious index, moreover, gives facility of reference. A list of geological books and papers would have been a valuable addition, some authors are indeed mentioned, but without references to their works.

REPORTS AND PROCEEDINGS.

ANNUAL GENERAL MEETING.

I.—Geological Society of London.—The Annual General Meeting of this Society was held on February 17th, 1871. Joseph Prestwich, Esq., F.R.S., President, in the Chair. The Secretary read the Reports of the Council, of the Library and Museum Committee, and of the Auditors. The general position of the Society, as shown by the state of its finances and the continued increase in the number of Fellows, was said to be very satisfactory.

In presenting the Wollaston Gold Medal to Prof. Ramsay, F.R.S., F.G.S., the President spoke as follows :—

Professor Ramsay,—I have great pleasure in presenting you with the Wollaston Medal, which has this year been awarded to you by the Council of the Society, in recognition of your many researches in practical and in theoretical geology. Distinguished as your services have been in connexion with the Geological Survey since you entered upon it as the Assistant Geologist of Sir Henry de la Beche in 1841, and more particularly since your appointment as Local Director in 1845, during which period you have superintended and carried out the admirably minute style of mapping now general on the Survey, and done so much in training its members in the field, you have not less distinguished yourself by your investigations of the higher problems involved in the study of geology. Your first work was on the Isle of Arran; and although then only a beginner, you, instead of taking the rocks to be what they looked, worked out what they were, and gave a new and independent reading of them, which has since in great part proved to be the right one. In 1846 your well-known memoir "On the Denudation of South Wales and the adjacent Counties of England" showed the enormous amount of denudation that the Palæozoic rocks had undergone before the deposition of the New Red Sandstone. At subsequent periods you dwelt on the power that produced "Plains of Marine Denudation," a term introduced, I believe, by yourself, and showed in all cases, by a series of true and beautiful sections, how this has operated in planing across the older strata, and how valleys had been scooped out by subsequent aqueous causes in the great plains so formed.

Whilst unravelling the complicated interior phenomena of the Welsh rocks, you were not unmindful of the very different order of phenomena exhibited on their exterior surfaces. Here you showed the vast extent and power of ice-action, and what a glacier land Wales once was. Reasoning from the present to the past, you also boldly pushed your ice-batteries far back into geological time, and were the first to bring them to bear on rocks of Permian age. That advanced post you long had to hold alone; but other geologists have since followed your lead, and we have even lately had evidence in the same direction from Southern Africa, where it is asserted that boulders and glaciated surfaces have been found at the base of the Karoo formation of supposed Jurassic age.

You have also held a prominent place among those who, by their public teaching, have done so much during the last twenty years to advance the cause of our science. To myself personally, whose geological career has run nearly parallel in time with your own, it is a source of much pleasure that it has fallen to my lot to hand you this the highest testimonial the Society has to bestow.

Prof. Ramsay made the following reply :—

Mr. President,—I cannot say whether I am more pleased or surprised by the unexpected award to me of the Wollaston Medal by the Council of this Society. Pleased I well may be, not because I ever worked for this or any other honour, but because I feel a sense of satisfaction that the work on which I have been engaged for the last thirty years has been esteemed by my friends and fellows of the Council of the Society so highly, that they have deemed me a fit recipient of this honour. It is also a special satisfaction to me that this award has been bestowed by the hand of one of my oldest geological friends, who is so universally esteemed and beloved, and is himself so distinguished a contributor to physical and other branches of our science.

My first endeavour in geology (the construction of a geological map and model of Arran) necessarily drew my attention to the physical part of our science; and when, consequent upon that work, I was, through the intervention of my old and constant friend, Sir Roderick Murchison, appointed by Sir Henry de la Beche to the Geological Survey of Great Britain, my whole subsequent life was thereafter necessarily involved in questions of physical geology, for no man can work on or conduct the field-work of such a Survey who does not, aided by palæontology, necessarily make that his first aim. If some of my theories, induced by that work, were long in being recognized, the recognition has been all the more welcome when it came. Probably I never should have been able to do what I have done but for the wise example of my old master Sir Henry himself, in his time the best thinker in England on the physical branch of our science, and to whose remarkable work, "Researches in Theoretical Geology," all geologists are to this day indebted.

The papers which I have written are mere offshoots from my heavier work on the Geological Survey. Perhaps they are enough for the readers; but I wish they had been more numerous, for I certainly have had many more in my mind. Two of these, on old physical geographies, I have lately given to the Society; and if they should be printed, I should be well pleased should they soon or late be found worthy. The present physical geography of the world is but the sequel of older physical geographies; and to make out the history of these is one of the ultimate aims of geology. These are the subjects I have striven to master in part. I consider your award as a sign that I have had some success; and if, before I cease to work, I have a little more, I may well be content.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Robert Etheridge, Esq., F.G.S. in aid of the publication of his great Stratigraphical Catalogue of British Fossils, and addressed him as follows:—

Mr. Etheridge,—The Council of the Society has awarded to you the Proceeds of the Wollaston Fund, to aid in prosecuting your valuable work on the Fossils of the British Islands, stratigraphically arranged. In this work, on which you have been engaged during the last eight years, and which occupies nine volumes of MS., representing as many geological groups, you give the natural-history lists of each group, and trace the history of each species both in time and space. Of the magnitude of the work few can have any idea, nor would many have an idea of the marvellous extent of past life in our small portion of the globe without a comparison of our recent fauna with those (necessarily incomplete because only partly accessible) which you have enumerated in your most useful lists. This comparison shows :—

	Polyzoa. Zoophyta. Echinodermata.	Crustacea.	Mollusca.	Fishes.	Reptilia.	Birds.	Mammalia.	Plants.	Total.
Number of Species in the existing fauna and flora of Great Britain.	616	278	567	263	15	354	76	1820	3989
Number of Species found fossil in Great Britain	2574	746	7091	815	224	12	172	819	12,453

I trust that this work will not be allowed to remain in MS.; and that, presuming you will begin with the oldest, we may soon look for an instalment in the fauna of the Palæozoic rocks. I have much pleasure in presenting you with this token of the importance which the Geological Society attaches to your labours.

Mr. Etheridge made the following reply :—

I have great satisfaction in receiving from you Sir, and the Council of the Geological Society, the award of the Wollaston Fund. It is given for work known to be nearly done, and faith in its completion. The time and labour devoted to my book upon the Stratigraphical Arrangement of the British Fossils has extended over nearly nine years of incessant work, and has been an arduous yet pleasant undertaking, now made lighter by the recognition of those who know and value the researches made for so extensive a catalogue of the British organic remains, now numbering nearly 13,000 species. It is this estimation of my labour by the Council and Society that tends to increase the desire to make my work as perfect as possible, well knowing how difficult, if not impossible, it is to do so. This acknowledgment, Sir, from your hands will stimulate me to finish my researches into the literature of the British species, and their history through space and time throughout Europe.

The President then proceeded to read his Anniversary Address, in which he discussed in considerable detail the bearing of the recent deep-sea dredging operations upon geological reasoning. The Address was prefaced by biographical notices of deceased Fellows, including Sir Proby Cautley, Sir Frederick Pollock, Mr. Robert Hutton, and Professor Gustav Bischoff.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year :—*President:* Joseph Prestwich, Esq., F.R.S. *Vice-Presidents:* Sir P. de M. G. Egerton, Bart., M.P., F.R.S.; Prof. T. H. Huxley, LL.D., F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; Prof. John Morris. *Secretaries:* John Evans, Esq., F.R.S.; David Forbes, Esq., F.R.S. *Foreign Secretary:* Prof. D. T. Ansted, M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, Esq., F.R.S. *Council:* Prof. D. T. Ansted, M.A., F.R.S.; W. B.

Carpenter, M.D., F.R.S.; William Carruthers, Esq., F.L.S.; W. Boyd Dawkins, Esq., M.A., F.R.S.; Prof. P. Martin Duncan, M.B., F.R.S.; Sir P. de M. G. Egerton, Bart., M.P., F.R.S.; John Evans, Esq., F.R.S., F.S.A.; David Forbes, Esq., F.R.S.; J. Wickham Flower, Esq.; Capt. Douglas Galton, C.B., F.R.S.; R. A. C. Godwin-Austen, Esq., F.R.S.; J. Whitaker Hulke, Esq., F.R.S.; Prof. T. H. Huxley, LL.D., F.R.S.; J. Gwyn Jeffreys, Esq., F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; C. J. A. Meyer, Esq.; Prof. John Morris; Joseph Prestwich, Esq., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S.; R. H. Scott, Esq., M.A., F.R.S.; Prof. J. Tennant, F.Z.S.; Rev. Thomas Wiltshire, M.A., F.R.A.S.; Henry Woodward, Esq., F.Z.S.

II.—Geological Society of London.—February 22, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read.

1. "On supposed Borings of Lithodomous Mollusca." By Sir W. C. Trevelyan, Bart., M.A., F.G.S.

The author referred to Mr. Mackintosh's paper on this subject (Quart. Journ. Geol. Soc. vol. xxv. p. 280), and stated his conviction, from examination of specimens, that the holes in question are the work of *Helices*, or other terrestrial Mollusca. He ascribed the same origin to the so-called "*Pholas*-borings" in the limestone at Orme's Head and elsewhere. He considered length of time to be a necessary element in the formation of these holes. The author also remarked that he had suggested a glacial origin for the terminal curvature of the laminæ of slate-rocks as early as 1849.

Discussion.—Mr. Gwyn Jeffreys read extracts from a work published by the Rev. Mr. Hodgson in 1827, on the Natural History of Northumberland, in which these borings in limestone were referred to the action of snails. Mr. Jeffreys considered the foot to be the sole instrument employed by the boring Mollusca in excavating their burrows. He exhibited specimens of Lias from Lyme Regis perforated by *Pholas*, and of hard limestone from Malta perforated by *Lithodomus*, and remarked, in connexion with the notion that asperities on the shell might be boring agents, that the shell of *Lithodomus* is perfectly smooth.

Professor Ramsay mentioned that he had seen *Helices* taken out of these holes at Tenby by Dr. Buckland, who believed that the snails effected the perforations by the agency of an acid.

Mr. Charlesworth thought that if so much uncertainty could prevail upon such a subject, it threw great doubt upon some of the grandest generalizations of geology. He referred to the evidence connected with the glaciation of the Great Orme's Head, in which the origin of the perforations under discussion was of much importance, Mr. Darbishire maintaining that they were the work of *Pholades*, while Mr. Bonney asserted that they were produced by snails. In the same way the origin of the celebrated borings in the Temple of Jupiter Serapis might be disputed, and the generalization founded upon it rendered doubtful. Mr. Charlesworth noticed the necessarily small proportion of borers to the whole snail population of Britain, and remarked especially upon the absence of perforations in the Chalk districts. He considered that repeated observations were necessary before this snail-engineering could be admitted, and suggested a systematic course of experiments.

Mr. Boyd Dawkins suggested that the carbonic acid exhaled by snails in respiration might act upon limestones, and remarked that chalk weathers too rapidly to preserve the excavations.

2. "On the probable Cause, Date, and Duration of the Glacial

Epoch of Geology." By Lieutenant-Colonel Drayson, R.A., F.R.A.S. Communicated by Alfred Tylor, Esq., F.G.S.

In this paper the author started from the fact that the pole of the ecliptic could not be the centre of polar motion, as the pole varied its distance from that centre. He indicated the curve which the pole did trace, and this curve was such as to give for the date 13,000 B.C. a climate very cold in winter, and very hot in summer for each hemisphere. The duration of the glacial epoch he fixed at about 16,000 years. The calculations resulting from this movement were stated to agree accurately with observation.

Discussion.—Professor Ramsay inquired whether the author's theory involved the recurrence of glacial epochs, and whether he considered the course of phenomena to be constant in early astronomical epochs.

Rev. Osmond Fisher inquired whether the theory was founded on observed facts, or whether it was a purely physical theory. He also asked whether the line representing the change in the direction of the pole formed a re-entering curve, and whether the theory would account for the climate of Greenland in Miocene times. He suggested changes in the form of the earth which must have affected the direction of its axis.

The President remarked upon the difficulty that arose from astronomical theories differing so much among themselves. He referred particularly to Adhémar's theory, and remarked that the difficulty connected with it is, that it invokes a recurrent cause, which must produce similar effects every 21,000 years, whilst there is very little evidence of glacial action during the whole long period of the Tertiary epoch.

The author, in reply, stated that he could not go back beyond 30,000 years, but that he thought glacial conditions must recur. He had not astronomical data beyond 2500 years, and these were very vague. The motion would be the same in kind, but uncertain in degree. His theory was based entirely upon observed facts. In laying down the curve, he considered it safe to go as far as the semicircle, as he had observations covering 40°; but he could not say whether the curve would be a re-entering one, although it showed a tendency that way, and would certainly be very nearly so. With regard to the change of climate of Greenland, as evidenced by its Miocene flora, he was not sufficiently versed in botany to pronounce an opinion. He remarked, in conclusion, that the distance of a planetary body from the sun did not seem to affect climate, and stated that Venus is at present suffering under a most severe glacial epoch.

3. "On Allophane and an allied Mineral found at Northampton." By W. D. Herman, Esq. Communicated by Warington W. Smyth, Esq., F.R.S., F.G.S.

In this paper the author gave analyses of an amorphous, translucent, reddish-yellow mineral, found incrusting sandstone in the Ironstones of the Northampton sands, the comparison of which with Mr. Northcote's analysis of allophane from Charlton leads him to infer the identity of the two minerals. He also noticed a soft white substance found in certain joints of a section of the Northampton sand, likewise referred to allophane by the late Dr. Berrell, who analyzed it. This substance was said to occur not unfrequently in the inferior Oolite of the Midland Counties. By analysis, it was shown to agree nearly with Samoite and Halloysite.

Discussion.—Mr. David Forbes stated that he had found phospheric acid in the first-mentioned mineral, which was perhaps the cause of its lustre. The mineral was probably not pure allophane.

Professor Morris suggested a chemical and microsocopical examination of the strata above the places in which these minerals occur, which would probably reveal the conditions under which they have been formed. They were probably produced by the decomposition of silicates in the overlying rocks during the percolation of water. This applied also to the Charlton locality.

Mr. Carruthers mentioned that allophane often fills the inflorescence of the Cycads of the Yorkshire Oolite, entirely destroying the vegetable structure, and that it also occurs in clay nodules from the Coal-measures. Mr. Carruthers suggested that the decomposition of vegetable matter in clays might aid in the production of the mineral.

4. "Notes on the Peat and underlying Beds observed in the construction of the Albert Dock, Hull." By J. C. Hawkshaw, Esq., M.A., F.G.S.

The Albert Dock is situated on the foreshore of the River Humber. The excavations for the dock extended over an area of about thirty acres, and they were carried down to a depth varying from eight feet to 27 feet below low water of spring-tides. Beneath the more modern deposits of Humber silt a bed of peat, Hessle Clay, Hessle Sand, and purple clay, were successively met with. The peat was found at the west end of the Dock at the level of low water; at the east end the bed dipped so that the upper surface was found at eight feet below the level of low water. In the peat were found the remains of a fire, which the writer attributed to human agency. Oak-trees of large size were imbedded in the peat, some of which had grown where they were found, as was shown by the stools remaining with the roots penetrating the Boulder-clay beneath. In one oak-tree, five feet in diameter, a hole was found filled with acorns and nuts. Many of the nuts were broken open at the ends, and had evidently formed part of the store of a squirrel. Remains of Coleoptera were found, and one horn-core of a *Bos*. The excavation did not extend below the upper parts of the purple clay. Some of the borings, however, penetrated the chalk at a depth of 85 feet below low-water level, passing through a bed of sand 16 feet thick below the purple clay. Several thousand cubic yards of this sand were brought up into the foundations by springs of water which flowed up through old bore-holes. The abstraction of this sand from beneath the clay-beds caused it to subside many feet. The writer thinks that analogous subsidences may take place from natural causes; for instance, where large springs occur in tidal rivers. Two sections exhibited showed the beds above the chalk for a distance of rather more than a mile along the foreshore. The Hessle sand was shown to thin out to the westward. It does not, in the writer's opinion, increase in thickness in that direction, as it was shown to do in a section already published in the Proceedings of the Society.

Discussion.—The President remarked upon the singularity of the occurrence of a bed of ashes at such a depth in these deposits.

Mr. Gwyn Jeffreys referred to the President's paper on the Kelsey Hill beds, and remarked on some of the Mollusca obtained by Mr. Hawkshaw.

Mr. Boyd Dawkins mentioned the occurrence of a submarine forest on the coast of Somersetshire, forming a layer of peat, beneath which was a land-surface, on which the forest had grown, and in which flint flakes were found at Portlock and Watchet on digging through the peat. He remarked on the depression of the coast of Somersetshire within the human period, and suggested that the forest at Hull may have been contemporaneous with that of Somersetshire.

Professor Morris inquired whether any trees or roots were found as when growing. The shells obtained were estuarine. Professor Morris remarked on a submerged forest near Whittlesey, with terrestrial plants and freshwater shells imbedded in the overlying clay.

The author, in reply, stated that the trees had fallen where they grew. The general appearance of things led him to the belief that the fire which had destroyed part of the forest was of human production.

Geologists' Association.—3rd March, 1871.—The Rev. Thomas Wiltshire, M.A., F.G.S., etc., President, in the Chair. Professor T. Rupert Jones, F.G.S., Honorary member of the Geologists' Association, read a paper "On the Range in Time of the Foraminifera." The paper was preceded by an interesting *viva voce* recapitulation of the more noticeable features of the *Porcellanous* (imperforate), the *Hyaline* (perforate), and the *Arenaceous*, Foraminifera, the more important genera of which groups were illustrated by a fine series of diagrams. The variations of form of the Foraminifera are innumerable, and it is extremely difficult to construct satisfactory species and genera. In a strict zoological sense, indeed, a Foraminiferal genus has but the value of a species of a higher class. The tables and lists of genera prepared by the Professor might therefore be compared with lists of species of the higher divisions of the animal kingdom. Of the Porcellanous group, *Miliola*, *Nubicularia* and *Cornuspira* appear to have the longest range, being found in Triassic and Rhætic strata, and living in our present seas. The Arenaceous are older, five genera occurring in Carboniferous formations. Of the Hyaline Foraminifera, seven genera are Palæozoic. *Fusulina*, *Stromatopora* and *Eozoon* appear to be essentially Palæozoic forms. The essentially abyssal genera are *Arbulina*, *Globigerina*, *Pullœnia*, and *Sphæroidina*, all Hyaline. The *Globigerina*, as is well known, being abundant both fossil in the Chalk and living in the bed of the Atlantic. Contrary to the general impression, there are very few forms common to the Atlantic ooze and the Chalk, and this leads the author to doubt some conclusions which have recently been drawn.

Professor Morris exhibited some of the Foraminiferal mud from the bottom of the Atlantic, and pointed out the important part the class has played in the formation of the globe, reminding the Association that *Eozoon* forms masses of rock covering a vast area in North America, that Russian Mountain Limestone is made up of *Fusulina*, that the Nummulitic Limestone, of which the Pyramids are built, is found over a very great extent of the earth's surface, and, as Lonsdale was the first to show, our world famous-chalk cliffs are chiefly composed of the remains of this curious group of the animal kingdom.

Professor Rupert Jones replied to the remarks of the President and several members, and took occasion to explain the method, by means of successive boilings and siftings, of obtaining fossil Foraminifera from clays.

At the next meeting of the Association on April the 4th, a paper will be read by Mr. Alfred Bell, "On the English Crags considered in reference to the Stratigraphical Divisions indicated by their Invertebrate Fauna."

Edinburgh Geological Society.—February 16th, 1871.—At the fourth Ordinary Meeting of this Society held this evening, the following communication was read:—"Notes on the Coal-fields at Falkirk, illustrated with drawings and specimens of *Antholithes* and its fruit, *Halonia* and other fossil plants from that locality." By C. W. Peach, A.L.S.

Abstract.—Mr. Peach stated that he went to Falkirk for a summer ramble amongst the Coal-measures there, having long wished for such an opportunity. His son, Mr. B. N. Peach, of the Geological Survey, pointed out where he should work, and at once he set to. He commenced amongst the black shales of No. 1 Station Pit, and at the brick work a little beyond. It was however at the Cleuch, near Glen Village—a little more than a mile from Falkirk—amongst the grey shales from Coxroad pit, that he spent the most time and got the best and most interesting fossils. He exhibited a diagram and pointed out the position of these places in order of sequence. The Miller Coal and Johnston's Oil shale, being the highest; the craw coal next; and then the splint coal of No. 1 Station Pit and the brick work; at the latter place there is a splendid section, and from its being worked "opencast," the Boulder-clay, shales and mussel-band, coals and sandstones, are laid open to daylight, and thus all the strata down to the Coxroad coals may be seen in section, giving a key to the geology of the neighbourhood. The strata being flat over the whole district, the same beds are constantly recurring. He next referred to the diagram to show that the above beds overlaid the position of the gas coals at Lesmahagow, and the edge coals of Edinburgh, and added that although he intended to say most about the plants, he wished to mention that he had got in shale at Pirley, near Falkirk, a spine or two of an *Acanthodes.* At Lesmahagow, several nice specimens of *Acanthodes* in the gas coal and black-band of Auchenheath; and in the Parrot coal of Loanhead, near Edinburgh, a great number of *Acanthodes,* one being the *A. Wardii* of Egerton, this splendid spined and well-marked fish being far from rare there, and thus is now known both at Edinburgh and Glasgow, and is probably plentiful in the Scotch Coal-districts. He said he had many other fishes—some he believed new—and other things from the coals; these he reserved for the present. He then entered into a long description of the fossil plants of Falkirk district, and especially mentioning *Antholithes Pitcairniæ* and its fruit *Cardiocarpon,* which he had found attached; *Calamites nodosus, Lepidodendron, Halonia, Ulodendron,* and *Flabellaria borassifolia,* etc. These he fully described, and produced a splendid collection of specimens in all stages, illustrated with drawings and recent plants for comparison. He especially referred to the obligations he was under to Mr. Carruthers, of the British Museum, for his excellent papers on fossil botany, and to Principal Dawson for his Acadian Geology, he having derived the greatest assistance from these gentlemen's labours; and after showing how much the Flora and Fauna of the Coal-fields of Acadia agreed both generically and specifically with our own, concluded by thanking Messrs. Dougall and Potter and Mr. Walker, coal proprietors, to whom he felt deeply grateful, not only for freely allowing him to work, but assisting personally to help him in every possible way.

CORRESPONDENCE.

MEAN THICKNESS OF THE SEDIMENTARY ROCKS.

SIR,—Permit me space for a few remarks on Mr. J. Croll's interesting paper in your last number, on the mean thickness of the sedimentary rocks.

The leading idea of Mr. Croll's calculations on this subject is, that the sedimentary rocks are *wholly* derived from the detritus carried into the ocean by rivers; and, consequently, that their volume formed in any specified time, can be accurately gauged by a knowledge of the annual amount of sub-aërial denudation. This appears from the subjoined passage (p. 98, ad. fin.). "If we know the rate at which the land is being denuded, then we know with perfect accuracy the rate at which the sedimentary deposits are being formed in the ocean. This is obvious, because all the materials denuded from the land are deposited in the sea; and what is deposited in the sea is just what comes off the land, with the exception of the small proportion of calcareous matter which may not have been derived from the land, and which in our rough estimate may be left out of account."

On this I would remark: 1st. That no allowance is here made for the vast quantities of sedimentary matter carried into the sea by littoral erosion.

2nd. Can it be allowable to leave out of the account as "of such small proportion as to be unworthy of notice, the calcareous matter which may not have been derived from the land,"—a category which would include all coral-reef formations, as well as all sediment from the outflow of calcariferous springs at the bottom of the ocean—a combination in which probably the far greater part of the calcareous sedimentary Rocks had their origin.

3rd. Neither is any notice taken by Mr. Croll of the enormous amount of argillaceous and siliceous matter spread over the bottom of the ocean after its eruption from submarine, as well as from subaerial volcanic mouths in islands or in the vicinity of the sea. This matter either subsides where it falls near the vent, or is distributed by waves and currents over the bottom of the ocean. The vast amount of such fragmentary conglomerate or ash which is annually produced and deposited on the floor of the sea may be guessed at from the fact that all known volcanic orifices are in close proximity to the sea, and the probability that a far larger number are in frequent eruption at its bottom, though outwardly unobserved. It is well known that during some violent volcanic eruptions, though lasting but a few days or weeks, areas of ocean several hundred square miles in extent have been covered with floating pumice and ash, while the finer dust has been spread in quantities over still larger spaces; all which matter must speedily subside to the bottom. Moreover, before a submarine volcano can rear its head above the sea-level, its loose materials have probably been again and again swept away by the waves and currents, to form sedimentary strata on the floor of the surrounding ocean, as is known to have been the case with the Isle Julia, near Sicily, the Kaimenis in the crater of Santorino, and other instances.

Professors Ramsay and Geikie both bear witness to the large proportion of the sedimentary strata of early geological ages within the British Isles, that owe their origin to the fragmentary ejections of submarine or insular volcanos, wholly independent of sub-aerial denudations. So too Mr. Darwin, in his work on South America, describes an immense geographical area east of the chain of the Andes, as composed in great part of conglomerates alternating with beds of lava, all ejected from submarine volcanos.

These various sources of sedimentary accumulation at the bottom of the ocean, if added together, may fairly be considered as productive in the course of ages, of an aggregate mass of strata fully equal to that derived from the contemporary denudation of the land; and this, if admitted, would at the least double the figures in Mr. Croll's estimates of the mean annual amount of sedimentary strata produced by all causes combined. I should be the last of all geologists to underrate the effects of sub-aerial denudation. But it seems to me impossible to ignore the fact that immense accumulations of sedimentary strata are, and have always been, in course of production beneath the sea-level, by processes from which sub-aerial agencies are wholly excluded.

COBHAM, *March 14th*, 1871. G. POULETT SCROPE.

TERRACES OF NORWAY.

SIR,—Under this heading in your number for this month is a notice of a work by Professor Kjerulf. The Professor's facts accord exactly with the theory which I have had the honour to publish in your pages (GEOLOGICAL MAGAZINE, November, 1866, p. 519, and May, 1867, p. 1), and his theory would only differ from mine in this, that he supposes the alluviums of which the terraces are the remains to have been formed under a *permanent* "water-surface, which caused the materials washed down by the streams to be heaped up everywhere to the height marked out," p. 75; and I suppose them to be formed by deposit *on land* from repeated *temporary* overflows caused by rain or by melted snow which is frozen rain.[1] No one will dispute this as regards the marine alluvium of the Nile. It stands above the surface of the sea, and rises now by deposit from yearly overflow. But if the north of Africa were to rise ever so gradually, it would cause the Nile to *fall* into the sea. That is, directly as the rise of the land would be the fall of the river into the sea. Directly as its fall into the sea would be its power of deepening its channel. The river *would* deepen its channel, and a time would

[1] As I stated (GEOLOGICAL MAGAZINE, May, 1867, p. 2), the cause of every alluvium in the wide wide world is the stoppage of the lowering of the bed of the valley. The sea stops the lowering of the bed of every valley. Therefore the end of every valley next the sea is flat and alluvial.

come when it could no longer overflow its banks. It would then in floods tear its banks down instead of building them up, and the banks would recede from the river in the form of two parallel terraces. But when the river had cut its banks down to the level at which it could again overflow them, it would again deposit on them, and would form a new alluvium at the new level of the river. If the rising of the land continued, this new alluvium, like the old one, would recede as two parallel terraces; and so, step by step, would be formed, as long as the rising of the land continued, whether the rising was gradual or sudden. I have mentioned such terraces at Loch Ranza in Arran, in the *Athenæum*, 22nd July, 1865.

So far in reference to marine alluvial plains. With regard to inland *patches* of alluvial plains and their terraces, their formation has nothing to do with the rising of the land, and nothing to do with the comparative level of the sea and land. They result only from the different hardness of the different strata of the same valley. That is, directly as the strata are hard (owing to the retarding of atmospheric disintegration and erosion), the valley is narrow, and assumes the character of a gorge with falls or rapids in the river. Directly as the strata are soft, the valley is worn back wide and flat.[1] Rain floods checked at the gorge then overflow the flat, and deposit an alluvium, as the falls or rapids of the hard gorge or *narrows* sink from erosion, the bed of the river in the soft valley above sinks also, till a time comes when the river can no longer overflow the alluvium which it has formed. And the sinking of the bed of the river in the inland alluviums produces the same effects as the rising of the land does on the marine alluviums. That is, alluvium after alluvium is formed one below the other, and in succession driven back as parallel terraces against the hill-side.

If my theory is true, this must be going on now in Norway. That is, there must be alluviums (not "basins" or permanent "water-surfaces") *forming now* below the ancient terraces at the level at which each river overflows above each gorge or rapid. These actually progressing alluviums may be seen throughout nature. They may be seen in Lyell's engraving of the Parallel Roads of Glen Roy, in Lord Milton's and Cheadle's terraces of the Fraser river, GEOLOGICAL MAGAZINE, 1867, Vol. IV., p. 206, and in Hooker's terraces of the Yangma, *ibid*, p. 208.

Doubtless your MAGAZINE will be seen by Professor Kjerulf. Will he do me the favour to state whether this is so or not?

GEORGE GREENWOOD, Colonel.

BROOKWOOD PARK, ALRESFORD,
10*th February*, 1871.

[1] This is what Mr. Mackintosh has called Colonel Greenwood's "Hard gorge and soft valley theory."

NOTES AND QUERIES.

1.—True Syenite is an aggregate of Amphibole and Orthoclase, and quartz is often present (this ignores all other accessories present). If a rock consists of Amphibole +Orthoclase+Oligoclase, what should it be called? Quartz may be also present, not necessarily an essential—G. H. K. (Answer to 1. "Syenite" still.—T. R. J.)

2.—Kaolin occurs as a decomposed Felstone *in situ*. Does it often occur as a subaqueous rock, and where?—G. H. K. (Answer to 2. "As the white pipe-clay of Bovey-Tracey, Wareham, Bournemouth, Alum Bay," etc. T. R. J.)

3.—In speaking of the typical varieties of the felspars, Orthoclase, Oligoclase, and Labradorite, we wish to express the proportions of acid in each case. How can we do this? Is not Orthoclase a *neutral* or fully saturated salt. What prefix can be applied to the felspar in order to express the proportion of the saturation in each case.—H. L.

4.—Dana gives as Diorite a compound of Amphibole and Albite. This, however, appears to be incorrect, as Diorite ought to be a compound of Amphibole and Orthoclase, with or without Labradorite. What is the proper name for a compound of Amphibole and Albite, and when does it occur?—G. H. K.

5.—Daubuisson gave the name of *Eurite* to certain felstones on account of their fusibility, in fact to basic felstones in which Orthoclase was not present, or only in a subordinate quantity. Some authorities confine the name to an almost compact rock, an intimate mixture of Felspar and Quartz, occasionally showing specks of quartz. Still, however, there are more or less granular rocks, which must be classed among the Eurites, as they merge the one into the other. In some of these granular rocks Amphibole is visible, and by some the rock would be called *Diorite*. What percentage of Amphibole ought a Diorite to contain? (By a Diorite I mean a rock principally composed of Amphibole and Felspar, not Orthoclase.)—H. L.

6—Naumann confines the term *Greenstone* to Diabase, Brongniart to Diorite. Jukes, Cotta, and others use it, as a general rule, for all basic Plutonic rocks (the Trappean rocks of Jukes). To which class of rock is it best to apply it?—H. L. (Answer to 6. "Use 'Greenstone' as a general term for greenish trap-rocks; and do not make a special term of it." T. R. J.)

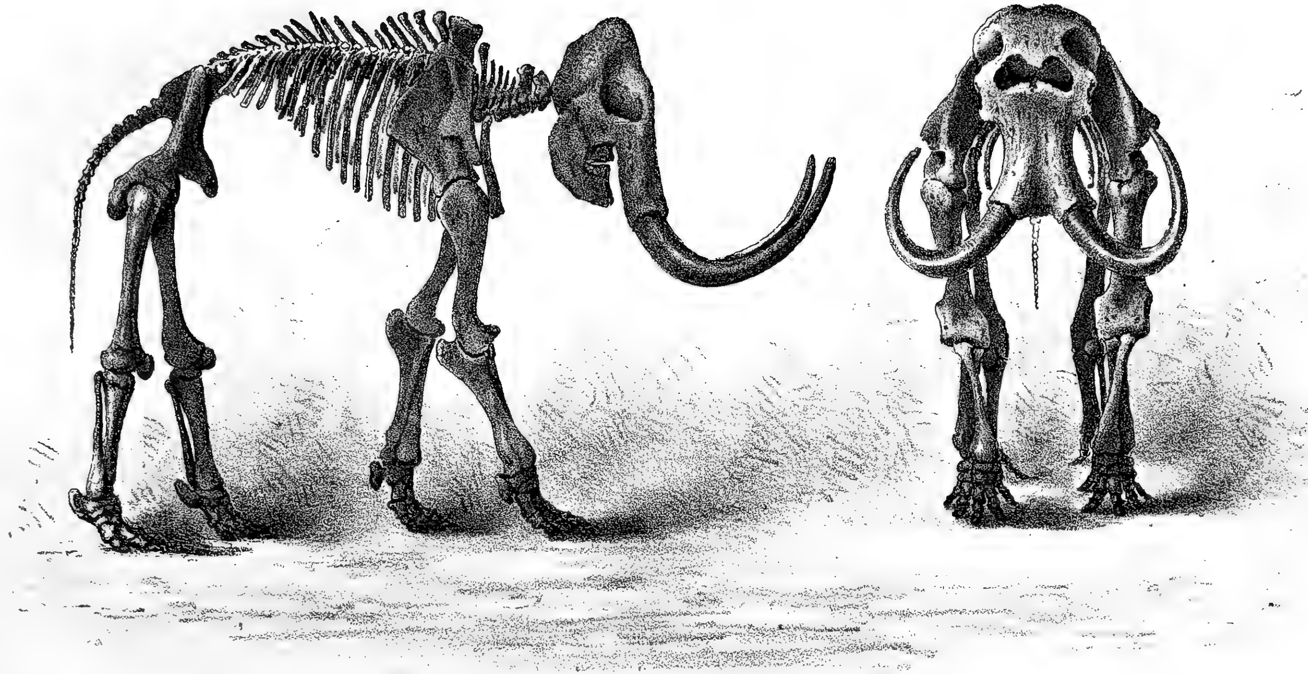
7—Lyell, in his new work (The Student's Elements of Geology), mentions that "the recent researches of Vom Rath and others, prove that the Mineral Tridymite, which is crystallized Silica of sp. gr. 2·3, is of common occurrence in the Volcanic Rocks of Mexico, Auvergne, the Rhine, and elsewhere, although hitherto entirely overlooked." Does it (Tridymite) occur as a rock constituent in these localities or as an accessory? In Trachyte, for instance, does it replace the ordinary quartz it may contain, is it associated with it, or does it merely occur in drusy cavities, and must its specific gravity be ascertained, that its presence may be determined?—H. L.

8.—Concretionary structure in a piece of plaster on the inside walls of a ruined house on the banks of the Eniff river, Mayo, Ireland. To what is it due? Each line seems to be an aggregate of minute crystals. The lines A and B seem to be shrinkage fissures or joints.—G. H. K. (What is the plaster composed of? Edit.—Geol. Mag.)

Concretionary Structure seen in old plastered wall, Co. Mayo, Ireland.

For Rock nomenclature "Cotta's Classification of Rocks" should be followed, we have no other work *at present* which can be equally recommended to students.

Answers to rest of queries will appear next month.—Edit. Geol. Mag.



G.R. De Wilde del et lith. Mintern Bros. imp.

(Scale 1/50th nat. size)

Skeleton of Elephas primigenius, Blum., found at Lierre, Belgium; preserved in the Royal Museum of Natural History Brussels.

THE

GEOLOGICAL MAGAZINE.

No. LXXXIII.—MAY, 1871.

ORIGINAL ARTICLES.

I.—Notes on a Visit to the Royal Museum of Natural History at Brussels, with some account of the "Mammoth" discovered at Lierre, and reconstructed by M. Dupont.

By Henry Woodward, F.G.S., F.Z.S.,
of the British Museum.

(PLATE IV.)

HAVING had the good fortune to visit Brussels in January last, I availed myself of a few hours' delay to pay my respects to M. E. Dupont, the Director, and M. A. de Borre, the Secretary, of the Museum of Natural History in that city, by whom I was most kindly received and introduced to M. Henri Nyst (whose descriptions of the Tertiary formations of Belgium and their invertebrate fauna have rendered his name familiar to almost every English geologist).

Through the kindness of these gentlemen I was enabled to see, in a very brief space, what would have otherwise taken days to accomplish.

The Natural History Museum, which, together with a fine Picture Gallery and Library, occupies an old Ducal palace, has already outgrown its exhibition space; but a grand series of galleries will shortly be completed, capable of affording ample accommodation for the rich collections now in store.

Among so many interesting objects it would be impossible to avoid neglecting some which deserve attention; before, however, speaking of the grand palæontological collections, I must not omit to observe that the Brussels Museum possesses one of the best collections of prepared and mounted skeletons of living Cetaceans I have anywhere seen. I counted upwards of twenty examples of entire whales, etc., including large specimens of *Balæna mysticetus* and *Balæna antiqua*, etc., etc.

The greater part of the Fossils which I had the opportunity to examine were derived from the Antwerp Crag, of Pliocene age; from the Quaternary Drifts of Lierre, etc.; and from the caverns in the Carboniferous Limestone district to the south of Belgium, more especially those in the neighbourhood of Dinant, and bordering the Meuse and its tributaries, explored personally by M. E. Dupont.

The Antwerp Crag has long been known and its Invertebrate Fauna described by M. Nyst. Recently, however, the extensive works which have been carried out for the enlargement of the fortifications of Antwerp have led to the discovery and collection of vast numbers of Corals, Mollusks, remains of Sharks, Cetaceans, etc.[1]

The Mollusca are being worked out by M. Nyst and Dr. M. Mourlon, the Assistant-Naturalist in the Royal Museum; they promise to yield a very magnificent series when fully catalogued and arranged.

In the basement store-rooms of the Museum I beheld a perfect hecatomb of the remains of the old German Ocean Whales, enough, if ground up into into superphosphate, to have manured all the farms in England and Belgium put together. The ear-bones and vertebræ formed the most striking part of the vast series of remains, the former especially testifying to the immense number of individuals represented.

Viscount du Bus, formerly Director of the Museum (but now a Senator), whose place is so ably filled by the present Director, M. Edouard Dupont, has, we understand, been engaged for some time in working out these very interesting Cetacean remains.[2] He has, we understand, already arranged the bones of three entire skeletons, which will be exhibited in due course.

The Squalidæ or Sharks were well represented in the Antwerp Crag period. M. Dupont informed me they had in the Museum not fewer than 20,000 teeth belonging to these predacious fishes.

Early in 1860, in digging a canal at Lierre, in the province of Antwerp, the workmen employed found a large quantity of bones of some extinct animal. As many of these were broken, they were at first unwilling to take the necessary trouble to collect them, but others being discovered as the work proceeded, the ground was more carefully excavated, and all the pieces of bone collected together.

Many of these remains proved of great palæontological importance and may be roughly enumerated.[3] They consisted of four large and blackened molar teeth, the two smaller ones being worn at the crown, and having from 15 to 20 plates. The two larger ones, less worn. They are probably the 2 second and 2 third molars of an adult *Elephas primigenius* (Blum.). With these were found two tusks of the Mammoth, and a vast number of bones probably representing three individuals. The skull, as is usually the case, was represented

[1] For a description of the Antwerp Crag, see Mr. E. Ray Lankester's paper "On the Crag of Antwerp," Geol. Mag., 1865, Vol. II., pp. 103–6 and 149–52; see also paper by Dr. A. von Koenen, "On the Belgium Tertiaries," Geol. Mag., 1867, Vol. IV., pp. 501–507; and "On the Kainozoic Formations of Belgium," by R. A. C. Godwin-Austen, Quart. Journ. Geol. Soc., 1866., vol. xxii., p. 228.

[2] See also the published memoirs of Prof. van Beneden, of Louvain, Memoires de l'Académie Royale de Bruxelles.

[3] For a full account of this discovery, see the paper by M. Francis Scohy, "Bulletins de l'Académie de Belgique," series ii., tome ix., p. 436, etc. From it these notes are partly derived.

by a mass of fragments and débris. With the Mammoth were found remains of Hyæna, Horse, Reindeer, *Rhinoceros megarhinus*, and Bison, with horn-cores measuring four feet along the curve of the cores.

To M. de Koninck, Professor of Palæontology, etc., in the University of Liège (one of the highest living authorities upon the fossils of the Carboniferous formation), was deputed the task of superintending the gathering together of these interesting remains for the Museum of the State. That learned *savant*, having examined the remains of the Mammoth, arrived at the conclusion that it was possible to reconstruct an entire skeleton therefrom. This opinion, however, was not shared by Viscount du Bus, then Director of the Museum; the bones were therefore allowed to remain ignominiously hidden away in the basement of the Museum.

Upon the appointment of M. E. Dupont as Director, that gentleman, with the ardour for which he is so well characterized, determined to signalize his entrance into office by carrying into effect the long-forsaken design of restoring the skeleton of the Mammoth from Lierre. At first the task seemed all but hopeless. The head was broken up into such an immense quantity of small fragments, the reconstruction of which seemed all but impossible; but the perseverance of M. Dupont—assisted by a modeller of remarkable sagacity, M. Louis Depauw—overcame all difficulties, and in October, 1869, the restored Mammoth adorned the centre of one of the Galleries of the Museum, surrounded by numerous remains of the same species, a remounted but very incomplete skeleton of *Elephas antiquus*, and other bones from the Post-Tertiary deposits which the fortifications around Antwerp have furnished in abundance.

The two views of the Belgian Mammoth in the accompanying Plate IV. are reproductions on stone by Mr. G. R. de Wilde, of photographs (issued by permission of the Director) prepared by M. de Blochouse, of Brussels, of whom copies may be obtained. Photographs on a larger scale have also been prepared for distribution to the principal Museums throughout Europe.

I was also informed by M. de Borre that the Brussels Museum was prepared to offer casts of the entire skeleton of the Mammoth to any Museum having sufficiently valuable duplicates to give in exchange.

The figures are on a scale of one-fiftieth of the natural size.

	ft.	in.
The actual height of the skeleton to the shoulders is ...	11	6
Length of the tusks	8	6
Length of the femur	4	0

That this example of the Mammoth was a young individual is proved by the epiphyses of the extremities of the humeri and femora, which remain imperfectly ossified. The broad iliac bones of the pelvis are exceedingly large and prominent. The tusks are more slender and less recurved than are those of our British Mammoth from Ilford. (See Geological Magazine, Vol. V. 1868, p. 540, Pl. XXII. and XXIII.) In the Ilford example the tusk *in sitû* in the socket shows eight feet eight inches (measured along the outer curve); whilst that which is detached shows it to be (with the alveolar end) ten feet six inches in entire length. (See Geological Magazine, 1864, Vol. I., p. 241, with a figure of skull.)

There are two molars above and two below, *in sitû*, on each side.

The inter-alveolar space in the Belgian specimen is very wide, and the alveoli diverge, and are separated along the median line for a short distance.

When the photograph was taken all the restored parts were left white, now they are tinted, but one sees at a glance each part that has been modelled or restored.

The imperfect skeleton of *Elephas antiquus* is sufficient to demonstrate the difference in stature between the two species.

The Mammoth, eleven feet six inches in height, is, nevertheless, only a young animal.

The *E. antiquus* is an aged individual, yet its height is only eight feet six inches or nine feet. The tusks are small and slender, and the ends are much worn. We notice in this specimen the same broad inter-alveolar space as in the Mammoth. The forehead is very high, and the front broad. The molar teeth are broad and flat, and much worn down. I counted eight to nine plates in each.

The remains of *E. antiquus* consist of the skull with lower jaw, one cervical vertebra, nearly all the ribs, the pelvis, and one hind-leg entire, save the carpal bones.

The immense value of the Belgian Mammoth will be the better understood when it is borne in mind that the only other equally perfect skeleton known is the Siberian example preserved at St. Petersburg, of which no correct representation has as yet been published.[1]

Should His Imperial Majesty the Czar desire to express that complete cordiality which he must doubtless now feel towards the British Government, on the settlement of the Black Sea question, he could not show it in a more pleasing form than by presenting the National Museum with the skeleton of a Siberian Mammoth to grace the Geological Gallery of the new National Museum of Natural History, which is shortly to arise at South Kensington.

In the event of our not obtaining a Russian Mammoth, it is agreeable to know that we can always procure a plaster-cast of the Belgian specimen in the way of exchange.

But the reconstruction of the skeleton of *Elephas primigenius* is by no means all, if even it can be said to be the most important, of M. Dupont's labours. Before his appointment in 1865, MM. Dupont and van Beneden were appointed to superintend the exploration of the ossiferous caverns in the valley of the Lesse (a tributary of the Meuse), and elsewhere, on behalf of the Belgian Government. The brilliant manner in which this work was done has been already told in various reports.[2]

[1] That which accompanies Dr. Tilesius's paper, printed in London in 1819, is far from correct. See the remarks in my paper, already quoted, Geol. Mag., 1868, Vol. V., p. 540, Pl. XXII. and XXIII. "On the Curvature of the Tusks in the Mammoth."

[2] See Geol. Mag., 1866, Vol. III., p. 566, *et seq.*

No less than twenty-five caves were explored, and their contents gathered together, both human and animal, and arranged with that accuracy and precision, both as to locality and anatomical details, which characterize all M. Dupont's scientific labours.

Human remains and thousands of flint implements, the greater part of the skeleton of *Felis spelæa*, remains of *Felis lynx*, *Ursus spelæus*, *Ursus priscus*, *Ursus arctos*, *Cervus tarandus*, *C. Guettardi* (? young of *C. tarandus*), *Rhinoceros tichorhinus*, vast numbers of horses, and numerous other animals,—these specimens, which occupied several years in collection, are now, under M. Dupont's direction, being mounted and prepared for exhibition, and for the convenience of the man of science and the comparative anatomist.

Some items deserve special attention :—

Of *Ursus spelæus* I saw twenty-two skulls; an entire skeleton of an adult individual; an adult cub (three feet long); a sucking cub; and lastly, a fœtus,—all of true *U. spelæus*.

M. Dupont has made some interesting observations as to how to distinguish the three species of bears, which I have tested since my return by typical specimens in the British Museum, and found his rule to hold good.

He asserts that out of the long series of remains of *U. spelæus*, not one possesses a false molar (= premolar) in the upper jaw.

Ursus arctos (found in the Cavern of Chaleux) has only one false molar (= p.m.^{4}) in the upper jaw.

Ursus priscus (the true species) has two false molars (namely, = p.m.^{1} and p.m.^{4}) in the upper jaw.

This last is asserted by Prof. Busk to be undistinguishable from *Ursus ferox*.[1]

M. Dupont also observed that *U. spelæus* has a wider zygomatic arch, and is shorter and broader than Schmerling's species.

A good character in *U. spelæus* also is the great size of the last upper true molar, which in this species is one and a half times as large as in either of the other two.

A typical specimen of *U. arctos*, from the Manea Fen, Cambridge (referred to by Prof. Owen in his "British Fossil Mammals," p. 105), and preserved in the British Museum, has the one p. m.^{4} and no other. An Irish specimen from King's County and the cast of another from the County of Longford, stated to belong to the true *U. arctos*, agree exactly in all their proportions with the type specimen of Goldfuss's *Ursus priscus* (from Sœmmering's collection), from the Cavern of Gailenreuth; they, moreover, have the two false molars (p.m.^{1} and p.m.^{4}). As it is decided by Prof. Busk, who has given so much careful study to the Ursine species, that *U. priscus* is undistinguishable from *U. ferox*, it seems most reasonable to conclude that these Irish skulls belonged to the grisly bear of Northern Europe, and not to the *Ursus arctos* at all.

[1] See abstract of Prof. Busk's paper, Quart. Journ. Geol. Soc., 1867, vol. xxiii., p. 342, and Geol. Mag., 1867, Vol. IV., p. 418. It is much to be regretted that this important paper has not yet appeared in full, as it contained much valuable information, and was the result of long and careful study of the Bears.

I cannot conclude these brief and somewhat desultory remarks without expressing my deep indebtedness to MM. A. de Borre, Dupont, and Nyst, for the very kind attention they showed me when in Brussels, and the hope that it may soon be my good fortune again to visit their most attractive and hospitable capital.

II.—On the Chalk of the Cliffs from Seaford to Eastbourne, Sussex.

By William Whitaker, B.A. (Lond.), of the Geological Survey of England.

(A Paper read before the Geological Society of London, December 1, 1870.)

JUST out of Seaford the Chalk rises sharply from beneath the sand of the Woolwich Beds, on an outlier of which the small town is built. The dip however soon lessens, until the Chalk is flat, with slight waves. Some of the layers of flint are continuous, and some nearly so, but most are not continuous, and they are rather closer together in the lower part of the cliff. There are a few thin beds of hard chalk, and at the top a capping of "clay-with-flints."

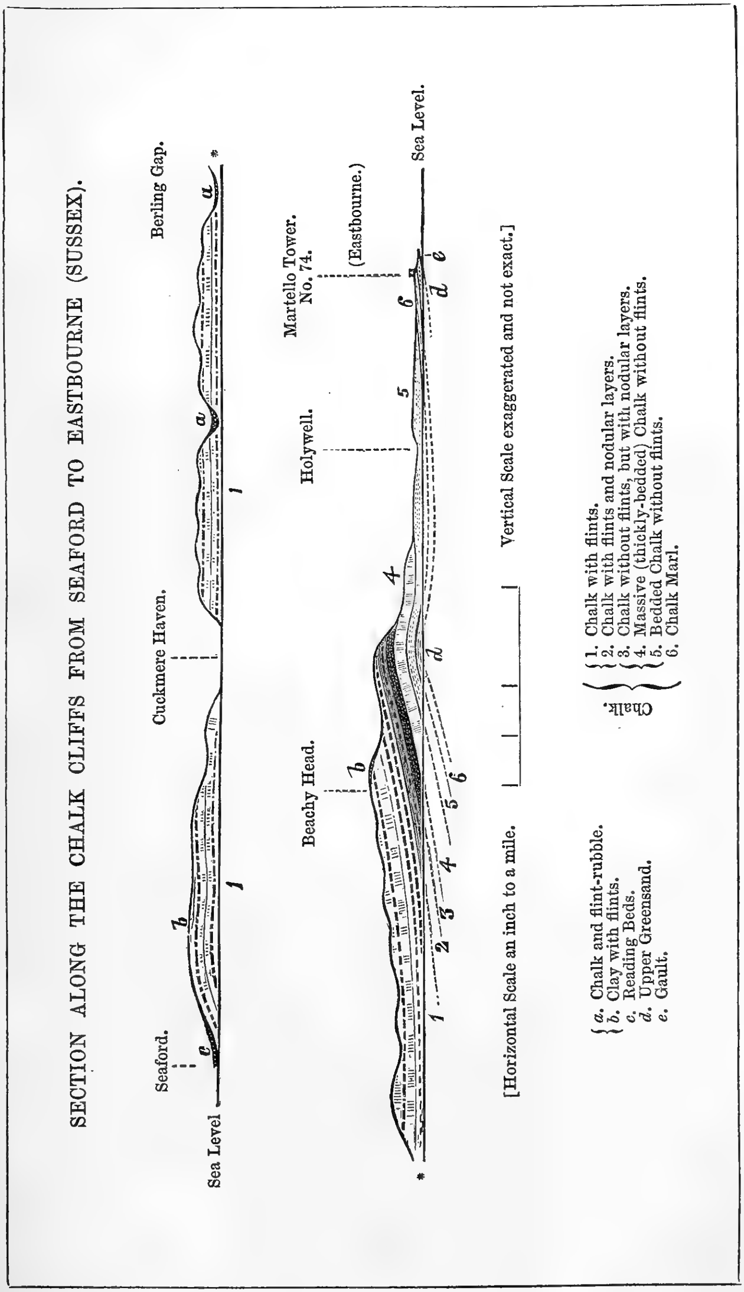
This thick mass of "Chalk-with-flints" (1 of the figure) occurs again on the other side of Cuckmere Haven, and thence forms the whole of the cliff (except for the flinty soil at top and for the rubble in the hollows) almost to Beachy Head. The beds are flat as far as the Lighthouse, when they rise slightly eastward; and just before getting to the Head this uppermost division passes downwards into chalk, with layers of flints, and with cream-coloured nodular layers that weather to a rough surface (2).

Then, from the increase of the westwardly dip, still lower beds, without flints, crop up eastwards; firstly a bed with nodular layers, as in the division above, which weather rough and give the whole a darker colour (3); and then thick-bedded massive chalk (4). All of the above four divisions occur at Beachy Head.

After rounding the first point of the Head, there are, above the Chalk-with-flints, at the highest parts (south-west of the "signal" on the map) pipes of clay-with-flints and a little red sand, which last may perhaps be the same as the Iron-sands of the North Downs referred to the Crag by Mr. Prestwich.[1] At the bottom of the cliff there rises up a mass of bedded chalk (5), in which there is a bed of pale bluish-grey marl, here indeed divided into two, and altogether fifteen feet thick; but which at Holywell House, on the north-east, is undivided and only three or four feet thick; whilst just above there are other marly beds, giving the whole a darker colour (at the lime-kiln at the foot of the cliff).

At the second point of the Head (south-east of the word "signal" on the Ordnance Map) the Chalk Marl (6) crops up from below; and on rounding the point is succeeded by the green-grey sandstone of the Upper Greensand, which is but little shown however, as there is a small under-cliff, and as the dip changes and the beds fall northwards for some way, until the Chalk Marl also is hidden (about

[1] Quart. Journ. Geol. Soc. vol. xiv. p. 322.


SECTION ALONG THE CHALK CLIFFS FROM SEAFORD TO EASTBOURNE (SUSSEX).
Sea Level
Seaford.
Cuckmere Haven.
Berling Gap.
Beachy Head.
Holywell.
Martello Tower. No. 74.
(Eastbourne.)
Sea Level.
[Horizontal Scale an inch to a mile.
Vertical Scale exaggerated and not exact.]
a. Chalk and flint-rubble.
b. Clay with flints.
c. Reading Beds.
d. Upper Greensand.
e. Gault.
Chalk.
1. Chalk with flints.
2. Chalk with flints and nodular layers.
3. Chalk without flints, but with nodular layers.
4. Massive (thickly-bedded) Chalk without flints.
5. Bedded Chalk without flints.
6. Chalk Marl.

east of the *l* of "signal" on the Map), and the bottom of the cliff is in the division No. 5.

The dip lessens, and soon the beds are flat. There are springs at the foot of the cliff, thrown out by the marly bed in No. 5; and No. 4 ends off at the top of the cliff about half a mile southward of Holywell.

From Holywell there is a slight south-westerly dip, so that the lower beds again rise; and as the level of the ground falls north-eastward No. 5 ends off about a quarter of a mile before getting to the Martello Tower, and there is then nothing but the Chalk Marl (only 50 or 60 feet thick?) above the Upper Greensand. The former is hard at the bottom, and markedly bedded; the latter consists of green-grey and grey sandstone, coarsely bedded, with brown and green nodules in the top part, and is not very distinctly separated from the former.

Just beyond the Tower the Gault crops out: it is a light-grey sandy clay, calcareous at top, and drying hard; but only about six feet of it are shown.

On comparing this section with that of the Kentish cliffs, so well recorded by Mr. W. Phillips,[1] there seems to be a good deal of difference between the two chalk-coasts, as may be seen from the following Table, in which the divisions of the chalk in the two are correlated, as nearly as the evidence allows, though without certainty:—

	Kentish Coast.	*Sussex Coast.*
Margate chalk, with few flints.[2]		
Chalk, with many flints.	Chalk, with few organic remains...	1. Chalk, with flints.
	Chalk, with many organic remains (rough)	2. Chalk, with flints and nodular layers.
	Chalk, with few flints	? Absent.
Chalk, without flints.	Chalk with many organic remains (rough)	3. Chalk, without flints, but with nodular layers.
	Chalk, with few organic remains ...	4. Massive chalk, without flints.
	Absent, or included in the next below	5. Bedded chalk, without flints.
	Grey Chalk (or Chalk Marl)	6. Chalk Marl.

Possibly the highest division of the Kentish Chalk may be unrepresented in the Sussex section, and perhaps also the fifth division of the latter may be the equivalent of the upper part of the "Grey Chalk" of Mr. Phillips, which may include more than the "Chalk Marl."

III.—Denudation of the Coalbrook-dale Coal-field.

By Daniel Jones, F.G.S.

(PLATE V.)

Although the Coalbrook-dale Coal-field has received a large share of the attention of geologists, the progress of mining operations reveals new facts from time to time, enabling us to explain away some of the difficulties which have beset earlier writers.

[1] Trans. Geol. Soc. ser. i. vol. v. p. 16.

[2] Not noticed by Phillips, as it does not occur *on the coast* he described. See Quart. Journ. Geol. Soc. vol. xxi. p. 395.

One of the principal features pointed out by Sir R. Murchison, Bart.,[1] and J. Prestwich, Esq., F.R.S.,[2] is the want of persistency in the strata and Coal-seams. In the references which I am about to make to the works of authors on this Coal-field, I am desirous of saying that I do not wish to recall opinions expressed some thirty or forty years since, with the object of showing that they were incorrect, but merely to lay before the reader the state of knowledge upon the subject previous to the true explanation of the nature of the Symon fault made by Mr. Marcus Scott,[3] and by which alone I am able to offer the present interpretation of those difficulties which I have referred to.

When Mr. Prestwich gave his paper to the world in 1836, the true nature of the Symon fault had not been explained. It was to him, as to many others since he wrote, a very great puzzle, but now its explanation serves not only to elucidate the phenomena along the eastern boundary of the Coal-field, but also to account for the great difference between the strata of the northern and southern portions. It will be shown that the southern portion has been largely denuded, and subsequently laid over with Coal-measures of a younger age, and consequently that the Carboniferous deposits are not uniform or persistent. Thus the observation, "that from the care with which Mr. Anstice has had the sections of the pits at Madeley taken, they afford the most correct information of the number of strata and of the total thickness of the Coal-measures" in this Coal-field, is not supported. The details from which the following summaries have been deduced were in part supplied by that gentleman:—

	Depth.	No. of strata.
Madeley Meadow Pits	750 feet.	134[4]
„ Hills-lane	714 „	108

Now I would observe that the first of the older series of Coal-seams in the Meadow Pits is the Rider Coal (so called), which, however, is the same as the Double Coal of the other portions of the field; and I consider No. 67 of that section, described as "light rock full of pebbles, green, blue, and red hard," to be the point of division between the upper and lower, otherwise younger and older, series, or the line of abrasion of the older Coal-measures. If I am right, then there are only 65 strata which belong to the older Coal-measures in that section. The Hills-lane section shows no Big Flint Coal; and I consider No. 76, called "Bottom Coal Flint," is the first recognizable older stratum, and, consequently, there are only in that section 33 strata belonging to the lower Coal-measures. So that Madeley is not a locality in which the Coal-measures of the Coalbrook-dale Coal-field are at all well represented. We are given a

[1] Murchison's Silurian System, 1839, 4to. p. 86, etc.
[2] Prestwich, Trans. Geol. Soc. London, 1840, 2nd ser. vol. v. p. 413.
[3] Quart. Journ. Geol. Society, 1861, vol. xvii. p. 457.
[4] Prestwich on the Geology of Coalbrook-dale, Geol. Trans., vol. v.

table showing the number of strata passed through and their total thickness as follows:—

	Depth.	No. of strata.
Lightmoor........................	460 feet.	46
Dawley	450 „	58
Malinslee	560 „	51
Wombridge	540 „	70
New Hadley......................	440 „	57
Donington Wood	560 „	60

To which is added the following note—"The minuter sub-divisions in these sections not being generally given as they are at Madeley, will account for the disproportion between the thickness and number of the strata, and in one stratum at one pit may be included several of an adjoining pit." This may be the case; but I would observe that in the sections given a much larger proportion of older Coal-measures are met with than at Madeley, which measures generally have strata of greater thickness than the upper series. The Fungous Coal is the highest of the older Coal-seams in the district, and the Chance Pennystone the highest workable ironstone of the older strata. From the surface to the Chance Pennystone at New Hadley is 109 feet, about 80 feet of which is alluvium, and described as "wild red ground." At Hills-lane I consider that the whole of the strata from the Chance Pennystone to the Penny-measures proper have been removed by denudation, and the space has been since filled up with Coal-measure of the younger age, which consists of much thinner strata, and this accounts for the much greater number of strata in the southern portion. The geological horizon for these younger Coal-measures is of course above the Chance Pennystone. The persistency of the Clod Coal is remarked upon: this is due to the fact that being low in the series it escaped to a greater extent the denudation which overtook the higher strata. "If it were not for the Pennystone, Clod Coal, Best Coal, and one or two more beds, which serve as landmarks throughout the whole Coal-field," says Mr. Prestwich, "it would be difficult to recognize the connexion between the Donington district and the Malinslee, or between the Malinslee and the Madeley or the Broseley. The difference between the Amies and Donington sections is still more striking, and placed side by side they appear totally distinct." This is not surprising, seeing that at Amies only 79 feet of older Coal-measures exist, instead of about 384 feet, as at Donington. "It is singular to observe the great and rapid variations in the importance and lithological character of the larger portion of the strata composing these Coal-measures. One stratum will gradually disappear, whilst a thin one will rapidly acquire a thickness of several feet, and will again frequently wedge out." "The Chance Pennystone, which is 8 feet thick at Wombridge, is unknown at Malinslee." By reference to the map it will be seen that it has been denuded from the Malinslee district.

Mr. Prestwich points to the phenomena of the Symon fault in the neighbourhood of Malinslee, but it remained for Mr. Scott to point out that it was caused by the denudation of the older Coal-measures.

The same author was astonished to find that a Limestone (*Spirorbis* Limestone) was in the southern portion of the Coalfield only 170 feet above the base of the Coal-measures, and suggests as an explanation that about Broseley the formation was apparently littoral, and says, "the connexion of the strata between this locality and those where marine remains[1] occur is not clearly ascertained," for he had not been able distinctly to detect the band of limestone on the north side of the Severn. He further says, "Nevertheless, by tracing the prolongation of the bed by means of a few of the associated strata, its equivalents in other parts of the Coal-field may be approximated to. Accordingly, at New Hadley and Wombridge, the place which the freshwater stratum would hold, may be somewhere about that occupied by the marine deposit of Chance Pennystone." Now, connecting this with the observation about littoral deposits, I suppose he meant that a change of character, from freshwater to strictly marine, took place in the stratum as it passed from the shore, where rivers may have flowed in, to the deep sea, where only marine animals could exist. The Spirorbis Limestone is now known to be of marine origin; and, again, its geological position would be many yards above the Chance Pennystone. At Hemans Pit this Limestone is 105 feet above the Pennystone, whereas at Lodgewood we have Chance Pennystone 283 feet above the Main Pennystone, the Spirorbis Limestone holding a still higher position than the Chance Pennystone. If Mr. Prestwich could rewrite his most valuable paper—the text-book of all students of the geology of that district—with such corrections and additions as the evidence gleaned since he wrote would make desirable, it would confer a great benefit upon those who take his paper of 1836 as their guide. Indeed, it is the standard work on the subject, and should be corrected and brought down to the present time.

At page 435 a table is given of the thickness of Coal contained in the ground, and showing the number of beds into which it is divided, with this remark—"In these localities the productive Coal-measures are fully developed, and consequently the difference of total thickness does not arise from the cropping out at one place of beds which exist at another." Now it is this view which I hope in this paper to controvert, for I maintain that the upper strata have been entirely denuded from the southern portion of the Coal-field by the same denuding force as produced the Symon fault described by Mr. Marcus Scott (Journal of the Geological Society, 1861, vol. xvii., p. 457). Mr. Prestwich remarks, "The Ironstones thin out in their range southward in descending order; thus the Chance Pennystone first disappears, then the Blackstone, and others after; so that at Broseley we find only the Pennystone and the Crawstone, and to the south of Broseley the Crawstone by itself." The same remark holds good with the coals, and the reason why they are not observed to crop out is, that over the denuded older strata newer strata were laid, and covered up the denuded edges of the coal.

In the Silurian System of Sir R. Murchison we find the Hills-lane

[1] The limestone was at that time supposed to be of freshwater origin.

Section given as "an instructive example of the succession in one spot where the strata are pretty fully developed." This is not the case, as there are wanting "The Big Flint," "Yard Coal," "Double Coal," "Three Quarter Coal," "Top Coal," "Gur Coal," "Stone Coal," "Foot Coal," and "Fungous Coal," all of which have been denuded. Most of the other remarks on this question in "The Silurian System" appear to be derived from Mr. Prestwich's paper.

Now if we examine the various pit sections, commencing in the north and proceeding southwards, we shall find there has been a denudation of the older Coal-measures of precisely the same character as that shown to have taken place along the eastern boundary, and known as the Symon fault. For the purpose of showing my views upon a small map, and to avoid the confusion which would arise from having a vast number of lines drawn over the map, even if it were possible to get the exact data requisite to enable me to plot them, I have grouped the seams as they occur in a vertical position, distinguishing each group by a distinct kind of line, thus—

1. Chance Pennystone. Fungous and Gur Coal.
2. Top Coal to Yard Coal.
3. Big Flint Coal, Pennystone, and Sulphur Coal.
4. Best Randle Clod and Little Flint.

(See Explanation on Plate V.)

At the end a list is given of sections grouped according to the seams which they contain. We may thus draw lines which will approximately show the margin or denuded edge of the vertical groups.

I have been at some trouble in ascertaining whether the denudation took place before or after the dislocations; because, if before, then my lines would be a nearer approximation to the condition of things; but if after, then the denuded edges would be thrown forward or recede according to the "down-throws" or "up-throws." Mr. Marcus Scott and Mr. Parton have given me data, from which it appears quite certain that the denudation took place long before the dislocations. The Calaminker (a mottled clay of the upper Coal-measures, lining the valley of denudation, called the "Symon fault") and Upper Strata, which were deposited after the denudation, are influenced by the dislocations, which must have occurred necessarily even still later.[1]

I have before said, the highest workable stratum of what are called the lower or productive Coal-measures is the Chance Pennystone. We find it in the Donington Wood Colliery, and as far east as the Granville Pit. It is not found south of a line drawn from Ketley to a little south of Snedshill (*vide* Plate V.). Between Snedshill and Prior's Lee its boundary proceeds northwards, to join the stratum near Granville Pit. The Fungous Coal being about 50 feet below the Chance Pennystone, and consequently a little more protected from denudation, it ranges a little outside of the margin of

[1] In this I find my views at variance with those of Mr. Randall, expressed in his 13th letter to the *Mining Journal*, where he says, "The whole of the Coal-strata found in the Halesfield Pits of the Madeley Wood Company was saved from denudation by the mere fact of its having been let down by faults below the same strata which suffered from denudation in the neighbouring field of Stirchley," etc.

the Chance Pennystone. Mr. Prestwich seemed to think that the reason why the Chance Pennystone was not known in the southern part of the Coal-field was that the nature of the stratum had changed in its extension southward. But this is not so, as both it and the Fungous Coal are entirely absent. Mr. Randall, who recently contributed a series of letters to the *Mining Journal* on the Shropshire Coal-field, speaking of the Chance Pennystone (*vide* Letter No. 7), says, "This ironstone, as the name implies, has always been found to be irregular and uncertain; it was confined to the *south* of the Coal-field, like the others already described in this article, and is now, we believe, entirely exhausted." The word "south" should have been "north," as Mr. Randall has explained to me.

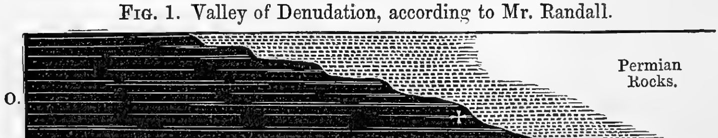
From 60 to 80 feet below the Gur Coal, we have the Top Coal, a seam having a much wider range to the south than any of those previously mentioned. We have it in the Granville Pit, which I may remark by the way is the only pit shaft in which a regular sequence from the lower Coal-measures into the upper is traceable, and is consequently the most typical of the original Coal-field; all the other shafts give evidence of subsequent change by denudation. The Top Coal is wanting in the Stafford Pit. As the Three Quarter Coal, lying a few feet below, is found in that shaft, the denuded edge of the Top Coal cannot be far to the west of the shaft. It then falls back to within a short distance east of the Puddley Hill Pit and Langley, then passing to the east as far as the new pit at Kemberton, it is there found to exhibit signs of denudation. Following an irregular line, somewhere between Madeley Court and the Meadow Pit at Madeley, it runs northward towards Great Dawley and east of Lawley, and is lost a little south of Ketley, against the western boundary fault. It does not occur in the Madeley Meadow Pit, and is not met with in any portion of the field to the south of that shaft. It will not be necessary to trace the boundary of the Three Quarter, Double, and Yard Coals; it is sufficient to say that they are cut off in succession by the same process of denudation one after another.

We will now trace out the denudation of another zone shown on the map (Plate V.), which will include approximately the Big Flint Coal, Pennystone, and Sulphur Coal. These strata are found as far south as Broseley. Their boundary passes a little north of Amies; it then passes eastward for some distance near Kemberton, and eventually northward in a line of the same character as that in the Top Coal, more or less parallel to it. The Clod Randle and Little Flint Coals behave in the same manner to the south, and eventually the base of the Coal-measures, Silurian Limestone, is met with, and there is an end of the productive Coal-measures. Coal-measures are met with still further south for many miles, but they are all upper Coal-measures, except at Harcott, where a patch of the older Coal-measures, like that at Shirlot, is met with beneath the younger formation. I believe I am the first to point this out; and I may go further by saying that I have established, to my own satisfaction at least, the co-relation between the patch at Harcott and those on the two Clee Hills; but this is not the place to enter into this subject, except for the purpose of showing that the Coal-field of Coalbrook-dale once extended far to the south, but was afterwards cut away by denudation to its present limits.

Taking this view of the matter, we can now readily understand how it is that the Spirorbis Limestone of the upper Coal-measures is found in the south of the field at 170 feet above the base of the older Coal-measures. The greater part of those older strata have been washed away, and the younger Coal-measures, with the Spirorbis Limestone, have been subsequently deposited upon the remaining reduced thickness of the old strata. When therefore Mr. Prestwich gives the total thickness of the Coal-measures of this field at 750 feet, as shown in the Madeley Meadow Pit, it should be added that a middle slice of about 250 feet is wanting in that shaft. Thus it appears that the denudation did not affect the eastern boundary, only producing what is now known as the Symon fault of Mr. Marcus Scott; but it affected the whole of the southern part of the Coal-field from a line drawn between Ketley and Prior's Lee. The plan, with its lines of denudation shown at several vertical ranges, is only given to illustrate my view, and those lines must only be taken as approximate.

There is one more point to which I must advert. Mr. Randall says, in his ninth letter to the *Mining Journal*, "The valley of denudation, however, does not appear to have been filled up by these younger members of the Coal-measure series, hence the Permains come up and overlap the whole along an undulating line running north and south parallel with that of the Symon fault." And again, "It is remarkably instructive as regards the nature of this fault that just on the line where the Coal-seams terminate the Permians make their appearance, rapidly increasing in thickness as one after the other of the former disappear." (Letter ix.) The following section would represent what Mr. Randall means:—

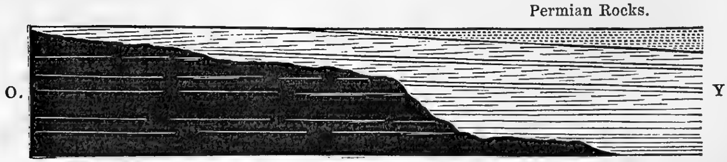
Fig. 1. Valley of Denudation, according to Mr. Randall.



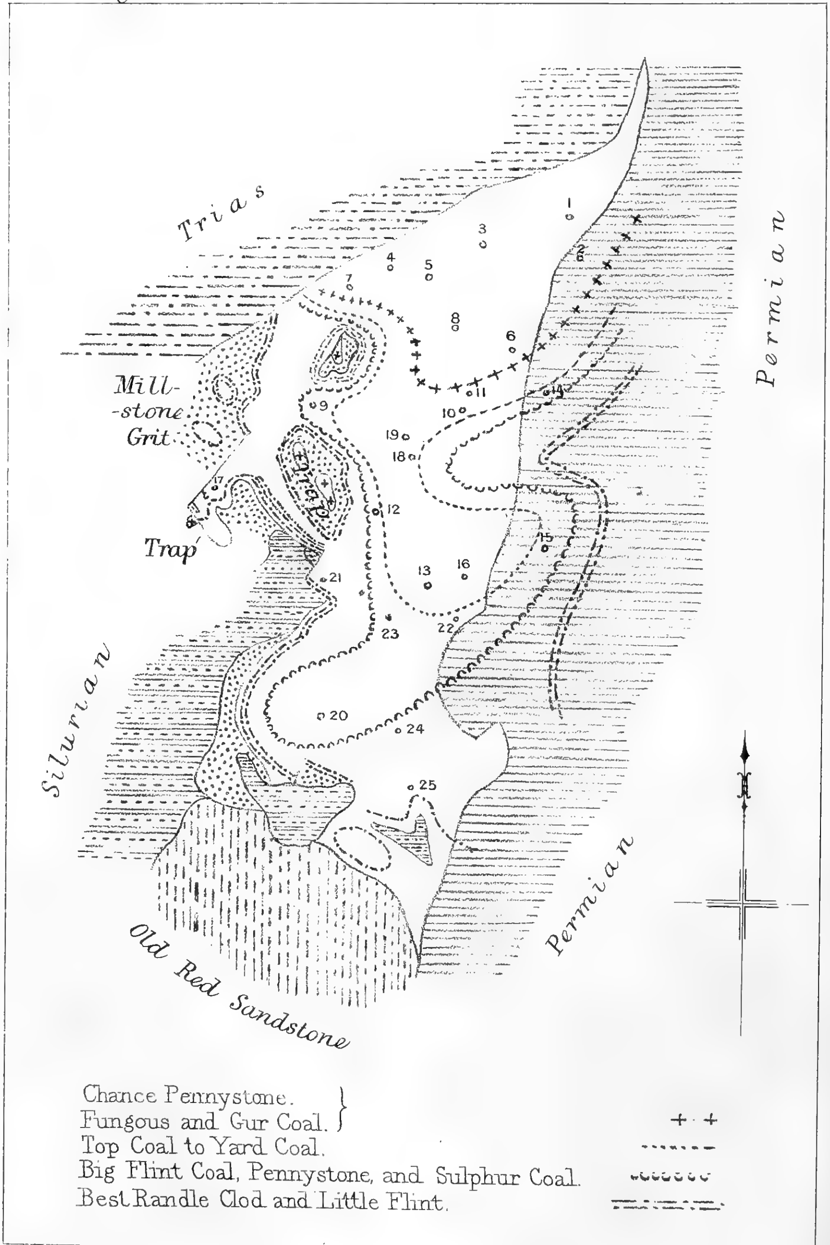
O. Older Coal-Measures. + Line of erosion.

Now the fact is that the younger Coal-measures not only fill up the eroded valley, but overlap the older Coal-measures, and the Permian overlie the younger formation, thus—

Fig. 2. Actual Valley of Denudation Coal-Measures.



O. Older Coal-Measures. Y. Younger Coal-Measures.



G.R. De Wilde del. et lith.

Mintern Bros. imp.

Coalbrook-dale Coalfield, Showinig the denudation of the Coal Measures.

Indeed, the younger Coal-measures not only fill up the vacuity and cover over portions of the older strata, but range over a large area to the south, as far as the Abberley Hills, in some places being not less than 1100 feet thick, as shown by the sinking at Shatterford.

I wish it to be clearly understood that the denudation to which I refer in this paper is that which took place previous to the deposit of the younger Coal-measures. This does not account for the exact condition of things in those parts of the Coal-field in which the younger Coal-measures are absent, as at the Hatch and Steeraway, where we find isolated patches of the lower coals. Several periods of after denudation may have caused this, and in the same way have reduced the patches at Cornbrook and Brown Clee from what they were as left by the denudation in question. It is probable that the Cornebrook, Clee Hill, and Shirlot districts stood above the level at which the younger coals are formed. We find no older Coal-measures underlying the Carboniferous patch, at Cleobury Mortimer, for instance, and thus the elevated strata have been exposed to all subsequent denudation, and would have given way to it had it not been for the capping of Trap which has protected it. Seeing that at Little Wenlock, No. 17, we have the Pennystone protected from this more recent denudation by faults, and it is certain that the faults came after the denudation of which this paper treats, I am inclined to think the Coal-measures extended much more to the west, and that the old line of erosion has been, with the Coal-measures, swept away by a much more recent washing; and it may be that some of the lines in my plan on the west side may be due to these later destructions.

A list of sections, in which the older series occurs from the horizon of the Chance Pennystone downwards.

(*Those which are numbered are shown on the map*, PLATE V.)

1. Lodgewood. } Sections by Doody.
2. Granville Pit. } Sections by Doody.
3. Donington Wood. } Geological Survey, Vertical Sections, No. 23.
4. New Hadley. } Geological Survey, Vertical Sections, No. 23.
5. Wombridge. } Geological Survey, Vertical Sections, No. 23.
6. Nelson Pit, Prior's Lee (from Stone Coal). } Geological Survey, Vertical Sections, No. 23.
7. Ketley. Prestwich, p. 445, "I am not aware of its existing further to the south than New Hadley and part of Ketley."
   Wombridge. Townson's Tracts. *Vide* Prestwich.
8. Snedshill. Prestwich, p. 478.
   Edwards Piece, Hadley. Prestwich, p. 480.
   New Hadley. Prestwich, p. 481.
   Tub Engine Pit, Donington Wood. Prestwich, p. 483.

The following range from the Top Coal, Double and Yard Coals, downwards:—

9. Lawley and Steeraway.
   Horsehays.
   Rickyard Pit, Prior's Lee.
10. Lawn Pit, Malinslee.
11. Puddley Hill.
    Portley Pit, Dawley.
12. Deepfield Pit, Dawley.
13. Madeley Court.

(9–13: Geological Survey, Vertical Section, sheet 23.)

14. Stafford Pit. Doody.
15. Kemberton Pit. W. Ward.

16. Halesfield. M. Scott.
    Lightmoor Whinney Pit. Prestwich, p. 475.
17. Little Wenlock. Prestwich, p. 477.
    New Works, New Lawley. Prestwich, p. 477.
18. Langley. (Double Coal.) Prestwich, p. 478.
19. Old Works at Dawley. Prestwich, p. 480.
    Wombridge Pit, near the engine. Prestwich, p. 480.
    Holywell Pits, Malinslee. Prestwich, p. 482.
    Dawley Pit. Prestwich, p. 483.
    Old Park Pits. Prestwich, p. 483.

The following pits range from the Lower Pennystone or Big Flint Coal:—

Hills-lane. }
20. Broseley. } Vertical Section, sheet 23.
21. Trial Pit, Castle Green. Prestwich, p. 475.
22. Lodge Pit, Madeley. Prestwich, p. 477.
    Trial Pit, near Lilleshall, Old Hall. Prestwich, p. 479.
    Hemans Pitfield, near Broseley. Prestwich, p. 481.
    Yew Tree Pit, Calcut Field, Broseley. Prestwich, p. 481.
23. Meadow Pits, Madeley. Prestwich, p. 485.
    Hills-Lane (with the local terms). Prestwich, p. 486.

The following range from about the best coal and below:—

Caughley. Vertical Section, sheet 23.
Limestone Pit, Lincoln's Hill. Prestwich, p. 480.
24. Amies Field, near Broseley. Prestwich, p. 478.
25. Inett. Prestwich, p. 478.

IV.—Alphabetical Catalogue of Type Specimens of Fossil Fishes in the British Museum.[1]

By Wm. Davies,
Of the Department of Geology, British Museum.

The fine series of Fossil Fishes in the National collection is exhibited in and constitutes the principal feature of Room II. in the Northern Geological Gallery. The arrangement adopted is in accordance with the classification of Prof. L. Agassiz, as indicated in his great work, "Recherches sur les Poissons Fossiles," but with such modifications as the subsequent investigations of ichthyologists have rendered necessary. These modifications occur chiefly among the fishes of the older formations.

Of the four divisions or Orders of Fossil Fishes,—viz., the Placoid, Ganoid, Ctenoid, and Cycloid—divisions founded upon the form or structure of their scales or dermal covering, the first (the Placoids) are arranged in table cases on the north side of the room, in cases in

[1] Having already published in the pages of this Magazine, lists of the types of Fossil Fishes in two of the grandest private collections in this country, namely, that of Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S. (see Geol. Mag. 1869. Vol. VI pp. 408–413), and that of the Earl of Enniskillen, F.R.S. (see same volume, pp. 556–561), it seemed desirable to complete as far as possible these valuable synopses of Fossil Fishes by the publication of the types in the British Museum. I therefore requested Mr. W. Davies, who has for many years made careful notes of the typical and figured specimens of the Fossil Vertebrates in the collection, to do me the favour to draw up for this Journal the accompanying particulars of our grand National collection, which I feel sure cannot but be most acceptable to palæontologists.—H. W.

the window recesses, and in a portion of wall case 7. As this Order comprises those fishes having a more or less cartilaginous skeleton, the parts preserved are chiefly detached portions, as teeth, bony palates, defensive and dermal spines, and vertebræ. But specimens of the Ray family have been found preserved entire in the lithographic stone deposits and in a fissile Limestone, of the Cretaceous Period, in the Lebanon.

The other Orders (the Ganoid, Ctenoid, and Cycloid) are arranged in and upon the wall cases 1 to 6 inclusive, in a large, instructive, and continuous series, where every diversity of form and detail of anatomical structure, as yet known, of each Order or group, may be compared and studied—from specimens derived from the most ancient deposits in which fishes are found, up to the most recent; exhibiting every variety of rock-matrix in which their remains have been preserved.

In a portion of wall case 7 are placed for exhibition those Fishes whose exact place in the system of arrangement is not determined; and of genera and species which have not been described.

The collection, although very far from perfect in regard to the number of known and described genera and species, is fairly represented as regards families. It contains examples of nearly 300 genera and about 700 species, many of which are extremely rare, and some probably unique. Much of its value is due to the gems of many private collections, which have been acquired from time to time. Firstly, may be mentioned that of the late Dr. Mantell, whose zeal as a collector, and whose skill in developing his fine series of Chalk and Wealden Fishes, were well known. It was from his museum that Agassiz obtained most of the specimens for his descriptions and figures of the fishes of these deposits. Subsequently, the late Mr. F. Dixon's collection was obtained; so rich in these remains from the Tertiary and Chalk formations of Sussex, many of which are figured in his work on the Geology and fossils of that county.[1] More recently examples from the London Clay of Sheppey and the Chalk of Kent have been added from the collections of Dr. Bowerbank and of Mr. Toulmin Smith, and a remarkably fine collection made by Dr. Haberlein from the Lithographic stone-quarries of Bavaria.

In the subjoined catalogue references will be found to a few specimens which, although not absolutely the types, yet, from the works of acknowledged authority and reference in which they have been figured and described, may be considered as typical examples. These references are marked with an asterisk.

ACRODUS, Ag.
— *Anningiæ*, Ag. (*spines*), GEOL. MAG. Vol. I. p. 37, Pl. 4. L. Lias, Lyme Regis.
— *Illingworthi*, Eg. (*teeth*), Dixon, F. S. p. 361, pl. 30, fig. 11. Chalk, Sussex.
— ,, Eg. Dixon, F. S. p. 361, pl. 30, f. 12.
ACROGNATHUS, Ag.
— *Boops*, Ag. P. F. tom. 5, p. 108, tab. 60*a*, figs. 1–4. Chalk, Lewes.
ACROTEMNUS, Ag.
— *Faba*, Ag. P. F. tom. 2, pt. 2, p. 203, tab. 66*a*, figs. 16–18. ib. loc.

[1] The fishes are described by Sir Philip de Malpas Grey Egerton, Bart., F.R.S.

ÆCHMODUS, Eg. (*Tetragonolepis*, Ag.).
— *dorsalis*, Ag. P. F. tom. 2, p. 211, tab. 21, figs. 1, 2. Lias, Byrford.
ÆTOBATES, Müll. and Henle.
* — *irregularis*, Ag. Dixon, F. S. p. 200, pl. 11, figs. 3, 4. M. Eocene, Bracklesham.
— *marginalis*, Dixon, F.S. p. 201, pl. 12, fig. 1. ib. loc.
— *rectus*, Dixon, F. S. p. 201, pl. 11, fig. 8. ib. loc.
AMPHERISTUS, König.
— *Toliapicus*, König, Icon. F. S. fig. 190. London Clay, Sheppey.
ANGUILLA, Thunb.
— *elegans*, Winkler, P. F. d'Oen. p. 57, pl. 7. Miocene, Oeningen.
ARCHÆONECTES, v. Meyer.
— *pertusus*, Meyer, L. and B. Jahrb. 1858, p. 205. D. and M. Palæont. band 7. p. 12, tab. 2, figs. 1, 2. Devonian, Gerolstein.
ASTERACANTHUS, Ag.
— *granulosus*, Eg. M. G. S. Dec. 8, pl. 1, figs. 2–4. Wealden, Tilgate Forest.
AULOLEPIS, Ag.
— *typus*, Ag. P. F. tom. 5, p. 109, tab. 60*a*, figs. 5–8. Chalk, Sussex.
BELONOSTOMUS, Ag.
— *cinctus*, Ag. P. F. tom. 2, pt. 2, p. 142, tab. 66*a*, figs. 10–12. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 142, tab. 66*a*, fig. 13. ib. loc.
BERYX, Cuv.
— *microcephalus*, Ag. P. F. tom. 4, p. 119, tab. 14*b*, figs 3, 4. ib. loc.
— ,, Ag. P. F. tom. 4, p. 119, tab. 14*c*, fig. 10. ib. loc.
— *ornatus*, Ag. P. F. tom. 4, p. 115, tab. 14*a*. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*b*. figs. 1, 2. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*c*, fig. 1. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*c*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*d*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*d*, fig. 3. ib. loc.
— ,, Ag. P. F. tom. 4, p. 115, tab. 14*d*, fig. 1, *Zeus Lewesiensis*, Mant. G. S. p. 234, tab. 35, fig. 2. ib. loc.
— ,, Ag. *Zeus Lewesiensis*, Mant. G. S. p. 234, tab. 35, fig. 1.
— ,, Ag. *Zeus Lewesiensis*, Mant. G. S. p. 234, tab. 36. ib. loc.
— *radians*, Ag. P. F. tom. 4, p. 118, tab. 14*c*, figs. 7–9. ib. loc.
* — ,, Ag. Dixon, F. S. p. 371, pl. 36, fig. 4. ib. loc.
— *superbus*, Eg. Dixon, F. S. p. 372, pl. 36, fig. 5. Chalk, Southeram.
BOTHRIOLEPIS, Eichwald.
— *ornatus*, Eichw. P. F. V. G. R. p. 99, tab. 29, fig. 3. Devonian, Elgin.
— ,, Eichw. P. F. V. G. R. p. 99, tab. 29, fig. 4. ib. loc.
— ,, Eichw. P. F. V. G. R. p. 99, tab. 29, fig. 5. ib. loc.
BRACHYICHTHYS. Winkler.
— *typicus*, Winkler. Nat. Verh. Holl. Wet. Tweede Verzameling, 16, Deel, 1862, p. 53, fig. 9. Upper Oolite, Solenhofen.
BUCKLANDIUM, König.
— *diluvii*, König, Icon. F. S. fig. 91. London Clay, Sheppey.
CAMPODUS, de Koninck.
— *Agassizianus*, de Kon. A. F. p. 618, tab. 55, fig. 1*a*. Carboniferous Limestone, Belgium.
CATURUS, Ag.
— *similis*, Ag. (*jaw*), P. F. tom. 2, pt. 2, p. 118, tab. 66*a*, fig. 9. Chalk, Lewes.
CEPHALASPIS, Ag.
— *Lyelli*, Ag. P. F. tom. 2, p. 142, tab. 1*a*, fig. 2. *Eucephalaspis*, Lank., F. O. R. S. p. 43, pl. 8, fig. 1. Devonian, Glammis.
CHIMÆRA, Linn.
— *Agassizi*, Buckl. (*Ischyodus*, Eg.), P. F. tom. 3, p. 341, tab. 40*a*, figs. 3, 4. L. Chalk, Hamsey.
— ,, Buckl. (*Ischyodus*, Eg.), P. F. tom. 3, p. 341, tab. 40*a*, fig. 5. Chalk, Lewes.
— *Bucklandi*, Ag. (*Edaphodon*, Buckl.), P. F. tom. 3, p. 351, tab. 40*d*, figs. 19–24. M. Eocene, Bracklesham.
— *eurygnathus*, Ag. (*Edaphodon*, Buckl.), Dixon, F. S. p. 111, pl. 10, fig. 18. ib. loc.

CHIMÆRA, Linn.

— *eurygnathus*, Ag. (*Edaphodon*, Buckl.), Dixon, F. S. p. 111, pl. 10, fig. 19. ib. loc.

— ,, Ag. (*Edaphodon*, Buckl.), Dixon, F. S. p. 111, pl. 12, fig. 5. ib. loc.

— *Hunteri*, Eg. (*Elasmodus*, Eg.), M. G. S. Dec. 6, pl. 1, figs. 1, 2. ib. loc.

— ,, Eg. (*Elasmodus*, Eg.), M. G. S. Dec. 6, pl. 1, figs. 3, 4. ib. loc.

— ,, Eg. (*Elasmodus*, Eg.), M. G. S. Dec. 6, pl. 1, figs. 5, 6. ib. loc.

* — ,, Eg. (*Elasmodus*, Eg.), Dixon, F. S. p. 111, pl. 10, figs. 11, 12. ib. loc.

— *leptognathus*, Ag. (*Edaphodon*, Buckl.), P. F. tom. 3, p. 352, tab. 40*d*, figs. 13–18. ib. loc.

* — ,, Ag. (*Edaphodon*, Buckl.), Dixon, F. S. p. 111, pl. 10, fig. 20. ib. loc.

* — ,, Ag. (*Edaphodon*, Buckl.), Dixon, F. S. p. 111, pl. 10, fig. 21. ib. loc.

— *Mantelli*, Buckl. (*Edaphodon*, Buckl.), P. F. tom. 3. p. 64, tab. 10*b*, fig. 17 (*spine*). Chalk, Lewes.

— ,, Buckl. (*Edaphodon*, Buckl.), P. F. tom. 3, p. 318, tab. 40*a*, fig. 1. Chalk, Lewes.

— ,, Buckl. (*Edaphodon*, Buckl.), P. F. tom. 3, p. 318, tab. 40*a*, fig. 2. ib. loc.

— *orthorhinus*, Eg. (*Ischyodus*), Proc. Geol. Soc., April 5, 1871. L. Lias, Lyme Regis.

— *Tessoni*, Buckl. (*Ischyodus*, Eg.), P. F. tom. 3, p. 342, tab. 40, fig. 19. Oolite, Normandy.

CHONDROSTEUS, Ag.

— *crassior*, Egert. Phil. Trans. 1858, p. 883. L. Lias, Lyme Regis.

CLADOCYCLUS, Ag.

— *Lewesiensis*, Ag. P. F. tom. 5, p. 103, tab. 25*a*, figs. 5, 6. Chalk, Lewes.

CLIMAXODUS, M'Coy.

— *ovatus*, Barkas. GEOL. MAG. Vol. 5, p. 496, Figs. 1, 2. Coal-measures, Newcastle.

CŒLORHYNCHUS, Ag.

— *rectus*, Ag. Dixon, F. S. p. 205, pl. 11, fig. 26. M. Eocene, Bracklesham.

CORAX, Ag.

— *falcatus*, Ag. P. F. tom. 3, p. 226, tab. 26*d*, figs. 1, 3, 6. Chalk, Sussex.

— ,, Ag. *Squalus galeus* ? Mant. G. S. p. 227, tab. 32, fig. 12. ib. loc.

— *maximus*, Dixon, F. S. p. 366, pl. 30, fig. 17. ib. loc.

DAPEDIUS, De la Beche.

— *Colei*, Ag. P. F. tom. 2, p. 217, tab. 25*c*. L. Lias, Lyme Regis.

DERCETIS, Munst. and Agass.

— *elongatus*, Ag. P. F. tom. 2, pt. 2, p. 258; tab. 66*a*, figs. 1, 2. Chalk, Lewes.

— ,, Ag. P. F. tom. 2, pt. 2, p. 258, tab. 66*a*, fig. 3. ib. loc.

— ,, Ag. P. F. tom. 2, pt. 2, p. 258, tab. 66*a*, fig. 4. ib. loc.

— ,, Ag. P. F. tom. 2, pt. 2, p. 258, tab. 66*a*, fig. 5. ib. loc.

— ,, Ag. *Muræna Lewesiensis*, Mant. G. S. p. 232, tab. 34, fig. 10, tab. 40, fig. 2. ib. loc.

DREPANEPHORUS, Eg., Dec. 13 (in the press). Cestracion, Cuvier.

— *canaliculatus*, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 62, tab. 10*b*, fig. 8 (*spine*). Chalk, Lewes.

— ,, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 62, tab. 10*b*, fig. 10 (*spine*), ib. loc.

— ,, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 62, tab. 10*b*, fig. 11, *Balistes*, Mant. G. S. p. 229, tab. 33, fig. 6 (*spine*). ib. loc.

— ,, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 62, tab. 10*b*, figs. 12, 13 (*spine*). ib. loc.

— ,, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 62, tab. 10*b*, fig. 14. *Balistes*, Mant. G. S. p. 229, tab. 33, fig. 5 (*spine*). ib. loc.

— ,, Eg. (*Spinax major*, Ag.), P. F. tom. 3, p. 370, tab. 40*a*, fig. 6 (*vertebræ*). ib. loc.

EGERTONIA, Cocchi.

— *isodonta*, Cocchi, Pesch. Lab. p. 58, tab. 4, fig. 2. London Clay, Sheppey.

ENCHODUS, Ag.

— *halocyon*, Ag. P. F. tom. 5, p. 64, tab. 25*c*, fig. 1. Chalk, Lewes.

— ,, Ag. P. F. tom. 5, p. 64, tab. 25*c*, fig. 2. *Esox Lewesiensis*, Mant. G. S. p. 287, tab. 41, figs. 1, 2. ib. loc.

ENCHODUS, Ag.
— *halocyon*, Ag. P. F. tom. 5, p. 64, tab. 25*c*, figs. 3, 4. ib. loc.
— ,, Ag. P. F. tom. 5, p. 64, tab. 25*c*, fig. 5. *Esox Lewesiensis*, Mant. G. S. p. 237, tab. 25, fig. 13. ib. loc.
— ,, Ag. P. F. tom. 5, p. 64, tab. 25*c*, fig. 6. ib. loc.
— ,, Ag. P. F. tom. 5, p. 64, tab. 25*c*, fig. 7. ib. loc.
— ,, Ag. P. F. tom. 5, p. 64, tab. 25*c*, figs. 10, 14, 15. ib. loc.
* — ,, Ag. Dixon, F. S. p. 373, pl. 30, figs. 20, 27, pl. 31, fig. 11. Chalk, Sussex.

FISTULARIA, Lacép.
— *Königii*, Ag. P. F. tom. 4, p. 279, tab. 35, fig. 5. Eocene, Engi, Glaris.

GLYPTOPOMUS, Ag.
— *minor*, Ag. P. F. V. G. R. p. 57, tab. 26. Devonian, Dura Den.
— *sp.* M. G. S. Dec. 10, p. 4, fig. 4, Dec. 12, pl. 1, fig. 2. ib. loc.

GYRODUS, Ag.
* — *angustus*, Ag. Dixon, G. S. p. 370, pl. 30, fig. 14. Chalk, Sussex.
* — ,, Ag. Dixon, G. S. p. 370, pl. 33, fig. 1. ib. loc.
— *cretaceus*, Ag. Dixon, F. S. p. 370, pl. 30, fig. 15. ib. loc.

HETEROLEPIDOTUS, Eg. (*Eulepidotus*, Eg. *Lepidotus*, Ag.)
— *latus*, Eg. M. G. S. Dec. 13, in the press. L. Lias, Lyme Regis.

HOLOPTYCHIUS, Ag.
— *Andersoni*, Ag. P. F. V. G. R. p. 72, tab. 22, fig. 3. Devonian, Dura Den.
— *nobilissimus*, Ag. P. F. V. G. R. p. 73, tab. 23. Devonian, Clashbinnie.

HYBODUS, Ag.
— *Dubrisiensis*, Mackie. Geol. vol. 6, p. 241, pl. 13. L. Chalk, Dover.
— *elongatus*, Ag. (*Sphenonchus*, Ag), *cephalic spine*, P. F. tom. 3, p. 202, tab. 22*a*, fig. 18. Wealden, Tilgate Forest.
— *pyramidalis*, Ag. P. F. tom. 3, p. 182, tab. 22*a*, figs. 20, 21 (*teeth*). L. Lias, Lyme Regis.
— *striatulus*, Ag. (*spines*), P. F. tom. 3, p. 44, tab. 8*b*, figs. 1. 1*a*. *Silurus*, sp. Mant. F. T. F. p. 58, tab. 10, fig. 6. Wealden, Tilgate Forest.
— ,, Ag. *Silurus* (*spine*), Mant. F. T. F. p. 58, tab. 10, fig. 6. ib. loc.
— *sulcatus*, Ag. (*spines*), P. F. tom. 3, p. 44, tab. 10*b*, figs. 15, 16. Chalk, Lewes.

HYPSODON, Ag.
— *Lewesiensis*, Ag. P. F. tom. 5, p. 99, tab. 25*a*, fig. 1. Chalk, Sussex.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*a*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*a*, fig. 3. ib. loc.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*b*, fig. 1. Mant. G. S. p. 241, tab. 42, figs. 1, 4. ib. loc.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*b*, fig. 2. Mant. G. S. p. 241, tab. 42, fig. 3. ib. loc.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*b*, figs. 4, 5. ib. loc.
— ,, Ag. P. F. tom. 5, p. 99, tab. 25*b*, figs. 6, 7. Mant. G. S. p. 41, tab. 42, fig. 2. ib. loc.
— *minor*, Dixon, F. S. pl. 32*, figs. 9, 9*. ib. loc.

LAMNA, Cuvier.
— *acuminata*, Ag. P. F. tom. 3, p. 292, tab. 37*a*, fig. 54. Dixon, F. S. pl. 30, fig. 19. ib. loc.
* — ,, Dixon, F. S. tab. 30, fig. 26, tab. 31, fig. 18. ib. loc.
— *elegans*, Ag. P. F. tom. 3, p. 369, tab. 40*b*, fig. 24. London Clay, Sheppey.
— *raphiodon*, Ag. P. F. tom. 3, p. 296, tab. 37*a*, figs. 11, 12, 13. Chalk, Sussex.
* — ,, Ag. Dixon, F.S. tab. 30, fig. 32. ib. loc.

LEPIDOSTEUS, Ag.
— *sp.* L. G. J. p. 6, figs. 9, 9*a*, 9*b*. M. Eocene, Hordwell.

LEPIDOTUS, Ag.
— *Fittoni*, Ag. P. F. tom. 2, p. 265, tab. 30*a*, fig. 1, tab. 30*b*, fig. 1. Wealden, Tilgate Forest.
— ,, Ag. P. F. tom. 2, p. 265, tab. 30*a*, fig. 3. ib. loc.
— ,, Ag. P. F. tom. 2, p. 265, tab. 30*b*, fig 3. ib. loc.
— *gigas*, Ag. P. F. tom. 2, p. 235, Baker, Hist. Northampt. vol. 1, p. 440, pl. Lias, Northamptonshire.

LEPIDOTUS, Ag.
— *Mantelli,* Ag. P. F. tom. 2, p. 262, tab. 30*c*, fig. 1. Wealden, Tilgate Forest.
— ,, Ag. P. F. tom. 2, p. 262, tab. 30*a*, figs. 4, 5. ib. loc.
— ,, Ag. P. F. tom. 2, p. 262, tab. 30*b*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 2, p. 262, tab. 30*c*, figs. 2, 3. ib. loc.
— *rugosus,* Ag. P. F. tom. 2, p. 246, tab. 33*a*, fig. 4. Lias, Whitby.
LOPHIOSTOMUS, Eg.
— *Dixoni,* Eg. M. G. S. Dec. 6, plates 10, 10*. Chalk, Alfriston, Sussex.
MACROPOMA, Ag.
— *Mantelli,* Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*a* (*bis*), fig. 1. *Amia? Lewesiensis,* Mant. G. S. p. 239, tab. 38. Chalk, Sussex.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*a* (*bis*), fig. 2. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*b*. *Amia? Lewesiensis,* Mant. G. S. p. 239, tab. 37. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*c*, fig. 1. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*c*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*c*, fig. 3. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*c*, fig. 4. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2. p. 174, tab. 65*d*, fig. 1. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*d*, fig. 2. ib. loc.
— ,, Ag. P. F. tom. 2, pt. 2, p. 174, tab. 65*d*, fig. 3. ib. loc.
— ,, Ag. (coprolites) P. F. tom. 2, pt. 2, p. 177, tab. 65*a* (*bis*), figs. 3, 4, 5, 11. ib. loc.
MICRODON, Ag.
— *nuchalis,* Eg. Dixon, F. S. p. 369, pl. 32, fig. 7. Chalk, Washington, Sussex.
MYLIOBATES, Dumeril.
— *contractus,* Dixon, F. S. p. 200, pl. 11, fig. 17. M. Eocene, Bracklesham.
— *Dixoni,* Ag. Dixon, F. S. p. 198, pl. 10, figs. 1, 2. ib. loc.
— ,, Ag. Dixon, F. S. p. 198, pl. 12, fig. 3. ib. loc.
— *Edwardsii,* Dixon, F. S. p. 199. pl. 11, fig. 16. ib. loc.
* — *Toliapicus,* Ag. Dixon, F. S. p. 198, pl. 10, figs. 3, 4. ib. loc.
MYRIACANTHUS, Ag.
— *paradoxus,* Ag. P. F. tom. 3, p. 38, tab. 6, figs. 1, 2. L. Lias, Lyme Regis.
NOTAGOGUS, Agass.
— *Pentlandi,* Ag. P. F. tom. 2, p. 294, tab. 49, fig. 2. Oolite, Torre d'Orlando, near Naples.
OPHIOPSIS, Ag.
— *penicillatus,* Ag. P. F. tom. 2, p. 290, tab. 36, figs. 2–4. Purbeck Limestone.
ORTHAGORISCUS, Schneider.
— *species,* Dixon, F. S. pl. 32, figs. 3, 4. Chalk, Sussex.
OSMEROIDES, Ag.
— *Lewesiensis,* Ag. P. F. tom. 5, p. 105, tab. 60*b*, fig. 1. Chalk, Lewes.
— ,, Ag. P. F. tom. 5, p. 105, tab. 60*b*, fig. 2. *Salmo Lewesiensis,* Mant. G. S. p. 256. ib. loc.
— ,, Ag. P. F. tom. 5, p. 105, tab. 60*b*, figs. 3, 4. ib. loc.
— ,, Ag. P. F. tom. 5, p. 105, tab. 60*c*, fig. 1. ib. loc.
— ,, Ag. P. F. tom. 5, p. 105, tab. 60*c*, fig. 2. ib. loc.
— ,, Ag. *Salmo Lewesiensis,* Mant. G. S. p. 235, tab. 40, fig. 1. ib. loc.
OSTEOLEPIS, Valenc. and Pentl.
— *arenatus,* Ag. P. F. tom. 2, p. 122, tab. 2*d*, fig. 1. Devonian, Gamrie.
— ,, Ag. P. F. tom. 2, p. 122, tab. 2*d*, fig. 4 (*counterpart*). ib. loc.
OTODUS, Ag.
— *appendiculatus,* Ag. P. F. tom. 3, p. 270, tab. 32. Figs. 1, 5, 6, 11, 14. *Squalus mustelus,* Mant. G. S. p. 226, tab. 32, fig. 6. Chalk, Sussex.
OXYRHINA, Ag.
— *crassidens,* Dixon, F. S. p. 367, pl. 31, figs. 13, 13*a*. Chalk, Houghton.
— *Mantelli,* Ag. P. F. tom. 3, p. 280, tab. 33, figs. 2, 4, 6, 7. 8, 9. Chalk, Sussex.
— ,, Ag. *Squalus mustelus,* Mant. G. S. p. 226, tab. 32, fig. 11. ib. loc.
— ,, Ag. *Squalus zygæna,* Mant. G. S. p. 227, pl. 32, figs. 8, 26, 28. ib. loc.

PACHYRHIZODUS, Ag.
— *basalis*, Dixon, F. S. p. 374, pl. 34, fig. 10. Chalk, Steyning.
— *glyphodus*, Blake and Mackie, Geol. vol. 6, p. 133, pl. 21, figs. 12, 13. Gault, Folkestone.
PERIODUS, Ag.
* — *Kœnigii*, Ag. Dixon, F. S. p. 205, pl. 10, fig. 13. M. Eocene, Bracklesham.
PHACODUS, Dixon.
— *punctatus*, Dixon, F. S. p. 371, pl. 30, fig. 16. Chalk, Lewes.
PHANEROPLEURON, Huxley.
— *Andersoni*, Huxl. M. G. S. Dec. 10, pl. 3, fig. 1. Devonian, Dura Den.
— ,, Huxl. M. G. S. Dec. 10, pl. 3, fig. 3. ib. loc.
PHOLIDOPHORUS, Ag.
— *ornatus*, Ag. P. F. tom. 2, p. 280, tab. 37, figs. 6, 7. Purbeck, Swanage.
PHYLLODUS, Ag.
— *Bowerbanki*, Cocchi, Pesch. Lab. p. 36, tav. 2, fig. 2, *2a*. London Clay, Sheppey.
— ,, Cocchi, Pesch. Lab. p. 36, tav. 2, fig. 3. ib. loc.
— *hexagonalis*, Cocchi, Pesch. Lab. p. 28, tav. 1, fig. 3. ib. loc.
— *medius*, Ag. Pesch. Lab. p. 50, tav. 2, fig. 14. ib. loc.
— *petiolatus*, Owen, Pesch. Lab. p. 45, tav. 3, fig. 2. ib. loc.
— ,, Owen, Pesch. Lab. p. 45, tav. 3, fig. 5. ib. loc.
— *secundarius*, Cocchi, Pesch. Lab. p. 38, tav. 2, fig. 7, *7a*. ib. loc.
— ,, Cocchi, Pesch. Lab. p. 38, tav. 6, fig. 3, *3a*. ib. loc.
— *speciosus*, Cocchi, Pesch. Lab. p. 32, tav. 1, fig. 6, *6a*. ib. loc.
— ,, Cocchi, Pesch. Lab. p. 32, tav. 1, fig. 8, *8a*. Red Crag (derived), Sutton.
— ,, Cocchi, Pesch. Lab. p. 32, tav. 2, fig. 6. ib. loc.
— *submedius*, Cocchi, Pesch. Lab. p. 54, tav. 2, fig. 13, *13a*. London Clay, Sheppey.
— *Toliapicus ?* Ag. Pesch. Lab. tav. 2, fig. 15. Red Crag (derived), Suffolk.
PLATYGNATHUS, Ag.
— *Jamesoni*, Ag. P. F. V. G. P. p. 77, tab. 25. Devonian, Dura Den.
PLATYLÆMUS, Dixon.
— *Colei*, Dixon, F. S. p. 205, pl. 10, fig. 23. M. Eocene, Bracklesham.
— ,, Dixon, F. S. p. 205, pl. 12, figs. 11, 12, 13. ib. loc.
PLATYSOMUS, Ag.
— *striatus*, Ag. King. Perm. Foss. p. 231, pl. 27. Permian, Ferry Hill.
PLINTHOPHORUS, Gunther.
— *robustus*, Gunther, GEOL. MAG. Vol. 1, p. 114, Pl. 6. L. Chalk, Folkestone.
PRIONOLEPIS, Eg.
— *angustus*, Eg. Dixon, F. S. p. 368, pl. 32*, fig. 3. Chalk, Burwell.
PRISTIS, Latham.
— *bisulcatus*, Ag. P. F. tom. 3, p. 382*, tab. 41 (*rostral bone*). Eocene? Sheppey?
— *contortus*, Dixon, F. S. p. 202, pl. 12, figs. 9, 10 (*rostral tooth*). M. Eocene, Bracklesham.
PTERICHTHYS, Ag.
— *macrocephalus*, Eg. J. G. S. vol. 18, p. 104, fig. 2, pl. 3, fig. 8. Devonian, Farlow.
PTYCHODUS, Ag.
— *arcuatus*, Ag. P. F. tom. 3, p. 58, tab. 10*a*, fig. 2. *Balistes ?*, Mant. G. S. p. 231, tab. 40. fig. 3 (*fin-rays*). Chalk, Lewes.
— *articulatus*, Ag. P. F. tom. 3, p. 58; tab. 10*a*, figs. 5, 6, Mant. G. S. p. 231, tab. 34, fig. 8 (*fin-rays*). ib. loc.
— *decurrens*, Ag. P. F. tom. 3, p. 154, tab. 25*b*, fig. 8, 9 (*tooth*). ib. loc.
* — ,, Ag. Dixon, F. S. p. 362, pl. 30, fig. 7, 8, pl. 31, fig. 1 (*teeth*). Chalk, Sussex.
— *depressus*, Eg. Dixon, F. S. p. 363, pl. 31, fig. 9 (*tooth*). ib. loc.
— *gibberulus*, Ag. P. F. tom. 3, p. 58, tab. 10*a*, fig. 4 (*fin-rays*). Chalk, Lewes.
— *mammillaris*, Ag. P. F. tom. 3, p. 151, tab. 25*b*, figs. 12, 14, 15, 18 (*teeth*). Chalk, Lewes.
— *Oweni*, Eg. Dixon, F. S. p. 364, pl. 31, fig. 2 (*tooth*). Chalk, Snodland.
— *paucisulcatus*, Eg. Dixon, F. S. p. 363, pl. 30, fig. 3 (*tooth*). Chalk, Sussex.

PTYCHODUS, Ag.
— *polygyrus*, Ag. P. F. tom. 3, p. 156, tab. 25, figs. 4, 5, 8, Mant. G. S. p. 231, tab. 32, fig. 29 (*teeth*). Chalk, Lewes.
— *spectabilis*, Ag. P. F. tom. 3, p. 57, tab. 10*a*, fig. 1 (*fin-ray*), "*allied to Balistes*," Mant. G. S. p. 229, tab. 39. ib. loc.
— ? sp. Ag. P. F. tom. 3, p. 59, tab. 10*b*, fig. 18. ib. loc.
PYCNODUS, Ag.
— *Mantelli*, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 6. Wealden, Tilgate Forest.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 7. ib. loc.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 8. ib. loc.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 9. ib. loc.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 11. ib. loc.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 12. ib. loc.
— ,, Ag. P. F. tom. 2, p. 196, tab. 72*a*, fig. 14. ib. loc.
— *liassicus*, Eg. (*Mesodon*, Wagn.), M. G. S. Dec. 8, pl. 10. Lias, Barrow-on-Soar.
RHYNCHONICHTHYS, Mantell. Mss.
— *Taylori*, Mant. Mss. Chalk, Kent.
SAUROCEPHALUS, Harlan.
* — *lanciformis*, Harl. P. F. tom. 5, pt. 1, p. 102, tab. 25*c*, figs. 21, 24, 27, 28, 29. Chalk, Lewes.
* — ,, Harl. Dixon, F. S. p. 374, pl. 31, fig. 12. Chalk, Kent.
— *striatus*, Ag. P. F. tom. 5, p. 102. tab. 25*c*, figs. 17, 18. Chalk, Lewes.
SAURODON, Hays.
* — *Leanus*, Hays, P. F. tom. 5, p. 102, tab. 25*c*, figs. 30, 31. ib. loc.
* — ,, Hays, Dixon, F. S. p. 373, pl. 30, figs. 28, 29. Chalk, Sussex.
SCAPHASPIS, Lankester.
— *Dunensis*, Roem. (*Archæoteuthis*, Rœmer), L. and B. Jahrb, 1858, p. 55, (*Pteraspis*, Kner). J. G. S. vol. 17. p. 163. Devonian, Wassenach.
— *rectus*, Lank. F. O. R. S. p. 23, pl. 2, fig. 7. Devonian, Heightington.
SILURUS, Linn.
— *Egertoni*, Dixon, F. S. p. 204, pl. 11, fig. 11. M. Eocene, Bracklesham.
— ,, Dixon, F. S. p. 204, pl, 11, fig. 12. ib. loc.
— ,, Dixon, F. S. p. 204, pl. 11, fig. 13. ib. loc.
SPHENONCHUS, Ag. v. HYBODUS.
SPHYRÆNODUS, Ag.
— *tenuis*, Dixon, F. S. p. 112, pl. 11, fig. 24. M. Eocene, Bracklesham.
SPINAX, v. DREPANEPHORUS.
STENOSTOMA, Ag.
— *pulchella*, Dixon, F. S. p. 373, pl. 36, fig. 2. Chalk, Steyning.
STROPHODUS, Ag.
— *asper*, Ag. P. F. tom. 3, p. 128*b*, tab. 10*b*, figs. 1–3. Chalk, Lewes.
— *medius*, Owen, GEOL. MAG. Vol. 7, p. 193, Pl. 7. Oolite, Caen.
TERATICHTHYS, König.
— *antiquitatis*, König, Icon. F. S. p. 4, fig. 79, 79*. London Clay, Sheppey.
TETRAGONOLEPIS, Ag.
— *droserus*, Eg. J. G. S. vol. 9, p. 278, pl. 11, fig. 4 (teeth only figured). Lias, Boll, Wurtemberg.
TETRAPTERUS, Ag.
— *minor*, Ag. P. F. tom. 5, p. 91, pl. 60*a*, figs. 9–13. Chalk, Lewes.
* — ,, Ag. Dixon, F. S. pl. 31, fig. 16. Chalk, Sussex.
THLATTODUS, Owen.
— *suchoides*, Ow. GEOL. MAG. Vol. 3, p. 55, Pl. 3. Kimmeridge Clay, Downham.
TOMOGNATHUS, Ag.
— *leiodus*, Dixon, F. S. p. 377, pl. 30, fig. 31. Chalk, Sussex.
TRISTICHOPTERUS, Eg.
— *alatus*, Eg. M. G. S. Dec. 10, p. 51, pl. 5 (*counterpart*). Devonian, John o' Groats House.
Shagreen of a Placoid Fish, Ag. P. F. tom. 3, tab. 10*b*, figs. 6, 7. Chalk, Lewes.

Jaw of a Fish (? Enchodus), in flint, Ann. Nat. Hist. vol. 19, p. 7. Chalk, Kent.
Remains of a Large Fish, undescribed, L. G. J. p. 21, Woodcuts. Chalk, Kent.

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Geol. The Geologist.
Icon. F. S. Icones Fossilium Sectiles, by Charles König, 1825.
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P. F. d'Oen. Description de quelques nouvelles espéces de Poissons Fossiles des Calcaires d'eau douce d'Oeningen, par T. C. Winkler.

NOTICES OF MEMOIRS.

I.—THE INTERNAL FLUIDITY OF THE EARTH.[1]

The following is a translation of a letter addressed by Professor H. Hennessy, F.R.S., to the Secretary of the Academy of Sciences of Paris, which has appeared in the *Comptes Rendus* for March the 6th:

"On the 13th of July, 1868, M. Delaunay made a communication to the Academy, in which he treats of the rotation of the earth considered as a hollow shell inclosing a nucleus of fluid matter. By a simple train of reasoning he was led to conclude that the very slow motions of rotation which produce the phenomena of precession and nutation of the earth's axis would take place as if the whole earth were absolutely solid, and therefore that the phenomena of precession and nutation could not afford any foundation for an estimate of the thickness of the solid crust of the globe. When I read M. Delaunay's paper in the *Comptes Rendus*, I was much pleased to find

[1] Communicated by Prof. E. Hull, F.R.S., etc.

so remarkable a confirmation of conclusions, to which I had been long since led, and which I have developed in my publications, thus emanating from such an eminent mathematician. At the time I thought it unnecessary to put forward any claim as to priority, but since 1868 I have noticed that several geologists have quoted M. Delaunay's results as if they were unexpected, and I may therefore be excused for calling the attention of the Academy to what I had previously made public. In my "Researches in Terrestrial Physics," published in the *Philosophical Transactions* for 1851, I endeavoured to investigate the structure of the earth by the aid of known physical and mechanical laws. I was thus led to reject the hypothesis always openly or tacitly made by mathematicians in treating of the earth's figure, namely, that the particles of the fluid mass from which it had partly solidified underwent no change of position during the process of solidification. From a consideration of the mechanical and physical properties of the materials of the earth's crust which are known to us, I was led to conclude, that in the process of solidification of the crust, its interior surface would assume an ellipticity at least as great as that of its exterior surface.

A conclusion nearly equivalent was announced soon afterwards by a distinguished geometer, Baron Plana, of Turin, in a paper inserted in Schumacher's *Astronomische Nachrichten,* No. 860. This result must follow, no matter what may be the law of density of the strata of the interior fluid nucleus, because the removal of each successive outer stratum by solidification and adhesion to the inner surface of the crust modifies the pressure on the remaining fluid and allows it to assume a shape possessing almost the same ellipticity as the primitive spheroid.

In the investigation made by Mr. Hopkins on the phenomena of precession and nutation, he assumed the absence of friction between the solid shell and its contained fluid, and in this way he was led to establish the expression—

$$P^1 - P_1 = \left(1 - \frac{\epsilon}{\epsilon_1}\right)\left\{1 - \frac{\eta}{1 + \frac{h}{q^5 - 1}}\right\} P_1$$

where P^1 denotes the observed precession, P_1 that of a solid homogeneous spheriod having the ellipticity ϵ_1 equal to that of the shell's outer surface, ϵ is the ellipticity of the inner surface of the shell, the other letters represent functions depending on the density of the shell and nucleus, but such that the quantity $\frac{\eta}{1 + \frac{h}{q^5 - 1}}$ is a small fraction, always much less than unity. The application of the above formula to the question of the thickness of the earth's crust manifestly depends upon the value of the fraction $\frac{\epsilon}{\epsilon_1}$. In order to determine this value, Mr. Hopkins tacitly assumed the hypothesis which I rejected, and found the value of ϵ on the supposition that it contained the same at every stage of the earth's solidification. If, in accordance with my results, we make ϵ equal to or at least not less than ϵ_1, we would have $P^1 = P$ or $P^1 \angle P_1$, values so entirely different from the observed value of precession that I was led to conclude that the motion of rotation of the crust and its contained fluid takes place nearly as if the mass were entirely solid. Six years afterwards I reiterated the same result in the *Atlantis*, and also showed from independent reasons why great friction and pressure should be expected to exist between the fluid nucleus and the inner surface of the crust. At the meeting of the British Association, at Manchester, in 1861, I took an opportunity, in the presence of Mr. Hopkins, of pointing out the inconclusiveness of his results regarding the internal structure of the earth, and I again distinctly repeated my former conclusions. Mr. Hopkins promised a reply to my remarks, but this promise has never been fulfilled."

It appears from the number of *Nature* for March 23 that at the meeting of the French Academy of Sciences, on the 13th of March, M. Delaunay read a declaration, stating "that he acknowledged that Mr. Hennessy had used the same arguments as himself against Mr. Hopkins's theory relative to the fluidity of the interior parts of the earth."

II.—Review and Synopsis of the Contributions to Fossil Botany Published in Britain in 1870.[1]

By William Carruthers, F.L.S., F.G.S., of the British Museum.

Carruthers, W.—On Fossil Cycadean Stems from the Secondary Rocks of Britain. Trans. Linn. Soc., vol. xxvi. pp. 675–708, pl. liv–lxiii.

After investigating the nature of the Palæozoic remains referred to *Cycadeæ*, the author describes twenty-five species belonging to eight genera. Four of the genera are placed in one or other of the tribes of the existing Cycads, while two new tribes are established for the remaining genera.

——— On the Petrified Forest near Cairo. Geol. Mag. Vol. VII. pp. 306–310, Pl. XIV.

The so-called forest is described, and the different specimens of silicified woods found in it are referred to two species of the genus *Nicolia.*

——— On the Structure of a Fern-stem from the Lower Eocene of Herne Bay, and on its Allies, Recent and Fossil. Quart. Journ. Geol. Soc. vol. xxvi. pp. 349–353.

The stem (*Osmundites Dowkeri*) is minutely described, and compared with that of *Osmunda regalis*, L. A new arrangement of some described Fern-stems from Palæozoic and Mesozoic rocks is proposed by the author.

Dawson, J. W.—On the Pre-carboniferous Floras of North-eastern America, with especial reference to that of the Erian (Devonian) Period. Abstract. "Proceedings of Royal Society," May 5, 1870.

The Erian Flora is revised, and twenty-three new species added. Large trunks of *Prototaxites* were described, and also two species of *Psilophyton*, with details of their form, structure, and fructification. The occurrence of *Lepidophloios* and *Calamodendron*, noticed for the first time in the Middle Devonian; specimens of *Cyclostigma* and *Cardiocarpum*, and a new genus, *Ormoxylon*, were described.

[1] Reprinted from *The Journal of Botany* for April, 1871.

——————— On the Graphite of the Laurentian Rocks of Canada. Quart. Journ. Geol. Soc. vol. xxvi. pp. 112–117.

The author estimates that the quantity of carbon in the Laurentian is equal to that in similar areas of the Carboniferous systems. This carbon has been obtained from the deoxidation of carbonic acid by plants, and consequently indicates the existence of plants side by side with the *Eozoon.*

M'NAB, W. R.—On the Structure of a Lignite from the Old Red Sandstone. Trans. Bot. Soc. Edin. vol. x. p. 312.

The author proposes to name the wood which he describes *Palæopitys Millerii.* It was found by Hugh Miller at Cromarty.

VON MUELLER, F., and R. BROUGH SMYTH. Observations on some Vegetable Fossils from Victoria. GEOL. MAG., Vol. VII. p. 390.

The specimens were fruits from surface deposits, and were obtained from one of the deep leads at Haddon. One is a coniferous fruit allied to *Solenostrobus*, of Bowerbank, to which the name of *Spondylostrobus Smythii* is given. The others are not named, but suggestions are given as to their affinities, and these indicate, according to Von Mueller, a flora analogous to that of the existing forest-belt of Eastern Australia.

WILLIAMSON, W. C.—Contributions towards the History of *Zamia gigas*, Lindl. and Hutt. Trans. Linn. Soc., vol. xxvi. pp. 663–674, pl. 52, 53.

The author gives an account of the different structures which he believes to belong to this plant, describing in detail the stem, leaves, and male and female flowers.

Synopsis of the Genera and Species described in the preceding Papers.

FILICES.

Chelepteris, Quart. Journ. Geol. Soc. vol. xxvi. p. 352.

Osmundites Dowkeri, Carr. Quart. Journ. Geol. Soc. vol. xxvi. p. 349. *Lower Eocene.* Herne Bay.

CYCADEÆ.

Bennettites Gibsonianus, Carr. Trans. Linn. Soc. vol. xxvi. p. 681, pl. lviii–lx. *Lower Greensand.* Luccombe Chine, Isle of Wight.

B. maximus, Carr. l. c. *Wealden.* Isle of Wight.

B. Peachianus, Carr. l. c.; pl. lxii. *Middle Oolite.* Helmsdale, Sutherlandshire.

B. Portlandicus, Carr. l. c.; pl. lxi. *Lower Purbeck.* Isle of Portland, Dorsetshire.

B. Saxbyanus, Carr. l. c.; pl. lvii. *Wealden.* Isle of Wight.

Bucklandia anomala, Presl, Trans. Linn. Soc. vol. xxvi. p. 679; pl. liv. fig. 1–3. *Wealden.* Cuckfield, Sussex.

B. Mantellii, Carr. l. c.; pl. liv. fig. 4. *Wealden.* Cuckfield, Sussex.

B. Milleriana, Carr. l. c.; pl. lv. fig. 1. *Coral Rag.* Brora, Sutherlandshire.

B. squamosa, Brongn. l. c. *Stonesfield Slate.* Stonesfield.

Crossozamia Buvignieri, Pomel, l. c. p. 680. *Jurassic.* St. Michel, France.

C. Moreaui, Pomel, l. c. *Jurassic.* St. Michel, France.

Mantellia inclusa, Carr. l. c. p. 681; pl. lxiii. fig. 2 and 3. *Lower Greensand.* Potton, Cambridgeshire.

M. intermedia, Carr. l. c.; pl. lxiii. fig. 4 and 5. *Lower Purbeck.* Isle of Portland, Dorsetshire.

M. microphylla, Brongn. l. c.; pl. lxiii. fig. 6. *Lower Purbeck.* Isle of Portland, Dorsetshire.

M. nidiformis, Brongn. l. c.; pl. lxiii. fig. 1. *Lower Purbeck.* Isle of Portland, Dorsetshire,

Raumeria Reichenbachiana, Göpp. l. c. p. 682. *Formation unknown.* Wieliczka, Gallicia.

R. Schulziana, Göpp. l. c. *Formation unknown.* Gleiwitz, Silesia.

Williamsonia gigas, Carr. l. c. p. 680; pl. lii. and liii. *Inferior Oolite.* Scarborough, Yorkshire.

W. hastula, Carr. l. c. *Inferior Oolite.* Saltwick, Yorkshire.

W. pecten, Carr. l. c. *Inferior Oolite.* Gristhorpe, Yorkshire.

Yatesia crassa, Carr. l. c. p. 680; pl. lv. fig. 7. *Coral Rag.* Brora, Sutherlandshire.

Y. gracilis, Carr. l. c.; pl. lv. fig. 2. *Lias.* Lyme Regis, Dorsetshire.
Y. Joassiana, Carr. l. c.; pl. lv. fig. 8 and 9. *Coral Rag.* Brora, Sutherlandshire.
Y. Morrisii, Carr. l. c.; pl. lv. fig. 3–6. *Lower Greensand.* Potton, Cambridgeshire.
Zamia gigas, Lindl. and Hutt. Trans. Linn. Soc. vol. xxvi. p. 663; pl. lii. and liii. *Inferior Oolite.* Yorkshire.

CONIFERÆ.
Ormoxylon, Dawson, Proc. Roy. Soc., May, 1870.
Palæopitys Millerii, M'Nab, Trans. Bot. Soc. Edin. vol. x. p. 312.
Spondylostrobus Smythii, Von Muell. GEOL. MAG. Vol. VII. p. 390. *Post-Tertiary.* Haddon, near Smythesdale, Victoria.

ANGIOSPERMOUS DICOTYLEDONS.
Nicolia Ægyptiaca, Endl. GEOL. MAG. Vol. VII. p. 309, Pl. xiv. Fig. 1 and 2. *Tertiary.* Desert of Suez, east from Cairo.
N. Owenii, Carr. GEOL. MAG. Vol. VII. p. 310, Pl. XIV. Fig. 3 and 4. *Tertiary.* Desert of Suez, east from Cairo.

REVIEWS.

I.—METALLOGRAPHY AS A SEPARATE SCIENCE, OR THE STUDENT'S HANDBOOK OF METALS, CONSISTING OF NOTES OF FIFTY-FIVE METALS. By THOMAS ALLEN BLYTH, M.A., Ph. D., etc. London: 8vo. pp. 128. (Longmans, Green, Reader, & Dyer, 1871.)

THIS small treatise appears to consist of contributions which had previously appeared in various Magazines, to some extent revised by the author, and is now reprinted in a separate form.

The design of the work is a useful one, and is intended to convey in an elementary manner the general character, properties, and uses of the various metals. It consists of 58 chapters, each of which, except the first three, are devoted to one of the Metals, arranged in alphabetical order. The first three chapters are devoted to the general physical characters and properties of the various metals, which, we think, might have been somewhat more extended to the benefit of the reader, inasmuch as when treating of mettallic lustre, specific gravity, fusibility, or crystallization, the author does not mention the different kinds of lustre, or the mode of taking their specific gravity, the various degrees of hardness, their relative degrees of fusibility, or the crystalline forms which many of the metals are known to assume.[1] Nor does he distinctly enumerate all those metals which are found in a native state from others which occur merely in combination. And further, the author does not give a complete list either of the native metals or of all the other elements with which they are found associated in nature. Even amongst those that are mentioned as the most general combinations are oxygen and sulphur, as well as carbon and phosphorus: the two former, either as oxides or sulphides, are very abundant in the

[1] In chapter 3, a brief account is given of the *alloys* of metals and their general characters as to their density and fusibility.

mineral kingdom; but the two latter, as carbides and phosphides, are of excessively rare occurrence.

The only one mentioned under iron is the carburet, a name applied sometimes to plumbago or graphite, which is usually placed by mineralogists in close proximity to the diamond as another variety of carbon; the iron being considered to be only mechanically mixed with it, inasmuch as the iron occurs in variable quantities, while the phosphides have only been found native in meteoric stones in exceedingly small quantities; the general occurrence being that of a phosphate.

Chapter 1st contains a table of the metals alphabetically arranged with their symbols, equivalents, specific gravity, and date of discovery.

In the last Chapter is also given a classification of metals, based on their relative affinity for oxygen, as also according to the nature of their oxides, which is followed by a very brief account of their mode of occurrence.

The author has evidently a strong admiration for rhymes, but is not always equally happy in the selections he has made; take, for instance, the following, signed "Eulalia Gurson,"—but quite worthy of Mr. Tupper,—on the metal *Potassium,* p. 85:—

"When thrown upon water, this metal ignites,
And leaps o'er its surface with violet-tinged lights;
Or, if upon ice this substance you cast,
It will melt by degrees and be dissolved at last."

There is a Glossary of eight pages devoted to the explanation of common words, to be met with in most dictionaries, but hardly deserving the name it bears.

II.—AMERICAN GEOLOGICAL SURVEYS.

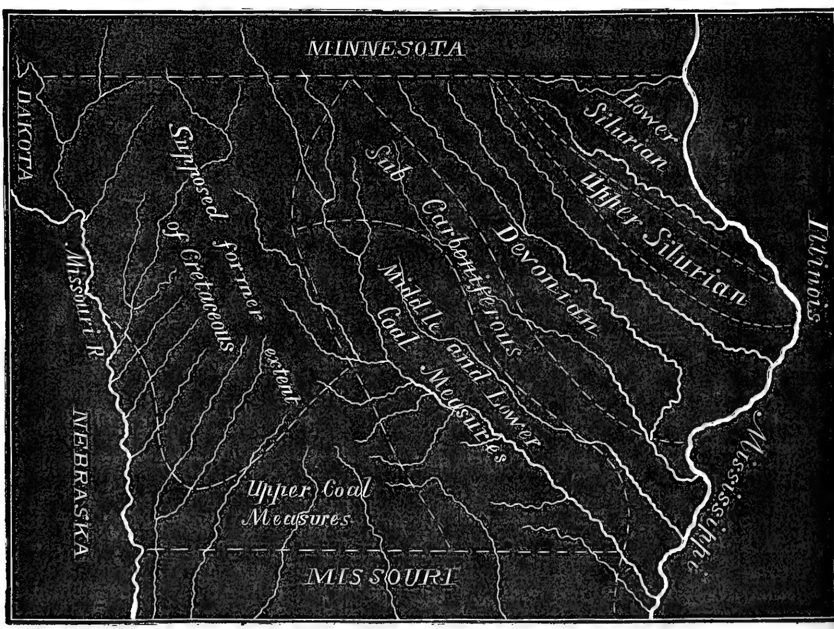
(*Continued from page* 180.)

Report on the Geological Survey of the State of Iowa. By C. A. White, M.D. Two vols. 8vo., 834 pages, and numerous Lithographic Illustrations. (1871.)

These are the results of observations made in the years 1866—1869, at an expense of 26,000 dols. for field-work, and of 18,000 dols. for publication. Iowa had previously issued two octavo reports in 1859, under the superintendence of Prof. James Hall, LL.D., of Albany, N.Y., which described exclusively the geological features of the eastern portion of the State, including the sketch of the Mineral Region near Dubique, by Prof. J. D. Whitney. Dr. White's reports relate chiefly to the fields not explored by Professor Hall. The earlier volumes describe the fossils so far as they were known ten years ago. The later ones contain no palæontological descriptions, although there exists in private hands an immense amount of material, chiefly the Mountain Limestone Crinoids from the vicinity of Burlington.

The following is Dr. White's table of the formations of Iowa :—

SYSTEMS. (*Ages.*)	GROUPS. (*Periods.*)	FORMATIONS. (*Epochs.*)	Approximate thickness in feet.
	POST-TERTIARY.	DRIFT.	
Cretaceous.	Lower Cretaceous.	Inoceramus beds	50
		Woodbury Sandstone and shales ...	130
		Nishnabotany Sandstone	100
Carboniferous.	Coal Measures ...	Upper Coal-measures	200
		Middle Coal-measures	200
		Lower Coal-measures	200
	Sub-Carboniferous.	St. Louis Limestone	75
		Keokuk Limestone...	90
		Burlington Limestone	190
		Kinderhook beds	175
Devonian.	Hamilton.	Hamilton shales and Limestone ...	200
Upper Silurian.	Niagara.	Niagara Limestone	350
Lower Silurian.	Cincinnati.	Maquoketa shales	80
	Trenton	Galena Limestone	250
		Trenton Limestone	200
	Primordial ...	St. Peter's Sandstone	80
		Lower Magnesian Limestone ..	250
		Potsdam Sandstone	300
Azoic.	Huronian (?)	Sioux Quartzite	50
			3170



SKETCH MAP OF STATE OF IOWA.

The first part of the report relates to Physical Geography and Surface Geology. The State has an area of 55,044 square miles. The surface is rolling, but is essentially part of a great plain, continuous from the surrounding States, the valleys having been eroded in Glacial Drift deposits. This plain averages 800 feet in height above the ocean; the lowest point in the south-east corner being 444 ft., and the highest 1,200 feet, though more than a thousand miles from the sea. There are two systems of river drainage; about one-third of the streams flowing south-westerly into the Missouri River, and about two-thirds emptying south-easterly into the Mississippi River. Lakes are numerous, generally in the Drift, rarely rock-basins. Frequently walls of boulders from two to ten feet high, and from five to thirty feet wide, occur on the borders of these lakes. They were called "Lake Ramparts" by the elder Hitchcock, and seem to have been brought into their present position by the expansion of the water in freezing.

The Drift is common, having the composition of the ordinary Boulder-clay, without stratification; the largest surface-boulders weigh fifty tons. The Drift of the north-west part of the State contains proportionally more boulders, pebbles, and sand, while that of other districts shows more clay and finely comminuted materials. In the north-east part there is a "driftless region," bordering the Mississippi 130 miles long, and about 2,700 square miles in area. In this boulders are very rare, but there are some Drift-clays. It is a part of the driftless area of over 30,000 square miles pointed out by J. G. Percival and J. D. Whitney in the Geology of Wisconsin. Immediately parallel to it on the west the boulders are unusually numerous. The maximum thickness of the Drift is from 150 to 200 feet, and it is best developed along the dividing ridge. It is so abundant in the north-west quarter of the State that the underlying formations are not represented upon the Geological Map which accompanies the report, on the scale of twenty miles to the inch. The Drift is universally of northern origin, and striæ are found in only four out of 102 counties. Near Burlington and generally their course is S. 10°—40° E., but near Council Bluffs they run S. 50° W. The ice is thought to have been produced by glaciers. The "Bluff," or deposit, overlies the Drift, and is confined to the Missouri valley. It is part of a continuous band, more than 200 miles in length, and nearly half as wide; it is a sort of a terrace, and composed of Silica, 82·15; Iron, 3·89; Alumina, 6·7; Carbonate of Lime, 9·66; and thus closely resembles the silt of the Missouri now forming. Professor White thinks the material of the Bluff came from the calcareous Cretaceous strata along the upper Missouri river.

Dr. D. D. Owen was the first to publish the existence of Cretaceous beds in Iowa, but Jules Marcou was the first to notice it away from the immediate vicinity of Sioux city. The beds probably covered a fourth part of the State, though but a few patches of it are represented upon the map. The rocks are incoherent sandstones and chalky limestones. Remains of Squaloid Selachians, *Ptychodus*, three *Teleostei*, scales of a Lepidoganoid; *Inoceramus*, *Ostrea*, and *Globulina* comprise the fauna of these beds. The Iowa division of the Cretaceous is the south-east extension of the enormous Cretaceous area described on the Upper Missouri by Meek and Hayden.

The Coal-measures in America are not usually subdivided by geologists, but are very naturally divided in Iowa into three portions, Upper, Middle and Lower—the latter containing the principal coal-beds; but the two lower divisions composed of sandstone, shales and thin beds of limestones. The upper portion is almost entirely a limestone, without coal. It is in the south-west part of the State. The general dip of the strata is south-westerly, with several minor undulations. Hence the opinion of a synclinal structure, the same limestones appearing in the valleys of the Missouri and Mississippi rivers, is no longer tenable, even though upheld by the authority of Dr. H. B. Geinitz, in 1867. If Dr. White's identifications need revision, the upper limestone would be referred to the Permian. Of that the reader may judge after the enumeration of the fossils thus far discovered in it. There are among Selachian forms the genera *Cladodus*, *Diplodus*, *Petalodus*, *Chomatodus*, *Peripristis*, *Petrodus*, *Helodus*, *Psammodus*, and *Deltodus*; of Crustacea, *Phillipsia*, *Beyrichia*, and *Cytherina*; of Mollusks numerous *Cephalopods*, *Gasteropods*, *Lamellibranchiates*, and *Bryozoa*, whose genera are not mentioned; of Brachiopods, the *Orthidæ* are represented by *Orthis*, *Meekella*, *Hemipronites*, and *Syntriclanna*; the *Productidæ* by *Productus*, *Chonetes*, and *Aulosteges*; the *Spiriferidæ* by *Spirifera*. *Martinia*, *Athyris*, and *Retzia*; Echinoids and Cyathocrinidæ; Corals by *Campophyllum*, *Axophyllum*, *Zaphrentis*, and *Syringopora*. *Fusulina* composes rock masses, and *Amphistegina* is present. The middle division has six thin beds of coal, the largest two feet thick. The lower division contains five beds of coal, from one to seven feet thick. Of 64 samples of coal analysed, when undried, the average percentages were these: of moisture, 8·57; of volatile combustible matter, 39·24; of fixed carbon, 45·42; of ash, 6·77; total volatile, 47·81; total combustible, 84·66; coke, 52·19. When dried the averages of the same samples were as follows: of volatile combustible, 42·92; of fixed carbon, 49·70; of ash, 7·38; total combustible 92·62; coke, 52·08. The composition of the coke was 87·25 carbon, 12·25 of ash.

The area covered by the outcrop of the Coal-measures is a little less than half the State, and in no portion of it would valuable beds of coal be found below 1000 feet from the surface. Hence Dr. White suggests for the benefit of the people of the State, that future wants in the direction of fuel can be easily supplied from their own territory.

The "Mountain Limestones" of Iowa are well known on account of the beautiful Crinoids abounding in the Burlington beds. Wachsmuth's collection of them contains fifty genera and three hundred and sixty-six species. The topmost member, the Chester Limestone, is not found in Iowa. The Keokuk and Burlington Limestones disappear in succession as one passes north-westerly, while the overlying St. Louis Limestone is persistent, and is found coextensive with the Kinderhook beds. It therefore overlies the three members beneath it unconformably.

Near Fort Dodge is an extensive deposit of gypsum, with only eight per cent. of foreign matters, which covers an area of about twenty-five square miles, while it varies from ten to thirty feet in thickness. Its age is uncertain, as it lies upon the Coal-measures. It was from a block of this rock that the notorious imposition called "Cardiff Giant" was carved.

The lowest rock in the State is called the "Sioux quartzite," of which only about fifty feet thickness is exposed. It is probably of Huronian age, and contains no fossils.

The two volumes of this Report are full of special details respecting the several formations throughout the State. It is perspicuously written, and reflects great credit upon the State and the author. The latter suggests that more work is required to set forth properly the Geology of the Coal-measures and the Palæontology. Mr. O. H. St. John has been the geological, and Mr. Rush Emery the chemical, assistant.—C. H. H.

(To be continued.)

REPORTS AND PROCEEDINGS.

Palæontographical Society.—Annual General Meeting held in the Apartments of the Geological Society, Somerset House, London, March 31, 1871, Dr. J. S. Bowerbank, F.R.S., President, in the Chair.

Report of the Council.—In presenting their Twenty-fourth Annual Report, the Council have again to congratulate the Members on the continued well-being of the Society. In the matter of Subscriptions the progress has been highly satisfactory, the addition of new names having more than balanced the loss arising from the absence of old and valued friends—an absence occasioned by the lapse of time, and not through any want of confidence or interest in the yearly memoirs. Much care has been bestowed to lessen the arrears and to publish the annual volumes with greater regularity; that this endeavour has not been in vain, may be shown by the fact that the volume for 1870 was wholly printed off by the close of last year, and that for 1871 is in so advanced a state that it will be issued before the winter. The volume for 1870, now completely distributed and forwarded to all members not in arrear of subscriptions, was rich in information and illustrations; produced at a cost of more than £650, it has added 174 species to those already catalogued. (For a full account of this volume see the Geological Magazine for April last, p. 175, which also contains a notice of Mr. Thos. Davidson's great work, with a memoir of that eminent Palæontologist, p. 145.) The volume for 1871 has most of its plates ready and a part of its text in type; its contents will embrace memoirs from the pens of Prof. Owen, Prof. Duncan, Dr. Lycett, Dr. Wright, Mr. Binney, Mr. Woodward, and Messrs. Boyd Dawkins and Sanford, and will treat of the *Iguanodon*, the Oolitic Corals, the *Trigoniæ*, the Coal Plants, the Older Crustacea, and the Pleistocene Mammalia. The preparation of forthcoming Monographs has not been neglected. During the last twelve months upwards of 36 plates have been drawn upon stone and copper in illustration of works connected with this and future years. Of these plates nine have been witnesses of the troubles on the Continent. The stones employed for the plates of the Trigoniæ, designed in Paris, were in great haste carried away from that city previous to the siege, and happily escaped to Switzerland without damage. The period of nearly a quarter of a century, during which the Society has flourished, has produced good fruit in Palæontographical matters through the mutual co-operation of the authors and the members of the Society. There is some satisfaction in the thought that the Monographs on the Corals, the Polyzoa of the Crag, the Tertiary Echinodermata, the fossil Cirripedes, the Tertiary and Cretaceous Entomostraca, the fossil *Estheriæ*, the Tertiary, Cretaceous, Oolitic, Liassic, Permian, Carboniferous, Devonian, and Silurian Brachiopoda, the Mollusca of the Crag, the Great Oolite Mollusca, the fossils of the Permian formation, the Reptilia of the London Clay, the Reptilia of the Cretaceous, Wealden and Purbeck formations, and the fossil Mammalia of the Mesozoic formations, can be mentioned as subjects which have been completed, and which can be separately bound as finished; and that the Flora of the Carboniferous formation, the Crag Foraminifera, a Supplement to the Corals, the Echinodermata of the Oolitic and Cretaceous formations, the fossil Merostomata, the Trilobites, the Eocene Mollusca, the Belemnites, the Fishes of the Old Red Sandstone, the Reptilia of the Kimmeridge Clay and of the Lias, the Pleistocene Mammalia, and the Cetacea of the Crag, are in course of publication. Seventy plates, mostly belonging to works in preparation and not yet issued, are also in stock, foreshadows of future contributions to the yearly volumes. Already £16,987. 7*s*. 6*d*. have been expended in the furtherance of the object designed by the founders of the Society. Since the commencement, in the year 1847, 24 volumes have been issued, and 3,718 species have been illustrated by 1,044 plates, together with many woodcuts, embracing altogether 19,547 figures, and accompanied by 6,769 pages of text. In conclusion, the Council ask the members to co-operate with them in obtaining new subscribers. So national a work, so carefully written and prepared, so fully illustrated, claims public support. Scattered far and wide are the memorials of former organisms, silent, yet ready to speak when invoked by the ardent student of nature.

The following is a list of the Council duly elected for the ensuing year:—*President:* J. S. Bowerbank, LL.D., F.R.S., F.G.S. *Vice-presidents:* E. W. Binney, Esq., F.R.S., F.G.S.; T. Davidson, Esq., F.R.S., F.G.S.; Prof. Owen, M.D., F.R.S., F.G.S.; T. Wright, M.D., F.R.S.E., F.G.S. *Council:* J. J. Bigsby, M.D., F.R.S., F.G.S.; Sir Antonio Brady, F.G.S.; Prof. P. M. Duncan, M.B., F.R.S., F.G.S.; Sir P. de M. G. Egerton, Bart., F.G.S., V.P.G.S.; R. Etheridge, Esq., F.G.S.; J. W. Flower, Esq., F.G.S.; R. A. C. Godwin-Austen, Esq., F.R.S., V.P.G.S.; Sir W. V. Guise, Bart., F.G.S.; J. W. Ilott, Esq.; J. Gwyn Jeffreys, Esq., F.R.S., F.G.S.; H. Lee, Esq., F.L.S., F.G.S.; J. Pickering, Esq.; J. Prestwich, Esq., F.R.S., Pres. G.S.; Prof. Tennant, F.G.S., F.Z.S.; Capt. Tyler, F.L.S., F.G.S.; H. Woodward, Esq., F.G.S., F.Z.S. *Treasurer:* Searles Wood, Esq., F.G.S. *Secretary:* Rev. T. Wiltshire, M.A., F.G.S.

Geological Society of London.—I. March 8, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communication was read:—1. "On the Red Rocks of England of older date than the Trias." By Prof. A. C. Ramsay, LL.D., F.R.S., V.P.G.S.

The author stated that the red colour of the Triassic beds is due to peroxide of iron, which encrusts the sedimentary grains as a thin pellicle. This could not have been deposited in an open sea, but rather in an inland salt lake or lakes. The peroxide of iron, which stains the Permian, Old Red Sandstone and Cambrian rocks, is believed by the author to have been deposited in the same manner, in inland waters, salt or fresh.

Agreeing with Mr. Godwin-Austen, the Old Red Sandstone was of Lacustrine origin. The absence of marine shells helps to this conclusion. The fish do not contradict it, for some of their nearest living congeners live in African and American rivers.

The life of the Upper Silurian deposits of Wales and the adjoining districts continued in full force up to the passage-beds, which mark the change from Silurian to Old Red Sandstone. In these transition strata, genera, species, and individuals are often few, and dwarfed in form. Near Ludlow and May Hill the uppermost Silurian strata contain seeds and fragments of land-plants, indicating the neighbourhood of land, and the poverty of numbers and the small size of the shells a change in the condition of the waters. The fish of the Old Red Sandstone also indicate a change of condition of a geographical kind.

The circumstances which mark the passage of Silurian into Old Red Sandstone were as follows;—First, shallowing of the sea, so that the area changed into fresh and brackish lagoons, afterwards converted into great fresh-water lakes. At the present day marine species are occasionally found living in fresh water, as for example in the Swedish lakes. The same may have been the case in the Old Red Sandstone period. The Old Red Sandstone waters at their beginning are comparable to the Black Sea, now steadily freshening; or the Caspian, once united to the North Sea, if by a change of amount of rainfall and evaporation it freshened by degrees, and finally became a fresh-water lake.

The Permian strata, to a great extent, consist of red sandstones and marls in the greater part of England; and the Magnesian Limestone of the north of England is also in less degree associated with red marls. These do not occur in the same districts of England, excepting in Lancashire, where a few beds of Magnesian Limestone are interstratified with the marls. The sandstones and marls being red, the colouring-matter is considered to be due to peroxide of iron, possibly precipitated from carbonate of iron, introduced in solution into the waters.

Land-plants are found in some of the Permian beds, showing the neighbourhood of land. No mollusca are found in most of the red beds, except a brachiopod in Warwickshire, and a few other genera in Lancashire, in marls associated with thin bands of Magnesian Limestone.

The traces of amphibians are like those found in the Keuper Sandstone, viz., *Cladyodon Lloydii*, and Labyrinthodont footprints in the Vale of Eden and at Corncockle Moor, printed on damp surfaces, dried in the sun, and afterwards flooded in a way common in salt lakes. Pseudomorphous crystals of salt and gypsum help to this conclusion.

The molluscous fauna of Lancashire, small in number, in this respect resembles the fauna of the Caspian Sea. The fauna of the Magnesian Limestone of the East of England is more numerous, comprising thirty-five genera and seventy-six species, but wonderfully restricted when compared with the Carboniferous fauna. The specimens are generally dwarfed in aspect, and in their poverty may be compared to the Caspian fauna of the present day. Some of the fish of the Marl-slate have strong affinities to Carboniferous genera, which may be supposed to have lived in shallow lagoons, bordered by peaty flats; and the reptiles lately described by Messrs. Howse and Hancock have terrestrial affinities.

Besides the poorness of the Mollusca, the Magnesian Limestone seems to afford other hints that it was deposited in an inland salt lake subject to evaporation. Gypsum is common in the interstratified marls. In the open sea limestone is only formed by organic agency, for lime, in solution, only exists in small quantities in such a bulk of water; but in inland salt lakes carbonates of lime and magnesia might have been deposited simultaneously by concentration of solutions due to evaporation. Some of the Magnesian Limestone strata have almost a tufaceous or stalagmitic aspect, as if deposited from solution.

The Cambrian strata also show some evidence of not being true marine deposits. They are purple or red, like the other strata previously spoken of; and the surfaces of the beds sometimes exhibit sun-cracks and rain-pittings. The trilobite *Palæopyge Ramsayi* is considered by the author to be an accidental marking, simulating the form of a trilobite; and the fossils of St. David's are found in grey beds, which may mark occasional influxes of the sea, due to oscillations of level.

The foregoing reasonings, in the author's opinion, lead to the conclusion that a continental area existed more or less in the northern hemisphere from the close of the Silurian to the end of the Triassic epoch, and that this geographical continuity of land implies probable continuity of continental genera.

There is therefore no palæontological reason why the *Hyperodapedon, Telerpeton*, and *Stagonolepis* of the Elgin country should be considered of Triassic age, especially as the beds in which they occur are stratigraphically inseparable from the Old Red Sandstone.

Finally, terrestrial and marine European epochs were rapidly reviewed.

1. The Cambrian epoch was probably fresh water.

2. The Old Red Sandstone, Carboniferous, Permian, and Trias were formed during one long continental epoch.

This was brought to an end by partial submergence during the

Jurassic epoch; and by degrees a new continental area arose, drained by the great continental rivers of the Purbeck and Wealden series, as shown in various parts of Europe.

3. This continent was almost entirely swallowed up in the Upper Cretaceous seas.

4. By subsequent elevation the Eocene lands were formed, and with this continent there came in a new terrestrial fauna. Most of the northern half of Europe since then has been continental, and its terrestrial fauna essentially of modern type.

If, according to ordinary methods, we were to classify the old terrestrial faunas of North America, Europe, Asia, and probably of Africa, a Palæozoic epoch would extend from Old Red Sandstone to Wealden times, and a Neozoic epoch at least from the Eocene period to the present day. The Upper Cretaceous strata would at present remain unclassified. The marine epoch would also temporarily be divided into two, Palæozoic from Laurentian to the close of the Permian times, and all besides down to the present day, would form a Neozoic series. The generic gaps between the two begin already to be filled up. The terrestrial and the marine series at their edges at present overlap each other.

The great life-gaps between the two terrestrial periods may some day be filled up by the discovery of the traces of old continents containing intermediate developments of structure as yet undiscovered.

Discussion.—Prof. Huxley was pleased to find that the author, on physical grounds, extended some views which he himself had, from other reasons, brought before the Society. He mentioned that there had lately been found in the fresh-waters of Australia a remarkable fish, which had been described, he thought erroneously, as a *Ceratodus*, but which, in many essential characters, was a *Dipterus*, though allied in some respects to *Phaneropleuron*. In other respects it was connected with *Lepidosiren*. It was about to be fully described by Dr. Günther. The dentition of this fish is curiously similar to that of the Devonian *Dipterus;* and its existence, he thought, corroborated Prof. Ramsay's argument. He agreed with the author as to his views respecting the terrestrial fauna of ancient times, and was quite prepared for the discovery of mammalian remains in earlier formations than those in which they are at present known. He did not so cordially agree with his views as to the marine fauna. He would carry back the forms from which those of the present day are immediately derived to Cretaceous rather than Eocene times. Between the Cretaceous and the Liassic strata there was what appeared to be a middle group, succeeding the Palæozoic.

Mr. Etheridge commented on the dwarfed condition of our Permian fauna, which corresponds in the main with that of the continent, though with fewer genera and species.

Prof. Rupert Jones protested against some of the reasons adduced for regarding some of the areas cited as having been inland lakes, though no doubt such lakes must have existed. He thought that mere colour could not be taken as a criterion. If it were, he inquired why the bottoms of the present lakes were not red? Many of the red rocks were, moreover, full of marine fossils. He contended for the true trilobite character of *Palæopyge Ramsayi*, and mentioned its occurrence and that of *Lingula ferruginea* in red Cambrian rocks as proving the marine character of the beds. The Magnesian Limestone he also insisted upon as a purely marine and open sea deposit.

Prof. Morris thought the subject required further consideration before the whole of Prof. Ramsay's views were accepted. The Cambrian beds, for instance, containing great beds of conglomerate, seemed such as could only be due to marine action, and would derive their red colour from the decomposition of the old hornblendic gneiss from which they were derived. With regard to the Red Sandstone, he would inquire whether the colour might not be derived from the decomposition of rocks composed of hornblendic materials. The Old Red Sandstone beds, though in this country containing fishes which might be of fresh-water genera, had in Russia the same fishes associated with marine shells; and much the same was the case in the Trias.

Dr. Carpenter had been led to the conclusion that wherever there was an inland sea connected with the ocean by a strait even of moderate depth there was a double current tending to preserve some degree of similarity between the waters of the two, the difference of specific gravity in the Mediterranean as compared with the Atlantic being about as 1·026 to 1·029. In the Red Sea, where so little fresh water came in, and there was an evaporation of nearly eight feet per annum, the water was but little salter than that of the ocean with which it was connected. In the Baltic there is an undercurrent inwards, which still keeps it brackish; for otherwise the influx of fresh water was so enormously in excess of the evaporation, that it would long ago have become perfectly fresh. Such facts bore materially on the speculations of the author.

Capt. Spratt maintained that in the Dardanelles there was not a trace of such an undercurrent as mentioned by Dr. Carpenter. In the winter months, when the flow of the rivers into the Black Sea was for the most part arrested by ice, the salt water of the Mediterranean was carried into the inland seas, and these being much deeper than the channel of the Dardanelles, the salt water, by its greater specific gravity, remained in the bottom of the sea of Marmora, so that while the upper portion of the water and that on the shores were fresh, marine conditions existed in the deep centre of the sea.

Dr. Duncan mentioned that in certain coral reefs intersected by freshwater currents, the corals still continued to be formed; so that the existence of dwarfed forms of corals in ancient times was quite consistent with modern facts.

Mr. Forbes commented on the chemical features of Prof. Ramsay's views, and could see no reason why the beds containing iron should not have been deposited in the open sea. Many beds, for instance the Gault, contain more iron than those which are now red, though they may be grey or blue. In sands the grains are often coloured only superficially with iron, probably derived from sulphates. In other cases the sands consist of fragments of rocks already red. There was, in fact, no reason why the beds deposited in the open sea might not subsequently, by oxidation, become perfectly red.

Prof. Ramsay replied to the remarks of the various speakers, and summed up by contrasting the usual colour of marine fossiliferous beds with that of the thick, almost non-fossiliferous rocks of which he had been treating.

II. March 22nd, 1871.—Prof. John Morris, Vice-President, in the Chair. The following communications were read:—1. "On the 'Passage-beds' in the neighbourhood of Woolhope, Herefordshire, and on the discovery of a new species of *Eurypterus*, and some new Land-plants in them." By the Rev. P. B. Brodie, M.A., F.G.S.

The author described as the "passage-beds" between the Silurian and Old Red Sandstone formations near Woolhope, a series of shales and sandstones, which at Purton attain a thickness of about 17 feet. Here the section includes, in descending order: 1. Thin-bedded sandstones; 2. Dark brownish shales; 3. Yellow Sandstone; 4. Olive shales; 5. Thin-bedded sandstone; 6. Olive shales, similar to No. 4. At some localities vegetable remains (*Lycopodites*, and perhaps *Psilophyton*) occur in the olive shales, which also contain several Crustacean fossils, including *Pterygotus Banksii* and a new species of *Eurypterus*, named by Mr. Henry Woodward *E. Brodiei.* Upon this species Mr. Woodward presented a note supplementary to Mr. Brodie's paper.

Discussion.—Dr. Duncan inquired whether any metamorphoses had been recognized among the Eurypteridæ, and, if so, whether the variation in the thoracic plates mentioned by Mr. Woodward might be connected with them.

Mr. Woodward, in reply, remarked on the difficulty of distinguishing the sexes in the Eurypteridæ. The thoracic plate in the fossil species no doubt varied in form in the male and female, as it is found to do in the recent King Crabs, and this variation might be connected with sex. In some *Slimoniæ* from Lesmahago the only difference to be found was in the thoracic plate, and it had been suggested by the speaker that this was due to difference of sex. He had also suggested that the small *Pterygotus* and the great *Slimonia* might be only the male and female forms of the same species, a great diversity in size between the male and female existing in many living crustaceans—the males, too, having clasping organs for holding the female—of which the chelate antennæ of Pterygotus might be the homologues. On fragmentary remains it was, however, unsafe to attempt to generalize; but he thought *Eurypterus Brodiei* was a well-marked species.

Rev. H. H. Winwood inquired whether there was any evidence as to *Eurypterus* being fresh-water or marine.

The Chairman observed that the seeds from the passage-beds did not appear to him other than those of land-plants, and had been previously described by Dr. Hooker as spore-cases of Lycopodiaceæ.

2. "On the Cliff-sections of the Tertiary Beds west of Dieppe in Normandy and at Newhaven in Sussex." By William Whitaker, Esq., B.A., F.G.S.

The author gave details of the sections of the Tertiary beds at the above places, and noticed the occurrence of London clay. Below this formation, at Dieppe, is a mass of sand, the same as that of the "Old Haven beds" in East Kent, but here less markedly divided from the clay above; and beneath this sand come the estuarine shelly clays, &c. of the Woolwich beds.

In the older accounts of the Newhaven section a much less thickness of the Tertiary beds is chronicled than may now be seen; indeed the successive descriptions end upwards with higher and higher beds, owing to the destruction of the coast and the wearing-back of the cliff into higher ground, the highest point seeming to have been at last reached.

Here the Oldhaven sand is absent, but the Woolwich clays are in greater force: and the ditch of the new fort shows some very irregular masses of gravel, more or less wedged into those clays.

Both sections show the comparatively wide extent of like conditions to those of the Woolwich beds of West Kent.

Discussion.—The Chairman, in inviting discussion, called attention to the existence of Tertiary beds of similar character near Epernay and Rheims, and in other parts of France.

Mr. Evans remarked on the bearing which this extension of soft, yielding strata had on the excavation of the Channel. The disturbances in the sands and clays might be due to the springs having formerly, owing to the distance of the sea and the river-valley not having been excavated, stood at a higher level, and having thus softened or even washed away, the bed beneath the gravels.

Mr. Pattison mentioned that in all the combes along the French coast towards Trêport there were traces of soft Tertiary beds, possibly Thanet sands.

Mr. Whitaker, in reply to a question from the Chairman, stated that, to the best of his belief, the sandstones at Dieppe were not calciferous. The sands were above the Woolwich beds, and therefore not Thanet sands.

3. "On New Tree Ferns and other Fossils from the Devonian." By Prof. J. W. Dawson, LL.D., F.R.S., F.G.S.

The author referred to the numerous species of ferns known in the Upper and Middle Devonian of America, and to the fact that he had described several large petioles as probably belonging to arborescent species, and also two trunks covered with aërial roots, viz., *Psaronius*

Erianus and *P. textilis.* He also referred to *Caulopteris Peachii* of Salter as the only tree-fern known in the Devonian of Europe.

He then described remains of four species of tree-ferns in collections communicated to him by Dr. Newberry of New York. The first of these, *Caulopteris Lockwoodi,* was found by the Rev. Mr. Lockwood at Gilboa, the locality of the Psaronites already mentioned, in rocks of the Chemung group. It is a fragment of a well-characterized stem, with parts of five petioles attached to it, and associated with remains of the leaves. It must have been entombed in an erect position, and is not improbably the upper part of one of the species of *Psaronius* from the same locality.

The second species, *Caulopteris antiqua,* Newberry, is of much larger size, but less perfectly preserved. It is a flattened stem on a slab of marine limestone from the Corniferous formation in the lower part of the Middle Devonian (Erian) of Ohio.

The third species, *Protopteris peregrina,* Newberry, is from the same formation with the last, and constitutes the first instance of the occurrence of the genus to which it belongs, below the Carboniferous. The specimens show the form and arrangement of the leaf-scars, the microscopic structure of the petioles, and also the arrangement of the aërial roots covering the lower part of the stem.

The fourth species is a gigantic *Rhachiopteris,* or leaf-stalk, evidently belonging to a species quite distinct from either of the above, and showing its minute structure. It is no less than four inches wide at the base. In the cellular tissue of this petiole are rounded grains similar to those regarded by Corda and Carruthers, in Carboniferous and Eocene specimens, as starch granules.

In addition to these species, the paper described a new *Nœggerathia* (*N. Gilboensis*), and noticed a remarkable specimen from Caithness, in the collection of Prof. Wyville Thomson, throwing light on the problematical *Lycopodites Vanuxemii* of America; also interesting specimens of *Psilophyton* and other genera seen by the writer in the collection of Mr. Peach of Edinburgh.

Discussion.—Dr. Duncan doubted the desirability of basing generic and specific terms on imperfectly preserved and indistinct specimens, and pointed out the disagreements among botanists that had resulted from so doing. He would prefer calling fossils such as those described "cryptogamous forms from certain strata." He was doubtful also whether the supposed petrified starch was not merely orbicular silex.

The Chairman remarked on the four different conditions exhibited by existing tree ferns—first, with roots running down the stem; secondly, the lower portion with oval scars; these are, thirdly, further up the stem, rhomboidal vertically; and fourthly, higher up still, rhomboidal horizontally; so that were the plant fossil, distinct genera and species might be founded upon the different parts.

Geologists' Association.—Evening Meeting, 4th April, 1871. The Rev. Thos. Wiltshire, M.A., F.G.S., etc., President, in the Chair. 1. A paper was read by Messrs. Alfred and R. Bell, "On the English Crags, considered in reference to the stratigraphical divisions indicated by their Invertebrate Fauna." In this paper the authors object to the divisions of the Crag series at present adopted, and especially to the series of beds termed "Red Crag." For their modified divisions they propose the terms Upper, Middle, and Lower Crag, and they supported their arguments by newly-prepared lists of the Molluscan and other remains, collected by themselves. Professor Morris, Messrs. Woodward, Lobley, Leighton, Evans, etc., took part in the discussion which followed the reading of Messrs. Bell's paper.—[This paper will probably be reprinted in full in the GEOLOGICAL MAGAZINE for June next.]

2. The next paper read was by Professor Tennant, F.G.S., etc., "On South African Diamonds," illustrated by a large series of rough and polished diamonds from South Africa, Brazil, etc. In the discussion which followed Professor Morris, the Rev. Thos. Wiltshire, and Mr. Rabone took part. Mr. Rabone has just returned from the Diamond Fields, and gave an account of the operations now in progress. The district in which Diamonds occur is perhaps 20,000 square miles in extent, and not fewer than 13,000 persons are engaged in searching for these gems at the present time.

Visit of the Geologists' Association to Cambridge.—On Monday, the 10th of April last, a considerable number of the members of the Geologists' Association visited Cambridge for the purpose of inspecting the Woodwardian Museum and the exposures of Cretaceous strata in the neighbourhood. On arriving at Cambridge the party proceeded at once to the Woodwardian Museum, where they were met by the Rev. Dr. Cookson, Master of St. Peter's College, the Rev. Thos. Wiltshire, M.A., President of the Association, Prof. Morris, the Rev. T. G. Bonney, M.A., Fellow of St. John's College, the Rev. Osmond Fisher, M.A., and Mr. Harry Seeley, F.G.S. as representative of the venerable Professor Sedgwick, who, much to his regret, was prevented being present. The fine collection of fossil Mollusca from the district was ably described by Mr. Bonney, and the Reptilian remains were the subject of an interesting discourse by Mr. Seeley, after which Professor Morris, in the Geological Lecture Theatre, delivered an address on the Geology of the country around Cambridge, which was listened to with great attention and interest by a large audience. The afternoon was devoted to a visit to the Coprolite workings and other excavations at Barnwell. Proceeding along the banks of the Cam a fine section of Pleistocene deposits, yielding mammalian remains and the usual species of Mollusca, was reached. This exposure exhibits some beautiful examples of "false bedding," and many granite and other boulders from the "drift" were here seen. A very extensive excavation in the Gault, capped by a thin deposit of Upper Greensand, was next visited. The Gault, excavated for brick-making purposes, is exposed to a depth of 70 or 80 feet, and, from the evidence of well-sinkers, it is here probably 200 feet thick. Fossils are rarely met with in the Gault-clay at this place, though in other localities this formation is very fossiliferous. Lying on the Gault, at its junction with the Upper Greensand beds before mentioned, occurs the stratum containing the phosphatic nodules, or "Coprolites," for which this locality is famous, and which were first noticed as being valuable for agricultural purposes by the late Professor Henslow. At a short distance from this excavation the Coprolite workings are found on all sides. Indeed, the whole of the land is here being systematically explored for these valuable nodules, which lie at an average of six or seven feet from the surface. One field after another is taken in hand, the surface soil removed, the Coprolite bed of about twelve inches in thickness is then taken out, the soil is carefully replaced on the surface, and the field is then again ready for tillage. The so-called "Coprolites" are washed by horse power to remove the sand and loam in which they are embedded, and then they are ready for conversion into manure. A considerable number of fossils, chiefly Brachiopods, *Terebratula biplicata* being most abundant, were obtained. The party returned to Cambridge, and in the evening were most hospitably entertained at St. John's College by the Rev. T. G. Bonney, M.A., Fellow and Tutor of the College.—On the following day, Tuesday, the 11th, Upware, between Cambridge and Ely, was visited. At this place, situated in the fens and near to the river Cam, very interesting sections have been exposed in consequence of the search for Coprolites. The Gault, which here becomes very thin, has been cut through, and Lower Greensand strata reached. In the latter deposit at the top of the Gault, a bed abounding in "Coprolites" is found, and this bed contains characteristic Lower Greensand fossils, together with several new species of Brachiopods, described by Mr. J. F. Walker, B.A., F.G.S. Cropping out within a very short distance from this exposure of Gault and Lower Greensand is a remarkable rock full of fossil corals, which has hitherto been called Coral Rag, but which Mr. Harry Seeley, who has devoted great attention to the strata of this district, considers to be of Kimmeridgian age. This rock, to which Mr. Seeley has given the name "*Upware Limestone*," is underlain by "Ampthill Clay," which would appear to be the equivalent of the Coral Rag of Oxfordshire, Wiltshire, Dorsetshire, etc. The Brachiopods in the Infra-Gault coprolitic bed are abundant, especially *Terebratula sella*, *T. prælonga*, and *Waldheimia* or *Terebratella Davidsoni*, many fine specimens of each of which species were obtained. The drive back to Cambridge, twelve miles through the fens, was quickly and agreeably accomplished, and the party returned to London highly gratified with their visit to Cambridge. During May the Association will visit Oxford, Grays in Essex, and Yeovil in Somersetshire.—J. L. L.

Geological Society of Glasgow.—I. The ordinary monthly meeting of this Society was held in Anderson's University, on Thursday evening, 5th January. Mr. Edward A. Wünsch, Vice-president, in the Chair.

Mr. James Thomson, F.G.S., read a paper "On the Occurrence of *Cœlacanthus lepturus* at Newarthill, and *Palæoniscus Wardii* at Possil." He briefly described the scales, fin-rays and head plates of *Cœlacanthus*, which had been found in a detached form in the neighbouring coal-measures, and which the examination of a nearly entire specimen from the Staffordshire coal-field had now enabled him to identify. It occurs in the upper members of the Carboniferous system in Scotland, in a shale overlying the Ironstone of the Airdrie coal-field.

Mr. Thomson then exhibited specimens of *Rhizodopsis sauroides*, *Amphycentrum granulosum*, and *Platysomus parvulus* from the Staffordshire coal-field, observing that the scales of *Rhizodopsis* had been found in our Scottish coal-beds, but as yet no complete specimen of the fossil had thence been obtained.

Mr. Young said it was worthy of being noted that three of the Ichthyolites referred to—the *Cœlacanthus, Palæoniscus,* and *Platysomus*—are the three most characteristic forms of fish life in the immediately succeeding formation, the Permian or New Red Sandstone. These three were the principal forms that were continued from the one period to the other. With that system, most of these forms died out, and are not met with in any subsequent formation.

II.—February 2nd, 1871. Mr. John Young, Vice-President, in the Chair. The Society elected office-bearers for the ensuing year, viz. :—*President:* Professor John Young, M.D., F.G.S. *Vice-Presidents:* Messrs. E. A. Wünsch, J. Young, and James Thomson, F.G.S. *Secretaries:* Messrs. D. Bell and John Burns. *Treasurer:* Mr. John Wight, C.A. *Librarian:* Mr. Thomas Naismith.

Charleston Phosphates.—A collection of phosphates from Charleston, United States, was exhibited by the Rev. J. F. Potts and Mr. Naismith, together with some large fossil teeth, vertebræ, etc., from the same locality. Mr. Potts stated that large quantities of these phosphates are being used in America, and also imported into this country, for the manufacture of artificial manures. The specimens on the table had been collected from some cargoes lately brought to the Clyde. The deposit from which they are taken is found along the banks of many of the rivers in South Carolina, and immediately under the surface soil of the land lying between; and is supposed to underlie a large portion of the coast and sea-island region of that part of America. It consists of layers, varying from six inches to several feet in thickness, of irregularly rounded nodules, mixed up with an immense quantity of bones—ribs, vertebræ, tusks—of various species of animals, all more or less petrified. The nodules yield fifty to sixty per cent. of bone phosphate; while from some of the bones as much as eighty to eighty-five per cent. of this fertilizing substance had been obtained.

The Chairman said there could be no doubt this remarkable deposit of phosphates belonged to the Tertiary period, and probably its earlier division, the Eocene. The Tertiary formation is largely developed along the southern coast of North America, stretching in a belt of considerable breadth from North Carolina to the Gulf of Mexico, and leaving the coast line only at the delta of the Mississippi.

He then gave an interesting account of the Cetacean and Squaloid remains which characterize this remarkable deposit.

Local Boulders and Boulder-clay.—Mr. Robert Craig read a paper "On the Boulders found in cuttings on the Beith Branch Railway, considered in relation to their parent Rock; with observations on the local character of the Boulder-clay."

III. March 2nd, 1871.—Mr. John Young, Vice-President, in the Chair.

Coast Section at Arran.—Mr. E. A. Wünsch, V.P., read a paper on a section of the northern shore of Arran, giving an account of some transported blocks of Limestone which he had observed there during the previous summer. After describing the remarkable succession of deposits which had made that part of Arran classic ground for the geologist, he referred more particularly to a characteristic bed of Limestone found near the Salt Pans, on the north-eastern shore of the island. This Limestone is of a deep red colour, and is full of the shells of *Productæ*—especially *Producta latissima*—together with fragments of *Encrinites* and other organisms. The bed is very regularly jointed, and breaks up into beautiful cubical masses. He had noticed several detached boulders and smaller fragments, down to minute pebbles, of this Limestone at various distances along the shore, sometimes in sheltered bays, and as far as four or five miles from the parent bed. One block of considerable size, to which at present he wished to call attention, he had observed a little above high-water mark, fully a mile from the original deposit, and within a quarter of a mile of the beds of volcanic ash which he had formerly described. It had been drifted, most probably by floating ice, over a massive ledge of sandstone and indurated shale intervening between it and the sea, and projecting above the general inclination of the shore.

The Chairman said there could be little doubt that the various boulders of Arran rocks found perched on the old raised sea-beach which fringes the coast of the island had been carried and dropped into their present position by coast-ice during the Glacial period, when the land stood at a lower elevation than at present. Many of the boulders are of large size, and have been carried by drifting ice to various parts of the coast, distant from where the rocks occur *in sitû.*

Mr. James Thomson, F.G.S., read a paper on the occurrence of *Stigmaria stellata* (Eichwald) in the Lower Carboniferous series, at Wildshaw, in the Upper Ward of Lanarkshire.

Natural History Society of Montreal.—The fifth monthly meeting of this Association was held on Monday evening, 27th February, the President, Principal Dawson, F.R.S., in the Chair.

Principal Dawson exhibited illustrations of "some new facts in fossil Botany." The following is an abstract of his remarks:—The first point mentioned was the occurrence in the Devonian Shales of Kettle Point, Lake Huron, of beds containing immense quantities of spore-cases, probably of *Lepidodendron.* These beds are referred by the Geological Survey to the horizon of the Genesee shales of New York, and are stated to be twelve or fourteen feet in thickness, and to extend over a considerable area of country. Specimens in the collection of the Survey show that the bituminous matter which causes the combustible quality of the shale is due entirely to the immense quantities of spore-cases present, which under the microscope appear as flattened discs scarcely more than one hundredth of an inch in diameter. Specimens of the trunks of *Lepidodendron, Veltheimianum* and *Calamites inornatus* occur in the same beds. This is probably the oldest bed of fossil spore-cases known; but in later geological periods similar beds occur; the Tasmanite or "white coal" of Tasmania, which consists of spore-cases of Ferns, being a notable instance. Prof. Huxley has recently directed attention to the abundance of spore-cases and spores in some English coals. Similar bodies occur in American coals, particularly in those of Ohio; but though they are found locally, and in some layers in great numbers, they do not constitute the mass of the material. It is to be observed also that the coal-making property of these bodies is due to a chemical composition, which they share with all cortical or epidermal tissues. Dr. Hunt has kindly prepared a table for the author, showing the composition of the corky matter or suberin which forms the cuticle of plants, and the walls of spore-cases. This substance is almost identical in composition with bituminous coal, and is besides very indestructible and impermeable to water. These qualities cause it to be especially suited to the production of coal; and this perfectly accords with the results arrived at by the author many years ago, and published in his papers on the structure and mode of accumulation of coal in the Quarterly Journal of the Geological Society of London, viz., that coal consists mainly of cortical or epidermal tissues; ordinary cellular matter and wood proper being comparatively unimportant in its production. Details on these points will be given in a paper shortly to appear in the American Journal of Science. The author next referred to the discovery of specimens indicating the existence of three or four species of tree ferns in the Upper and Middle Devonian rocks of New York and Ohio. Descriptions of these plants will probably appear in the *Proceedings* of the Geological Society of London, and in the forthcoming report of the Geology of Ohio, by Professor Newberry.

Dr. T. Sterry Hunt made some remarks on the subject, and gave an interesting account of the chemical composition of these spore-cases, and of the cuticle and cortical layer of plants generally.

Diamonds in New South Wales and America.—Mr. A. R. C. Selwyn, Director of the Geological Survey of Canada, read a paper on "The Occurrence of Diamonds in New South Wales," by Mr. Norman Taylor, late of the Geological Survey of Victoria, and Professor Thompson, of the University of Sydney. The authors state that the Diamond Drifts are on hills above the present river-bed, and are overlaid by from thirty to forty feet of basalt. These hills greatly resemble the balsaltic hills in some gold districts in Victoria. The underlying rock is Upper Silurian or Devonian, intersected by Greenstone dykes, and the whole watershed to the Cudgegong Valley is carboniferous, resting in places on granite. The carboniferous rocks are full of *Glossopteris, Sphenopteris,* etc. The authors are of opinion that the diamonds are not of drifted origin, but that they have been formed where they are now found. There is no "Itacolumite" or "Psammite." The works were commenced in 1869, and

6,000 diamonds have been collected in one district, extending about seven miles along the valley of the Cudgegong river, in latitude 33° south. The view of the diamond having been formed in the Tertiary drift deposits coincides with the view expressed by Dr. Hartt on this subject in his recent work on the Brazils.

Dr. Hunt gave a succinct account of what is known up to the present time with regard to the geological history of the diamond. In India, Brazil, Virginia, North Carolina, Oregon and Europe, diamonds have been found associated with other gems, and with gold in drift deposits. He said that the original matrix of the gem was not clearly ascertained, but that he was inclined to the view that it would be found to be in the oldest geological formations, possibly in veins in granite. He stated that he had carefully examined many samples from the Chaudière gold regions, but failed to detect diamonds in any of them.

The meeting was a good one, and the several papers were listened to with a great deal of interest.—*Montreal Daily Witness*, March 1, 1871.

CORRESPONDENCE.

GEOLOGY OF THE CUMBERLAND LAKES.

Sir,—I wish to enter a protest against the statement of a friend of your correspondent, Mr. Wollaston, that the Cumberland hills resemble "great heaps of rubbish shot out of a cart," for no district in England shows more distinctly, even to the most untrained eye, how valleys have been cut out of pre-existing "plains of marine denudation," by the long-continued agency of running water, which has cut vertically deeper and deeper, until portions of the plain, his "heaps of rubbish," were separated by gorges and valleys often 2,000 feet in depth.

In regard to the glaciation of the district, the question between Mr. Mackintosh and some other geologists, is not whether the Lake country is, or is not moutonnéed, but how it became so, whether by icebergs, as suggested in 1828 by Mr. Maclaren, to account for the glaciation of Scotland, and held by Mr. Mackintosh to have been the glacial agent in the Lake District, or by a cap of land-ice, as suggested by Mr. Croll, universally wrapping over mountain and valley, or by land-ice, in the form of small ice-sheets, and large glaciers, as held by myself, not wholly filling up the valleys, but entirely covering the lowland plains moving from the mountains of Cumberland towards the Solway Firth, and southwards over the Lancashire and Cheshire plains, and over much of what is now sea to the Mountains of Wales. On the glaciated rock surfaces in the plain, rest indiscriminately lower Boulder-clay, sand and gravel, and upper Boulder-clay, proving that all these deposits are of later date than the period of land-ice, which clearly occurred before the submergence, all the above deposits being of marine origin, and roughly corresponding to the "Stratified Drift of Scotland," described by Mr. Geikie, F.R.S.

The Shap Fell boulders occurring in Yorkshire are found in the Purple Clay of Mr. S. V. Wood, jun., and in the upper Boulder-clay of Mr. Mackintosh, both of which deposits I consider to be synchronous with the upper Boulder-clay of Lancashire, in which I have found a few pebbles of this granite as far south as the Mersey. The blocks I believe to have been detached during the middle sand period by the action of breakers, which formed them into a beach on the slope of the Fell, which on the climate becoming colder were floated off by coast-ice, and carried by the *flow tide* eastwards to Yorkshire and southwards to Lancashire. I cannot therefore agree with Mr. Croll, admirable as are his investigations as regards Scotland, that the total ice-wrap theory is applicable to north-western England, and more especially to the transport of Shap Fell boulders.

Charles E. de Rance, F.G.S.

TERRACES OF NORWAY.

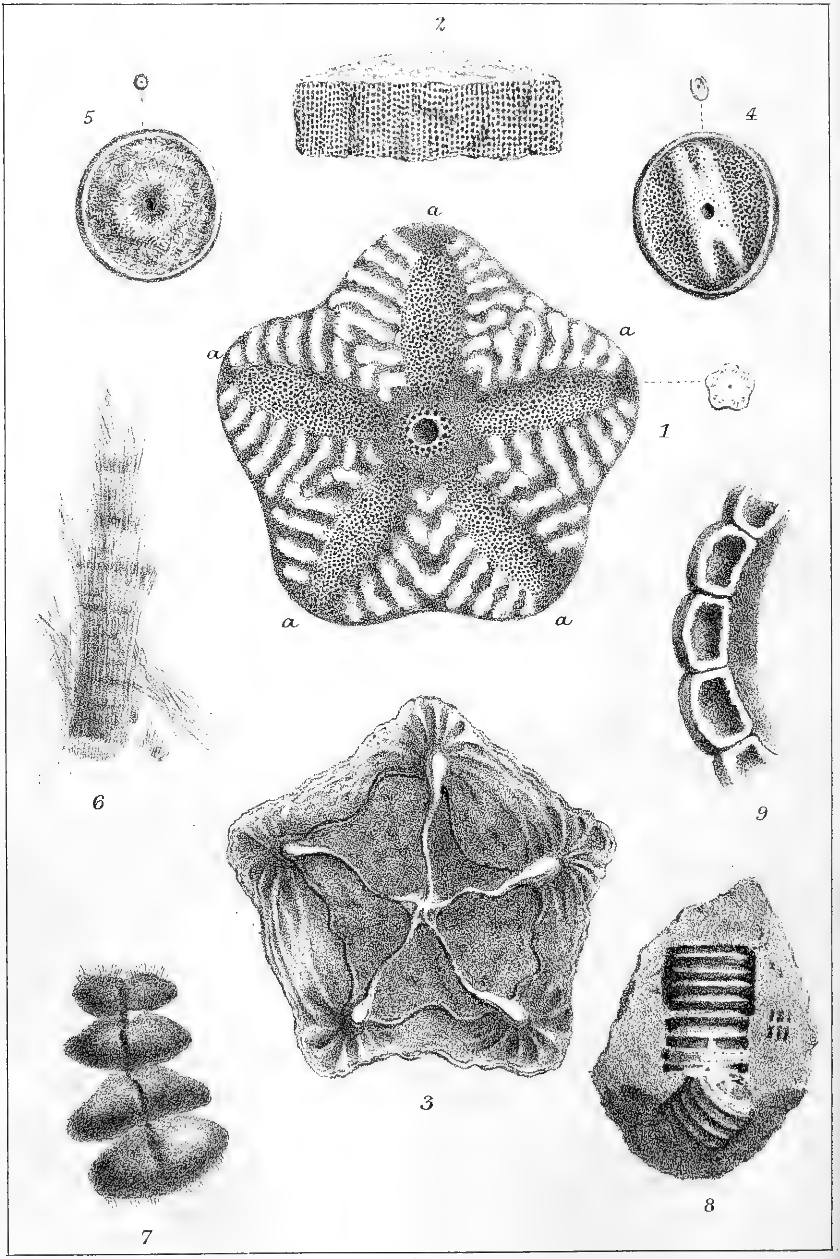
Sir,—As I have had the opportunity of examining several of the terraces of Norway described by Professor Kjerulf (as noticed in the Geological Magazine, p. 74), and agree with his explanation of them, I may, perhaps, be excused for replying to Colonel Greenwood's letter (p. 191). I have never felt satisfied with his explanation of the Fraser River and Himalaya terraces, and I feel convinced that it will not apply to those of Norway. The latter are, I believe, formed as follows:—First a delta has been deposited, when some physical cause has diminished the velocity of a stream which sweeps along detritus; *e.g.* where a river enters a fjord. This delta has, after a time, been raised above the water, and during the period of upheaval and the subsequent pause the stream has cut away a considerable portion of the loose materials of the delta. A further upheaval, with an increase in the velocity or reduction in the volume of the stream, has carved another and lower set of terraces during another pause, and so on. Of course, if local conditions permit, new deltas may form further down the valley in the part which yet remains under water; and these in turn may be subjected to erosion, if the upward movement is resumed. My reasons for differing from Colonel Greenwood are—putting them as briefly as possible—(1) Regular cliffs and grooves, to say nothing of deposits of marine shells, at various heights above the present sea-level, show that Norway has risen during recent epochs, and that there have been pauses in the upheaval. (2) Many valleys (as at the head of the Alten fjord) in the neighbourhood of these signs of upheaval are filled with wide plains of drift, out of which the river has cut a channel, and the fjord face of this plain is regularly terraced. (3) That, as in some of the valleys of the Sogne Fjord (and doubtless in many others), the terraces show similar faces looking both to the fjord and to the river, suggesting the same cause for their formation, viz., the erosion of incoherent materials by water in motion. (4) That in ascending a valley you not unfrequently find sets of terraces rising step above step, not *from* the stream, but *up* the stream; so that in the upper part of the valley the corresponding sets are at much higher levels than in the lower part: there is an excellent instance of this at the Sogndal in the above fjord. (5) That deltas are now forming in the fjords below these terraces, as, for example, at Lierdalsoren; where the head of the fjord is becoming a marshy swamp (the valley for a considerable distance behind the village is a level plain), and then a well-marked terrace some 30 feet high, ending abruptly, is met with, and continues for some miles till the rocky bed of the valley rises from beneath it. (6) That considering the coarse materials of which the terraces are not unfrequently composed, one would expect their upper surfaces to slope away (like the Mississippi banks) from the stream. This is not the case. (7) The general arrangement of the terraces, which of course could only be shown by elaborate diagrams, is to my mind quite inexplicable on Colonel Greenwood's theory.

I believe, therefore, that the terraces of the Fraser River, of the Yangma, and of Norway, are all to be attributed to the same cause, viz., the erosion of detritus deposited by a river in a pre-existing valley, when, in consequence of a change in its velocity or volume, it cuts away that which it has previously been depositing or covering.

St. John's College, Cambridge. T. G. Bonney.

OBITUARY.

Wilhelm von Haidinger is no more. He died at the age of 77 years on the 19th of March. His father, Karl Haidinger, was a mineralogist, and for several years Professor of Mining at Schemnitz. The young Haidinger inherited his father's taste for minerals, for he joined the class of the distinguished mineralogist Mohs at Gratz, and subsequently went to Freiberg to complete his training in Mining. Count Breunner, who came to England in 1822, invited the young mineralogist to accompany him. They travelled together through England to Edinburgh, where Mr. Allan, the banker, invited young Haidinger to make a home of his house while employed in translating the Mineralogy of Mohs into English; he accordingly made Mr. Allan's house his head-quarters till 1827. With Mr. Robert Allan, the eldest son of his friend, he travelled during four years through Cornwall, Norway, Sweden, Denmark, Germany, Austria, Italy, and France. During these travels the famous collection, afterwards the property of Mr. Robert Greg, and now in the British Museum, was formed. At this time he brought out his translation of Mohs' treatise, and wrote several Mineralogical papers for the Wernerian Society and the Transactions of the Royal Society of Edinburgh. In 1840 he returned to his native city, Vienna, to devote himself more exclusively to the scientific pursuits he loved. A compendious and valuable treatise on Mineralogy, brought out in 1845, to take the place of an earlier treatise, was continually undergoing revision for new editions; while new investigations of minerals were also appearing under his name. From the foundation of the Geological Institute for the Empire in Vienna, Haidinger was its Director until some two or three years ago, when he retired from the position he had filled so well, with a Ritter's rank and a well-earned pension. For the last twelve years of his life he had given his attention almost exclusively to the subject of meteorites. He leaves behind him a name which Austria may cherish as that of one of her illustrious sons, and which many an Austrian and many a foreigner will remember with warm respect.—Extracted from *Nature*, April 6th.



G. R. De Wilde del et lith. Mintern Bros. imp.

To illustrate Mr. Rofe's paper on the Structure of Recent & Fossil Crinoidea.

THE

GEOLOGICAL MAGAZINE.

No. LXXXIV.—JUNE, 1871.

ORIGINAL ARTICLES.

I.—NOTES ON THE CRINOIDEA.

By JOHN ROFE, F.G.S.

(PLATE VI.)

WHEN reading the very interesting article[1] in the "Student" for October last, "On the Deep Sea," by Dr. Carpenter, I was struck by the description of an Echinidan, which had been dredged up, and which is represented as looking "externally like a sea-egg flattened by pressure; it was about five inches in diameter, and of a brilliant crimson hue. Its test being composed of plates, separated by membrane, instead of being united by suture, was quite flexible, so as to resemble an armour of chain mail rather than the inflexible cuirass with which the ordinary Echinida are invested." This statement as to the flexibility of the test so corresponds with what I have long suspected to be the case with some, at least, of the Crinoids, that I have been induced carefully to re-examine a large number of specimens, both of heads and columns of fossil, and to make some experiments on recent Crinoids; and I propose now to state shortly the result, and to suggest some points for the consideration of those who may take an interest in such subjects, and who are better qualified than I am, by their knowledge of the animal kingdom, to give an opinion on them.

That the Crinoidea, both recent and fossil, have or had flexibility in their columns, rays, and side-arms, cannot admit of doubt; the two latter, from their nature and use, must have been flexible, and sometimes fossil columns are found so much curved that they might at a casual glance be mistaken for Ammonites, and they frequently have the appearance of being furnished with a membrane or cushion, intervening between the plates, expanded on the outer side of the circle so formed, and contracted on the inner. A membrane so situated would, like the intervertebral substance (cartilage) in the vertebrata, evidently admit of this flexure, and such has been supposed to exist by Messrs. Austin and others. The so-called screw

[1] "The Student," vol. v., 1870, p. 361.

stones,[1] so common in the Chert of Derbyshire, there is good reason to believe, are in reality siliceous pseudomorphs of this membrane, the calcareous part of the column having been entirely dissolved and removed. (See Plate VI., Fig. 8.)

To test this belief, some portions of a *Pentacrinus caput-medusæ* were procured, and a few joints of the column gently boiled for some minutes in a test tube with liquor potassa, when the membrane was dissolved; some of the plates fell asunder, and the others were easily separated, whilst warm, by the point of a needle. The figures formed by the articulating surfaces are beautifully defined, as shown in Fig. 1, where the five radiating elliptical lobes *a, a,* are well seen. The central aperture, generally called the alimentary canal, is surrounded by a ring, in which there is seen a circle of minute tubes,[2] indeterminate in number. The interspaces between the lobes are of reticulated, or, perhaps more correctly, of vesicular structure. The lobes are similar in structure, but are pierced with innumerable small tubes or pores, through which pass the fibres below described. This experiment leaves the calcareous portion of the joints of the column in a state similar to those separated by the natural decomposition of the membrane, and found fossil, in many limestones, such as the Saint Cuthbert's beads from Holy Island. Having thus separated the calcareous part, to exhibit the membrane, another portion of the column (which had been accidentally fractured longitudinally, but leaving the central opening and the whole of three lobes perfect) was slowly decalcified by very dilute muriatic acid, occasionally adding more acid when required, as shown by the cessation of chemical action, until the decalcification had gone as far as it was prudent in this instance to carry it, as it was doubtful, if the whole of the lime were removed, whether from the fracture the fibres would not have collapsed. Very shortly after chemical action commenced bundles of very fine fibres (above alluded to), and insoluble in the acid, were visible, projecting from the lobes *a, a,* at both ends of the specimen, and the fibres were visible in the broken lobe the whole length of the fracture. Figure 6 shows the fibres from one of the broken lobes, the cross lines being the membrane between the calcareous plates. This membrane was found to envelope every joint on every side, and the longitudinal fibres passed through it as in this figure. The longitudinal fibres being probably the organs by which the motion of the column is produced and regulated, and the membrane that by which fresh matter, necessary for growth or for repairs of injury, is secreted.[3] A decalcified section of a portion of the column, allowed to dry, shows that the central canal is lined by the membrane and connected to that between the plates, and thus with the longitudinal fibres. (See Plate VI., Fig. 3.)

[1] See Buckland's Bridgewater Treatise, new edition, p. 393.

[2] A similar circle of minute pores is very perceptible round the central canal in an oval plate of the column of a *Platycrinus*, from Mountain Limestone, in my collection.

[3] In Volume VI. of this Magazine, p. 351, some cases are described in which new layers are formed round and inclose foreign matter attached to the column.

The column of the recent *Pentacrinus* (on which these experiments were made) has a pentagonal floriform section, and, as above stated, has the longitudinal fibres distributed amongst the five lobes and the ring round the central canal, but the columns of many of the Mesozoic and most of the Palæozoic Crinoids are circular in section, and in these the fibres appear to be confined to the part of the column adjacent to the central canal. With respect to pentagonal columns, Messrs. Austin state that "there is one character which distinguishes those from the Lias and more modern strata from the pentagonal columns which existed in the Carboniferous seas, namely, the former invariably articulate by pentagonal, crenated, star-like forms, while the articulating surfaces of the latter are furrowed by linear striæ radiating from a central axis." There is much difficulty, however, in detecting the fibres in fossils, owing to mineralization, which, in a majority of cases, has obliterated organic structure, and it is not very easy to distinguish them, even in the recent column, until the calcareous and the animal constituents are separated.

A few joints from one of the side-arms of the column were next boiled in liquor potassa (Plate VI., Figs. 4 and 5), with the same action on the membrane, but in these the calcareous plates were slightly elliptical in outline, with a mesial ridge on the transverse axis, and strongly resemble the elliptical plates of the column of the Mountain Limestone *Platycrinus.* Some connected joints of the same side-arm were decalcified so perfectly that they floated in the calcareous solution, but preserving the membrane on all sides, whilst at each face of the section, when mounted for the microscope, were exhibited, with a low power, two tufts of fibres, one on each side of the median ridge. (See Plate VI., Fig. 7.)

I may here remark that, in breaking off a portion of a side-arm, these fibres draw slightly from the lobes before they rend, and may, with the help of a pocket lens of moderate power, be distinguished without any preparation. The rays and pinnulæ acted on in the same manner give similar results, and indicate a calcareous skeleton surrounded by a membrane or epidermis, which, in the extreme joints, is almost semi-corneous. The calcareous portions show the groove on the upper side of the ray, and the pinnulæ have the same grooved section to their extremity. This may be found also in the pinnulæ of many of the Crinoids of the Silurian and Mountain Limestone formations, and probably in the Crinoids generally, but not universally, as *Rhodocrinus,* for one, appears to be without gooves to the arms.

These experiments on the recent Crinoids, combined with the structure shown in the screw-stones, appear to prove the envelopment of the joints of the column, pinnulæ, rays and side-arms by an elastic membrane, capable of allowing a certain limited power of motion.

With regard to the heads, we have no recent calices to experiment upon, but we have heads, and plates from them, so identical in their condition with the screw-stone casts that very little doubt can arise that the plates of that part of the animal were also enveloped in, and connected to each other by, a similar membrane, and not by sutures, and were so far analogous to the Echinidan described by Dr. Carpenter. When the test is entirely calcified, as is mostly the case when in solid rock or encrinal marble, the joints of the plates have a minutely wrinkled surface, probably due to the junction of the membranes which have become calcified, and apparently form part of the substance of the plate, and these, being in actual contact, would not suggest the idea of any power of modifying the form of any part of the calyx. But specimens are occasionally found, some of which are in my collection, which, like the screw-stones, are represented only by a siliceous pseudomorph of the membrane surrounding the plate, from which the calcareous part has been removed. In these cases the membrane retains its shape and separate existence, and where any of the calcareous nucleus remains, as is sometimes the case, it may easily be separated by dilute acid, frequently leaving the external form of the fossil and the outer covering and ornamentation of the plates perfect. The heads generally have the appearance of being much weathered and partially decayed empty tests, but still having the external characters so visible that the genus, and not uncommonly the species, may be distinguished. Some of them had been in my possession some time, when Mr. Parker, of Manchester, well known in the district for his knowledge of Bolland and Clithero fossils, called my attention to the fact of their being siliceous, as they would scratch glass. On this hint I made some experiments which justified Mr. Parker's suggestion, and combining this with the siliceous screw-stones of which I was before aware, it appeared a fair inference that, in the one case as in the other, the animal membrane was replaced by silica and thus apparently preserved, whilst the calcareous portion of the echinoderm had been dissolved and removed, and that the plates of the head as well as of the column were united by membrane, and not by suture, and were consequently flexible.

Specimens of *Actinocrinus* and *Rhodocrinus* have been found in this state, and Fig. 9, Plate VI., shows a portion of a *Rhodocrinus* in which sections of the membranous envelopes of some of the plates are seen in contact, but the calcareous centres or cores have been dissolved out.

Detached plates of an Echinidan from the Mountain Limestone are not unfrequently found near Clithero, which are also enveloped in a siliceous case, and in many instances, although detached, a considerable number of plates are found so close together as to have the appearance of being part of an Echinidan flattened out by pressure.

That the enveloping membrane should be sometimes calcified, as it undoubtedly is in encrinal marble and in limestone generally, and at other times silicified, as in the chert and in the cases under consideration, is a subject which will admit of more than one hypothesis equally applicable to fossils in Chalk and flint, but which has no immediate connexion with the present question.

Miller, who, in his work on the Crinoidea, assumes the proboscis to be the mouth, describes it as being situated in the centre of a plated integument which extends over the abdominal cavity, and is capable of being contracted into a conical or proboscidial shape; and Messrs. Austin also express their opinion that some Crinoids had a limited power of expansion and contraction of the upper part of the body. This change of shape would be permitted by the membrane under consideration, supposing it to be elastic, and it is very probable that the whole test, like the Echinidan alluded to by Dr. Carpenter, was to a certain extent pliable and capable of adapting itself to the necessities of the animal; for we rarely find two specimens of even the same species exactly symmetrical; the dome in many cases, where proboscidial, being elevated so as to form a cone, at the summit of which is the proboscis, whilst in other specimens of the same species, identical in every plate and found in close proximity, the dome is nearly flat and the proboscis projecting but little from it. The axis of the calyx also is frequently not in a right line with that of the column, the base plates of the cup being apparently slightly contorted, giving it the appearance of drooping or leaning to one side. The plates of the calyx are also frequently distorted (although not fractured), as if by pressure, thus showing an amount of flexibility or elasticity. The compressibility of the investing membrane, if not of the plate itself, is also evidenced by the not uncommon occurrence of a portion of a column, when falling to pieces by the decay of its membrane, being pressed against and becoming partially imbedded in a plate of a calyx, and, when removed, leaving such a mould as would be the result of its being squeezed into a plastic material.

Before considering the application of this power of expansion and contraction, we may shortly refer to another point in the organization of the Crinoids. In the year 1858 Mr. Billings, in "the third decade of the Canadian Organic Remains," announced the existence in some of the Crinoids of certain "tunnel-like passages, which lie under the external plates and extend nearly to the apex of the dome," and in 1865 these passages were more minutely described by me in a paper in this Magazine, Vol. II., p. 245, and it was there suggested that they might be for the purpose of supplying food to an internal mouth as well as water for respiration. Since that date Professor Loven has published an account of a recent Australian Echinoderm (Crinoid?), *the Hyponome Sarsi*, Loven, from which the following description is extracted:—

"The general appearance of this very remarkable Echinoderm is that of a small Star-fish, or a Euryalid. It has a disk, convex on the ventral surface, flattened on the dorsal." "As in the recent genera, *Antedon* and *Pentacrinus*, a large conical proboscis-like funnel rises in one of the interradial spaces of the ventral surface of the disk, and from a point situated a little before the centre of the same surface five narrow channels, protected by marginal scales, radiate and defurcate thrice, and run out on the rays and their branches." "On the rays the channels are open, but upon the disk between their first bifurcation and their common starting-point, their marginal scales close over them, forming a vault, so that the five channels are converted into covered ducts converging into a common subcentral aperture, concealed beneath the integument and not visible from the outside. In the covered parts of the channels I found masses, consisting of microscopic crustacea, larval bivalves, and other remains of the food of the animal, apparently taken through the ends and open parts of the channels, and on its way through their covered parts to the concealed mouth." The description here given of the ventral disk and the covered channels, to the central internal mouth of the *Hyponome*, closely agrees with that of similar covered channels on the disk of a *Cyathocrinus* in my paper above alluded to, and strengthens the suggestion therein made that the mouth of these Crinoids was central and internal, and adds to the probability that the Crinoids as a rule had an in-current, excited by cilia or by the fimbriated pinnulæ on the sides of their channelled arms, which passed through the covered passages to the internal mouth. If this is allowed, and in the case of the *Hyponome* it can scarcely be doubted, there can be little hesitation in assuming that the proboscis in some Crinoids and the lateral or interbrachial openings in others, is the anal aperture for the ex-current. In this case the animal being provided with an in-current and an ex-current opening, as in the Tunicata, would thus approach the Molluscoidea. In some other respects there appears to be an approximation of some of the Crinoidea to some of the Tunicata, as in the pyramidal valvules of Cystidea and the Chelyosoma; and the outer tough bags of some of the Tunicata also contain radiated concretions sometimes siliceous, but more frequently calcareous, thus approaching the test of the Echinodermata. If also, as is above supposed, the Crinoids received their nourishment and the water necessary for respiration through the arms and the covered channels connected with them by an internal mouth, probably the power of expansion and contraction above alluded to may have been used by the Crinoids for the purpose of rapidly ejecting water to clear the internal passages, as is done by the *Ascidium* or sea-squirt, and by the mollusca generally.

No doubt many objections may be raised to this supposed approach of two different and perhaps distinct orders; we know, however, that nature draws no hard lines, but abounds in connecting links, and it may be possible that the Molluscoidea and the Echinodermata are connected by the link now suggested.

EXPLANATION OF PLATE VI.

Fig. 1. Plate of the column of recent *Pentacrinus caput-medusæ*, after boiling in Liquor potassa. Magnified seven times.

a. a. a. The five radiating elliptical lobes.

Fig. 2. Cross-section of another plate, similarly treated, showing the tubuli and pores.

Fig. 3. Plate of column of same, decalcified by very dilute Muriatic acid, and then allowed to dry, showing the central axis and the shrunk lobes.

Fig. 4. Joint from one of the side-arms in the column, boiled in Liquor potassa.

Fig. 5. Unprepared side-arm, broken off, showing the fibres projecting from the pores.

Fig. 6. Bundle of fibres from fractured lobe of column of recent *Pentacrinus*. The cross-lines show the intervening membranes of the column.

Fig. 7. Side arm of recent *Pentacrinus*, decalcified by very dilute Muriatic acid, showing tufts of fibres on each side of the median ridge.

Fig. 8. Specimen of Chert with "screw-stone." In this specimen the silicified membranes at one end are perfect, and extend to the circumference, but more than half are broken off. Drawn of the natural size.

Fig. 9. Magnified drawing, showing silicified margins of plates, forming part of body of *Rhodocrinus*, apparently the pseudomorph of the membrane in which each plate was enveloped.

II.—On the Microscopical Structure and Composition of a Phonolite from the "Wolf Rock."

By S. Allport, F.G.S.

With a Chemical Analysis by Mr. J. A. Phillips.

THE rock described in the following paper is, I believe, new to British petrology; and as the value of microscopical analysis is not yet fully recognized, a detailed description may be acceptable to many readers of the Geological Magazine. The specimens examined were kindly sent to me by Mr. J. A. Phillips, together with a chemical analysis, which, with his permission, is also added.

The "Wolf" is a rugged rock lying about nine miles south-east of the Land's End, and covered by the sea at high water. At low water of spring tides its length is about 175 feet, and its breadth 150 feet. Its highest point at low water is 17 feet above the level of the sea, whilst at high water it is covered by it to a depth of 2 feet.

Examined by the eye or simple lens, the rock is seen to consist of a yellowish-grey compact base, in which crystals of clear glassy felspar are embedded; they exhibit no striæ; their fracture is sharp and splintery.

A thin section examined in polarized light with crossed prisms exhibits a beautiful group of crystals of felspar and nepheline porphyritically embedded in a fine-grained matrix composed of minute crystals of nepheline, felspar, and hornblende; when cut very thin, the hornblende alone exhibits colours, the hexagonal sections of nepheline being black, the rectangular white; the felspar is also either dark or light, and the general appearance is that of a mosaic of dark and light stones interspersed with small brilliant coloured crystals of hornblende; the whole forming a matrix in which the larger crystals are set. In thicker sections the felspar and nepheline display fine colours, but the minute structure is not so well seen.

The microscopic constituents are for the most part evenly distributed throughout the base, but not unfrequently they are crowded together along the sides of the larger crystals and irregular grains of nepheline. This is an important fact, as it clearly indicates that both the nepheline and the smaller crystals had been formed while the surrounding mass was still in a plastic state; it would also appear that the felspar was the last to crystallize, as it frequently incloses crystals of nepheline and hornblende, which must have been caught up in it at the time of consolidation.

The nepheline occurs in the sections in hexagonal and rectangular forms, or as imperfect crystals and irregular grains; some are perfectly clear and transparent, but the greater number appear to be filled with a fine grey dust; it is sometimes equally distributed, but is also frequently collected together so as to form a dark, or even black mass in the centre, the edges of which are sharply defined, and correspond exactly with those of the crystal. Hexagonal crystals, for example, exhibit a border filled with fine grey dust, and a central portion occupied by a well-defined black hexagon; or, there is sometimes a black band running parallel with, and at some distance from the sides, the central and outer portions of the crystal being occupied by the grey dust. With a magnifying power of 800, a portion of the dust is resolved into minute granules, having a translucent centre surrounded by a dark ring; they are therefore probably *glass cavities*. It is especially worthy of remark that this grey dust occurs in precisely the same way in the nepheline of the basalts and phonolites of Tertiary age, and from widely separated localities. The clear crystals frequently exhibit faint lines parallel with the sides, and they often inclose slender acicular prisms; compound and twin crystals are not uncommon.

The felspar is perfectly clear and transparent, and evidently belongs to the orthoclase group, no striæ are observable, and one or two crystals give an angle of 90° by measurement with the goniometer. The prisms are frequently much fractured transversely to the long axis, and in this respect, and in their optical character, they closely resemble the sanidine of some trachytes and phonolites. Twin crystals showing different colours on opposite sides of the plane of junction are not uncommon. The felspar contains numerous glass cavities and extremely minute crystals, which are sometimes irregularly distributed, but are also frequently arranged in rows parallel with the edges of the larger crystals; the latter have also caught up crystals of nepheline, and a few long slender prisms, probably apatite.

The hornblende occurs in minute green prisms, varying in length from $\frac{1}{600}$ to $\frac{1}{200}$th of an inch, and in width from $\frac{1}{3000}$ to $\frac{1}{1000}$ in. They are regularly interspersed with the other constituents of the base, but occasionally great numbers of them are crowded together in closely compacted groups, having a nucleus of black grains of magnetite; a few prisms may also be seen imbedded in the nepheline and felspar.

There may perhaps be some little uncertainty whether this pyroxenic mineral be hornblende or augite. I have not met with any reliable angles, as most of these minute prisms appear to be broken or imperfectly formed at the ends; a few of larger size are, however, distinctly dichroic, and would therefore appear to be hornblende.

The greater part of the mass of the rock is seen to consist of nepheline; the crystals forming the base vary in size from the $\frac{1}{150}$

to $\frac{1}{300}$ in. across, but there are perfect hexagons which do not measure more than the $\frac{1}{2000}$th of an inch; most of them are indistinct in outline when seen by ordinary light, but become well defined when examined with a half-inch objective between crossed prisms.

Two analyses of this rock afforded Mr. J. A. Phillips the following results:—

	Sp. Gr. = 2·54. I.		II.
[1] Water	2·05	per cent.	2·05
Silica	56·46	„ „	56·40
Alumina	22·29	„ „	22·20
Peroxide of Iron	2·70	„ „	2·61
Protoxide of Iron	·97	„ „	·97
Manganese	Trace		Trace
Lime	1·47	„ „	1·35
Magnesia	Trace		Trace
Phosphoric Acid	Trace		Trace
Potassa	2·81	„ „	2·73
Soda	11·13	„ „	11·11
	99·88		99·42

Any one who has made a careful examination of the Tertiary phonolites, or is acquainted with Professor Zirkel's researches on them, will at once recognize the identity of their mineralogical composition with the rock here described, and will be struck with the thoroughly characteristic appearance of the nepheline, which is absolutely the same in both. In fact, no one would hesitate to call it a phonolite, if it were known to be of Tertiary age. The age, however, is unknown, and likely to remain so, for the rock stands alone in the sea, and its actual relations with others cannot be observed. Situated between the Land's End and Scilly Islands, it is in a Palæozoic district, disturbed and penetrated in all directions by granites, porphyrites, and diorites; few, therefore, will hesitate to place it among the older series of igneous rocks. It is at present the practice among many petrologists to name rocks according to their supposed geological age; a dark-coloured augitic rock, for example, would be a *basalt* if of Tertiary age, but must be a *melaphyr* or *aphanite*, if of some indefinite early age. In accordance with this absurd system, the rock in question would probably be called a *Foyaite*, if it were known to be old, as it agrees well with descriptions of that rock, except that the elæolite is here represented by nepheline crystals which cannot be distinguished from those of true phonolites.

After some hesitation, I have adopted the name of *porphyritic phonolite* for this rock, and will take the present opportunity of suggesting that one name only should be assigned to all igneous rocks composed of the same constituent minerals, irrespectively of their age; or, in other words, that we should assimilate the nomenclature to that employed in the sedimentary rocks. We speak of Carboniferous or Tertiary sandstones, etc., why not Carboniferous or Tertiary dolerites or melaphyres? When the age cannot be precisely ascer-

[1] Of which ·94 was lost in water-bath.

tained, an approximation may generally be made, and such terms as *post-Carboniferous, ante-Triassic*, etc., might be used.

If some such system were adopted, all the basic, augitic rocks containing much iron oxide, would form one group, and we should get rid of a number of useless names which have been applied to rocks in utter ignorance of their mineralogical composition or structure.

Until quite recently such a suggestion could not have been adopted, as there were no means of ascertaining with certainty the constituents of the fine-grained rocks; but now that improved methods of microscopical research are available, it is quite time that the unscientific nomenclature still in use should be supplanted by one more in accordance with the present state of knowledge.

III.—On the Drifts of the West and South Borders of the Lake District, and on the Three Great Granitic Dispersions.

By D. Mackintosh, F.G.S.[1]

THE following is a continuation of the results of observations in the Lake District and neighbourhood, made during the greater part of last year, and the beginning of the present year.

Drifts around Whitehaven, Cleator, Egremont, St. Bees, etc.—About Workington, and farther south, the sea-coast zone of Criffell granitic drift (described in last article, Geol. Mag., Dec., 1870, Vol. VII., p. 564) is very narrow, but to the S. of Whitehaven it becomes wider, and the great road from Whitehaven to Ravenglass, by way of Egremont, very nearly delineates its inland or eastern boundary. Boulders of this granite, along with porphyry (including the tesselated kind from the Caldbeck-fells), syenite from Ennerdale, etc., may be found on and in a red clay to the S.W. of Whitehaven, where the ground reaches a height of more than 400 feet above the sea, and is completely cut off from the Cleator and Ennerdale areas by the deep pass which runs from sea to sea between Whitehaven and St. Bees. On the brink of a quarried sea-cliff, about 300 feet above Saltom Bay, the Permian sandstone is planed, smoothed, and finely striated N. 30° E.

On the way from Whitehaven to Cleator Moor I saw many boulders of Ennerdale syenite, one of them measuring $5 \times 3 \times 3$ feet. On the E. side of the Ehen Valley, about 400 feet above the sea, the

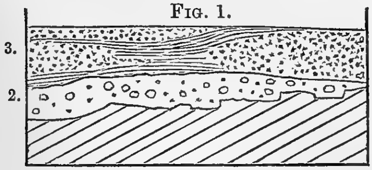
[1] It may be desirable to give a short explanation of some of the lithological terms used in this article:—*Granular felstone*, a fine-grained rock, mainly felspathic, with uneven fracture, and graduating from light-grey (like the well-known Penmaenmawr rock) to a colour nearly black. This rock has often been erroneously termed both greenstone and basalt.—*Compact felstone*, a felspathic rock with comparatively even fracture, and often more or less flinty in appearance.—*Felspathic breccia*, a rock consisting of angular or irregular fragments chiefly of compact felstone, generally from one-fourth of an inch to two or three inches in diameter, sometimes much larger. It looks like petrified pork-shop brawn.—*Syenite*, a rock (in the Lake District) generally pinkish or reddish, and finer grained than ordinary granite, consisting of felspar, quartz, and hornblende, or two of these minerals. It is always intrusive, and passes into a rock approaching the character of greenstone.—*Granilite*, a convenient name for a very fine grained granite.

New Waterworks excavation has revealed blue clay (running into gravel), overlain by yellowish-brown clay, and containing boulders of Ennerdale syenite from the E., limestone from the W. or N., etc. In one place the striæ (on Skiddaw slate) run nearly E., in another, E.N.E., both pointing over high ground towards Ennerdale. The adjacent height called Dent, as previously stated, is covered with boulders of syenite and porphyry up to 1,100 feet. About Egremont there is an unknown thickness of unstratified or rudely stratified gravel, with stones and boulders of syenite, porphyry, slate, sandstone, a little Criffell granite, and enormous rough blocks of local limestone. Some distance N.N.W. of Egremont there is a red clay with glaciated pebbles and boulders, lying on a very uneven and uptorn surface of limestone rock. Farther N. there is a great thickness of clean gravel. On the table-land between Egremont and St. Bees, the drift is chiefly angular sandstone, tumultuously worked up from the rock below, and graduating upwards into a covering of clay and loam, sometimes rudely stratified, with boulders of greyish-blue porphyry, syenite, Criffell granite, etc. In St. Bees village there are some large boulders of syenite and porphyry.

Between St. Bees and the sea there is an array of abrupt drift-knolls, which reach a height of 100 feet, and might readily be regarded as moraines if they occurred at the mouth of any valley leading down from the mountains, or consisted of anything like moraine-matter, neither of which is the case. They are composed of sand, with highly contorted beds of unwashed gravel, which rise up from beneath the beach-shingle to the top of the cliff-section. This drift rests on reddish-brown Boulder-clay. Between St. Bees and Seascale there is a succession of mounds and plateaux of stratified and frequently contorted sand and gravel, more or less covered with blown-sand, and (as is evident from the boulder "scars" visible at low-water) underlain by Boulder-clay. Between Seascale and Gosforth, and all around, there are great knolls of sand and gravel, often separated by swamp-basins. The pebbles consist of dark granular felstone, grey porphyry, syenite, and, nearly as far inland as Gosforth, Criffell granite.

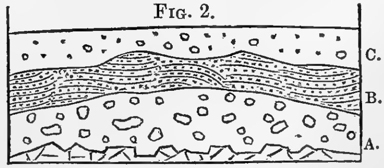
Drifts around Gosforth.—The new red sandstone, immediately N. of Gosforth, rises to a considerable height above the sea, dips at a rather high angle to the S.S.W., and is covered with drift containing porphyritic stones and boulders. (See Fig. 1.) The tops as well as

Fig. 1.



2. Red Boulder loam and sand.
3. Fine gravel, with irregular layers of sand.

Fig. 2.



A. Greenish or reddish brown, argillaceous, hard Boulder-clay.
B. Fine hard gravel and sand, with waved lamination, and many round stones.
C. Foxy-coloured loam, with very few stones.

the sides of the ridge, between the river Bleng and Wastdale, is covered with drift, consisting mainly of pinel, frequently overlain by foxy-coloured loam. A great part of this ridge must always have been beyond the reach of precipitated valley-glacial moraine-matter. The boulders, many of which are very large, are chiefly bluish-grey porphyry, probably from the high ground to the N.E., but in part, possibly, from concealed rock *in situ.* On this ridge there are so many glaciated boulders that I had no need to have recourse to the expedient once recommended to me by a Yorkshireman, who, after stating that there were no rounded and scratched stones in his neighbourhood, advised me to go to an adjacent sandstone quarry, where I could find plenty of square blocks which I could round and scratch for myself!

Drifts and Glaciated Rocks of Wastdale.—Between the neighbourhood of Gosforth and one-third of a mile W. of Strands, a fine-grained felspathic rock rises through the drift in bosses. Thence to Wastwater-foot, the rock is principally granilite, and this rock occupies a great part of the space between Strands, Buckbarrow, and Greendale. Near the lake it graduates northwards into a quartzo-felspathic rock.

In the neighbourhood of Kidbeck and Gap, contorted gravelly pinel, with stratified sand seams, and real typical pinel covered by foxy-coloured loam, may here and there be seen. Great numbers of surface blocks, both angular and rounded (as well as those imbedded), strew the ground, and rise up the slope to the summit of the Moor above Yewtree. At Gill, the pinel graduates downwards into rough angular breccia. The latter and the coarse local limestone and sandstone débris previously mentioned may possibly represent the first land-ice period. The stones and boulders about Gill are pink and light grey granilite, and a dark grey porphyry. Farther on, flat knolls of pinel, sometimes greyish-brown, run underneath the screes or fallen débris, with a distinct line of demarcation. Between Greendale and Wastwater, there are many *roches moutonnées,* which have been smoothed or glaciated chiefly from the E., sometimes E.S.E. and E.N.E., in a few instances from the S., in all instances obliquely or directly from the direction of the Screes escarpment. A glacier from the N.E. moving *along* the valley could not have accomplished this, either by its direct action or by a lateral process of grinding, as the configuration of the ground would have enabled ice from the N.E. to gain free access to what are now the jagged or lee sides of the bosses.[1] The idea at first suggested itself that a great stream of land-ice may once have tumbled over the Screes escarpment, and smoothed the above rocks in its passage across the dale. Mr. de Rance has expressed a similar idea (Geol. Mag. March, 1871), but I do not think that it can be reconciled with an attentive consideration of the physical geography of the district. The glaciation of rock-surfaces directly or obliquely across valleys is in many parts of the Lake District the general rule, and not the exception. Can it be

[1] Professor Phillips, some time ago, after a particular examination, came to the conclusion that no glacier could ever have flowed along the whole length of Wastdale (Geol. Mag. Vol. II. p. 513).

explained by what Dr. Robert Brown calls "a monstrous regurgitation of waves," caused by ice falling down from the tops of cliffs or ridges, and struggling to become launched, at the time when the valleys were occupied by the sea?

At one spot, near the lake, on the E. or upstream side of a glaciated boss of rock, a section has been exposed of a deposit of drift. (See Fig. 2.)

E. of Strands one may see plateaux and knolls of stratified and contorted sand and gravel, with sub-angular stones and boulders of granite from the E., and porphyry from the N. In some places pinel appears underneath. W. of Strands, a fine section of pinel, surmounted by loam, may be seen on the road-side. About a quarter of a mile W. of Strands, the granilite is distinctly striated E. 10° N., which accords with the direction above assigned to the glaciation of the bosses near Greendale.

Philosophy of Screes.—Wastdale Screes escarpment rises to an average height of about 1,650 feet above the lake. Near the top the slope is about 40°, in the middle 50°, towards the base 40°. The solid rock *generally* comes half-way down, and the broken rocks or screes run half-way up. The screes are chiefly in deltas, under rakes or gulleys, from which they have been precipitated by frost, or washed down by rain torrents. (See Fig. 3.) In the process of scree-

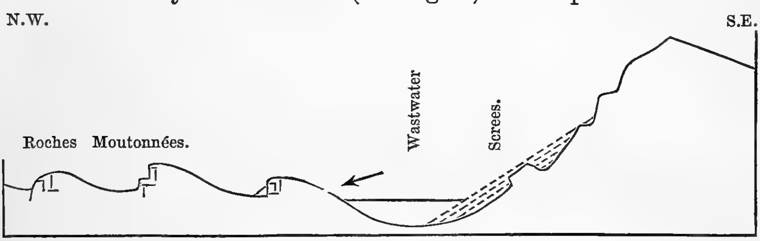


FIG. 3.—Section of Wastdale.

making, the tops of previously-existing cliffs have been bevelled off, and their bases shored up. At the lower end of the lake the Screes consist of greyish-blue, sometimes nearly black, fine-grained felstone graduating into ill-defined porphyry. Pebbles and boulders from the Screes may be readily traced all the way S. as far at least as Chester, their derivation being witnessed by the peculiar granilite and granite with which they are associated.

With the exception of a very little comminuted matter, which in some places has been washed down from above, the Screes have not been mixed with fine sand or clay. They nearly all consist of bare stones. Rain cannot grind stones, and the lake is almost equally incapable, as may be seen at its lower end, where it has thrown up a heap of very small, bare, angular fragments, with three terraces marking different water-levels. The brook from Illgill, above Wastwater-foot, has made a section in scree-matter (a part of which it has probably itself brought down), revealing its bare stony character. In the greater part of the Lake District, the screes are bare fragments of rock, and continue so after becoming covered with certain kinds of vegetation. Where glaciers were able to collect moraines, these screes would supply them, and the re-precipitated screes or moraines would be hillocks, banks, or ridges of bare stones. But in those exceptional cases where ochreous matter, or previously comminuted drift from the tops of cliffs or sides of steep slopes (or matter arising from the chemical decomposition of certain kinds of rocks), might be washed down on the surfaces of glaciers, the moraines would still be distinct in their composition and structure from plateaux and knolls of elaborately ground-up pinel, with smoothed, rounded, polished and striated stones and boulders. The term moraine, therefore, ought never to be applied to an accumulation of Boulder-clay, unless indeed it be coupled with the word *profonde*, supposing the writer adheres to the theory that Boulder-clay was formed *under* land-ice.

The Eskdale Granitic Area.—E. of Wastwater-foot the granilite runs into, and here and there (between Red Brow and Beckfoot, for instance) alternates with the very coarse-grained granite of the Eskdale fells. The latter is very confusedly crystalline, with much greasy-looking quartz, ill-defined crystals or patches of felspar, and so very little dark mica, that a block of this granite often looks nearly as white as chalk. In many places, as in Muncaster fell, it has more or less of a reddish hue. In Irton Park, between Santon Bridge and Steathwaite, there is a succession of rounded, but nowhere distinctly moutonnéed granitic bosses, with tails of hard unwashed gravel surmounted by stratified gravel and sand. On the S.W. side of Irton Pike there are great masses of stratified and false-bedded gravel and sand overlying rudely stratified pinel with enormous boulders. On going down from Irton Pike to Keyhow, real argillaceous pinel or Boulder-clay may be seen on the road-side. E. of Red Brow the locally-limited granilite is decidedly moutonnéed in the direction of the valley. The cliffs of coarse granite on the N. side of this part of Eskdale, rise to a considerable height, and their bases are strewn with myriads of massive blocks, the successors of as many myriads which were probably floated off during the glacial submergence, and which may now be found scattered as far south as Trescott, near Wolverhampton. There is no vestige of a glacial moraine in the lower part of Eskdale.

Drifts between Irton, Drigg, and Ravenglass.—Eskdalefell granite has found its way a short distance to the west of a line drawn from Irton to Drigg, where it has been mixed up with Wastdale dark granular felstone and granilite, and to some extent with Criffell granite. These rocks may be found not only as boulders, but as pebbles imbedded in great knolls of sand. Red, stiff, hard lower Boulder-clay makes its appearance at the railway-station and on the sea-beach at Ravenglass. East of Muncaster High School there is a great expanse of triturated granite, with many stones of granite, slate, porphyry, sandstone, quartz, etc., rudely stratified and dipping at a greater angle than that of the slope,—the whole suggesting a meeting place of tides or currents. On the east side of the trumpetshaped mouth of Eskdale there are many fine cliffs, and slopes strewn with large cubical blocks of granite, which would furnish a future ice-laden sea with great cargoes of boulders for transportation in a southerly direction.

Drifts between Blackcombe and the Sea.—From the mouth of Eskdale, a stream of mixed drift, with large granite boulders, runs southwards over the country between the mountains and the sea. Much pebbly gravel and sand covers the longitudinal depression between Blackcombe and the higher ground bordering the sea. It rises here and there into knolls separated by swamp and peat basins, and in some places is covered by, or alternates with, Boulder-clay. Nine out of ten of the large boulders on many parts of the west slope of Blackcombe (on the surface or imbedded in drift) are Eskdale granite or granilite, and Wastdale granilite. A beach of drift, with a foundation of pinel in some places, runs along the base, and rises up to 500 or 600 feet on the side of Blackcombe. North of Whitbeck this beach consists of well-rounded gravel and sand, which, in one flat-topped knoll, must be 120 feet thick. There are other abrupt sand and gravel eskers farther north. Many boulders of Eskdale granite choke up the mouth of Holebeck gulley, where they have been mixed with the granilite *in situ* discovered by Mr. Marshall, of Leeds.

Mr. Eccleston, of Carlisle, some time ago discovered a stream, or rather a series of groups, of granite blocks, running from the fells on the east side of Eskdale along the ridges and slopes as far as the southern extremity of Blackcombe, and reaching a height of at least 1000 feet above the sea.[1]

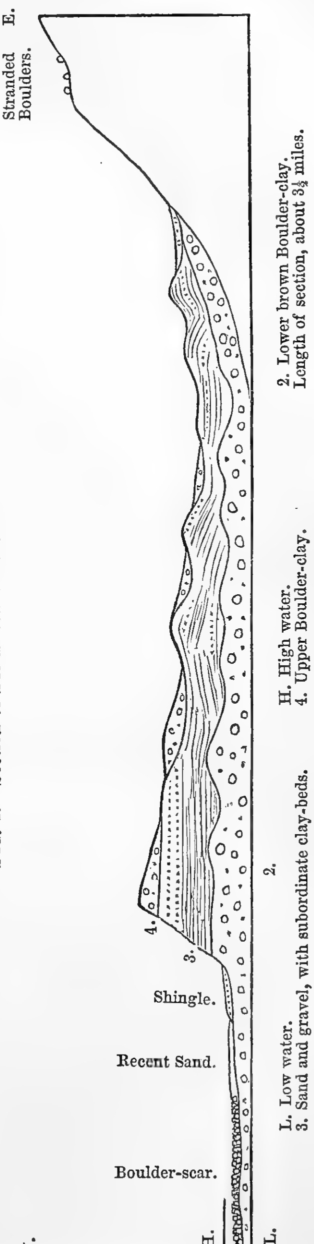


Fig. 4.—Section of Drifts from Blackcombe to the Sea.

[1] I afterwards saw two of these ice-floe loads, the principal one being on a plateau,

Some of the finest sections of drift in the north of England, though often much obscured by talus, may be seen on the sea-coast adjacent to Blackcombe. (See Fig. 4.) For more than three miles the cliff-line consists of stratified sand, gravel, and Boulder-clay. For at least two miles (walking north from the neighbourhood of Silecroft), the sand attains a thickness of from 100 to 120 feet, exclusive of blown sand. Here and there it contains layers of gravel and subordinate beds of clay. In many places it is capped with upper Boulder-clay. (See Figs. 5 and 6.) Northwards, the upper clay here and there swells out to a great thickness, and the lower brown Boulder-clay rises up to a considerable height above high water-mark. At the most northerly point I visited, the latter terminated abruptly under a series of steeply-inclined beds of sand. (See Fig. 5.) The lower clay contains more boulders and is more argillaceous than the upper, excepting where it runs into a bright red clayey loam similar to what may be seen on the beach at Blackpool and elsewhere. The three drifts contain granite, along with many other erratics.

Fig. 5.

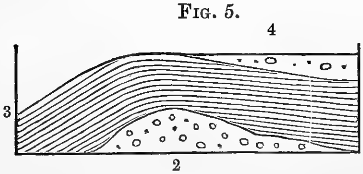
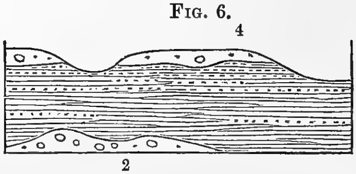


Fig. 6.



Sections illustrating the mode of occurrence of Drifts on the coast near Blackcombe.

2. Lower Boulder-clay. 3. Sand and gravel. 4. Upper Boulder-clay.

(*To be continued.*)

IV.—The English Crags, and their Stratigraphical Divisions indicated by their Invertebrate Fauna.[1]

By A. and R. Bell.

CERTAIN opinions have been put forth during the last few years which do not seem to be quite in accordance with some facts which have come to our knowledge in working out systematically, various pits and sections in the Red Crag district, and we propose discussing in the following paper a few of the more salient points bearing upon the fauna, and the position in time and place of this particular series of deposits.

In place of the commonly accepted terms Coralline, Red, and Norwich or Fluvio-marine Crag, we suggest for future use the terms Lower, Middle, and Upper Crags, as both palæontological and strati-

on the south side of the upper part of Fossbeck, at a height of about 1000 feet, and in a situation where one might almost see the boulders in course of being stranded. One measured $8 \times 7 \times 3$, another $6 \times 4 \times 3$, and a third $10 \times 8 \times 4$. They were accompanied by a few boulders of other rocks.

[1] Read before the Geologists' Association April 4th, 1871.

graphical considerations render an alteration imperative. In the two latter instances the names are very inappropriate: Red, because all gradations of colours may be noticed, and the colour is not peculiar to this deposit; the Norwich, or Fluvio-marine, because the formation extends beyond the confines of Norfolk, and is in many places exclusively marine.

The horizons proposed for adoption stand thus:—

The Pre-glacial, or Chillesford series, comprising the Chillesford sands and clays, the Forest Bed, and all deposits intervening between the Upper Crag and the Lower Glacial beds.

The Upper Crag = the Norwich Fluvio-marine, and the upper part of the Suffolk Red Crag (as hereafter indicated).

The Middle Crag = the Red Crag proper.

The Lower Crag = the Coralline Crag.

Our calculations have been chiefly based upon the Mollusca, these only having yielded sufficient results for comparison; but as no table has been published of the organic remains known to exist in each of the Crags, we present the nett total of each group of which we have lists.

SUMMARY.	Lower Crag.	Middle.	Upper Red (marine).	Norwich Fluvio-marine.	Pre-glacial.
Cetacea	2	21			3
Other Mammalia	1	14		6	23
Aves				1	
Pisces	9	3	2	2	5
Insecta					1
Crustacea	9	2	1		
Ostracoda	21	4			
Cirripedia	10	8	3	3	3
Annelida	4	1	2		1
Echinodermata	17	11	2		3
Land and Freshwater Mollusca		5	9	22	19
Marine Gasteropoda and Solenoconcha	193	178	108	64	46
Opisthobranchiata	14	5	3	4	3
Pteropoda	1				
Lamellibranchiata	169	135	74	71	73
Brachiopoda	5	1	2	2	
Polyzoa	125	30	5		3
Cœlenterata	4	5	2		
Protozoa	1	2			
Rhizopoda	88	26		10	5
Plantæ	2	1			12
Total in each formation	675	452	213	185	200

With reference to the much vexed question of species or varieties, we are of opinion that a well-defined variety, one easily recognizable, and accepted as a distinct species by the majority of naturalists, or even one that is the characteristic form in other seas or formations, is of as much value, both geologically and palæontologically, as is the specific type. It so frequently happens that the variety precedes, co-exists with, or succeeds the received specific type, that an elimination of the variety from the list of a fauna is likely to lead to serious complications and even errors; *e.g.*, to take the case of *Tellina obliqua*, *T. prætenuis*, and *T. calcarea* (or *proxima*). The first ranges upwards, from the Coralline Crag to the Upper Glacial, or Bridlington, beds, where it dies out. The second variety first appears in the lower part of the Red Crag rather abundantly, even at first; and dies out in the Chillesford series, and *T. calcarea*, the specific type of the whole, as so suggested by Prof. Forbes, occurs only sparely at first in the Red Crag, and attains its maximum development in the Post-glacial beds of the north. The type form itself does not occur in the Coralline Crag.

The points we propose discussing are—

1st. The derivation of species from the destruction or abrasion of the older deposits.

2nd. The position of the Red Crag with respect to the Coralline, and fluvio-marine formations.

3rd. The evidence in favour of a redistribution of the Crag areas.

First. The derivation of species, etc. No two authors are agreed either as to the number of species, or even to the species themselves, which are to be regarded as extraneous. In the abstracts of some papers "Upon the Structure of the Crags, etc." (Quart. Journ. Geol. Soc. 1868-70), Mr. Prestwich states that all three crags contain derivate forms, the Red Crag list especially being reduced by means of derivatives and varieties from 245 to 146 species. Mr. S. Wood (Lyell, Students' Elements) admits 25 species as extraneous, against 60 in 1858. Till some harmonization of this complication takes place, all endeavours to fully comprehend the fauna are useless.

From our observations we have come to the conclusion *that there is no evidence whatever, either external or internal*, to justify us in separating from the fauna of the Red Crag any species except where such forms are of Eocene or of older date (the "box stone" fauna being out of court at present). Individual specimens undoubtedly do occur that are the relics of preceding stages, but we cannot find any grounds for believing that all the members of any species are extraneous to the fauna or deposit in which they occur.

Again, the reasons assigned for considering any of the forms of the Red Crag derivative are by no means satisfactory, even when any reasons are given, which is not always the case. In his paper upon the "Extraneous Fossils of the Red Crag," Mr. S. Wood considers 54 species are probably derivative, and six others positively so, and he remarks that "the shells may have suffered little or no abrasion during the removal." No reason for this opinion is given.

Mr. Wood, junior (On the Red Crag, etc., of the Eastern Counties, Ann. and Mag. Nat. Hist. 1864), says of the Walton deposit that it is "destitute of those derivative shells, etc.," and "bivalves are frequently found in pairs, and univalves uninjured in the pullus or apex." These evidences of non-derivation are by no means peculiar to the Walton-on-the-Naze shells, as we shall show presently; and we may mention that our Walton list of shells enumerates 170 species, 116 of them being common to the Coralline Crag. Speaking of some forms from a particular stage, he remarks, they are "worn and travelled, and show their origin to have been mainly derived from older materials." Sir Charles Lyell also dwells upon the subject in his Students' Elements, p. 179. He says, "There can be no doubt Conchologists have occasionally rejected from the Red and Norwich Crags shells which really belong to the seas of those periods because they were extinct, or unknown as living," and suggests that extreme scarcity, colour, and worn condition may sometimes be indicative of derivative origin.

An analysis of the quotations just made will therefore give the following as marks of extraneous origin:—Separation of bivalves, damaged univalves, mixed without regard to position, and mostly, if not always, in bad and worn condition. Extreme scarcity and colour, or want of it, being dependent upon local consideration, do not bear upon our argument.

These characters are not universally applicable to the members of the Red Crag fauna; thus, we find bivalves in pairs and *in situ* everywhere, of course more abundantly in some places than in others, and we have prepared a list of upwards of fifty species. These species are many of them of the most delicate structure, especially as regards the ligamental apparatus. The Brachiopoda, and species of *Hinnites, Pecten, Astarte, Cardium, Solen, Mya, Tellina, Mactra,* and *Pholas* constantly occur in pairs. Of *Terebratula grandis*, var., we have seen upwards of 500 examples, perfect in many cases, even to the preservation of the internal apparatus. Perhaps the most striking proof of the non-derivation of the Brachiopoda is furnished by their situation in the Crag. They occur in groups imbedded in fine sand, and are almost always surrounding large round stones, and only want the connecting pedicles to make the group complete. Of the univalves the following forms, *Voluta, Mitra, Pyrula, Cancellaria, Ovula, Scalaria, Fusus* with perfect apices, *Emarginula, Scaphander* and various others equally fragile, or highly sculptured, occur in fine preservation.

Even if this were not so, the arguments derived from worn specimens are equally illusory. All naturalists are aware that the proportion of worn and imperfect, as compared to perfect specimens, is generally large in dredgings taken below low-water mark, especially if the shells are in the condition technically known as "dead."

The worn and decorticated appearance of many of the Crag shells, in our opinion, is owing more to the nature of the investing matrix than to anything else.

Again, we find in many places traces of an undisturbed sea-bottom determinable by the position and condition of the animal remains. If the bottom of a recent sea was laid dry, we might expect to find, according to local conditions, *Terebratulæ* and *Rhynchonellæ*, in groups, larger or smaller; *Gastranæ* and *Myæ* imbedded in sandy mud and clay, *Saxicavæ*, *Pholades*, and the boring *Veneridæ* in their several cists, with dead shells and cavities frequently occupied by *Kellias*, and other bivalves, and in some places *Mytili* and *Cardia* closely packed, with other more solitary species intermixed, according to depth, habitat, soil, etc. The univalves, as a rule, are less gregarious, but even these would be found to occupy more or less certain zones and favourable feeding-grounds. In other places heaps of dead shells, parted bivalves, worn univalves, together with occasional individual specimens in a more perfect state of preservation. Corals would be found more plentiful at certain depths than others, and the sea-bottom itself composed of comminuted shells, minute organisms, fragments of Corals, *Polyzoa*, *Echinoderms*, and the debris of a vast fauna; sandy tracts bare of organic life occurring here and there.

Now this is precisely the condition we find presenting itself in pit after pit in the Red Crag district, and we venture to say that there is no part of a modern sea-bottom which we could not parallel within reasonable limits, in the bed of the ancient Red Crag Sea.

Before quitting this part of our subject we would only notice further that those sections in the Coralline and Red Crags which have the greatest number of species in common, are those farthest apart. Thus, to parallel Sutton and Gedgrave in the higher part of the Coralline zone, we must look south to Walton-on-the-Naze, and for the Orford and Sudbourne Crags, to the pits at Sutton (Red Crag) and Waldringfield, especially to the latter. All these pits are miles apart. In those sections seen in juxtaposition, as is the case occasionally in Sutton parish, the greatest diversity prevails.

We will now proceed to consider the position of the Red Crag in its relations to the Coralline and Fluvio-marine formations. "Many geologists are of opinion that the different patches of the Red Crag formation are of different ages, although their chronological arrangements cannot be decided by superposition." Several attempts in this direction have been made. Mr. S. Wood enumerates, in a valuable paper upon the Structure of the Red Crag (Quart. Journ. Geol. Soc., 1866), three stages, which he denominates the Walton, Sutton, and Butley Crags. Mr. Wood, junior, finds four beach stages and one horizontal, in all five stages. Messrs. Prestwich and Jeffreys, by eliminating "extraneous" fossils, and by the reduction of species into varieties, have brought the whole, including the Fluvio-marine and Chillesford series, into one palæontological group, but admit that some division in the lower (or Red Crag) bed is to be found.

Our views having been expressed as to the genuineness of the Crag Mollusca, we now proceed to point out that which we consider to be the true reading of the difficulties presented in working out the Red Crag in its various aspects.

Having already suggested a re-distribution of the Crags, the area occupied by each has now to be particularized.

The Coralline (or Lower) Crag occupying its present area, we propose allotting the other Crags thus:—The Middle Crag to consist of the lower deposits commencing at Walton-on-the-Naze, and extending to Bentley on the west, thence running eastward to Butley Abbey and Hollesley.

The Upper Crag to consist of the uppermost beds of Red Crag, the Chillesford Scrobicularian Crag, and the Fluvio-marine, and marine Crags of the Norwich Series. The uppermost beds of the Red Crag overlying the lower at Shottisham Creek, Ramsholt Dock, and possibly at Bawdsey and other parts south of Butley Corner.

Putting aside the question of physical structure as not bearing upon our argument, we may yet observe that in most instances comminuted fragments are more abundant in the Lower Red Crag than in the Upper.

The reason why Mr. Prestwich could not observe any order of succession in the greater part of the Red Crag we believe to be, that there is not any order, physically speaking, but only palæontologically. The oblique lamination of Mr. Prestwich, and the beach stages of Mr. Wood, junior, constitute, in our view of the question, one distinct stage, and not more. In a valuable map appended to Mr. Wood's paper on the Red Crag, a horizontal stage overlying certain beach stages is shown, but for want of systematically working out the fauna of his sections, he has only foreshadowed the great truth (as we think) embodied in them as shown by their organic contents, that his horizontal Crag, as a whole, possesses a fauna so vastly different from that of his beach Crags, that their agreement, in point of community of species, is hardly more than their disagreement.

This observation, of course, only applies to the district we have worked. In the coming summer we hope to trace this Upper Crag south of the Deben; Mr. Wood has done so physically, we hope to do so palæontologically.[1]

It seems as yet to have escaped the notice of most observers, that the fauna of the Red Crag presents two aspects, *i.e.* a deep-water and a shallow-water one; and herein lies the solution of a difficulty met with in comparing different pits. As judged by the fossils, the lower Crag sea was deepest about the localities of Waldringfield and Sutton, evidenced by the presence of *Terebratulæ* in large numbers, especially at the former section, and which shallowed out towards Walton-on-the-Naze. In the upper deposit the deepest water occurred at Shottisham Creek, becoming shallower towards Butley, Chillesford, Tunstall, and farther to the north. At Shottisham Creek we have obtained several specimens of *Rhynchonella psittacea*, together with many Terebratulæ, the latter measuring from $\frac{1}{4}$ inch to $1\frac{3}{4}$ inches or more in length; *Fusus Largilliertii* and *F. Turtoni* also being found in the same place.

It is a characteristic of modern sea life that the deep-water fauna is more persistent in time than the shallow-water one, and it is so in

[1] In justice to ourselves we ought to say that our investigations in the horizontal Crag were begun long before our attention was called to Mr. Wood's map, or paper. Should the physical and palæontological evidence concur, as we believe it will, the question as to the superposition of the Upper Crag over the Lower will be settled, and it will then be necessary to show the agreement in the fauna of all the deposits which we have comprised under the heading Upper Crag. This must, however, be left till a future opportunity. A slight indication how matters stand in this direction is all that we now propose giving.

the Crags. Both the upper and lower Crag deep-sea fauna have more species in common than have the deposits formed in shallower waters, such as Walton-on-the-Naze and Butley Corner. Yet, in comparing collections, even from these deeper sea-bottoms, we find sufficient evidence of change, either in the size, or relative abundance of forms, or presence of particular species, and the absence of others.

The aspect of both the shallow zones of Walton-on-the-Naze and Butley differs very materially, one looking as if of southern origin, the other of northern; this, of course, is effected by the outgoing and incoming of characteristic forms. The greatest variation is, perhaps, that presented by the *Echinodermata*, five or six *Echini* being peculiar to one deposit, and one to the other.

Having thus briefly indicated the areas over which our proposed division extends, we pass on to the evidence upon which such division is founded, and to this end we give, first, an abstract of the species of Mollusca contained in each division, and of those which they have in common.

In the Lower (or Coralline) Crag........ ...	382	species.
„ Middle (or older Red) „	324	„
„ Upper (or newer Red) „	196	„
„ „ (Fluvio-marine) „	163	„
Common to both divisions of the Red Crag...	217	„
Peculiar to the Lower Crag	170	„
„ „ Middle „	129	„
„ „ Upper (marine)	33	„
Or including the fluvio-marine species	60	„

Total number of species in the Red Crag, *i.e.* Middle and Upper (marine) Crags, 407.

Beyond these tables we do not think it necessary to go at present, and shall therefore notice only a few of the more prominent characters of each division.

Only one species of extinct *Helix* has been found in the Red Crag; it was obtained at Walton and Waldringfield. All the land-shells of the upper horizon are of recent British forms. We would call attention to the occurrence of *Paludina parilis* and of *Corbicula fluminalis* at Waldringfield as being a step backwards in time of the known occurrence of these two freshwater species.

Of the Brachiopoda little can be said, one of the only two species, *i.e. Terebratula grandis*, var., occurring in both series. In one respect this is interesting, as we have been able to trace the shell from the fry to the adult state, with the perfect loop, and this form or variety is one which Mr. Davidson informs us is not found in the Coralline Crag. The circular ridges are stronger, the foramen larger, even in young specimens, and the neck or beak much longer, and more constricted than is the case with the specific type. *Rhynchonella* is confined to one horizon at present.

The Lamellibranchiata of the Lower division, when compared with those of the Upper, have an older facies, and one that indicates a warmer climate than prevailed afterwards. Perhaps this may be better understood by our mentioning some of the peculiar shells, thus *Ostrea cochlear*, *Pecten septemradiatus*, *Lima inflata*, *Modiolaria Petagnæ*, *Limopsis aurita*, and *pygmæa*, *Chama gryphæoides*, *Astarte incrassata*, *Isocardia cor*. *Cytherea* or *Venus chione*, *Lucinopsis Lajonkairii*, *Tapes texturata*, and *Mactra glauca*, have a much more southern aspect than does the upper horizon, the characteristic bivalves of which are *Cardium Grœnlandicum*, *Leda* (*Yoldia*) *hyperborea* and *L. Myalii*, and *Acila Lyallii*.

The difference is perhaps more particularly apparent in the univalves, thus *Cancellaria* and *Pyrula*, *Nassa prismatica*, and *N. elegans*, *Desmoulea conglobata*, *Defrancia histrix*, *Pleurotoma Bertrandi*, *P. lævigata* and *P. carinata*, *Mitra ebenus*, *Ovula spelta*, *Odostomia suturalis*, *Vermetus triquetra*, *V. glomeratus*, and *Dentalium rectum*, are decidedly Mediterranean forms; whilst *Fusus Largillierti*, *F. Turtoni*, *Pleurotoma bicarinata*, *Columbella avara*, *Amaura candida*, *Natica borealis*, and the large variety of *N. affinis*, *N. occlusa*, are equally northern.

Having noticed the Mollusca, a few words in reference to the Echinoderms and Corals will not be out of place before bringing our paper to a close. Of the twelve species of Radiata known by us in both divisions of the Red Crag, *two only* can be recognized as common to each, a *Spatangus*, and *Echinocyamus*. Out of the five Corals two are common to the Lower and Upper Red Crags, these are *Balanophyllia calyculus*, and a *Sphenotrochus*.

The areas which we have considered as indicating the deeper seas are those in which this Cœlenterate fauna abounds, *Balanophyllia* attaining to exceedingly large dimensions. *Flabellum Woodii* also obtains here, but in all our specimens we notice that the Coral is much smaller and stonier in composition than in those from the Lower Crag; they are also free at the base, but this and the separation of the laminæ forming the septa appear to be the result of age. At present Dr. Duncan considers them to be the same species. Perhaps the most interesting Coral in our list is *Solenastræa Prestwichii*, Dunc., a new species (essentially a reef-building one).

In a further paper we hope to amplify our remarks, and as the lists of Fossils will shortly be published by the Geologists' Association, we meanwhile beg criticism upon them, and information that may bear on the subject of the English Crags.

V.—Metamorphic Rocks of Scotland and Galway.

By G. H. Kinahan, M.R.I.A., F.R.G.S.I.

(With a Page-Plate VII.)

It appears evident from the history of the metamorphic, granitoid, and granitic rocks of Scotland, written exactly half a century ago by MacCulloch,[1] that those rocks are very similar to rocks of the same classes in West Galway, Ireland. This acute observer evidently examined the Scotch rocks most minutely, as the groups, sub-groups, and varieties of his "primary rocks" are carefully classed and de-

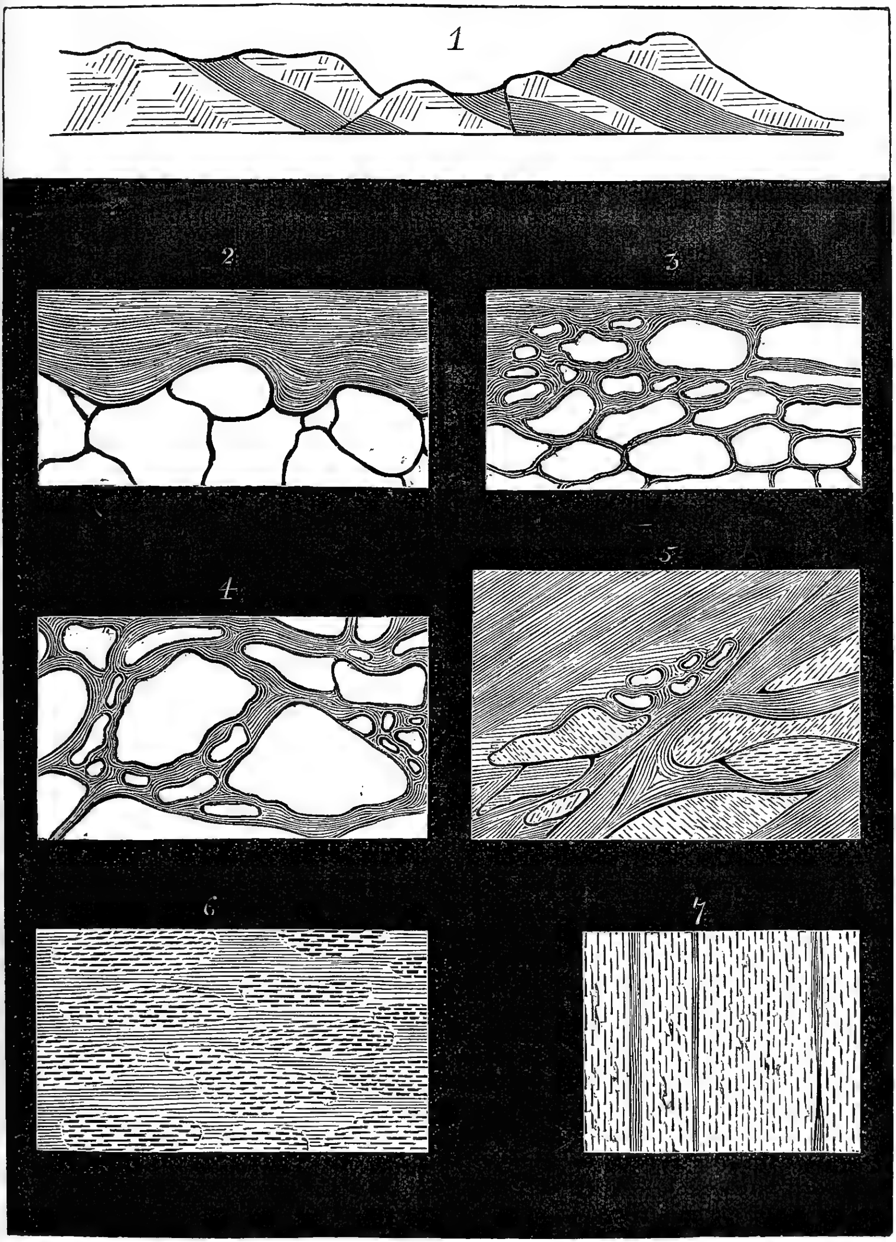
[1] A Geological Classification of Rocks, etc., by John MacCulloch, M.D., F.R.S., etc. A.D. 1821.

scribed. Still, however, his arrangement seems to require modification, as many of the rocks he has put among his granites seem not to be true granites, but rather granitoid rocks, due to the metamorphism of igneous rocks.

In the Memoirs of the Irish branch of the Geological Survey of the United Kingdom (Exs. sheets 95, 105, etc.) it has been pointed out that while some granites are undoubtedly intrusive, others seem to have been formed in the position they now occupy by the extreme metamorphism of both igneous and derivate rocks. In that country the metamorphosed sedimentary rocks form three well marked groups, namely, the *Schist series*, the *Gneiss series*, and the *Oligoclasic granite* (Galway-type granite). As, however, some rocks are more susceptible of change than others, on account of their mineral constituents, subordinate beds of gneiss will occur in the *Schist series*, while beds of schist will be found in the *Gneiss series*, or even on some occasions in the *Oligoclasic granite*. As mentioned by MacCulloch, so also in this country, the unaltered rock graduates into schist, the schist into gneiss, and the latter into granite. (See Plate VII. and explanation of same.)

The argillaceous rocks at the first become glazed or micaceous on the surfaces of the most conspicuous structure of the original rock, changing them into argillite or argillaceous schist, while pyrite and such minerals as chiastolite and phyllite are developed, usually on the surface planes of the stratification, lamination, or cleavage, but often promiscuously through the mass. Moreover, the joint lines are often sealed, or a thin film of rock alongside them hardened. Subsequently the rocks change into mica-schist and the like, and thence through gneiss into granite. Some arenaceous rocks at the first become schist (mica-schist or quartzite), while others, on account of their constituents, are gneissic from the first. The latter, although containing the essential constituents, are not typical gneiss, that is, the quartz, mica, and felspar are not arranged in leaves or plates; nevertheless, in general there is more or less of an incipient foliation. (Plate VII., Fig. 6.)

Seemingly, as first pointed out by Sorby, in all schists the foliation is induced by and follows the most conspicuous or marked structure in the original rocks; let it be cleavage or lamination, whether the latter be parallel, oblique, spheroidal, curled, folded, nodular, concretionary or conglomeritic; except perhaps in some argillites and mica-schist which have a sharply folded or frilled foliation, while a similar lamination is rare in argillaceous rocks. This, however, is not necessarily the case in gneiss, for the *Gneiss series* consists of two sub-divisions. First, ordinary gneiss, having the foliation following similar laws to those just mentioned, and among which subordinate beds of schist are not uncommon. Second, granitoid gneiss, in which the foliation, with rare exceptions, is in parallel lines, and dips at a high angle, if it is not perpendicular. The strike of the foliation of the latter and of the original stratification of the rocks, appears generally if not alway to coincide, but in no other way does the original structure seem to affect it, as all the other structural pecu-



To Illustrate Mr. G. H. Kinahan's Paper on the Metamorphic Rocks of Scotland and Galway.

liarities are obliterated, save and except when the original rock was conglomeritic, some blocks in which may have resisted the action which tends to make the foliation regular and nearly perpendicular;[1] consequently in some granitoid gneiss, blocks or nodules may occur differing in appearance, structure and composition from the rest of the mass; moreover they nearly always, more or less, deflect the strike of the foliation in their vicinity; but they are generally more or less elongated in the direction of the strike. Furthermore the structure of the constituents of the granitoid gneiss seems to have undergone an entire change. In ordinary gneiss many of the particles, as to form and composition, seem in a measure to partake of their original nature, while in the granitoid gneiss all seem to be crystalline, while the felsitic portions are developed into felspar and quartz. Perhaps hereafter Microscopists will point out that such rocks should be classed as *Foliated granite,* and removed from the *Gneiss series.* Nevertheless the granitoid-gneiss or foliated-granite will always be the passage-rock between gneiss and typical granite.

The granite due to extreme metamorphism of derivate or sedimentary rocks, as pointed out by Haughton and others, is very varied in composition on account of the diversity of the rocks from which it is formed; and nearly all the changes just enumerated have been previously pointed out by MacCulloch, except that he has not mentioned the peculiarities of the foliation of the granitoid gneiss.

The historian of the Scotch rocks has grouped among his Granites certain intrusive rocks, on account of their aspect, make, and position. This grouping to a certain extent is not unnatural, as the rocks have a granitoid aspect and occur as intrusive masses; nevertheless many, if not all of them, in favourable localities, will be found to be metamorphosed igneous rocks.

In the portion of Galway before referred to, it has been found that some of the high silicious felstones (*Petrosilex*), many of the basic-felstones (*Eurytes* of Daubuisson, included in the *Hybrid rocks* of Durocher), also some of the Whinstones or basic igneous rock (*Dolerite, Melaphyre, Diabase,* etc.), more especially if affected by a scaly, platy or cleaved structure, will become first, schistose; second, gneissic; and lastly, granitic. The homogeneous or compact varieties however, generally change by gradually becoming more and more highly crystalline and granitoid in aspect, till eventually they are

[1] In the description of the Geology of Abyssinia (Geology and Zoology of Abyssinia, by W. T. Blanford, p. 169), the learned author calls particular attention to the regular and nearly perpendicular foliation of the gneissic rocks of both that country and also the southern part of the Indian peninsula. This is evidently similar to the foliation in the granitoid-gneiss of West Galway, and probably is due to the same cause. In the countries to which he refers, Blanford suggests that cleavage induced the foliation; this, however, could not be the case in West Galway, as evidently cleavage was not developed in the associated metamorphosed sedimentary rocks. Therefore, it is impossible it could have existed in the portions now changed into granitoid-gneiss, more especially as some are small and isolated, and may surround a centre that has been changed into typical granite. To me, therefore, it seems that this linear-parallel, nearly perpendicular, foliation of granitoid-gneiss must be due to a high state of metamorphism, and not to an original rock-structure; and if this has been the cause in West Galway, it was also probably the cause in Abyssinia and India.

altered into granite. Granites formed by metamorphism from Petrosilex or any other highly silicious felstone will be more or less highly silicious, while those due to Euryte or Whinstone will be more or less basic, containing as essentials oligoclase, amphibole, titanite, ripidolite, and such like minerals.

From this it would appear that the rocks included in MacCulloch's Granite of the first division under A and B,[1] are highly silicious felstone (*Petrosilex*) in the schistose stage, while the rocks classed under D are partly metamorphosed whinstone.[2] As among the original rocks of Galway, so also among the original Scottish rocks, there were bedded masses of whinstone and euryte graduating into tuff and agglomerate, and these, when metamorphosed, became hornblende-rock (more or less basic according to the nature of the original rock), hornblende-schist, and conglomeritic schists. This, however, does not seem to have impressed itself on MacCulloch, who gets over the difficulty by classing some of the hornblende-rocks among the granite, and the rest among the hornblende-schist, although he allows that the rocks are identical; this will be also seen from his descriptions. Furthermore, while writing of the varieties (*b* and *c*) of this rock, he points out their similarity to Plutonic-rocks, which only goes further to prove their metamorphic origin, as such varieties in West Galway only occur among partially metamorphosed sedimentary rocks.

In his "second division" of the Granite, MacCulloch is rather obscure, as his group A[3] would include both the highly silicious granite and the metamorphosed or granitic-felstones of West Galway. In that country the amorphous felstones at the first become a felsitic mass mixed with mica; second, a felsitic mass in which there is more or less mica, felspar, and quartz developed; till eventually all the minerals are developed, changing it into a true granite. Although MacCulloch's classification is adopted by most geologists and petrologists of the present day, nevertheless, I believe, it is incorrect, as the metamorphosed felstones generally can be found graduating from a felstone through a gneissic-rock into a granite; moreover, when studied and consequently known, their make, form and character are peculiar, and readily distinguishable from those of the highly silicious granite. The typical highly silicious granite weathers with the rough rugged aspect so characteristic of all typical granites, while the granitic-felstone has a weathering not smooth, like the weathering of felstone, or yet rough, like that of granite, but rather partaking of the nature of both; it moreover is inclined to form a whitish crust like a felstone. In typical highly silicious granite the rock may graduate from coarse to fine; but in the granitic-felstone the rock is often thin, very fine or coarse bands striping the rock, like ribbon, differing not only in texture, but usually in colour and composition. These bands apparently follow a structure in the original rock, probably the lines of viscid fusion. Moreover, the outside of large veins and masses may be quite granitic, while the inside portions are very little altered. Furthermore, these rocks

[1] MacCulloch, p. 234. [2] MacCulloch, p. 235. [3] MacCulloch, p. 236.

occur in more or less regular protrusions and dykes, and not in the irregular and tortuous intrusions and veins so common to some granite.

MacCulloch's remarks on this class prove that some at least of them are not typical granites, as he distinctly mentions that all the constituents are not crystallized out.

The rocks of MacCulloch's class B, second division of the granite,[1] would answer the description for some of the varieties of the hornblende-rock. These rocks in the first stage are a highly crystalline compact mass, that might perhaps be called Hornblende-aphanyte, or it may be for the most part a crystalline aggregate of amphibole + felspar, not orthoclase (*Diorite*), or amphibole + orthoclase (*Syenite*), or ripidolite, talc or mica may replace more or less the amphibole. In these rocks quartz may be present as an accessory, but eventually it appears as an essential, and they merge into granite.

In the third division,[2] class A is the typical metamorphic granite of the "Galway type," while C, D, and E, are varieties, and class F appears not to be a normal rock. Class B is evidently one of the metamorphosed felstones previously described, in which part of the felsite is not developed into quartz and felspar, a not uncommon rock in parts of West Galway. Of these rocks MacCulloch makes a similar remark to that in reference to those in his second division, class A, pointing out that all of the constituents may not be crystallized out, and a similar remark is applicable to these rocks in West Galway. As a supplement to the granite,[3] there is a rock described called *Whitestone*, a compound of "mica and compact felspar" (*felsite*). Under this head apparently are classed two distinct rocks, one being a felstone in the schistose stage of metamorphism, and the other being a felsite-schist, a metamorphosed sedimentary rock; both kinds occur in West Galway.

In conclusion, it may be pointed out that this author, as he himself allows, did not fully understand the nature of serpentine; consequently he has mixed up together rocks of quite different origins. These rocks, however, and their origin, will be described in forthcoming Memoirs of the Irish branch of the Geological Survey.

EXPLANATION OF PLATE VII.

Fig. 1. Diagrammatic sketch, showing flows of Hornblende-rock, interstratified with schist.

Fig. 2. A junction of Hornblende-rock with schist.

Fig. 3. Nodular Hornblende-rock graduating upwards into Conglomeritic-schist.

Fig. 4. Nodular Hornblende-rock graduating at the margin of a flow into Conglomeritic-schist.

Fig. 5. Conglomeritic-schist; showing irregular foliation in the matrix, while in the enclosed blocks (most of them being some one or other variety of Hornblende-rock) there is a faint foliation developed, which is evidently induced by the grain or structure of the original rocks.

Fig. 6. Conglomeritic-gneiss changing into Granitoid-gneiss, a linear foliation having been developed both in the enclosed blocks and the matrix, the texture of the former being coarse and of the latter fine.

Fig. 7. Granitoid-gneiss or Gneissoid-granite, with schistose layers or seams.

[1] MacCulloch, p. 237. [2] MacCulloch, p. 238. [3] MacCulloch, p. 241.

NOTICES OF MEMOIRS.

I.—On the Discovery of Actual Glaciers on the Mountains of the Pacific Slope. By Clarence King, U.S. Geologist.

(*American Journal of Science and Arts.* Third series, vol. i., no. 3, March, 1871.)

THE researches of the last ten years in the extreme height of the mountains of the far west of the United States has shown the remarkable feature, on the one hand, of the absence of glaciers in situations which in altitude and configuration resemble the glacier regions of Switzerland and Norway, and on the other, especially in the higher Cordillera, of the ancient presence of glaciers in the form of modified surface configurations, vast moraines flanking the upper gorges, roches moutonnées, and polished rocks, at various levels above 9,000 feet. The researches of Prof. Whitney and his assistants in the Sierra Nevada have developed a glacier system as extensive and as vast as that once occupying the valleys of the Alps, but, unlike it at the present day, no traces of glaciers are to be met with in the Sierras, save one or two rudimentary masses of ice, and the fields of perpetual névé. This snow, though deep and extensive, is not sufficient to initiate glaciers, the whole region being traversed by a west wind, the moisture of which is wrung from it by warm ascending currents from the valleys below, and there is not sufficient left to cause any great precipitation on the mountain peaks; thus the heights of Colorado are less snowy than those of the Sierras, and the Wind River, Wahsatch and Uintah ranges, were found by Mr. King to be even less than the Laramie range in Colorado.

In September, 1870, Mr. King, "with a small detachment of the U.S. Geological Exploration of the 40th parallel," visited Mount Shasta, Northern California, to make a detailed survey of the lava systems which flow east from the peak, and are connected with the basalt of the Desert of Nevada.

Between the main mass of Shasta and the secondary conical cone (the lesser Shasta), occurs a deep gorge, through which flows a glacier curving round the base of the latter, its width there being about 4,000 feet, and not less than three miles of it being in view, starting almost at the crest of the main mountain, the top of which was found to be 14,440 feet above the sea-level. From this crest three glaciers were seen, one being four miles and a half in length, and from two to three in width. On the south side no glaciers or even snow occurred, which accounts for Prof. Whitney's party failing to find glaciers on this mountain, an east and west line dividing the tract with glaciers from the tract without.

Small masses of ice were found on the shaded side of many of the deep ravines or cañons which intersect the lava flows, some of these masses being from one to two thousand feet in length; one larger one occurred in a deep cañon on the eastern side of the volcano, being divided into two branches by an uprising dome of lava, the one extending for a mile and a half down the cañon, the surface being nearly covered by the falls of stone from the walls or cliffs, the ice being only seen where the stones have found their way in, or through the glacier, the other branch being abruptly terminated by a rounded bluff 900 feet in height. A larger glacier occurs on the north-east slope, and a still larger on the northern; this latter covers the slope for four miles in breadth, and sub-dividing into many smaller streams on reaching the cañons below, where it is believed to be not less than 1,800 to 2,500 feet thick, and traversed by crevasses 2,000 long by 30, and even 50 feet in width.

With the exception of thin sharp edges of lava projecting upwards above the general level, the whole northern face is one vast body of ice, which is traversed by streams which pour into wide crevasses, and which flow out milky with suspended sand at the lower ends. Here the whole face of the ice is covered with sheets of *angular débris,* but neither moulines nor dirt bands were observed. On the snowless side of the mountain, at a height of 8,000 feet, a great terrace occurs, nearly 3,000 feet in width, entirely composed of moraine matter.

In a letter to Mr. King, Mr. S. F. Emmons, Assistant Geologist, describes the glaciers of Mount Tachoma or Rainier, which form the source of four rivers in Washington Territory. The summit of Tachoma he describes as consisting of three peaks, the eastern being the highest, separated from the others by deep valleys; it is a circular crater, a quarter of a mile in diameter, bare to a depth of 60 feet below the rim, below which, down to 2,000 feet, the mountain slopes are covered with an immense sheet of white granular ice, broken by a few long transverse crevasses; below this it is divided up by projecting rock ridges into ice cascades for 3,000 feet, at angles almost approaching the perpendicular; from the foot flow true glaciers, sinking deeper, becoming narrower, and exhibiting smaller angles as they descend.

The Nisqually, the narrowest of the three main glaciers, is traversed at its lower end by longitudinal and horizontal crevasses, where it passes over unyielding unconformable syenite; walls of lava, 1,000 to 1,500 feet, rise as precipices above the surface of the ice. But in the Cowlitz glacier the slopes above are not so steep, and are occasionally covered with the *Pinus flexilis* and the mountain fir, the former growing as high as 2,000 feet above the mouth of the glacier.

The largest glacier of all is that of the White River, which flows out of the crater, extending at least ten miles, being five miles broad on the mountain, and a mile and a half below. It appears to have eroded and cut away not *less than* a third of the mass of the mountain, the thickness of rock removed being not less than a mile. It has two principal medial moraines, which form ridges, with peaks nearly 100 feet high. It is divided in two at the foot of the slope by a rocky ridge, at the back of which a secondary glacier has scooped out a basin-shaped bed.

In a report to Mr. King, Mr. Arnold Hague, Assistant Geologist, describes the extinct volcano of Mount Hood, in the Cascade range of Oregon, on the southern slope of which he found three distinct glaciers flowing out of a basin of ice and snow, filling the crater, which is nearly half a mile in width. In these glaciers, which are known as those of White, Sandy, and Little Sandy Rivers, there are numerous marginal crevasses, ice caves and caverns, and fine examples of veined and laminated structure in ice, glacial groovings, and boulders. The White River glacier descends 500 feet below the level of timber trees upon the slopes of the mountains.

Around Mount Hood are the remnants of far more extensive glaciation, which has cut trough-shaped valleys in the earlier trachytic lava flows of the volcano.

This important paper is not only interesting for the light which it throws upon the past and present glaciations of this old volcanic region of Northern California, but as throwing light on that of the English Lake District and Welsh Mountains, showing how it is possible for ice to entirely cover the mountains above, without filling up hill and valley below. C. E. De Rance.

II.—Journal of the Royal Agricultural Society of England. Second Series. Vol. VII. Part I. 1871.

THREE papers in this number of the Agricultural Society's Journal command our attention. (1). Mr. Jenkins, F.G.S., reports on some features of Scottish agriculture, paying particular attention to the subjects of Lowland farming, Dairy-farming, Aberdeenshire cattle-feeding, Highland sheep-farming, and West Highland cattle-breeding. The subject of Lowland farming, including arable farming in the East and West of Scotland, has been illustrated with an account of four Lowland farms. The geology of the farms is briefly noticed. On one a rich red loam, derived from the Old Red Sandstone is endowed with great natural fertility; on another the soil generally rests on interbedded felstone, but in parts intrusive greenstone or columnar basalt comes to the surface; there is also a blowing sand, certainly an ungrateful soil, for the crops are liable to be blown away. The description of these farms shows the various methods by which good crops may be produced under different circumstances, whether by good land, good cultivation, or liberal manuring.

(2). The agricultural capabilities of the New Forest form the subject of a paper by Mr. W. C. Spooner. This tract of land comprises from 63,000 to 66,000 acres in the south-west of Hampshire; formerly indeed it was far greater, for in Domesday Book its extent is given as no less than 147,200 acres. So favourable is its aspect, that were its soil equally good, the most sanguine expectations of its future productiveness would be realized. The sub-soil, however, ranges from a retentive clay to the most arid sand, and the surface-soil, never very deep, varies from a few inches of the poorest material to 6 or 8 inches of hazel loam. The geological formations represented belong to the Middle and Upper Eocene groups, and these have been described in an article incorporated with this paper, by Mr. T. Codrington, F.G.S., etc.[1] They include the Headon Beds, the Upper Bagshot Beds, the Barton, Bracklesham, and Lower Bagshot Beds. Overlying these formations is a sheet of flint-gravel, which varies from 2 feet to 6 or 8 feet in thickness, and extends over the open plains and heaths of the Forest, covering about a third of the district. The Headon Beds, consisting of clays and marls, afford some of the best land in the Forest. In regard to the cultivation of the Forest, Mr. Spooner conjectures that not less than 20,000 acres would be found to repay the expense of tillage, for there are great facilities for ameliorating the land by means of marl and chalk.

(3). The Comparative Agriculture of England and Wales is treated of by Mr. W. Topley, F.G.S., of the Geological Survey of England. In order to obtain some accurate knowledge of the distribution of crops, with the view of comparing them with the physical structure of the country, Mr. Topley has calculated the percentage of acreage devoted to each. A table accompanying his paper shows the percentage of each crop to the total acreage of each county in England and Wales. He remarks that in trying to classify the English counties according to their leading physical features, we find that the western part of the country contains the largest portion of high land, and that this higher western land is occupied by the older geological formations. A map of rainfall and temperature shows that the greatest fall is over the western high lands; and, speaking generally, over other districts the fall is in proportion to the height of the ground. Summer temperature is of great importance; this is highest over the eastern central district. Considered agriculturally, we find that the western counties are characterized by their large acreage of grazing land, whilst in the eastern there is a high percentage of corn land. There is thus a general coincidence between geological structure, contour, climate, and agricultural products. These four classes of facts are of importance in the order here given; each is controlled by the one that precedes it. Agriculture depends mainly on climate, climate mainly on contour, and contour mainly on geological structure.

Mr. Topley's paper is deserving of careful study by all those who are interested in agricultural geology.

REVIEWS.

I.—Geological Survey of India—"Annual Report" and "Records."

THE progress of British Systematic Geological inquiry being important, we are glad to observe that the close of the financial year brings with it the Report of the Geological Survey of India, occupying the first fifteen pages of the Records of that Survey for 1871; and although Indian affairs short of a political catastrophe are said to excite but little interest here, this Indian Survey Report will

[1] Mr. Codrington has also laid down the geology of the New Forest on an admirable chromo-lithographic map accompanying this paper.

at least receive the attention of the geological world in Europe, and in addition, perhaps, that of some others, now the commercial as well as scientific subject of the development of New Indian Coal-fields has been recently under notice.

Dr. Oldham first alludes to the decreased number of his assistants during the past year, death, disease, and absence on leave, having reduced the effective staff from some sixteen individuals to only three-fourths, who have nevertheless, as the report shows, energetically carried forward the large and widely extended operations of the Survey.

The results for the year are not stated in square miles, nor is this desirable, space bearing an indefinite relation to value, where all is more or less difficult of access; but the great areas shown upon the accompanying map as "in progress," and preparing for publication, give an idea of what the Survey has accomplished in dangerous wilds, which compares favourably with the lighter labours of field geologists in our own highly civilized and more accessible land; while the publications for the year, some of which we have previously noticed,—together with those nearly ready, but unavoidably delayed by the preparation of the maps,—place the Survey in a light in this respect quite as advantageous as that in which British Home and Foreign Geological Memoirs have always been deservedly regarded.

A sadly large proportion of death vacancies on the small staff of the Indian Survey retards its progress by rendering it difficult to replace the losses, owing to the illiberality of the terms accorded by Government regarding leave and retirement; the laboriously, and often expensively, educated officers being placed in that, to Europeans, least favourable grade, the uncovenanted service, together with crowds of natives, for whom its rules apparently were framed—two years' furlough out of thirty years' service comparing but badly with the six and eight enjoyed by the Civil and Military Services respectively. The difficulty of supplying the vacancies on present terms will hardly be lessened by the Superintendent's observation that Assurance Companies decline to insure the lives of the officers, as *no premium whatever would cover the risk!* After this, it is not surprising that the last vacancy has not been filled by an English geologist, and Dr. W. Waagen deserves credit for displaying German bravery in accepting the appointment.

It appears from the body of the report that the Survey has been employed in about a dozen different districts, independently of the coal-regions now attracting general attention, and of which it is satisfactory to learn that the efforts to prove the extent of one field by means of borings have been most successful. "The continuance in almost unbroken extension and in thick beds, at no point more than seventy yards from the surface, of coal, easily accessible and abundant, throughout almost the entire length of the Wun district in East Berar, along the valley of the Wurdha, having been established by the Geological Survey in a portion of one season's work."

It is also satisfactory that these mining operations have passed into the control of local authorities, upon whom the responsibility will rest, rather than upon the small Survey Staff, whose proper avocations in geologically surveying the country will be needed in other directions, and are of a different and higher nature than mere miners' calling, in mechanically tracing underground beds of coal.

We are sorry to observe, however, that notwithstanding the existence of the Indian Survey, Geological Maps, for which they are in no way responsible, have been published "in public documents which entirely misrepresent the true state of the case." Surely these ought to have been submitted to the very competent supervision of the Indian Survey before being permitted to appear with authority, and Doctor Oldham's disclaimer should be remembered.

In connexion with the subject of Indian coal, inflated statements regarding coal discoveries found their way into the Indian newspapers, and to these an unthinking public seems to have attached undue credit; indeed, the positive nature of some led to investigation on the part of the Survey, the results fully proving the necessity of having sound scientific opinions, instead of newspaper reports or unsupported statements in cases upon which the general public and many otherwise well-educated persons still lack the unaided ability to form sound conclusions. Two cases of the kind are mentioned in the report. In the first, "excellent steam coal" and "beautiful coal-plants" were stated to have been found within a short distance of a railway! The coal turned out to have occurred in angular fragments on the surface of a hill of *granite-gneiss!* within three miles of a contractor's coal depôt, and in the line followed by the carts which had conveyed a quantity of similar North of England coal to the depôt!! while the "beautiful coal-plants" were the impressions of the existing grass rootlets which had forced their way between the divisions of the rock!!!

In the other instance, thick and valuable coal-beds were reported to have been discovered, and borings were prosecuted with great vigour under charge of an executive engineer. Months later the matter came to the cognizance of the Survey; the place was visited by Dr. Oldham himself, but nothing like satisfactory evidence was obtained. No actual coal-bed had ever been cut, but coal-fragments were brought up mixed with slush and clay. Ultimately new borings were put down in the most likely direction; but just when one of these had nearly reached the asserted depth of the bed, the overseer in charge disappeared, and on searching his house lumps and broken fragments of coal identical with that brought up by the borings were found, leading to the strong suspicion that the coal fragments had been put into the bore holes. The last of these was carried right through the space in which the bed was stated to exist, but not a trace of coal was met with.

This fraud might not have been perpetrated if the pay and position of the overseer had been such as he would not like to have endangered, and several months of boring operations might have been saved either by employing a well-paid respectable man, or by an earlier application to the Geological Survey. This part of the Report is commended to those whose duty it ought to be to protect the public interests.

Further on, the publications of the Survey are enumerated, and the alteration of the issue of the "Palæontologia Indica" from quarterly to annual parts is mentioned, the latter appearing to be the most advantageous form in which to send them forth. The Report concludes with notices of the additions to the Library and Meteorological Collection, the progress in cataloguing the Museum specimens and analyzing coals, the usual list of Societies and other institutions from which publications have been received being appended.

The remaining papers in this number of the "Record" are two: one on the alleged Discovery of Coal near Gooty, and of the indications of Coal in the Cuddapah District, by R. Bruce Foot, Esq., F.G.S., in which the first *discovery* above alluded to is more fully treated of, and another noticed; the dribblings from the guano of bats and birds issuing from cavities in recent travertin having been mistaken for petroleum by a certain Dr. H——, whose statements led to Mr. Foot's investigations, and whose name we charitably suppress, as his alleged discoveries can confer on him no credit according to this paper. The other is a sketchy but interesting record of the Mineral Statistics of Kuamon Division, etc., by A. W. Lawder, Esq., C.E., Divisional Engineer.

II.—AMERICAN GEOLOGICAL SURVEYS.

(*Continued from page* 225.)

1.—Report on the Progress of the State Geological Survey of Michigan. Presented November 22, 1870. By Alexander Winchell, LL.D., Director.

THE Government appropriate 8000 dols. annually for the Geological Survey of Michigan. Half of it is applied to the investigation of the rocks of the Northern Peninsula. Field-work, has been carried on for two years. The assistants are Major T. B. Brooks and Professor R. Pumpelly. The sub-assistants are Professors N. H. Winchell, M. W. Harrington, and E. A. Strong; A. S. Wadsworth, C. B. Headley, A. O. Currier, J. H. Emerton, J. N. Armstrong, C. M. Boss, S. W. Walker, A. R. Marvin, and L. G. Emerson. This pamphlet briefly sets forth the progress of the work, and the plan of the Final Report, much of the material for which is already in hand. Attention is paid to the Geography, Hydrography, Topography, Climatology, Magnetography, Vegetation, Sanitary Characteristics, Statistics of Population and Improvements, Fruit Production, and Agriculture of the State, as well as its Geology, the latter claiming the lion's share.

The Survey of the Iron region near Marquette is nearly completed. Eleven large maps of the most important mines are nearly ready for the engraver. Discoveries have been made of new and large beds of iron ore in the forest unsettled country, upon lands owned by the State. The older beds belong to the Huronian system, several thousand feet thick. All the rocks appear to have been of sedimentary origin, though often presenting combinations suggestive of an igneous character. The following is their order, in descending scale:—1. Quartzite, 2. Hematitic and Magnetic Ores, 3. Ferruginous Quartzite, 4. Diorite, 5. Ferruginous Quartzite, 6. Diorite, 7. Ferruginous Quartzite, 8. Diorite, 9. Ferruginous Quartzite, 10. Diorite, 11. Talcose schist, 12. Quartzite, 13. Laurentian. The Copper region, under the superintendence of Professor Pumpelly, is being mapped upon the scale of 300 feet to the inch. The field-work has led to the accumulation of numerous details respecting the distribution of the several formations, which cannot be presented in a report of progress, but they have necessitated many improvements upon the Geological Map.

Closely connected with the results of the field-work is an elaborate paper by Professor Winchell upon the Marshall Group, in the *Proceedings* of the American Philosophical Society. The Michigan Reports present an array of many new local names. This has been necessitated by the isolated position of the Carboniferous and Devonian Rocks of the Lower Peninsula. The Marshall Group is proved to lie at the base of the Carboniferous system, and to be the equivalent of part of the Waverley series of Ohio, the Catskill group in New York, the Goniatite Limestone of Indiana, the Kinderhook group of Illinois, the Yellow Sandstones (Hall) of Iowa, the Chonteau Limestone, vermicular Sandstone and lithographic Limestone of Missouri, and the Silico-bituminous shales at the base of the Siliceous group of Tennessee. This is a novel conclusion in American Geology. Most geologists have followed the lead of Professor James Hall, who regarded them generally as the equivalents of the Chemung and Portage groups, at the summit of the Devonian, while the Catskill Red Sandstone has headed the column of the New York system for the past thirty years as beneath the Carboniferous. This conclusion is adopted, at least for the State of Ohio, by Dr. Newberry and others. The theory is based both upon lithological and palæontological grounds. In this "Marshall group" Professor Winchell finds that there have been collected 416 species of fossils, viz., nine plants, thirteen Polypi, 27 Crinoids, one *Fenestella,* 124 Brachiopods, 116 Lamellibranchiates, 13 *Bellerophon,* four *Porcellia,* 48 Gasteropods, 46 Cephalopods, nine Trilobites, one Ostracod, four Fishes, and one *Pleurodictya.* These identified species have been collected in eleven detached districts or States, which have yielded severally the following numbers:—North Michigan, 23; South Michigan, 93; Ohio, 139; Indiana, 45; Illinois, 27; Iowa, 160; Missouri, 77; Kentucky, 2; Tennessee, 13; New York, 9; Pennsylvania, 9; total, 597. Great additions have since been made to this list in Ohio.

The Waterlime division of the Lower Helderberg formation has now been found in Michigan. It contains the *Eurypterus remipes* (De Kay). An apparently new assemblage of Hamilton and Corniferous Limestone species is found in the rocks of the Lower Peninsula, and has received the name of the "Grand Traverse group." The "Huron group" contains a peculiar assemblage of fossils, and the term may be a better one than its New York equivalent, the Genesee and Portage groups.

The Director shows that an immense amount of good field and office work has been well done, and he estimates that two appropriations of 30,000 dols. and two years' work will enable him to complete the Survey and publish the results. C. H. H.

2.—THE GEOLOGICAL SURVEY OF OHIO.—In 1836 and 1837 there was a public Geological Survey of the State of Ohio, under the direction of Mr. W. W. Mather. Nothing more was done towards exploring the geology of this interesting region for more than thirty years, when a bill was passed (1869) providing for a thorough Survey. Prof. J. S. Newberry, LL.D., was appointed chief geologist, assisted by E. B. Andrews, Edward Orton, and John H. Klippart; also by the following "local assistants": Rev. H. Hertzer, M. C. Read, Fred Prime, junr., W. P. Ballantine, G. K. Gilbert, Andrew Sherwood, R. D. Irving, W. A. Hooker, W. B. Potter, Henry Newton, and H. A. Whiting.

During the interval of thirty years between the two geological Surveys of Ohio, the States on all sides had been explored, but it was impossible to synchronize satisfactorily all the formations of the West with those of New York, as they had not been traced across Ohio. It was generally believed that the Waverley group was Devonian, and the Black shales the equivalent of the Genesee slate. Dr. Newberry, immediately after his appointment, commenced to map the distribution of all the formations, and to collect their fossils, and has met with eminent success. His scheme for the Ohio rocks is the following, entitled, *Preliminary Geological Map of Ohio*, prepared from the notes of the Geological Corps, by J. S. Newberry, Chief Geologist, 1870.

SILURIAN, 1. Cincinnati group (Trenton and Hudson); 2. Clinton group; 3. Niagara group; 4. Waterlime and Salina. DEVONIAN, 5. Oriskany Sandstone; 6. Corniferous Limestone; 7. Hamilton group; 8. Huron shale (Genesee and Portage); 9. Erie shales (Portage and Chemung). CARBONIFEROUS, 10. Waverley group; 11. Lower Carboniferous Limestone; 12. Carboniferous Conglomerate; 13. Coal-measures.

No rock lower than the Cincinnati group appears at the surface in Ohio; but at an artesian boring at Columbus both the Calciferous and the Potsdam sandstones were found The Cincinnati group is about 1,000 feet thick. The Clinton is from 10 to 100, and the Niagara about 80 feet thick. The Salina and Waterlime groups had not been known in the State previous to Newberry's explorations, and they seem to cover more of the territory than any other formation except the Coal-measures. They contain gypsum and salt. The Oriskany Sandstone was also a new discovery, and is about 20 feet thick, commonly destitute of fossils. The Corniferous Limestone, or the Upper Helderberg of New York, had long been known to exist in Ohio, and Dr. Newberry succeeded in finding enormous fishes in it, besides remarkable specimens of trees, the oldest land plants yet found in America. About 20 feet of the Hamilton group, with its characteristic fossils, was also newly discovered by the

Survey. The old band of the Black slate proved to be Nos. 8 and 9 of the series. The Chemung group, which is a sand-rock in New York, passes into a slate in Ohio. Not aware of this lithological change, it is not strange that the earlier geologists attempted to correlate it with the higher Waverley group. So satisfactory is the new identification, that it was immediately adopted by the Geological Section of the American Association for the Advancement of Science without a dissenting voice. The Huron shale is a new name borrowed from the Michigan Survey, and it seems to be a better designation than the New York equivalents. It had been supposed to be the equivalent of the Hamilton. It contains the *Dinichthys Herzeri.*[1] The Erie shales on a superficial view appear to be identical with the Huron group, but the imbedded fossils show that the two groups do not run parallel to each other,—they meet along the line of strike. They are 400 feet thick—and contain few fossils of interest.

The old Waverley series is now sub-divided in the north part of the State into the Cuyahoga shale 150 feet, Berea grit 50 feet, Bedford shale 60 feet, and the Cleveland shale 20 to 60 feet thick. It is the equivalent of the Marshall group of Michigan, as earnestly maintained by Winchell before the organization of the Ohio Survey. Fifteen species of fish rewarded the collectors in 1869, belonging to the genera *Palæoniscus, Ctenacanthus, Gyracanthns, Orodus, Helodus, Polyrhizodus, Cladodus.* The Carboniferous Conglomerate is a hard rock about 100 feet in thickness, forming the floor of the Coal-measures, and containing many plants like those of the Coal-measures. It is the Millstone Grit of the Old World.

None of the final results of the Survey will do more for the advancement of Palæontology than the history of the Coal-measures. Dr. Newberry has devoted many years of his life to the study of its plants and animals, and has finer illustrations of them than any other person in the country. Fifty plates of drawings are ready for publication. There are ten workable beds of coal in this State, covering about one-fourth of its area, or 10,000 square miles, and belonging to the great Appalachian Coal-field.

The material on hand a year since, ready for publication, was sufficient to form an octavo volume of 500 pages, consisting of an historical sketch of geological investigation in Ohio, descriptions of physical geography, the relations of Ohio geologically to North America, with detailed descriptions of the formations themselves and their characteristic fossils. The first part of it has already appeared, forming an octavo volume of 184 pages. C. H. H.

[1] See Geological Magazine, 1868, Vol. V., p. 184.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—April 5, 1871.—Professor Morris, Vice-President, in the Chair. The following communications were read:—1. "On a new Chimæroid Fish from the Lias of Lyme Regis." By Sir Philip Grey Egerton, Bart, M.P., F.R.S., V.P.G.S.

This fish, for which the author proposed the name of *Ischyodus orthorhinus*, was represented by a specimen showing the anterior structures imbedded in a slab of Lias. It exhibited the characteristic dental apparatus of the Chimæroids, surrounded with shagreen, a very large prelabial appendage six inches long, and terminating in a hook abruptly turned downwards, and a process which the author regarded as representing the well-known rostral appendage of the male Chimæroid, but in this case attaining a length of 5½ inches, and covered more or less thickly with tubercles, bearing recurved central spines somewhat tooth-like in their aspect. This appendage is attached to the head by a rounded condyle, received into a hollow in the frontal cartilage. The dorsal spine, which measured 6 inches in length, was articulated by a rounded surface to a strong cartilaginous plate projecting upwards from the notochordal axis, and was thus rendered capable of a considerable amount of motion in a vertical plane. This structure also occurred in *Callorhynchus* and *Chimæra*.

Discussion.—Dr. Günther commented on the interest of this discovery, as in no other Sharks is the same articulation of the dorsal spine as that described in the paper to be found. He inquired whether the granulated plate supposed to be dorsal might not be a part of the armature of the lateral line, as in Sturgeons. He thought that the Chimæroids would eventually prove to be intermediate between the Ganoid and Shark types, and that all belonged to one sub-class.

Mr. Gwyn Jeffreys inquired what other remains were found with these fishes, such as might represent the food, molluscan or otherwise, on which they lived.

Sir P. Egerton replied that there was no deficiency of pabulum for any kind of fish in the sea represented by the Lias of Lyme Regis. He also made some remarks on another somewhat similar specimen in his own museum. The plate referred to by Dr. Günther, he stated, was symmetrical, and not like the lateral plates on the Sturgeon, which are unsymmetrical. He therefore thought it dorsal.

2. "On the Tertiary Volcanic Rocks of the British Islands." By Archibald Geikie, Esq., F.R.S., F.G.S., Director of the Geological Survey of Scotland, and Professor of Geology and Mineralogy in the University of Edinburgh. (First paper.)

In this communication the author gave the first of a series of papers which he proposes to lay before the Society upon the volcanic rocks of Britain of later date than the Chalk. In a general introduction to the whole subject, he pointed out the area occupied by the rocks, showing that they are chiefly developed along the broad tract which extends from the south of Antrim, between the chain of the Outer Hebrides and the mainland of Scotland, up into the Faroe Islands, and even to Iceland. The nomenclature of the rocks was discussed, and the following arrangement was proposed:—

	Felspathic series.					Pyroxenic, or Augitic.					
	Syenite.	Felstone and Quartz-porphyry.	Trachyte and Trachyte-porphyry.	Pitchstone.	Porphyrite.	Dolerite.	Basalt.	Trachylite.	Diallage-rock ? altered dolerite.	Felspathic tuffs.	Pyroxenic tuffs and agglomerate.
I. INTERBEDDED OR CONTEMPORANEOUS.											
A. *Crystalline.*											
Sheets or beds	...	...	?	*	*	*	*	...	*		
B. *Fragmental.*											
Beds or layers	...	...	...	...	...	...	...	...	...	?	*
II. INTRUSIVE OR SUBSEQUENT.											
A. *Crystalline.*											
α. Amorphous masses	*	*	?	...	...	?					
β Sheets	...	...	...	...	...	*	*				
γ. Dykes and veins	*	*	?	*	...	*	*	*			
δ. Necks	...	?	...	...	...	...	?				
B. *Fragmental.*											
Necks	...	...	...	...	...	...	...	...	..	...	*

The age of the rocks was shown to be included in the Tertiary period by the position of the volcanic masses above the Chalk, and by their including beds containing Miocene plants.

As an illustrative district, the author described the volcanic geology of the Island of Eigg, one of the Inner Hebrides, and brought out the following points:—

1. The volcanic rocks of this island rest unconformably upon strata of Oolitic age.

2. They consist almost wholly of a succession of nearly horizontal interbedded sheets of dolerite and basalt, forming an isolated fragment of the great volcanic plateau which stretches in broken masses from Antrim through the Inner Hebrides.

3. These interbedded sheets are traversed by veins and dykes of similar materials, the dykes having the characteristic north-westerly trend, with which they pass across the southern half of Scotland and the North of England. Veins of pitchstone and felstone, and intrusive masses of quartziferous porphyry, like some of those which in Skye traverse or overlie the Lias, likewise intersect the bedded dolerites and basalts of Eigg.

4. At least two widely separated epochs of volcanic activity are represented by the volcanic rocks of Eigg. The older is marked by the bedded dolerites and by the basalt veins and dykes which, though strictly speaking younger than the bedded sheets which they intersect, yet probably belong to the same continuous period of volcanic action. The later manifestations of this action are shown by the pitchstone of the Scuir. Before that rock was erupted, the older do-

leritic lavas had long ceased to flow in this district. Their successive beds, widely and deeply eroded by atmospheric waste, were here hollowed into a valley traversed by a river, which carried southward the drainage of the wooded northern hills. Into this valley, slowly scooped out of the older volcanic series, the pitchstone and porphyry *coulées* of the Scùir flowed. Vast, therefore, as the period must be which is chronicled in the huge piles of volcanic beds forming our dolerite plateaux, we must add to it the time needed for the excavation of parts of those plateaux into river-valleys, and the concluding period of volcanic activity during which the rocks of the Scùir of Eigg were poured out.

5. Lastly, from the geology of this interesting island we learn, what can be nowhere in Britain more eloquently impressed upon us, that, geologically recent as that portion of the Tertiary periods may be during which the volcanic rocks of Eigg were produced, it is yet separated from our own day by an interval sufficient for the removal of mountains, the obliteration of valleys, and the excavation of new valleys and glens where the hills then stood. The amount of denudation which has taken place in the Western Islands since Miocene times will be hardly credible to those who have not adequately realized the potency and activity of the powers of geological waste. Subterranean movements may be called in to account for narrow gorges, or deep glens, or profound sea-lochs; but no subterranean movement will ever explain the history of the Scùir of Eigg, which will remain as striking a memorial of denudation as it is a landmark amid the scenery of our wild western shores.

Discussion.—Prof. Haughton inquired whether Mr. Geikie's attention had been called to the Morne Mountains in Ireland, which seemed to present some analogous phenomena to those described in the paper. In the Morne district were dykes of dolerite, pitchstone, and other volcanic rocks of the same constitution as those of Antrim. He believed that a chemical examination of these rocks in different districts would prove their common origin. The evidence in Antrim was conclusive as to their Tertiary age in Ireland, and he was glad to find that the view of their belonging to a different age in Eigg was erroneous.

Prof. Ramsay had hitherto believed in the Oolitic age of these trap-rocks in Eigg, but accepted the author's views. The interbedding of volcanic beds among the Lower Silurian beds in Wales was somewhat analogous. He was glad to find the history of these igneous rocks treated of in so geological a manner, instead of their being regarded from too purely a lithological and mineralogical point of view. The great antiquity of these Middle Tertiary beds had, he thought, been most admirably brought forward in the paper as well as the enormous amount of denudation; and he would recommend it to the notice of those who had not a due appreciation of geological time.

Mr. Forbes hoped that the geologist would remember that his father was a mineralogist. It was as refreshing to find a paper of this kind brought before the Society, as it was to be regretted that the details of mineralogy were so little studied in this country when compared with the Continent; and this he attributed to the backward state of petrology (admitted by Mr. Geikie) in this country. He quite agreed in the view of the Tertiary age of these rocks. With regard to the terminology employed by the author, he objected to the use of the word "dolerite," as distinct from basalt; basalt properly comprised, not only dolerite, the coarse-grained variety, and anamezite, the finely-grained variety, and the true basalt, but also trachylite, which was frequently confounded with pitchstone. All four names merely referred to structure, and not to composition.

Mr. Geikie, in reply, stated that he had not examined the Morne Mountains. He had not in any way wished to disparage mineralogy, but, on the contrary, had attempted to classify the different rocks according to their petrological character. He used the term "dolerite" in the same sense as the German mineralogists, both as the generic name for the whole series, and also for the coarser variety of basalt.

3. "On the formation of 'Cirques,' and their bearing upon theories attributing the excavation of Alpine Valleys mainly to the action of Glaciers." By the Rev. T. G. Bonney, M.A., F.G.S.

The paper described a number of these remarkable recesses, which, though not restricted to the limestone districts of the Alps, are best exhibited in them. The author gave reasons why he could not suppose them to have been formed either as craters of upheaval, or by the action of the sea, or by glacial erosion. With regard to the last he showed that, even if glaciers had been the principal agents in excavating valleys, there were some cirques which could not have been excavated by them; and then went on to argue from the fact that glaciers had occupied cirques, and from the relation between them and the valleys, that they could not be attributed to different agents. He also showed that commonly the upper part of a valley, where the erosive action is perhaps least, is very much the steepest, and urged other objections to the great excavatory powers often attributed to glaciers. He then described one or two cirques in detail, and showed that they were worked out by the joint action of many small streams, and of the usual meteoric agents working upon strata whose configuration was favourable to the formation of cliffs.

Discussion.—Mr. Whitaker suggested an analogy between the cirques and the combes in our own limestone countries.

Mr. Geikie regarded the cirques as analogous to the combes of Wales and the corries of Scotland. They were not, however, confined to limestone districts, but occurred also in gneiss and granite rocks. He thought that the shape was much influenced by the bedding and jointing of the rocks, as there was an evident connexion between these and the shape of the combes. He could not, however, see his way to account for the vertical cliffs surrounding the cirques.

The Rev. T. G. Bonney, in reply, observed that though cirques were not confined to limestones, the finest instances occurred in such rocks. When cirques occurred in crystalline rocks, the talus was usually much larger than in limestone.

II.—April 26, 1871.—Prof. Morris, Vice-President, in the Chair.
The following communications were read:—

1. "On a new species of Coral from the Red Crag of Waldringfield." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

Prof. Duncan described, under the name of *Solenastræa Prestwichi*, a small compound Coral obtained by Mr. A. Bell from Waldringfield, and stated that it was particularly interesting as belonging to a reef-forming type of corals which has persisted at least from the Eocene period to the present day. The single specimen consisted of several small crowded corallites, having calices from $\frac{1}{20}$ to $\frac{3}{20}$ inch in diameter, united by a cellular epithecal cœnenchyma. It was much rolled and worn before its deposition in the Red Crag, and hence the author regarded it as a derivative fossil in that formation, and he stated that it probably belonged to the rich reef-building coral-fauna which succeeded that of the Nummulitic period.

Discussion.—Mr. Etheridge remarked that the origin of this interesting fossil seemed uncertain. It appeared, however, to be derived from some other source, and not to have originally belonged to the Red Crag. In England the genus was hitherto unknown in beds newer than those of Brockenhurst. The presence of this single specimen showed how much we had still to learn with regard to the Crag formation. It was to be hoped that the coral might eventually be found attached to some organism from which its age might be determined.

Prof. T. Rupert Jones remarked that he would be glad to hear of more corals being discovered in the so-called Coralline Crag. He inquired whether cœnenchymatous corals were necessarily reef-corals, observing that this coral was referred to the Miocene on account of its presumed reef-forming character. He added that some of the Foraminifera of the White Crag had the aspect of existing Western Mediterranean forms, and thus supported some of Prof. Duncan's remarks.

Mr. Gwyn Jeffreys observed that the distinction between the Coralline and the Red Crag seemed to be every day diminishing. The appearance of the fossil seemed to betoken its derivative character. Like other speakers, he complimented Mr. Alfred Bell on his great intelligence in the collection of Crag fossils.

Prof. Duncan, in reply, maintained that the differences between deep-sea and reef-building corals were well established, and around modern reefs in the deeper sea the forms were quite distinct, and the deep-sea corals never presented the cœnenchyma distinctive of the reef-building form. This, he suggested, might be connected with the difference in the amount of sea-water with which it was brought in contact, which in the surf was much greater than in the almost motionless depths of the sea.

2. "Notes on the Minerals of Strontian, Argyllshire." By Robert H. Scott, Esq., M.A., F.R.S., F.G.S.

The paper stated that the existing lists of minerals to be found at Strontian were incorrect. The discovery of apophyllite, talc, and zircon, seemed to be hardly sufficiently confirmed. On the other hand, Mr. Scott named several species which he had himself observed *in situ*, and which are not noticed in any of the books, viz. two felspars, orthoclase, and an anorthic felspar in the granite. Two varieties of pyroxenic minerals in the granites and syenites, neither of which have as yet been analyzed. Natrolite in the trap-dykes, muscovite or margarodite in very large plates, lepidomelane and schorl.

Specimens of these minerals and of the others found at the mines were exhibited; but it was stated that, owing to the fact that the old workings at the mines in Glen Strontian had been allowed to fall in, it was now no longer possible to ascertain much about the association of the species.

One is galena, containing very little silver. The gangue is remarkable for the absence of fluor and the comparative rarity of blende and heavy spar. Harmotome is found principally at a mine called Bell's Grove, both in the opaque variety and in the clear one called morvenite. Brewsterite occurs at the mine called Middle Shap, and at the mine Whitesmith Strontianite is found with Brewsterite, but without harmotome. Calcite is also very common.

Within the last few years a new mine has been opened called Corrantee, which is in the gneiss, whereas the other mines lie on the junction of the granite and gneiss. At this mine several fine specimens of calcite have occurred, many of them coated with twin crystals of harmotome, similar to those from Andreasberg, whereas the crystals found at the old mine are not so clearly macled.

Associated with these were found a number of small hexagonal prisms, perfectly clear, and exhibiting a very obtuse dihedral termination. They gave the blowpipe reaction of harmotome; and on analysis by Dr. J. E. Reynolds, proved to be that mineral.

Descloiseaux has already described a quadrifacial termination to harmotome, with an angle of 178° 20′.

Mr. Scott submitted that possibly the crystals which he exhibited might bear facies which had a close relation to those described by Descloiseaux.

He concluded by stating that Strontian promised as rich a harvest to the mineralogist as any locality in these islands.

Discussion.—Mr. W. W. Smyth mentioned the wonderful collection of minerals from Strontian which had been brought to the Great Exhibition of 1861, which gave a most striking idea of the mineral riches of the locality. The occurrence of such a series of different substances in one locality in the granite was almost unparalleled, though in the Andreasberg mines, in clay slate, they were to some extent rivalled. The features, however, differed in the two places, more silver and a greater number of zeolites being present in the Hartz mines.

Mr. D. Forbes observed that harmotome occurred also at the Königsberg silver-mines in Norway, at a distance from granite. He thought it remarkable that these crystals of peculiar form occurred in the same spot and in connexion with crystals of the same substance, but of the ordinary form.

Mr. Thos. Davies remarked that celestine was also to be placed on the list of the minerals from Strontian. Harmotome with Pyrrhotine had been found in the same form of double crystals at Bodenmais, in Bavaria.

Mr. Scott stated, in reply to a question from the Chairman, that the mineral had not been as yet optically examined, but that if he could procure more of it he should be happy to place it at the disposal of any gentleman who would examine it. As regarded the idea that harmotome usually occurred near the surface, he could give no information about the old mines, as they had been allowed to fall in; but most certainly the new specimens from Corrantee came from surface workings. He was very glad to learn from Mr. Davies that celestine had been found at the locality; and he felt sure that careful search would double or treble the number of species known to occur there. With reference to what had fallen from Prof. Smyth, he could fully corroborate his observations as to the difference between the forms of calcite associated with harmotome at Andreasberg, in the Hartz, and at Strontian. It was remarkable that the general facies of the crystals of calcite occurring at Corrantee, where the lode was entirely in the gneiss, differed from that usually observed in the old mines in Glen Strontian, which were partly in the granite and partly in the gneiss.

3. "On the probable origin of Deposits of 'Loess' in North China and Eastern Asia." By T. W. Kingsmill, Esq., of Shanghai. Communicated by Prof. Huxley, F.R.S., V.P.G.S.

The author stated that the Baron von Richthöfen had lately applied the term "Loess" to a light clay deposit covering immense tracts in the north of China. The author regarded this formation as in great measure corresponding to the Kunkur of India, and thought that it probably extended far into the elevated plains of Central Asia. Richthöfen considered that this deposit had been produced by subaërial action upon a surface of dry land; the author argued that it is of marine origin, having been deposited when the region which it covers was depressed at least 6000 feet, a depression the occurrence of which since the commencement of the Tertiary period he considered to be proved by the mode of deposition of the Upper Nanking Sandstones and Conglomerates, the bold escarpment of the hills on either side of the Yangtsze, and other peculiarities of the country.

Discussion.—Prof. Ramsay remarked that the author had not proved that the loess he described was really stratified. He could not agree with his views of the inland escarpments he mentioned having been old coast lines. It was only accidentally that sea cliffs had any connexion with the line of strike of the strata, whereas inland cliffs always followed the strike. He thought the phenomena were rather in accordance with a long exposure of the land to sub-aërial influences than with the the loess having been of marine origin. Even in England, in those parts which had long been free from marine action, beds of brick-earth had been formed. He also instanced the plains of Picardy as exhibiting a vast extent of such sub-aërial beds.

Prof. T. Rupert Jones said that though the area treated of by Mr. Kingsmill was too large to have its geology explained merely by reference to rain-wash and valley deposits, whatever his low-level loess might be, the higher accumulations of loamy deposits, stated to be 1000 feet thick at an elevation of 3000 feet, and regarded by Mr. Kingsmill as the quiet water sediments of a great gulf, with the Miocene conglomerates and sandstones of Nanking and elsewhere for its marginal equivalents, appeared to require different explanation. All loess need not be of sea origin; in oscillations of land marine deposits must be carried up to great heights; and, referring to Mr. H. M. Jenkins's determination of the marine origin of the loess of Belgium, Prof. Jones thought it highly probable that some at least of that in China may have been similarly formed.

Mr. Hughes said that the author appeared to have grouped together all the superficial deposits of a vast area without explaining very clearly the grounds upon which he identified those deposits at distant points. He did not prove that what he called the shore deposit was marine, or that it was of the same age as the loam which he described, and which Mr. Hughes thought, from the description, was far more likely to be sub-aërial.

Mr. Evans and Mr. Etheridge suggested the probability that much of the so-called loess might be derived from higher loamy beds, possibly derived from the decomposition of limestone rocks containing sand and clay, and redeposited by the action of rain.

Edinburgh Geological Society.—March 16, 1871. At the fifth ordinary meeting of the Society for this Session held this evening, the following communication was read:—"On a new species of *Amblypterus*, and other Fossil Fishes from the shale workings of Pitcorthie, near Crail, in the county of Fife." By Robert Walker, St. Andrew's.

Abstract.—In this paper the author commenced by giving a list of the Fossil Fishes he had obtained in a more or less perfect condition from the Pitcorthie beds. These embraced the following genera, of which *Eurynotus* was the most abundant; there were also numerous scales and teeth of *Rhizodus*, pieces of *Gyrolepis*, specimens of *Acrodus*, *Ctenacanthus*, *Centrodus*, *Heliodus*, *Diplodus*, *Tristychius*, *Palæoniscus*, *Amblypterus*, and some other forms not yet determined, some of which may ultimately prove to be reptilian. For the new species of *Amblypterus*, the author proposed the name *Anconoæchmodus*, from the peculiar form of the teeth, which along with the external ornamentation of the scales would be sufficient, he considered, to distinguish the species wherever it may be found.

The author gave a full description of the species, which however, without figures, would not be serviceable to publish in detail here.

CORRESPONDENCE.

MEAN THICKNESS OF THE SEDIMENTARY ROCKS.

Sir,—In the Geological Magazine, p. 189, Mr. Poulett Scrope has done me the honour of referring to my paper on the "Mean Thickness of the Sedimentary Rocks," and of pointing out some omissions in it. I may mention, however, that the main object of the paper was not so much to determine the thickness of the sedimentary rocks as to direct attention to a method how this might be done. On this subject all hitherto appears to have been little else than mere conjecture. My object was to endeavour to bring the matter out of the regions of mere opinion into that of positive knowledge. But even assuming Mr. Poulett Scrope's conclusions to be perfectly correct, viz., that if we take into account the various sources of sedimentary accumulation at the bottom of the ocean, omitted by me, it will double the figures in my estimate, and give 5,000 feet instead of 2,500 feet as the mean thickness of the sedimentary rocks, still, this is a very low figure. To know with tolerable certainty that the mean thickness of the sedimentary rocks lies somewhere between 2,000 and 5,000 feet is surely a considerable advance on our previous knowledge in this direction.

But is it probable that the amount of materials supplied by the three agencies referred to by Mr. Poulett Scrope would equal that supplied by sub-aerial denudation?

Take the first, viz., Marine denudation. Suppose the mean height of the coast line of the globe, now being cut down by the action of the sea, to be 25 feet, and the mean rate at which the sea is advancing on the land to be one foot in a century; the amount of denudation thus effected would amount to only $\frac{1}{1740}$ that of sub-aerial denudation.[1] The amount of material supplied by marine denudation would therefore add only $1\frac{1}{2}$ feet to the thickness of the sedimentary rocks. But supposing the rate of marine denudation to be ten times greater than the above, still we would have an addition of only 15 feet: an amount so insignificant as scarcely worthy of being taken into account in our rough estimate.

Second: Coral-reefs and limestones formed in the sea. From whence come the materials which go to make these formations? Is it not probable that the greater part of these materials are carried down in solution by rivers from the land? The sea, no doubt, has its calcareous springs, but so has the land. But the land has more than springs. Rain water, doubtless, washes into rivers far more calcareous materials than is supplied by springs. And as the country is being denuded, new surfaces are being continually exposed to the action of the water. But not so in regard to the sea; there springs seem to be the only source of supply.

Third: What is the amount of materials supplied by submarine and other volcanoes which deposit their materials directly into the ocean? No one is better qualified to answer this question than Mr. Poulett Scrope himself, and it would be desirable if he would turn his attention to this point, and endeavour to arrive at some estimate, however rough, as to the absolute amount. Without some positive knowledge on this point, one is very apt to be misled when he endeavours to compare the amount of materials supplied by this means with that supplied by sub-aerial or by marine denudation. We have a striking example of this in the case of the comparison of the rate of sub-

[1] See Phil. Mag. for May, 1868, p. 383.

aerial with that of marine denudation. Before positive estimates were made in regard to the two rates, no one ever imagined that marine denudation was so trifling in comparison to sub-aerial. Is the amount of materials deposited in the submarine volcanoes equal to that derived from marine denudation? The sea is continually at work, but volcanoes are only now and again in eruption. If the materials supplied by submarine volcanoes be not greater than that by marine denudation, all the three sources which we have been considering put together, must fall far short of supplying an amount of material equal to that supplied by sub-aerial denudation. There is this, however, to be said of volcanoes, viz., the materials which they do produce—lava and trap-rock—resist denudation, and are consequently better preserved than rocks formed out of materials derived from sub-aerial and marine denudation. This, no doubt, is the reason why, in rock sections the traps bear so large a proportion to the sandstones, shales, and other softer rocks. Still further, were it not for the protection afforded by cappings of trap, the sedimentary rocks would be much thinner than they actually are.

EDINBURGH. JAMES CROLL.

THE CRUST OF THE EARTH.

SIR,—With your permission I should like to ask a question or two suggested by one part of Mr. Forbes's very instructive paper in the April number of your MAGAZINE.

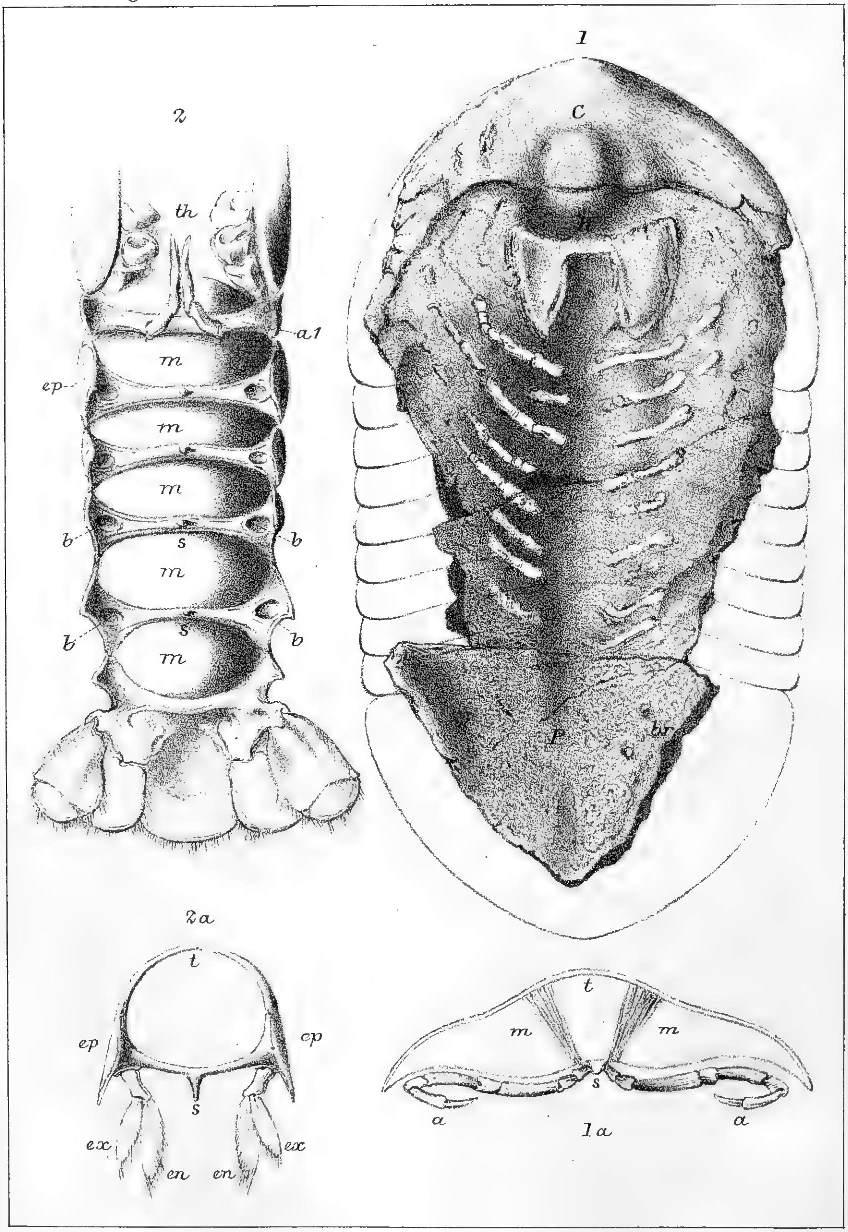
Is not the comparison there drawn between the crust of the earth and the shell of an egg likely to produce a somewhat inaccurate impression, which it is as well to avoid, and especially so when, as in the present instance, the illustration to some extent does duty as an argument? In the case of an eggshell, the vault consists of a single piece, so that the form is largely aided by the force of cohesion in supporting a load. The weight is equally distributed by the former, but transverse fracture, crushing of the material and the shearing, or sliding of particle on particle, are, up to a certain extent, prevented by the latter. It is, however, improbable that in the crust of the earth no joints or fissures exist reaching continuously or interruptedly from the top to the bottom. The igneous rocks, as we know them, are so fractured that it is hard to find a mass of many yards in length free from cracks and flaws. Does not the presence of these destroy the analogy between the crust of the earth and an *unbroken* eggshell? and every one can see how deft a hand would be required to build up the fragments of a *broken* one, so that it should bear even its own weight. Is it not more correct to liken the crust of the earth to a heavy, but unloaded arch, whose voussiors are constantly sliding on one another, in consequence of the ever-varying strain thrown upon the different parts, and the necessity of preserving equilibrium? Considerable up-and-down movement would thus be allowed, evidence of which may be seen in the enormous throws sometimes shown by faults. Cavities, too, might exist underneath the vault without endangering its stability, their size being limited by the ability of the material to resist crushing.

Again, does not a fallacy lurk under the inference that the crust of the earth is stronger than the shell of an egg because it is proportionally somewhat thicker, the former being the 158th and the latter the 200th part of the diameter. This seems to involve the assumption that the strength of a structure increases with its size, whereas, on the contrary, size is an element of weakness. The model is always stronger in proportion than the machine or the building, because the weight increases so much faster than the power to support it. The conclusion seems unavoidable, that while an egg-shell will bear its own weight, and even a large additional load, without giving way, the crust of the earth could not maintain itself in position unless its pieces rested everywhere, or nearly everywhere, on the liquid central mass, and, as it were, partially floated upon it.

E. W. C., B.A., B.Sc.

OBITUARY.

Sir J. F. W. Herschel, Bart.—This great philosopher died on the 11th ult., at the advanced age of 79, in the full possession of all his mental faculties. Though he devoted most of his time to astronomy, natural philosophy, chemistry, meteorology, physical geography, etc., geology did not altogether escape his attention. Among his suggestive contributions to this science may be mentioned the following:—1. On Changes of Climate arising from the varying excentricity of the earth's orbit (*Geol. Trans.*, 2nd series, vol. iii., referred to in *Lyell's Principles* as early as 1837). 2. On the effect of the Removal of Matter from above to below the Sea, producing "a mechanical subversion of the equilibrium of pressure and temperature;" On Subsidence and Elevation; The Influence of Subterranean Steam; The results of the Expansion of Rocks by Heat; The Fusion and Metamorphism of Sedimentary Rocks, etc. (letters written in 1836, and published in 1838, at the close of *Babbage's Ninth Bridgewater Treatise*). In one of these letters the following remarkable passage occurs:—"We are led by analogy to suppose that He (the Creator) operates through a series of intermediate causes, and that in consequence the origination of fresh species, could it ever come under our cognizance, would be found to be a natural, in contradistinction to a miraculous, process." 3. Remarks on Denudation, etc., in his article on Physical Geography in the *Encyclopædia Britannica*, since published separately. 4. Various important allusions to geology in articles lately published in *Good Words*, etc. In private life Sir John was characterized by a rare combination of candour and unaffected humility, and he was never known to write discourteously in his replies to the most discourteous opponents. His remains were interred in Westminster Abbey on Friday, May 19th, beside those of Sir Isaac Newton. A more appropriate place could not have been selected; for, though the fame of Herschel will not rival that of Newton, he was as industrious, skilful, and devoted a labourer in the same field, and contributed to extend the boundaries of that science which was alike dear to both.



G. R. De Wilde. del et lith. Mintern Bros. imp.

To illustrate Mr. Woodward's paper on the Structure of the Trilobita.

THE
GEOLOGICAL MAGAZINE.

No. LXXXV.—JULY, 1871.

ORIGINAL ARTICLES.

I.—On the Structure of Trilobites.

By Henry Woodward, F.G.S., F.Z.S.,
of the British Museum.

(PLATE VIII.)

TRILOBITES appear to have been among the very earliest recognized fossils, not only in this country, but on the Continent, their name having been given them by Walch, in his "Natural History of Petrifactions," published at Nuremberg a hundred years ago.

Looking at the long list of distinguished naturalists, who, since that date, have devoted more or less attention to these early representatives of the Articulata, it may at first sight appear surprising that we should have any doubt to-day as to their exact position in the Crustacean class, but such is nevertheless the fact.

To M. J. V. Audouin belongs the honour of having been the first to suggest a definite place for the Trilobita. In his "Recherches sur les rapports entre les Trilobites et les animaux articulés" (Paris, 1821), he compares them with the Isopoda, but believes they were destitute of feet, yet furnished with appendages for breathing organs.

Wahlenberg, Brongniart, Schlotheim, Dalman, De Kay, Pander, Green, and many others have contributed to a systematic knowledge of the Trilobita, but to Quenstedt, Burmeister, and Emmerich we are especially indebted for the most important views in regard to the structure and organization of this group.

In Dr. Burmeister's work[1] (edited from the German by Professors Thomas Bell and Edward Forbes, and published by the Ray Society, 1846), the author concludes that "there is good proof that the feet of the Trilobites must have been soft membranous organs, for the absence of the slightest remains of these in the numerous specimens observed, is of itself sufficient evidence of the fact, and it can indeed scarcely be supposed that hard horny extremities should be affixed to a soft membranous abdominal surface; since they would not

[1] Published in Berlin in 1843.

have possessed that firm basis, which all solid organs of locomotion require, in order that they may be properly available. That this abdominal surface also must have been of a membranous nature, seems quite clear, since it has in no instance been preserved in a fossil state, whilst the hard, horny, perhaps calcareous, dorsal surface is invariably retained."

Prof. Burmeister refers them therefore to the Entomostraca, from the numerous (not definite) number of the segments of the body, and is disposed to place them among the Phyllopoda. Prof. M'Leay gives them a higher position, intermediate between the Isopods and Phyllopods, he thinks "they probably adhere in masses, as chitons do; and as the mouth is like that of *Apus*, they were probably carnivorous as in that genus." (Silurian System.)

Although M. Barrande, in his magnificent work on the Trilobites of the Silurian System of Bohemia, has illustrated the development of some thirty species, he has not observed appendages in any of the 250 species he has so splendidly pourtrayed.[1]

MM. Milne-Edwards, Dana, and most other Carcinologists have accepted Prof. Burmeister's views as to the Phyllopodous affinities of the Trilobita.

After reviewing the observations of the various writers who had preceded him, Mr. Salter observes (in his Monograph of British Trilobites, part i., 1864, p. 9, Pal. Soc.), "We are compelled to conclude that Trilobites had not even membranaceous feet, and that the ventral surface was destitute of appendages. It is of course difficult to prove this, and almost all naturalists are disposed to allow them soft gills attached to the under side." "I do not see," adds Mr. Salter, "that the Trilobites had any need of appendages further than what might be necessary as breathing organs." "There is some reason to believe that, like its predecessor, the Annelide, the habit of the Trilobite was to gorge itself with the carbonaceous mud, and extract from it the nutritive portions." "The only hard portion of the under side is the immovable upper lip or labrum; and this may have been the instrument by which the food was scraped together."

In referring to them in various papers which I have published,[2] I have stated that as "no traces of antennæ or limbs had yet been detected, it seemed certain that the other appendages of the animal were wholly composed of soft and delicate tissue, too soft to have been preserved in the fossil state."

The first announcement indicative of any change in these opinions was made before the Geological Society of London on May 11th, 1870, by E. Billings, Esq., F.G.S., Palæontologist to the Geological Survey of Canada, Montreal.

The author described a specimen of *Asaphus platycephalus* in which

[1] M. Barrande refers to what he believes to be the cast of the straight intestinal canal in a species of *Trinucleus*.

[2] "Intellectual Observer," vol. viii., 1865, p. 324. "Descriptive Catalogue to Chart of Fossil Crustacea," p. 14, by J. W. Salter and H. Woodward, 1865. Reports on the Structure and Classification of the Fossil Crustacea, British Association, 1864–70.

the hypostome was not only preserved *in situ* (as is usually the case in the Trilobita), but also the remains (more or less well preserved) of eight pairs of legs corresponding with the eight segments of the thorax, to the under side of which they had been attached. The appendages take their rise close to the central axis of each segment, and all curve forwards, and are thus most probably ambulatory rather than natatory feet. They appear to have had four or five articulations in each leg. Three small ovate tubercles on the pygidium may, perhaps, indicate the processes by which the respiratory feet were attached.[1] The figure of Mr. Billings's *Asaphus* has been reproduced in the accompanying Plate VIII., Fig. 1., from the Quart. Journ. Geol. Soc., vol. xxvi., pl. xxxi., fig. 1.

In offering an explanation as to the large number of Trilobites which have been examined unsuccessfully, Mr. Billings suggested that only the most perfectly preserved specimens are likely to exhibit the organs on the under side of the body; just, in fact, those specimens which a collector would be least willing to cut into slices in search of appendages. Hence, probably, the want of success which has attended previous researches.

Whilst the Canadian Trilobite was in England I had the advantage of studying the original specimen, and fully concurred in the views put forward by Mr. Billings; indeed I felt unable to offer any more satisfactory explanation than that proposed by him; whilst the discovery of similar appendages in another *Asaphus* from the Trenton Limestone, in the British Museum, tended greatly to confirm them.

In a note upon this specimen communicated to the Geological Society, and published at the same time, I ventured to suggest that the evidence put forward by Mr. Billings tended to place the Trilobita near to, if not in, the Isopoda Normalia: and that we might fairly expect to find that the Trilobita represented a more generalized type of structure than the modern Isopods.[2]

Since the interesting specimen, described by Mr. Billings, has been returned to America, it has undergone a further examination by Prof. Dana and others, an account of which appears simultaneously in the Annals and Magazine of Natural History for May, p. 366, and in Silliman's American Journal for May, p. 320, a copy of which is subjoined.

"Besides," writes Prof. Dana, "giving the specimen an examination myself, I have submitted it also to Mr. A. E. Verrill, Professor of Zoology in Yale College, who is well versed in the invertebrates, and to Mr. S. J. Smith, assistant in the same department, and excellent in crustaceology and entomology. We have separately and together considered the character of the specimen; and while we have reached the same conclusion, we are to be regarded as inde-

[1] See GEOLOGICAL MAGAZINE, 1870, Vol. VII., p. 291.

[2] Dr. Bigsby's specimen in the British Museum not only shows the remains of three pairs of appendages united along the median line by a longitudinal ridge, but also what I have good reason to believe to be the remains of one of the palpi which has left its impression upon the side of the hypostome (see Quart. Journ. Geol. Soc. xxvi. 1870, p. 487, woodcut, fig. 1).

pendent judges. Our opinion has been submitted to Mr. Billings, and by his request it is here published. The conclusion to which we have come is that the organs are not legs, but the semicalcified arches in the membrane of the ventral surface to which the foliaceous appendages or legs were attached. Just such arches exist in the ventral surface of the abdomen of the *Macrura*, and to them the abdominal appendages are articulated. (See Plate VIII., Fig. 2). This conclusion is sustained by the observation that in one part of the venter three consecutive parallel arches are distinctly connected by the intervening outer membrane of the venter, showing that the arches were plainly *in the membrane* as only a calcified portion of it, and were not members moving free above it. This being the fact, it seems to set at rest the question as to legs. We would add, however, that there is good reason for believing the supposed legs to have been such arches in their continuing of nearly uniform width almost or quite to the lateral margin of the animal, and in the additional fact that, although curving forward in their course towards the margin, the successive arches are about equi-distant or parallel, a regularity of position not to be looked for in free-moving legs. The curve in these arches, although it implies a forward ventral extension on either side of the leg-bearing segments of the body, does not appear to afford any good reason for doubting the above conclusion. It is probable that the two prominences on each arch nearest the median line of the body which are rather marked, were points of muscular attachment for the foliaceous appendages it supported. With the exception of these arches, the under surface of the venter must have been delicately membranous, like that of the abdomen of a lobster or other macruran. Unless the under surface were in the main fleshy, Trilobites could not have rolled into a ball."

In order more clearly to explain to our readers the nature of the conclusion arrived at by Professors Dana, Verrill, and Smith, I have re-drawn Mr. Billings's *Asaphus* on Plate VIII., Fig. 1, and have placed beside it a ventral aspect of the abdominal segments of the "Norway lobster" (*Nephrops Norvegicus*, Leach).

Let us now proceed to compare Figs. 1 and 2. Each of the semi-calcified arches of the sternum *s*, (Figs. 2 and 2*a*) is, it will be observed, firmly united to the margins (epimera) of the tergum (*t*) of the corresponding segment forming one somite or body-ring (Fig. 2*a*). Referring to Fig. 1, does it not seem improbable that if these so-called legs are homologous with the sternal arches in Fig. 2, that they should retain their normal position near the median line, where, if they be sternal arches, they must have been *wholly unattached*, and be at the same time widely removed from the lateral border of the particular segment to which each must have been anchylosed?

Taking this fact alone, we are convinced that these appendages were attached along either side of a median line, and that the lateral extremities were free.

The statement that "three consecutive parallel arches are distinctly connected by the intervening outer membrane of the venter, showing that the arches were plainly *in the membrane* as only a calcified portion of it," is surely an error arising from the supposition that the matrix represented a part of the organism. As no membrane whatever is preserved, it can hardly be cited to prove the so-called legs to be semicalcified sternal arches imbedded in it.

Prof. Dana suggests that the supposed joints were points of muscular attachment for the foliaceous appendage it supported. The legs of the crustacea are usually bifid (giving rise to an endopodite and an exopodite, see Plate VIII., Fig. 2*a*), but they take their rise from a common base, not in a double series on each side.

Assuming the appendages to have been soft foliaceous gill-feet, then the presence of strong sternal arches would have been needless; on the other hand, if we accept Burmeister's decision, that such hardened sternal arches *must accompany* horny or calcareous feet, then it follows as a matter of course that—accepting Prof. Dana's interpretation—*Asaphus* must have had such hard appendages, which the very presence of semicalcified arches in the ventral integument proves to have existed.

In the mean time, however, seeing that these appendages really look more like feet (as at first suggested by Mr. Billings) than like semicalcified sternal arches (as now suggested by Prof. Dana), would it not be more philosophical to consider them to be feet, and seek to discover whether a semicalcified sternal arch underlies them?

Eventually it may be proved that a very thin and almost membranous sternum may have sufficed to give support even to chitinous or calcareous limbs, provided they were assisted by apodemata developed from the under side of the tergal arches, as in *Limulus*.

To this suggestion the fact of the strongly trilobed form of the tergal plates in many genera of Trilobites, and the development of spines and tubercles upon the segments, which doubtless served as points for muscular attachment within, lends considerable probability.

Prof. Dana observes, "unless the under surface were in the main fleshy, Trilobites could not have rolled into a ball." To this I entirely assent, but I do not see that the presence of slender ambulatory legs would have prevented this operation from taking place; but it should be borne in mind that many genera of Trilobites never rolled up, so that amongst them, as in the modern Isopoda, the habit was the exception, *not the rule*.

As to the regularity of the position of the limbs, this is not extraordinary among Fossil Crustacea, when preserved in a suitable matrix, those, for example, which occur in the Lithographic stone of Solenhofen, frequently presenting a most wonderful and perfect state both of preservation and arrangement of limbs, antennæ, etc.

Looking at the Crustacean class as a whole, it seems to be a constant rule that the test and the appendages have a direct relation to each other (save in Parasitic forms—in the Cirripedia, and among the Anomoura). Thus, if the general covering of the body be hard and calcareous, the limbs are covered in a similar envelope. If the crust be chitinous, the limbs are also chitinous or soft and membranous. Seeing, then, that the Trilobita—many of them at least—have a shelly covering of considerable thickness, it is not unreasonable to assume that their locomotory appendages were calcareous, or at least chitinous and of sufficient strength to enable them to crawl upon or burrow in the mud at the bottom of the Palæozoic seas in which they dwelt.

With regard to the buccal apparatus, we know that the hypostome or lip-plate is commonly present in most genera of Trilobites. This plate agrees most closely with the hypostome in *Apus* (see GEOL. MAG., Vol. II. Pl. XI. p. 401), a similar plate exists also in most of the Isopods. That its presence indicates the possession of maxillæ, I have no more doubt than I should feel in asserting the presence of jaws within the lips of a mammal. Looking at the group as a whole, it would also, we think, be a safe prediction that their branchiæ were abdominal, the great caudal shield offering a strong analogy to the tail-plate which, in the modern Isopods, covers those organs.

In the foregoing remarks my object has been mainly to show the reasons why it is desirable to adhere to the original interpretation of the appendages in the Trenton *Asaphus*, as proposed by Mr. Billings, rather than to adopt the conclusions of Prof. Dana, whose opinion, however, upon living Crustacea I hold in the highest estimation.

The patient examination and slicing of more specimens appears in the mean time to be the most hopeful method to adopt in order conclusively to settle the question of the structure and appendages of the Trilobites.

EXPLANATION OF PLATE VIII.

Fig. 1. *Asaphus platycephalus*, Stokes.—Underside, showing the legs. (Copied from figure in Quart. Journ. Geol. Soc., 1870, vol. xxvi. pl. xxxi., fig. 1.) C. Cephalon, to which is united the hypostome or lip-plate (*h*), followed by eight free thoracic segments, indicated in outline, bearing eight pairs of appendages on their underside. These again are followed by the pygidium or tail (*P*) composed of the abdominal somites welded together, and probably bearing the branchiæ upon the underside, to which the points (*br*) seen in the figure, may perhaps relate.

Fig. 1*a*. Ideal section of one of the thoracic segments, *t*=tergum, *s*=sternum, two legs *a a*, are seen beneath, articulated to the sternum near the median line, and having their muscular attachments *m m*, (and apodemata ?) on the underside of the tergum (*t*).

Fig. 2. Underside of abdomen in Norway lobster. *Nephrops Norvegicus*, Leach. *s s*, sternal arches; *m m*, membranous interspaces. *a* 1. 1st, thoracic somite, with its modified pair of appendages still attached to sternal arch. *b b*, points of attachment for abdominal appendages which have been removed, however, to exhibit the calcified arches of the sternum more clearly; ep=epimera; th=thorax.

Fig. 2*a*. One of the abdominal somites detached. *t*=tergum; *s*=sternum; ep=epimera; ex=exopodite; en=endopodite.

II.—OBSERVATIONS ON THE GENERAL RELATIONS OF THE DRIFT DEPOSITS OF IRELAND TO THOSE OF GREAT BRITAIN.

By EDWARD HULL, M.A., F.R.S., F.G.S.,
Director of the Geological Survey of Ireland.

THE valuable paper by Professor Harkness on "The Middle Pleistocene Deposits of Britain," published in the pages of this periodical,[1] was a completely successful attempt to synchronize

[1] GEOL. MAG., Vol. VI., p. 542.

the members of the Drift series of Ireland with those of England and Scotland. He shows that there exist in the East of Ireland detached portions of an Upper Boulder-clay resting on the shelly sands and gravels of the "Middle Drift," and that in other localities these sands and gravels may be observed resting on the Lower Boulder-clay, which is generally supported by rock with a glaciated surface. The order of succession of the members of the Drift series is, therefore, precisely similar to that of the North-western counties of England, where we have at the base (*a*) Lower Till or Boulder-clay; (*b*) Marine Sands and Gravels; (*c*) Upper Till or Boulder-clay;[1] —an order of succession which I have for some years felt satisfied would be found ultimately to hold good over the whole of England.

In 1867 I showed how Mr. Searles V. Wood's classification of the Drift deposits in the Eastern counties exactly corresponded with that of the North-western counties, and I expressed my belief that more extended investigations would show that the threefold division of the Drift series would be found to be a real and widely extended sequence of deposits of the Glacial Epoch.[2] How far this impression has been verified by subsequent observations, it is unnecessary to point out.

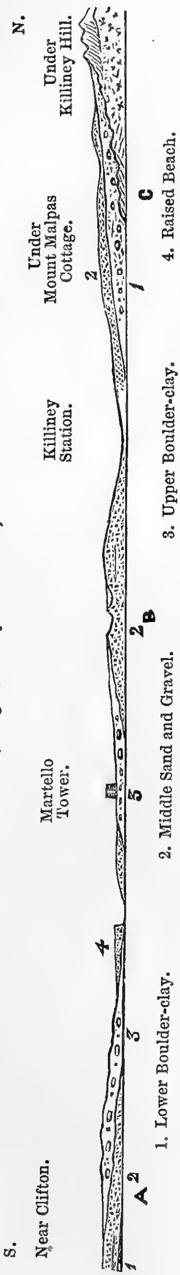
I was scarcely, however, prepared at that time to entertain these views to the extent of including Ireland, but during the last two years, having had frequent opportunities of observing the succession of the Drift deposits in various parts of the country (with the exception of the South), I had arrived at the very same conclusions with Professor Harkness, at the time he published his paper. I have therefore great pleasure in adding my testimony in confirmation of his views, and my purpose in this paper is to adduce some further evidence afforded by a series of sections which may be observed along the coast, and the cuttings of the railway between Killiney and Bray, South of Dublin; and to add some observations on the general relations of the Post-Pliocene deposits of the British Isles. I may here observe that, as far as my observations have yet gone, the sections along various parts of the Eastern coast of Ireland are very instructive; and, when the key to the threefold classification has once been obtained, are all consistent with each other.

Along the shores of Antrim and Down, we often find the Lower Boulder-clay resting on glaciated rock-surfaces, and capped by the sand and gravels of the middle division. Here also we have the raised beach (the representative of the 25 feet beach of the coast of Scotland), rising about 12 feet above the high-water line. In the neighbourhood of Howth the three divisions can be clearly made out, as stated by Professor Harkness; and the middle gravels are abundantly charged with marine shells, as determined in 1837 by

[1] The Upper Boulder-clay, of which I first showed the importance in 1864 in the district around Manchester, has since been traced and identified by Mr. de Rance, Miss Eyton, Mr. Mackintosh, and Mr. Taylor, over the district extending from the Lakes to the valley of the Severn; and by Mr. A. H. Green and the author over Cheshire.

[2] "On the Parallelism of the Drift Deposits in Lancashire and the Eastern Counties," Geol. Mag., Vol. IV., p. 183.

Fig. 1.—Drift Sections along the Shore of Killiney Bay, Co. Dublin.
(Length, nearly two miles.)



Dr. Scouler,[1] and subsequently by Dr. Oldham. At Kingstown, the Upper Boulder-clay may be observed to rest on the middle gravel; and at various points between Kingstown and Dalkey, the Upper (or Lower) Boulder-clay is found to rest on a surface of granite remarkably *moutonnéed* and striated. The general direction of the ice-flow being from the N.W. or N.N.W., a direction pointing to the central plain of Ireland.[2]

Proceeding further South, and rounding the granite and schistose cliffs of Killiney Hill and Mount Malpas, the shore sweeps inland, with a gentle curve terminated to the South by the bold cliffs of Bray Head. It is along this shore that the cliffs of Drift are exposed to view, which are represented in the accompanying illustrations (Fig. 1). The whole section forms a basin or trough, the beds rising both to the North and South. At the extreme Southern end of the section, we find the three divisions of the Drift in the same part of the cliff, which is about 35 feet high, the Lower Boulder-clay only just showing itself at the base. The middle sand and gravel (Fig. 2) is obliquely laminated, very coarse, and contains fragments of shells. The Upper Boulder-clay (Fig. 3) is composed of stiff reddish clay, with large boulders of granite, Silurian grit, etc., and glaciated stones. It descends from the top of the cliff to the base, with a gradual slope, cutting out beds of gravel in the middle division, as shown in Fig. 2. This circumstance is exactly similar to one which I noticed in Lancashire, where I often found the Upper Boulder-clay resting upon a greatly eroded surface of the middle sands, and of which illustrations will be found in my paper on the Drift deposits near Manchester.[3]

Returning to our section, we find the Upper Boulder-clay forming the cliff for some distance; but on approaching the outfall of Loughlinstown Brook, it gradually descends under a

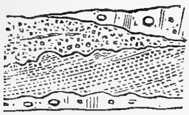
[1] Journ. Geol. Soc. Dublin, vol. i., p. 270.

[2] Some of these cases of *striæ* were originally noted by the late Mr. Du Noyer. See Explanation of sheets 102 and 112 of the Geological Survey of Ireland. It is remarkable that the striæ along the coast near Dublin point in a direction, and have been produced by ice coming from a region for the most part devoid of elevation.

[3] Mem. Lit. and Phil. Soc. Manchester, vol. ii., third series, p. 453.

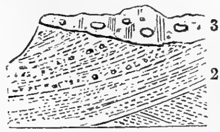
little terrace of very coarse gravel, which appears to be either a river-terrace or the remains of a raised sea-beach. This terrace rises eight feet above high-water mark.

Fig. 2.—Section at A, in Fig. 1.



Outcrop of the Upper and Lower Boulder-Clay (1 and 3), with the Middle Sand and Gravel (2) between.

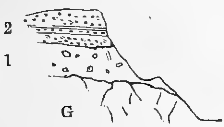
Fig. 3.—Section at B, in Fig. 1.



Upper Boulder-Clay (3) resting on Middle Sand and Gravel (2).

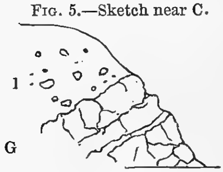
To the North of the Martello Tower, the Upper Boulder-clay again appears, now rising Northwards in the direction of the high ground of Killiney Hill; and from beneath this the sand and gravel (Fig. 3), which in its turn is succeeded by the Lower Boulder-clay (Figs. 4 and 5), resting upon granite, under Mount Malpas.

Fig. 4.—Section at C, in Fig 1.



2. Middle sand, etc., resting on Lower Boulder-clay (1), with a basis of Granite (G).

Fig. 5.—Sketch near C.



1. Lower Boulder-clay resting on Granite (G) shore of Killiney Bay.

Here, then, on both sides of a synclinal, we have the three divisions of the Drift series very clearly developed, but requiring the aid of some previous knowledge of other districts, in order to the elucidation of their relations to one another.

It is altogether unnecessary that I should refer to the order of succession of the Drift deposits further South, as, for instance, in Co. Wexford, after the able observations of previous authors, amongst whom may be especially mentioned Sir H. James, Prof. E. Forbes, and, most recently Prof. Harkness, in the paper already referred to. Suffice it to say that the superposition of the upper and middle divisions (Manure gravel) is there clearly maintained, and is in accordance with the arrangement of the strata in the district here described.[1]

Central Plain of Ireland.—The superposition of the Middle Drift (Limestone Gravel) on the Lower Boulder-clay is of common occurrence over the central plain of Ireland, though the presence of the Upper Boulder-clay has hitherto not been noticed. This is probably only because it has not been looked for; but, unquestionably, the principal cause of its general absence is recent denudation. That it once had a very general distribution over this area, from which it has subsequently been swept by both marine and atmospheric agents of waste, is a view which I very strongly hold.

One reason for this belief is the occurrence of large boulders of limestone and other rocks, which may be frequently observed strewn along the summit or sides of the Eskers. Now, without entering into the vexed question of the origin of these remarkable ridges,

[1] See Prof. Harkness's paper already quoted, p. 294.

there can be no doubt that they are for the most part formed of the Limestone Gravel or Middle Drift, in some places re-modelled, but in others apparently retaining its original form of stratification.[1] One of these boulders, resting on the flanks of an Esker near Durrow, called the "Pilgrims' Road Esker," formed of limestone, was found by Mr. J. O'Kelly, of the Geological Survey, to measure 18 by 15 by 12 feet.[2] Generally these boulders are to be found in such positions; and though I was for a time at a loss to account for their presence, I venture to suggest that they are the monuments of the former existence of a formation, viz., the Upper Boulder-clay, of which the soft and fine materials have been swept away, while the large boulders it once held imbedded have resisted the agencies of destruction, and remain behind stranded on the Eskers. As a parallel case, I may refer to the presence of the "Sarsen stones," or "Grey wethers," on the Chalk Downs of Wilts and Berks, relics of the Tertiary strata in which they were once imbedded, but of which there are frequently no traces in the immediate neighbourhood of the "Sarsen stones" themselves.

Varying levels of the Drift deposits.—The Limestone Gravel of the neighbourhood of Dublin has been traced to considerable elevations on the flanks of the Dublin and Wicklow Hills, by the Rev. Maxwell Close, Mr. Wyley, late of the Geological Survey, Dr. Scouler, and others. These elevations reach 1,200 and 1,235 feet on Montpelier Hill;[3] and as the gravels contain fragments of shells, these levels undoubtedly indicate the amount of depression of the land below its present level during the Middle Glacial stage.

These observations are in accordance with those I made very carefully in Lancashire,[4] where I found each member of the Drift to rise gradually towards the hills, and sink down under the plains. The position, therefore, which the Drift deposits assume, is not that of horizontal terraces, occupying successive levels as we ascend the sides of the hills (a very prevalent view of the subject), but one in which the different members accommodate themselves to the original form of the ground, rising and cropping out in succession at certain elevations, depending on the amount of denudation to which they have been subjected. This arrangement is illustrated in some degree by the section along the coast at Killiney and Ballybrack (see Fig. 1), where the beds are seen to slope (or dip) down from Killiney Hill into the plain below.

General Conclusions.—The division of the Glacial period into three stages, first clearly demonstrated by Professor Ramsay, in 1852, when treating on the Glacial phenomena of North Wales,[5] marked by corresponding deposits over the three kingdoms, is one which I think may now be regarded as fully established, and is an immense advance on our knowledge as compared with that a quarter of a century since. (3) The earliest stage was one of general elevation of the land and sea-

[1] See account of the Eskers at Stonepark by Mr. Symes, F.G.S., of the Geological Survey. Explanatory Memoir, Sheets 86, 87, and pp. 49–51, with woodcut.

[2] Explanation Sheets 98, 29, and p. 27.

[3] Explanation Sheets 102 and 112. Geol. Survey Maps, p. 67.

[4] "Drift Deposits of Manchester," supra cit. pp. 457–8.

[5] Quart. Journ. Geol. Soc., vol. viii.

bed,[1] accompanied by intense cold and the formation of extensive sheets of land-ice. (2) The second resulted in a general depression of the land,[2] with the return of a milder climate; (1) and the third was characterized by a partial re-elevation of the submerged land, and a partial return of a cold climate, productive of local glaciers and icebergs. This period gradually gave place to the climate of our own day, and its change is indicated by the retreat of the glaciers amongst the "Centres of Dispersion," as graphically described by Mr. de Rance, on a recent occasion, in Cumberland, and by Prof. Ramsay, in North Wales. These stages may thus be expressed in a concise form, as I have attempted to show in the accompanying page, on which I have only to remark that the changes from one stage to another are not to be regarded as sudden or abrupt; between each there was doubtless a period more or less extended, and partaking of the climatical condition of the preceding and succeeding stages; while the change from the third stage into the recent period is also to be regarded as of a gradual character.

Tabular View.—Intended to show the Physical Characters of the Three Stages of the Drift period over the British area.

PERIOD.	STAGE.	POSITION OF LAND.	CHARACTER OF DEPOSIT.		CLIMATE.
			ON PLAINS.	ON MOUNTAINS.	
Post-Pliocene or Drift.	Upper	Partial re-elevation as compared with the middle stage, but partial submersion as compared with the present day.	Upper Boulder-clay (generally Marine).	Local Glaciers producing Icebergs and Moraines, etc.	Changing from Arctic to Temperate.
	Middle or Inter-Glacial.	Greatest Depression: Submersion to a depth of 1,300 feet E. of Ireland, 1,400 feet Wales, 1,200 ft. Cumberland, compared with present levels.	Shelly Marine Sands and Gravels. ("Limestone Gravel" of Ireland.)	Mountains reduced to small Archipelagos, as shown in Lyell's "Antiquity of Man," p. 276.	For the most part temperate.
	Lower	Greatest elevation: Portions of existing seas being then land, and covered by ice.	Lower Boulder-clay of Scotland, the North of England, and a large portion of Ireland, due chiefly to land-ice.	Perennial snow and ice.	Arctic. The general surface of the Northern portions of the British Isles, including Ireland, resembling Greenland at the present day.

[1] Possibly to the extent represented by Lyell in his work on "The Antiquity of Man," p. 279. [2] To the extent shown by map, p. 276.—*Ibid.*

III.—The Submergence of Is, in Western Brittany.

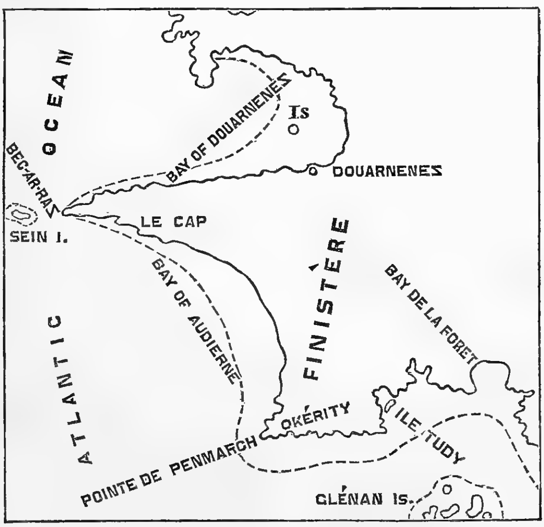
By G. A. Lebour, F.G.S., F.R.G.S.,
of the Geological Survey of England.

It has frequently been found that in cases of depression or elevation of land the records of historians have corroborated the inferences of geologists. The works of the ancient geographers have also been of use in this way. It is, however, more rarely that a tradition receives confirmation at the hands of geological observers, and this it is which leads me to call the attention of the readers of the Geological Magazine to the subject of the present paper.

The tradition to which I wish to refer is one which has for many centuries been current in Lower Brittany, and the substance of it is this: that in the time of King Gradlon, that is, in the fourth or fifth century, the chief town of his kingdom was situated far to the West of the present land where is now the Bay of Douarnenez; that the land on which it stood was very low, and in constant danger from inroads of the sea, which was kept out by what the ballads on the subject call "gates," but which may have been some kind of dykes. The name of this town was Is, and it was the seat of the king's government. The legend then tells how, by a romantic series of events, the town and the surrounding low-lying land were submerged, the king only saving himself at the expense of his daughter Dahu, whom he flung into the sea from the pillion on which she was escaping with him.

Now there are a number of circumstances which tend to give this legend more weight than such tales usually deserve. Most of these arguments in favour of the existence of Is are stated at length in the Chronicles of the Ligue in Brittany, by Chanoine Moreau, who wrote about the beginning of the seventeenth century. The principal among them are as valuable now as they were in the time of Moreau, and the utter absence of variation in the tradition as it was known to the Bretons then and as it is told and sung by them now, is some evidence to its original truth. The facts which are explicable only on the assumption of the existence of the town and land in question are chiefly these:—1. That several well-made roads, which are even now very easily traced across the country, run from various inland points (for the most part ancient shrines) in Brittany to the shores of the bay, and that these roads, which have at present no conceivable object, would, if prolonged, converge at a point within the bay, some miles from land. 2. That the Abbots of Landévénec (a large and rich abbey, founded by King Gradlon) were bound by the terms of their tenure to come and take formal possession at a rock on the beach at Pentrez, which is the point nearest to the supposed site of the lost town. This ceremony was continued until shortly before the great Revolution, and it was always understood that the Pentrez rock was used as a substitute for Is, which could no longer be reached. 3. That many of the villages and towns in the vicinity of the bay have the termination *is*, which is a point in the evidence to which I cannot grant as much importance as Chanoine Moreau seems to attach to it. 4. That the church at Lanval on the coast (now in ruins) had the following saying attached to it: "that sixty scarlet cloaks (these were the big-wigs), without counting others, used to come from Is to mass at Lanval," and that a common saying was, "Is ne cavas par da Paris," "Since Is, nothing has been seen like Paris." This last I have myself heard the natives say repeatedly.

These data, therefore, all point to the existence of Is, and to the general truth of the legend, and can scarcely be explained otherwise. If there did exist such a town in such a situation, then there must have been a considerable depression of the coast of Western Brittany at least in early Christian times, and traces of snch an occurrence should be discernible somewhere along the coast. With the view of ascertaining whether this was the case or not, I, during one of my later sojourns in the district, carefully explored the whole of the Western coast of the department of Finistère. The result is, I think, quite in accordance with the tradition, and renders it at once possible and probable.



SKETCH-MAP OF PART OF COAST OF FINISTÈRE.

The dotted line shows the approximate coast-line in the time of Is.

On the shores of the bay itself, and in the Rade de Brest, no signs of any comparatively recent subsidence were observed. On doubling the Bec-ar-Raz, however, and following the coast in a Southerly direction, past the beautiful stretch of beach which skirts the broad Bay d'Audierne, the ruined churches and other buildings of the sacked towns of Penmarch and Kérity afford some evidence of being nearer the sea than they originally were, or, in other and more proper words, of the sea having gradually encroached upon the land; one of the churchyards being already half eaten away by the waves of high tides, and displaying a by no means pleasing collection of bones below high-water mark. Moreover, it is asserted by sailors that the weird rock to the west of the ruins, well known as the *Torche de Penmarch,* is decreasing in height, and is no longer as excellent a land-mark as it was in former years. Proceeding westward from this point, we soon come to the Anse de Benodet, where, on the shores of the Ile Tudy, I was fortunate enough to discover two lines of boundary mounds, or stone dykes, which were continued some distance below low-water mark, thus plainly proving a subsidence of this low-lying shore at no very distant date. It is, however, further west still that the best and clearest proofs of depression are to be found, in the Bay de la Forêt, the very name of which should cause geological ears to prick up. This bay is small, the shores consisting of low-rounded rocks of very coarse-grained granite. It is two-thirds of a circle in shape, and is much used for oyster culture. It is shallow, the bottom being everywhere a mass of coralline. In dredging, however, for annelids, etc., I often brought up nuts and bits of wood, black and soft, as they are found in peat-bogs. During very low tides the shelving beach is seen to be studded very thickly with similarly blackened and decomposed trunks of trees (mostly oak and birch) apparently embedded in a layer of peaty mud full of nuts and leaves. In order to see these trunks, much clearing of the overlying sand is generally required, but their presence is so well known to the fishermen of the coasts, that it is always given by them as the origin of the name of the bay. That we have here a sunken forest there can be no doubt, and that the date of its submergence is by no means ancient (geologically speaking), is proved by the fact that on the western side of the bay the old wood is continuous with a living one on land at a place called Kerafloch. Besides this direct proof of submergence, I have it on the authority of a French naval officer, very familiar with the Brittany coast, that the Iles de Glénan (some eight miles to the south of the Bay de la Forêt) are in the modern charts sensibly smaller than they are drawn in the older maps. This is to some degree corroborated by the Ormer (*Haliotis*) fishers, who assured me that at the present day the Ormers are found much nearer the lighthouse on Penfret Island (one of the Glénan group) than they were formerly.[1] These two statements argue a rather rapid encroachment of the sea upon the land, and one which, when viewed in connexion with the other data furnished by the coast of the main-land, must in all probability have been continuing for a very considerable time. With such facts before us then, it is only necessary for our purpose to inquire whether the amount of depression displayed by them is sufficient to account for the submergence, fifteen centuries ago, of a portion of the present Bay of Douarnenez. In order to arrive at any results in this matter, the depth of the Bay of Douarnenez must of course be taken into ac-

[1] The Ormer can only be collected during very low tides, as its habitat is considerably below ordinary low-water mark.

count. Its bottom is a very gradually sloping one, tolerably deep at the western end or opening of the bay, and shallow at the eastern extremity. Now the eastern portion is the only one which we need consider, as it is within it that the site of Is is said, according to every version, to be. In this space then, the deepest sounding that I have been able to find is between seven and eight fathoms, so that an elevation to that extent would convert the whole of the eastern end of the bay into dry land. Now all the facts which we have detailed above, tend to show that the depression of the land is still at work, and assuming that it has continued ever since (how long before we need not inquire) the traditional date of the submergence of Is, we get an average rate of depression of three feet per century —by no means an extravagant allowance. The effect of the elevation of the land some forty-five feet would, it will be seen by referring to the accompanying sketch-map, not disturb the geographical descriptions of the district given by Cæsar and others. I wish it to be understood that I am in no wise arguing that the depression in question was anything more than a local one; as I am aware that it is held that the Northern, Southern, and South-western coasts of France are within the European area of elevation. That such a local sinking of the land exists in Basse Bretagne, I think I have shown sufficiently; and my object will be served if I have also shown that, at the time that Is is said to have been the pride of King Gradlon's kingdom, there is every probability that land did exist at the very spot with which that semi-mythical city has always been associated. That such a probability greatly enhances the value of the tradition, and of the otherwise slender evidence which supports it, is obvious. I have thus done my best as a geologist to bring back an old legend within the realms of truth, and I must now leave it to the antiquary to find out more concerning lost and forgotten Is.

IV.—On the Drifts of the West and South Borders of the Lake District, and on the Three Great Granitic Dispersions.

By D. Mackintosh, F.G.S.

(*Continued from our last number*, p. 256.)

Boulder-scars.—From Maryport to Parkgate, the E. coast of the Irish Sea at intervals exhibits accumulations or concentrations of large boulders, which are locally called scars. They may be seen in all stages of formation, from the denudational area, where they are in course of being left by the washing away of the clayey matrix, to the depositional area, where they have become half-covered with recent sand and shingle. In many places (as between Seascale and near Silecroft) there are so many boulders within a small area as to show that a considerable thickness of the clay must have been removed. With the exception of having tumbled down as the cliffs were undermined and worn back by the sea, many of the boulders may still rest nearly in the positions they occupied in the clay, but (as is evidenced on the coast at Parkgate) others, up to a great diameter, may have been shifted horizontally. Some of the scars exist where the Boulder-clay would appear to have risen up into ridges or mounds, as no clay is now found opposite to them at the base of the sea-cliff. Others are clay and boulder plateaux, visibly connected with the cliff-line. Most of the scars, I believe, are remnants of the great Lower Brown Boulder-clay. The most conspicuous boulder in the scars S.W. of Bootle, is Eskdale-fell granite, accompanied by a little Criffell granite, and a great number of the usual felspathic erratics.

Drifts near Silecroft and Holborn Hill.—The Eskdale granitic drift near Silecroft suddenly bends round and runs up Whicham valley for some distance E. of the Parsonage. The S.W. end of Millom Hill (which chiefly consists of cleaved felspathic ashes, granular felstone and porphyry), presents the appearance of a beach strewn with many pebbles of granite and other rocks. Here I saw a *roche moutonnée* with its glaciated side towards the hill, but not in the line of any valley. On the adjacent plain there is much granitic drift. Its inland boundary bends eastwards to the N. of Holborn Hill, crosses the Duddon estuary, and re-appears on Dunnerholme Island, and near Soutergate. The boundary then runs S.S.E. by Great Urswick, a little N. of which I found a granitic boulder.[1] Pebbles of it (probably washed northwards along the sea-coast from its original boundary S. of Baycliff) may be seen near Bardsea. Between Millom Station and Millom Hill, the Upper Boulder-clay knolls apparently alternate horizontally with sand and gravel knolls, but the few sections visible justify the supposition that the two drifts thin out below or above one another in a manner indicating distinct periods of deposition. Between Millom Station and Silecroft, a similar dovetailing of drift-knolls may be recognized, and in one part of the railway-cutting the sand is interstratified with subordinate beds of clay, but not Boulder-clay.

Striated Limestone crossed by Drift-carriage.—About half-a-mile S. of Millom Station, a gently-swelling eminence, 75 feet above the sea, has lately been quarried, and the result has been the exposure of the most thoroughly, continuously, and extensively glaciated rock-surface I have yet anywhere seen (Nov., 1870). The grey limestone has been uniformly planed down, polished, and traversed by white grooves and striæ. The finer lines have been cleanly cut, but in many places the coarser striæ and grooves (the latter about $\frac{1}{8}$th of an inch in breadth) consist of a close succession of rough dints, as if small, sharp, angular quartz fragments had been made to roll over, or as if the floating ice which held the fragments had vibrated after suddenly grounding (?). One might suppose that the polishing of the rock and the microscopic lines were produced by land-ice, were it not that the latter cross each other at nearly all angles.

[1] The boundary in Furness, and in many places further North and South, must have been more or less deeply submerged, and one cannot long trace drift-boundaries without having to abandon the notion that they must always have been marked by dry land, or that dry land necessarily existed where there are driftless areas.

Most of the lines visible to the naked eye point N.E. or obliquely across the valley of the Duddon. Most of the few strongly-marked grooves run between N. and N. 35° E., or approximately in the main direction of the Duddon valley. The ramifying rough crevices in the limestone would appear to have existed before the glaciation occurred. They are partly filled with sand and fine gravel, which may belong to the Middle Drift period, and which may have once covered the whole rock-surface, and furnished the ice with grinding material. If so, its removal by the ice must have been followed by the accumulation of the Upper (?) Red Boulder-clay which covered the glaciated rock-surface, and still covers it where quarrying operations have not extended. But this clay did not result from the grinding up of the limestone, for (according to an analysis made by Mr. Heywood, of Millom) it contains silica 62·97, and alumina, 17·50 per cent. Nearly all, if not all the stones and boulders in this clay, have come from directions which cross the grooves and striæ (a few of the microscopic lines excepted), and the main direction of the ice-marks (N.E.) is nearly at right angles to the main direction of the drift-carriage (N.N.W.). The glaciating agent, therefore, could not have been the carrying agent, though it may have been of the same nature. The boulders are chiefly Eskdale granite and Eskdale or Wastdale granilite, granular felstone apparently from Wastdale, etc. The existence of the striæ under a covering of Boulder-clay furnishes an illustration of one of the fundamental principles of geology, namely, that the sea preserves the most delicate marks on rocks in *areas of deposition*, a principle which Mr. de Rance overlooked when he asserted that the *roche moutonnée* at Grange Bridge could never have been touched by the sea (Geol. Mag., March, 1871).

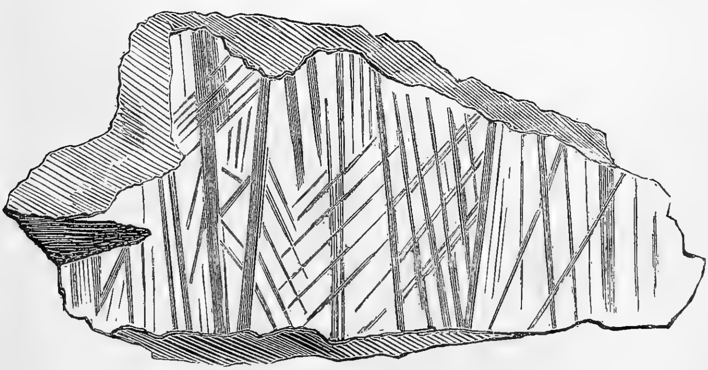


Fig. 7.—Glaciated Block of Limestone from the Rock-surface of a Quarry near Millom. Scale, one-fifth of original.

Limestone Sculptured by the Sea.—Not far from the above quarry, at Hodbarrow Point, the pebbles and boulders of the red clay are used by sea-waves to hollow out the originally rough and uneven surface of limestone strata, and the effect produced is a perfect facsimile of many of the smoothly sculptured rocks one may see in all limestone districts, where the irregularly pitting and roughening action of rain-water and frost has not obliterated the evidently ground-out basins and channels. On the hill-slopes between Silverdale Station and Yealand, and in many other places around Morecambe Bay, the Silurian grit pebbles may still be found in the hollows they once ground out. Under drift the sculptured limestone surfaces often become decomposed, while in the open air, in situations where rain-water innocuously runs off, they have remained nearly intact.

Valley of the Duddon.—Beyond the northern boundary of the granitic drift stream above described, and on the way to Thwaites, there are immense boulders of felspathic breccia, ashes, and porphyry. W. of Green the striæ run E. 30° N. I have elsewhere noticed the great pinel knoll near Green. About Thwaites there are many knolls and slope-coverings of pinel, with boulders up to eight feet in average diameter. Here, and all along the W. side of the Duddon estuary, there is much green, grey, and blue porphyry, *in situ,* along with ribboned or banded felspathic slag, felspathic breccia and felspathic ashes; and a tributary ice-laden current may have carried boulders of these rocks into the great drift-current already mentioned. Between Thwaites and Duddon Bridge there are numerous *roches moutonnées* on the slope rising from the W. side of the flat bottom of the Duddon valley, and among them we have the old story repeated, namely, the obliquely-upward glaciation of rocks *from* and *not along* the valley. The transverse configuration of the ground shows that (in many instances at least) the glaciation did not result from lateral grinding exerted by a valley-glacier, and it is worthy of remark that the direction of this glaciation approximately corresponds with the striæ W. of Green and at Millom quarry. The eastern slope of the upper valley of the Duddon is covered with a succession of gently-swelling knolls (with rocky nuclei) of pinel, and overlying loam, both containing large boulders. In many places there are *roches moutonnées,* with parallel undulations or wide ‿-shaped grooves (as well as minute striæ), pointing N.N.E. or nearly in the direction of the valley. But the great wonder of the Duddon valley is the

Lateral Moraine near Seathwaite.—On walking along the road near Seathwaite Church, in company with the Rev. F. A. Malleson, of Broughton-in-Furness, and Mr. Postlethwaite, a neighbouring squire, I was almost astounded at the appearance presented by what at first looked like a black causeway of large blocks thrown down in haste by a pre-historic race of giants, and I could not believe that the spectacle was natural, until Mr. Postlethwaite assured me that it was so. It runs along the grass-covered (and apparently drift-covered) slope which rises gently from the east side of the valley to the ridge called Walna Scar. There are no rocky scarps above from which the blocks could have tumbled down. They are nearly all quite angular, and are rudely congregated, often piled on one another, within a well-defined zone, a few scores of yards in breadth, and about two miles in length. At the northern end this post-marine lateral moraine (for such evidently it is) rises up to about 300 feet above the bottom of the valley. At the lower end it descends nearly to the bottom of the valley. N. of it, and at a higher level, there are numerous rocky scarps from which a shallow glacier may have collected the blocks. But they may have been partly derived from the tributary glacier which once evidently came down through Seathwaite tarn cwm, which left many perched blocks on the platform in front of the cwm, and finally deposited the small irregular moraine which, with solid rock at intervals, dams back the water of the tarn.

Notes on the Drifts of Furness.—I have described these drifts in the Quart. Journ. Geol. Soc. vol. xxv., and would here very briefly state the results of a second series of observations. The greatest masses of yellowish-brown pinel I have yet encountered are near Lindal, at a height of about 300 feet above the sea. They reach a thickness of about 120 feet, and, at a lower level, a still greater thickness is said to have been proved. It resembles the pinel which runs under the sea on the E. coast of Furness, and is evidently on the same horizon with the Lower stony Boulder-clay of Blackpool. In Furness we find what may be called the central and maximum development of this formation, and it graduates northwards into the pinel of the Coniston Old Man (which, on the Walna Scar road, rises to a height of at least 1200 feet above the sea), and southwards into the more sedimentary Lower Boulder-clay of Lancashire. In no part of the N.W. of England, so far as I have seen, is there any appearance of a line of demarcation between the pinel of the hill-slopes and the adjacent recesses and valleys, and the Lower Boulder-clay of the plains. The erratic boulders in the pinel at Lindal, Ulverstone Railway Station, the sea-coast near Bardsea, etc., would appear to have come in straight or curved lines from Millom Hill, and the slopes thence stretching Northwards to Duddon Bridge.

Dispersion around Hill-bases and up Valleys.—Beaches of pinel curve round the small hills and run up the small valleys N. and N.N.E. of Ulverstone. Most of the imbedded boulders are local, but a few, consisting of porphyry, would appear to have come from the W. side of the Duddon valley. It is difficult to conceive of their having come in a straight line over the elevated intervening hilly district, and no similar erratics, so far as I am aware, are to be found on the higher plateaux or passes of this district. We may, therefore, infer that these boulders were floated round by way of Ireleth, stranded on the jutting sea shores near Ulverstone, and carried up the small valleys by ice-laden flow-tides or wind-currents. But the lateral or *up-valley* dispersion of portions of drift diverted from the borders of great ice-laden currents has been a common and not merely an exceptional occurrence in the N.W. of England.[1]

[1] In E. Lancashire, along the boundary of the great North-western drift, boulders have found their way into valleys lying at nearly right angles to the general course of the drift. Far up in the narrow valley called Swineshaw, near Staley Bridge, there are many stones of Eskdale granite and Wastdale granilite which reach a height of 900 feet above the sea. They are associated with stones which must have come from various points of the compass.

From Greenod to Newby Bridge.—At Greenod, on the west side of a tidal channel, we may see a miniature illustration of the fact, that when angular fragments get imbedded in loam or clay, they soon lose all chance of ever becoming rounded,—a fact of much importance in speculating on the origin of hill-side drifts. In Haverthwaite Schoolyard a boss of rock has been glaciated from E. 30° N. Near Newby Bridge Cottages, the slate rock in the railway cutting is polished and striated between N. 40° E. and N. 60° E. Farther north, at the foot of Windermere Lake,[1] the striæ run N. 20° E. The glaciated surface is covered with well-rounded gravel and sand, and a little pinel fills up the underlying rough cavities. The drift here swells out into great knolls, which rise at least 100 feet above the level of the river.

Around Silverdale, Burton, and Milnthorpe.—Near Silverdale Station the limestone has been striated from the N. Between here and Yealand, more or less rounded limestone boulders may be found in positions where they might easily be launched, as many of their fellows probably were, by coast-ice. But the most wonderful array of limestone boulders, some of them 15 feet in average diameter, may be seen on the south side of Farlton Knott, near Burton. On walking from Burton to Heversham, I unexpectedly met with a great number of boulders of Shapfell granite, one of them $4 \times 3\frac{1}{2} \times 2\frac{1}{2}$ feet. They are abundant at and near Whasset, and all round Milnthorpe, but I saw only one pebble of this granite farther E. than the neighbourhood of Whasset.[2] The granite has come from about E. 15° N. or from Wasdale Crag, and I think it must be something more than a coincidence that this is nearly the general direction of the truly remarkable

Parallel Drift-ridges S.E. of Kendal.—The N.N.E. direction of these ridges (which are well represented on the shaded Ordnance Map) not only points to Wasdale Crag and the neighbourhood, but across a series of notches on the intervening crest of Whinfell Beacon and Greyrigg Forest (1544 and 1619 feet above the sea). On the watershed between Kendal and Low Gill, many of the ridges point in various directions, and this is the case with most of the ridges in the neighbourhood of the River Lune. At the mouths of Long Sleddale and Bannisdale (where Shapfell boulders have been found) most, though not all of the ridges point approximately N. and S. Over a considerable area S.E. of Kendal, and further S.

[1] I may here remark, in answer to Mr. de Rance, that while in Bowness and the neighbourhood, I ascertained from various persons, who were thoroughly acquainted with all the ins and outs of the lake, that none of the detritus or sediment brought in by the Brathay river can find its way through the lake to the lower end, and thence to the sea; and one reason assigned was that the currents generated by wind, etc. (which often reach a great depth, as proved by net sinking), more frequently flow from the S. or up the lake, than from the N. Lacustrine deposits, which have all resulted from the action of fresh-water, afford the only true measure of subaërial degradation since the Glacial period.

[2] I never saw any Shapfell granite farther S. than the road between Yealand and Silverdale. Professor Phillips mentions its occurrence in a canal S. of Lancaster. Within the area of the great North-western drift, farther south, a certain kind of Dalbeattie (Criffell) granite might be easily mistaken for Shapfell.

than Milnthorpe, the ridges are wonderfully parallel, and point, as already stated, N.N.E. It is certain that many of these ridges have rocky nuclei, and that many at least of these nuclei ran in the above direction before the Drift period is probable from its near coincidence with the larger axes of Benson Knott (1035 feet), New Hutton ridge (1097 feet), etc. The parallel drift-ridges vary in height from 20 to 30 feet near Burton Railway Station to more than 100 feet near Milnthorpe, and in the area where their parallelism is best defined between Farlton Knott and Oxenholme. As a general rule, the more northerly ridges consist chiefly of Boulder-clay, which (as between Oxenholme and Low Gill) rests on alternately jagged and glaciated rock-surfaces, but their shape has been completed, and their final direction given by an addition of gravel and sand. About Oxenholme Station, a great part, if not the whole, of some of the ridges is made up of stratified gravel and sand, and this remark applies more or less to the ridges further E. and S. The gravel in many instances is well rounded, in others subangular. Between Milnthorpe, Burton, and Carnforth, where I have more particularly examined them, the ridges, so far as can be seen, are all sand and gravel, with subordinate beds of red loam or loamy clay. I have been assured that, near Milnthorpe, the ridges, at some depth beneath the surface, contain a great thickness of sand. The low oblong knolls rising out of the peaty and marshy flat stretching W. and S. from Burton Station are of the same character as those which rise to a greater height in the neighbourhood. The hollows around these knolls were probably once occupied by a lake which gradually became filled up until conditions favourable to the growth of peat originated. But the knolls are distinct in shape, composition, position, and magnitude, from any deposits to which a small (or even a large) lake could ever have given rise, and are evidently a low-lying con-

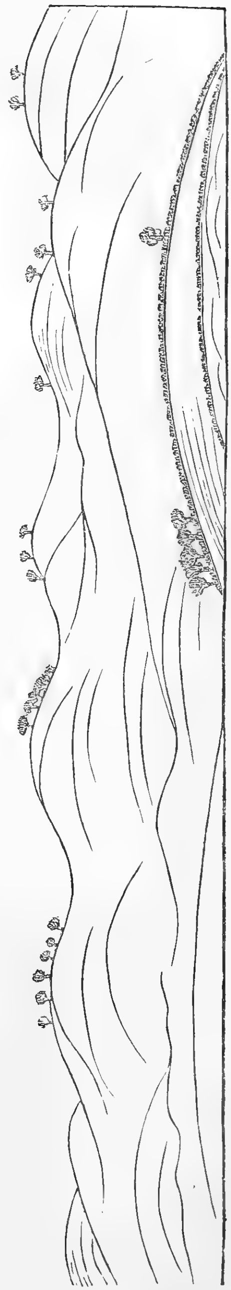


Fig. 8.—Parallel Drift-ridges, looking N.N.E. from the Railway Bridge, northwest of Holme.

tinuation of the sand and gravel ridges further north, and the Carnforth sand and gravel knolls further south.

The ridges under consideration are, generally speaking, not *linearly* parallel. In the same line an oblong hollow is succeeded by an oblong eminence, as if the eminence had been partly formed by the abstraction of matter from the hollow, but this may not necessarily have been the case. Most of the stones and boulders as far S. as Yealand have come from about N.N.E., and consist chiefly of upper Silurian grit or mudstone, and some porphyry, breccia, and dark felstone (from near Wasdale Crag, ?). At Carnforth, further S., the stones and boulders are nearly all limestone, which likewise probably came approximately from the N.

From these facts it may be inferred that the ridges may possibly represent three periods—the period when the rocky nuclei were formed by denudation—the period when the Boulder-clay was arrested by these nuclei—and the period when the sand and gravel which partly or entirely compose the ridges were deposited. However this may be, it may, I think, safely be asserted that *the present aspect and parallelism of the ridges* is due to the agency which deposited the sand and gravel, or to marine currents with or without floating ice; and this view of their formation may be applied to the curved parallel ridges which ramify like a fan from the neighbourhood of Wasdale Crag, and which have probably been finally shaped by the current that distributed the granitic boulders.

Southerly Extension of the Great N. Western Drift.—The Wasdale Crag and Carnforth[1] drift-stream would appear to have nearly, if not altogether, terminated a little S. of Lancaster. Some distance further S. the ground was monopolized by the great drift stream from the N.W., already described. This stream may have received some slight contributions from the N.N.E. stream. Among the boulders exhibited in Peel Park, Salford (nearly all of which were found in the neighbourhood), I detected many old Cumberland acquaintances. The following is a rough estimate of the relative per-centage of the larger boulders, which I made with the assistance of Mr. Plant, F.G.S.:—Felspathic trap running into porphyry and breccia, 50; Silurian grit (apparently from Furness) and local sandstone, 30; Eskdale fell granite, 19; Criffell granite, 1;=100. To the east of Manchester I have seen no Criffell granite. At Snape Green brickyard, near Southport, the Criffell seemed to preponderate over Eskdale granite. (For further remarks on the southerly extension of the north-western drift see explanation accompanying the Map, p. 312.)

General Results.—From the facts stated in the eight articles I have written on the Drifts of the N.W. of England,[2] I think it may be

[1] The finest sections of sand and gravel I have yet seen are at the Carnforth Railway Station, and on the Canal side. At the latter place there is gravel above and below, and sand in the middle. At the village, a great deposit of sand contains enormous limestone boulders, one of them $9\frac{1}{2} \times 9\frac{1}{2} \times 5$ feet. In addition to limestone, in the Carnforth drifts, there are Silurian grits and volcanic rocks from about N.N.E., and Carboniferous grits, etc., from the N.E.

[2] Geol. Mag., August, October, December, 1870, and February, June, and July, 1871; Proceed. W. Riding Geol. Soc., 1870; Quart. Journ. Geol. Soc. vol. xxv.

inferred that land-ice may have planed, smoothed, polished, and striated rock-surfaces, and pushed loose débris forward to the nearest protected situations, but that rounded, smoothed, and polished boulders must have been chiefly shaped by floating-ice and sea-waves,[1]—that floating or ground ice glaciated a great part of the Lake-district; that the four drifts were deposited by the sea and floating-ice, though more or less of the clay and loam composing them may have originated as subglacial mud; that the blue clay was accumulated

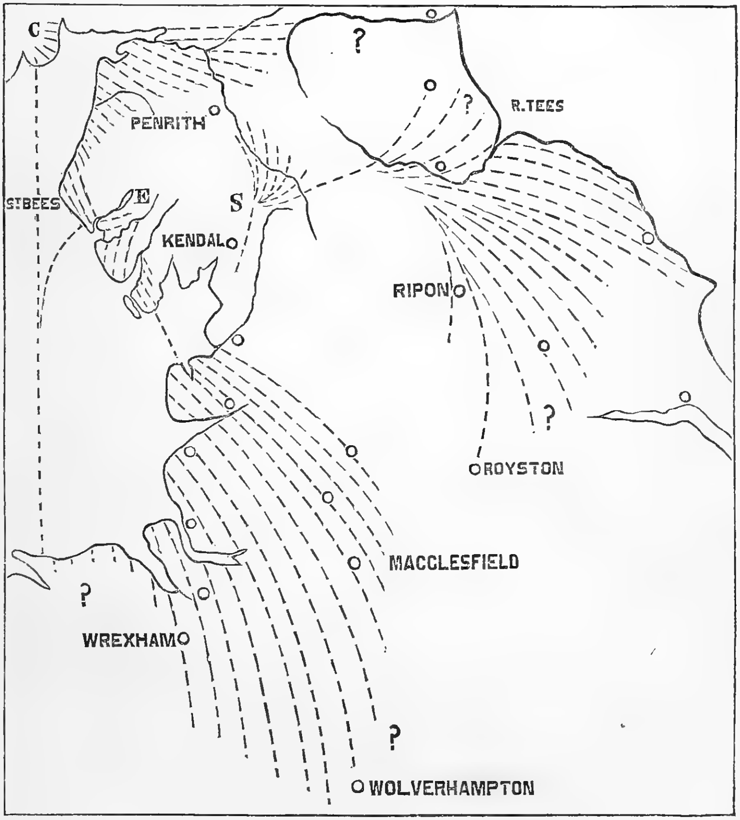


Fig. 9.—Map of the Three Great Granitic Dispersions in South Britain. (Explanation on page 312.)

under a comparatively shallow sea, and denuded (if not upheaved and again depressed), before it was overlaid by the pinel or Lower Brown Boulder-clay; that the middle sand and gravel were accumulated during the gradual *rise*, and not during the fall of the land, as Mr. de Rance believes; that the Upper Boulder-clay of the

[1] According to Forbes no *actual* glacier is capable of smoothing or polishing boulders, though by means of a gritty base it may smooth and polish rock-surfaces.

plains, which I believe to be equivalent to the foxy-coloured loam of the mountains, was deposited (in many places on the extensively denuded surface of the middle drift) during a succeeding submergence, the vertical extent of which was at the very least 1300 feet; that after the land again rose, glaciers lingered in the inner and upper valleys and cwms of the Lake-district, but that they did not reach a great length, or leave many extensive moraines; that during a great part (though not the whole) of the Glacial period in the Lake-district and W. Yorkshire, the conditions were similar to those now prevailing in nearly the same latitude, in the Baltic Sea, and in the Atlantic off the coast of Labrador.

Map of the Three Great Granitic Dispersions in South Britain.—C, E, S, the sources of the Criffell, Eskdale, and Shapfell (Wasdale Crag) Dispersions. The left hand finely dotted line represents the possible western boundary of the Criffell and Eskdale drift. According to Curry, the Criffell drift extends further eastwards than I have mapped it. According to Buckland, the Shapfell drift ramifies (as represented) to the neighbourhood of Durham. Green is my authority for the Shap boulder at Royston. I found granite near Longridge (a few miles N.E. of Preston), at Rochdale, the upper reservoir, Swineshaw valley, and at Stockport. Many boulders of granite have been found by Mr. Sainter at Macclesfield. Granite has found its way to an altitude of more than 1100 feet on Holcombe Hill, north of Manchester (Mr. Eccles). It has been discovered by Dr. Alexander at Mitholmroyd, east of Todmorden, and by Mr. Green in the Wye Valley, Derbyshire. These straggling dispersions are not included in the map. Trimmer has found stones of granite decreasing in size and numbers from Chester to Conway. Ramsay thinks that the foreign drift of Anglesey came from the N.N.E., so that the western boundary of the granitic drift in the map may not represent the extreme limit of the dispersion. I have traced the western boundary from near Pentre Halkin, Flintshire, to Padeswood Station, near Mold, and a short distance to the west of Wrexham. There are many large boulders of granite at Farndon, eight miles south of Chester. They are chiefly Eskdale granite. though Criffell is not altogether absent. Five out of six of them are intensely glaciated, whereas in Eskdale not one out of six can be said to be well glaciated. Between Wolverhampton and Bridgenorth there are numerous boulders and angular blocks of granite, some of which are four feet in average diameter.

V.—Description of the Recently Discovered Caverns at Stainton.

By Alan Grant Cameron, Esq.,
of H. M. Geological Survey of England and Wales.

HAVING formed one of a party of sixteen, who have lately further explored the recently discovered caverns at Stainton, notices of which have appeared in the *Times* and other journals, I wish to furnish a few details of the exploration, which may possibly prove interesting. The caverns are in the Carboniferous Limestone formation, and situated at a point one mile and a quarter south-east of the Dalton station of the Furness Railway, Lancashire.

The rock is being very extensively quarried there, and the entrance to the caverns is in the east side of the quarry, about the 250 contour line, and some 50feet from the bottom of the quarry. It is said to have been long known as a "fox-hole." This aperture leads into a gallery 235 yards in length, running a little north of east, and at an easy slope. Several short, blind galleries branch off from either side; one rather longer gallery, however, re-opening into the main one, after forming a sharp curve. The floor of the latter resembles in most places the bed of a dry mountain torrent, being thickly strewn with water-worn peebles and boulders. Soft yellow clay occurs frequently, also gravel; whilst again in other places there is a pavement of hard, dry clay, split up by cracks into octagonal-shaped masses. Lying on this pavement were a few small bones, probably a badger's. A stalagmite floor has once covered the present one, traces of which are to be seen in a narrow ledge of a few inches remaining on either side. In this gallery are also Silurian boulders, often cemented together in huge masses. A few of these boulders are of a larger size than to have allowed of their entrance through the as yet only known inlet to the place. Ireleth, distant about four miles and a half, is the nearest point at which the rock, of which these boulders are composed, is found in place.

The gallery is so narrow at one or two spots as to admit of progress being made only by lying face downwards, and, so to speak, wriggling through. At these very narrow points a notch occurs, requiring a drop of five or six feet, when the passage is again continued at the lower level. Boulders and fragments of rock are often met with, thrown against each other in the direst confusion, as if impelled along by a very strong current, and suddenly stopped. The 235 yard gallery terminates at the brink of a huge cavity, similar in shape to a swallow hole, but possessing a dome-shaped roof. The distance between roof and bottom might be 100 feet. The walls bear indications of having at one time confined a large body of water, which, revolving continuously and for a lengthened period within the limits of the cavity, has cut its way into the rock, and marked its course by circular lines.

Near the bottom of this cavity, and lodged against its sides, and against each other, are two large masses of Limestone, the larger weighing probably twenty tons. They have no support but that just indicated, and contribute not a little to the danger which attends a descent into the cavern, which it may be as well to state was effected in the present instance by means of a rope, secured at the termination of the gallery, and used as a kind of railing to facilitate progress down the clay-covered precipitous side of the cavity.

At the bottom of the cavity is a narrow opening, forming a shelving wall ten feet deep, terminating in a ledge, at the brink of a second cavity, the bottom of which, thirty feet lower, was reached by ropes in a manner similar to the first descent. From the bottom is again another short gallery, opening into a third cavity 50 feet by 30 feet, from which still another gallery branches off. Here the explorations were brought to a close, as this lowest gallery was found to be blocked by a mass of Drift after a very short distance. A stream of running water occurs here, as also a seam of iron-ore. Stones were dropped through a narrow opening in the Drift, and were heard to fall into apparently deep water.

Though the district of Furness is exceeding rich in both natural and artificial beauties, the caverns at Stainton must claim the first place in natural curiosities, and will, before long, in the event of a few of the more dangerous and difficult obstacles to investigators being removed, become one of the first attractions which bring so many thousand tourists to this part of England every summer.

VI.—The Relation of the Red to the Norwich Crag.

By J. E. Taylor, Esq.

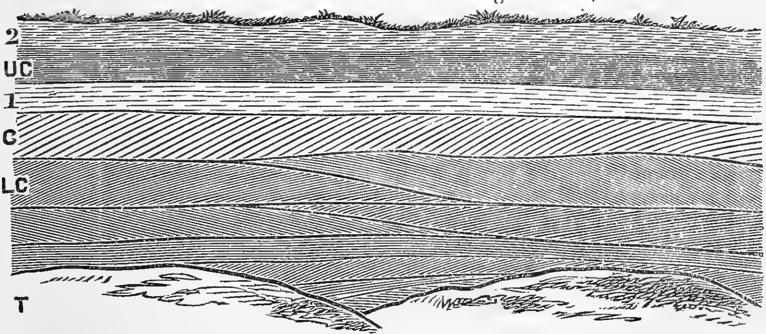
PERHAPS no question in English Pliocene geology has caused so much inquiry as the exact relation of the Red and Norwich Crags. The latter term I prefer as more palæontologically correct than the older one of "Mammaliferous," and it is now becoming generally used. In the year 1865 I divided the Norwich Crag into two divisions, an Upper and a Lower, and endeavoured to show that the latter was the true Fluvio-marine Crag, the former being distinguished by its purely marine character, and also by its containing a larger per-centage of Northern shells. This Upper Crag was subsequently termed the "Chillesford Crag" by Mr. Searles Wood, and by this name it is usually known. In my paper above mentioned my purpose was to show that this *Upper* or "Chillesford Crag" connected the latest of the older crags with the lower Drift-beds. The Fluvio-marine beds were formed along the floor of an estuary, but the Upper Crag was deposited along the sea-bottom, when the same area had been depressed. As a consequence, this Crag had a wider and more extensive geographical development. I was unaware at this time that Mr. Searles Wood was working at the same subject; and I subsequently found that he, with his usual indefatigability, had arrived at a similar conclusion respecting the Upper bed of Norwich Crag.

The marked presence of increased numbers of Arctic shells in this stratum, and the general absence of fluviatile and land shells, enabled Eastern Counties geologists soon to detect its actual extension. The shell-bed which had, at some distance from Norwich, always gone by the name of "Mammaliferous Crag," was in reality this Upper bed. In this way it was recognized at Horstead, beyond Norwich, and as far south as Chillesford, in Suffolk. A simple reference to the map will show what a very extensive geographical area is maintained by this important stratum.

Recently it was held by Mr. Searles Wood, sen., that the Fluvio-marine crag of Norwich was nothing more than an extension of the Red Crag, and of the same age. With this view I am perfectly agreed. The difficulty had long been felt of placing the Norwich Crag in a stratigraphical position. So recently as 1868, when Mr. Prestwich contributed the first of his able memoirs, "On the Structure of the Crag-beds of Norfolk and Suffolk," he stated that the distinction between the Mammaliferous (or Norwich) and Red Crags was purely palæontological, and that not a single case of superposition had been discovered. As regards the true Fluvio-marine Crag, this is still the case, and, on Mr. Searles Wood's theory of its being an extension of the Red Crag, is just what we should expect. At the same time, the anomaly has puzzled many geologists of the so-called Norwich, and *mis-called* "Mammaliferous"-Crag, having such an extension even in Red Crag districts. Only recently, in a paper read before the Geologists' Association, and published in the Geol. Mag. for June last, No. 84, p. 256, the Messrs. Bell, who have worked the organic remains of these beds in an admirable manner, stated that, from palæontological and other evidence, they concluded that the upper portions of the Red Crag ought to be associated with the "Mammaliferous" Crag. A little ambiguity arises here from not distinguishing the bipartite division of the "Mammaliferous" or Norwich Crag.

A few weeks ago, whilst on a visit to my friend Mr. Packard, of Ipswich, I had the opportunity of going over the "debatable" ground once more, and of adding to my notes on this important subject. The result has been that I have arrived at a conclusion which, to me, seems the only one which can finally settle this controverted matter.

Section of the Red and Chillesford Crags at Butley.



1 and 2. Chillesford Clay. U.C. Upper Crag. C. Crag. L.C. Lower Crag. T. Talus.

In the famous section in the stackyard at Chillesford, as well as in other pits in the neighbourhood, notably one at the "Neutral Farm" at Butley, the lower beds seem to be composed of Red and Norwich Crag shells almost equally. The Butley section is about twenty feet high, and displays this peculiarity even more than at Chillesford. The lower portion of the Crag here is seen to be very greatly comminuted, and deposited in strong lines of false bedding. Both these facts indicate shallowish water action. The same phenomenon is visible in the lower portions of the section at Chillesford, and elsewhere. At all the sections in this neighbourhood we find the strata becoming more regularly deposited towards the top, and freer from signs of current action. Not only so, but in these beds we have a marked *absence* of Red Crag shells, and a thorough Upper Norwich, or "Chillesford" facies.

Mr. Prestwich and other writers have drawn attention to the fact that the greater part of the Coralline Crag was ground up and redeposited during the subsequent Red Crag period. In like manner, I fully believe that when the submergence took place which brought the sea over the previous site of the Fluvio-marine Crag, as well as over the Red Crag, the latter was also taken up and re-deposited. This accounts for the extreme comminution of the shells in the lower parts of the sections above mentioned, and also for the strong evidences of false current bedding. Only the stronger shells, such as *Pectunculus glycimeris, Fusus contrarius,* etc., could survive this wear and tear, and these are the common Red Crag shells met with. At the same time they are associated with undoubtedly Norwich Crag forms, such as *Mya truncata, M. arenaria, Tellina obliqua, T. pretenuis, Buccinum undatum, Purpura lapillus, Littorina littorea,* etc. These lived in the sea where the Red Crag was being re-deposited, and their remains thus became admixed with those of a former period. Many of the shells last mentioned are more or less fragile, and show that they could not have been subjected to the same violence as their previously deposited associates. Of course the greatest amount of re-deposition would be seen in the lower beds, and the least in the upper, which is exactly the case inall these sections.

In conclusion, it seems to me clear that the old "Mammaliferous," or Norwich Fluvio-marine Crag, was a north-easterly extension of the Red Crag. When the depression of the area took place, there was formed along it the Upper Norwich or "Chillesford" Crag. Between this and the Fluvio-marine beds, strata of sand were thrown down and intercalated. But in Suffolk, where the Red Crag reached such an enormous thickness, its upper portions were taken up and re-deposited in false current bedded layers, where the stronger fossils became mixed with the shells of the later period. Hence in such areas this comminuted Red Crag, whose Norwich Crag forms have given such trouble, is really the work of the sea where the Chillesford beds were accumulated. At Sudbourne Church walks we find this Upper Crag reposing on the Coralline Crag, and the same phenomenon is visible in the railway cuttings near Aldborough Station, where it rests in a denuded hollow of Coralline Crag. I submit these views to Crag geologists, with the hope that they may assist in interpreting a perplexing phenomenon. If they are correct, then we have, in the Eastern Counties, a perfectly marked and unbroken sequence from the Coralline Crag up to the latest Drift deposit.

NOTICES OF MEMOIRS.

I.—On the Flotation of Sand by the Rising Tide in a Tidal Estuary.

By Professor Hennessy, F.R.S., Vice-President of the Academy.
(Read before the Royal Irish Academy, April 10, 1871.)

DURING the course of a tour along our western coast, in the summer of 1868, the following incident came under my notice; and, although I made a note of the facts at the time, I have never hitherto made them the subject of a scientific communication:—

On July 26, when approaching the strand at the river below the village of Newport, County Mayo, I noticed what appeared to be extensive streaks of scum floating on the surface of the water. As it was my intention to bathe, I was somewhat dissatisfied with the appearance of the water, until I stood on the edge of the strand, and I then perceived that what was apparently scum, seen from a distance, consisted of innumerable particles of sand, flat flakes of broken shells, and the other small débris which formed the surface of the gently-sloping shore of the river. The sand varied from the smallest size visible to the eye up to little pebbles, nearly as broad and a little thicker than a fourpenny piece. Hundreds of such little pebbles were afloat around me, and it is probable that the flakes of floating matter seen farther off contained also a considerable proportion. The air during the whole morning was perfectly calm, and the sky cloudless, so that, although it was only half-past nine, the sun had been shining brightly for some hours on the exposed beach. The upper surface of each of the little pebbles was perfectly dry, and the groups which they formed were slightly depressed in curved hollows of the liquid.

The tide was rapidly rising, and, owing to the narrowness of the channel at the point where I made my observations, the sheets of floating sand were swiftly drifting farther up the river into brackish and fresh water. On closely watching the rising tide at the edge of the strand, I noticed that the particles of sand, shells, and small flat pebbles, which had become perfectly dry and sensibly warm under the rays of the sun, were gently uplifted by the calm, steadily-rising water, and then floated as readily as chips or straws. I collected a few specimens of these little objects, but I regret that they have been since mislaid. This phenomenon, it is scarcely necessary to say, is due to molecular action, such as accompanies the familiar experiment of floating needles on the surface of a basin of water. Although the specific gravity of the floating objects exceeds that of the fluid on which they rest, the principle of Archimedes still holds good, because the displacement of liquid produced by the body is considerably greater than the volume of the body itself. In the case of a floating needle, the repulsion of the liquid from the polished surface of the metal presents a groove, whose magnitude is obviously many times greater than the needle; but in the case of the floating pebbles this was not so manifest. The specific gravity of needles made of fine hard steel may be taken at 7·9 nearly, while that of the little pebbles scarcely exceeds 2·6, so that other things being equal, the latter would require one-third of the displacement required by the former for perfect flotation. But, moreover, the small pebbles which I saw floating were always flat and thin, and rested with their broadest surface on the water. The attraction of the molecules of water for one another produces, as is well established, a tension at the surface of the liquid, which, although extremely feeble, and generally noticed only in connexion with capillary phenomena, yet interposes some resistance to the intrusion of foreign substances. This is seen in the experiment of floating broad spangles or sheets of dry gold-leaf on a vessel of water. When a piece of gold-leaf is held edgeways it sinks, and it also sinks if wetted. In fluids more viscid than water, such as lava or melted metals, flat pieces of the stone or solid metal are known to swim on their broad surfaces, while they sink when turned on their edges. I have recently made a few experiments on the flotation in water of small bodies of greater density than the liquid, and I find that needles have remained for days together floating. I have also easily floated sand, flat pieces of shells, and small pebbles for several days, and whenever they sank, it was due to some disturbance of the liquid sufficient to produce a wave on its surface. Mr. Alphonse Gages placed twenty-four needles on the surface of a large basin of water, and after a few hours they were found grouped in parallel parcels, varying in their contents from two to seven needles. They continued to float for more than five days, and their sinking was evidently due to the progress of oxidation, which destroyed their polish, together with their repulsive action on the liquid. I have floated small flat pebbles, similar in size and appearance to the largest of those observed floating on Newport river, for more than six days, while fragments of shells, and thin pieces of slate as broad as a sixpenny piece, have continued to float much longer. These little bodies occasionally sank from the gradual absorption of water, but much more frequently from some accidental motion of the vessel containing the liquid.

It is manifest that the flotation of sand in a tidal estuary, as in the instance I have seen, can occur only under favourable conditions. The shores must be very gently inclined, the air perfectly calm, and the weather dry and warm. Under these circumstances thin cakes or sheets of sand may not only be uplifted by the water, but if the tide flows rapidly they may continue afloat sufficiently long to allow many of them to be drifted far from their original place up to the higher limit of the brackish water. In this way fragments of marine shells and exuviæ might become mingled with those belonging to fresh water. The conditions favourable for sand flotation must exist during calm weather in a very high degree of perfection on the sandy shores of tidal rivers in tropical and subtropical districts of the earth. As this phenomenon can take place only with the rising tide, and never with the falling tide, the result must generally be favourable to the transport of sand and marine débris in the direction of the flow of flood tide; and this may sometimes hold good along a coast as well as on the shores of a tidal estuary. Geologists, as far as I am aware, have not hitherto noticed this phenomenon in connexion with the formation of stratified deposits by the agency of tides and rivers, although they have paid great attention to the influence of the molecular resistance of water to the sinking of very minute solid substances, with the view of explaining the wide surface over which matter held in suspension by water may be spread when ultimately deposited over the sea-bottom.[1]

[1] Since this paper was written, I have been informed by a lady, that she observed similar phenomena during a former summer, close to the sandy seashore at Youghal; and Dr. E. Percival Wright has stated that he has witnessed the realization of the results which are alluded to as likely to occur within the tropics.

II.—Geological Survey of Ireland.

1. Explanatory Memoir to accompany Sheets 104 and 113, with the adjoining portions of Sheets 103 and 122 (Kilkieran and Aran Sheets). By G. H. Kinahan, M.R.I.A., H. Leonard, M.R.I.A., and R. J. Cruise, M.R.I.A. 8vo. Dublin, 1871. pp. 92.

2. Explanatory Memoir to accompany Sheets 86, 87, 88, and Eastern part of 85. By G. H. Kinahan, M.R.I.A., and R. G. Symes, F.G.S.; with Palæontological Notes by W. H. Baily, F.L.S., F.G.S. 8vo. Dublin, 1871. pp. 63.

THE first Memoir is taken up with a description of the Aran Islands, and portions of the mainland of Galway contained in the maps enumerated. The mainland, which possesses no town, is intersected by numerous chains of lakes, bays, and creeks. The land is low, averaging from 200 to 500 feet in elevation. From the north-east shores of the Aran Islands the land rises in a series of cliffs or huge steps, which form continuous terraces; while from the summit of Inishmore, one of the islands, there is a gradual fall south-westward, ending at the sea-board, in cliffs now being formed by the Atlantic Ocean.

The formations met with include:—Bog and Alluvium, Glacial Deposits, Carboniferous Limestone, Granitic and Igneous Rocks. The Granites are of two classes, the intrusive, and those of apparently metamorphic origin.

The lithological character of these rocks is treated of at length; the authors then pass on to the relations between the form of the ground and its internal structure. The Aran Islands are composed of limestones, with thin shales and clay interstratified, and to the effects of denudation on them is due the terraced-form they now possess. In the metamorphic rock country are peaks and knolls composed of hornblende rock. The action of ice is very conspicuous in this district; a table of supposed ice striæ is given.

For convenience of description the area is divided into five sub-districts, and these are described in detail.

Of the drifts, there is a local boulder or moraine drift, consisting of a sandy or clayey mass, full of small and large fragments of local rock, often several tons in weight.

The Bogs are of two kinds, the low-lying, flat, or peat bogs, which are often of considerable depth, and the mountain bogs that frequently grow on steep slopes.

Some of the low bogs are most deceptive, being seemingly a solid surface, but having water or mud underneath; and, as they are clothed with vegetation in the spring, they are very dangerous to cattle. At this season, when grass is scarce, the cattle, and especially horses, are tempted to venture on them, when they go down bodily, and often only the heads of the horses remain uncovered. The authors think in this way to account for the skeletons of the *Megaceros Hibernicus* being so frequently found in small isolated bogs, and also for the fact of their skulls being found separate from the remainder of the skeleton.

There are some Notes on Mines and Mineral Localities, in which are noticed the spots where mining operations have taken place, and also the localities where lead, copper, and sulphur have been found.

2.—The second Memoir is occupied in the description of parts of the counties of Galway, Mayo, Roscommon, and Longford, situated between the towns of Ballinrobe and Longford. The country is gently undulating, with a good deal of bog on the east and west, and for the most part with bare crags in the centre. The outline of the eastern shore of Lough Mask (a part only of which is contained in the maps now described) presents a remarkable contrast to that of its western shore. For while the latter maintains a nearly even line, the eastern shore is indented by numerous bays and inlets, ranging in a N.N.E. direction, and running far into the heart of the limestone country, where they spread out into wide but shallow loughs. The general direction of these arms is shown to be parallel to the glacial striations of the district.

The formations represented are Alluvium, Peat Bog, etc.; Drift Gravel, Clay, and Boulders; Carboniferous Limestone, and Yellowish Grits and Conglomerates; Lower Silurian Rocks; and Felstone.

The Lower Silurian rocks, which consist of grits and slates, have yielded no fossils, but in all probability they are on the same geological horizon with the Silurian rocks of Cavan, Monaghan, and Armagh. The Yellowish Grits and Conglomerates rest on the denuded edges of the Lower Silurian beds, and in places they are seen to pass up into the Carboniferous Limestone. They are regarded by Mr. Symes as of Carboniferous age, an opinion in which Professor Hull concurs. Mr. Baily furnishes a list of fossils from the Carboniferous rocks of the area.

Separating the area into districts, the authors give a detailed description of each.

Three-fourths of it is covered with a thick mantle of Drift, which is divisible into Boulder-clay and Eskers. The Boulder-clay is for the most part of local origin.

The tortuous ridges of gravel called Eskers are composed of sand, gravel, and large boulders, running generally in a north-east and south-west direction. Tables of supposed ice striæ are given.

III.—Proceedings of the Bristol Naturalists' Society. Vol. 5. 1870.

PROMINENCE has been given to Geology in the papers read before the Bristol Naturalists' Society during the year 1870, and which are published in this the fifth volume of their Proceedings. These papers include the following:—

1. Temperature and Life in the Deep Sea, being some Account of the Deep-Sea Dredging Expedition in H.M.S. *Porcupine,* in the Summer of 1869. By W. L. Carpenter, B.Sc., B.A.

2. On some Evidence in favour of Subsidence in the South-west Counties of England during the Recent Period. By E. S. Claypole, B.Sc., B.A.—Referring to the peat-beds that exist in many places on our south-western coast, and particularly to those around Cornwall, Mr. Claypole pointed out their general arrangement as exemplified at Gyllyngvaes, Falmouth. Here the peat-bed overlies a very tenacious clay, and is covered by the ordinary shingle of the coast to such an extent that only at very low water is it exposed to view. Speaking of the plant remains of these peat-beds, he sees no ground for assuming that any of them belong to species even locally extinct. Their present position seems to him to indicate a subsidence of at least 42 feet, for they could hardly have been formed at a lower level than 20 feet above high-water mark. He considers the raised beaches to be of earlier date than the peat-beds, and that there is no evidence of upheaval since the growth of this vegetation.

3. The Quaternary Deposits of the Bristol Neighbourhood. By W. W. Stoddart, F.G.S., F.C.S.—The area to which Mr. Stoddart's remarks apply extends from Portishead and Falfield on the north, to Glastonbury and Bruton on the south. Its physical geography during the Quaternary period is shown on a small map accompanying the paper. During the Glacial period Mr. Stoddart thinks that the waters of what is now the Bristol Channel most likely reached the foot of the Mendip and Cotteswold Hills, and washed the sides of the innumerable islands that appeared above the waves, such as Glastonbury Tor, Dundry, Ashton, Clifton, etc., which then were completely isolated from the mainland. He then points out some of the subsequent changes, and the animals which flourished at the time, and are now found fossil in the caves. These caverns or fissures are considered by Mr. Stoddart as owing their origin to convulsions, when a "great volcanic outburst" formed the magnificent gorges of Clifton and Cheddar!

4. On the Igneous Rocks of Shropshire. By W. W. Stoddart, F.G.S., etc.

5. On Denudation. By C. F. Ravis.—The author pointed out some of the general effects of denudation in Somersetshire.

6. On the Structure of Rubies, Sapphires, Diamonds, and some other Minerals. By H. C. Sorby, F.R.S., and P. J. Butler. (From the Proceedings of the Royal Society, 1869.)

7. Notes on the Geology of Weymouth. By W. W. Stoddart, F.G.S., etc.

8. On Fossil Fish. By W. Sanders, F.R.S., F.G.S.—This was a continuation of the subject; the author described the characters of the Ganoid division of Fishes.

REVIEWS.

The Geology of Prussian-Silesia.[1]

THIS valuable work was prepared and published by direction of the Government of Prussia, who also appointed Dr. Roemer, Professor at the University of Breslau, as Superintendent of the Geological Survey of the Province of Silesia, so important as regards its mineral wealth. Dr. Roemer has shown himself admirably fitted for this task by completing, during the years 1862–69, a geological map (scale $\frac{1}{100,000}$), to which this book, with its numerous plates of fossils, sections, etc., etc., forms the key.

The author commences with the crystalline rocks, which appear only as a small zone at the western part of the section at Leobschütz, as *Gneiss*, *Mica-schists*, and *Granite*.

Gneiss occurs as a small zone between Würbenthal and Zuckmantel and Neisse, where it underlies Lower Devonian strata. Quartz-reefs, with insignificant indications of Copper-pyrites and Pecherz, also Malachite, and earthy Kupferlazur.

Mica-schists are limited to one locality near Ziegenhals.

Granite appears in dykes in a few localities, where it has burst through Mica-schists (as at Freiwaldau and Niklasdorf), or through Gneiss (as at Deutschwette and Ludwigsthal).

Sedimentary Rocks.—I. Palæozoic Group.

A. *Devonian formation on the Eastern slopes of the crystalline Altvater-mountains.*

1. *Würbenthal Quartzite and Clay-slate* (*Lower Devonian*) are characterized by white quartzite and black clay-slate, the latter with beds of crystalline limestone. The strata are raised up and much disturbed, striking from S. to N., and are overlain by "Engelsberg beds." They form a mountainous country, attaining heights of 3000 feet, and with deeply eroded valleys. In the map it is represented by a narrow zone between Neu-Vogelseifen and Ziegenhals, from whence it passes into Austrian-Silesia.

Eruptive Rocks.—Diorite and Diorite-schists are principally found within the Mica-schists, and occur only in one locality, at the Querberg in Quartzite. They form many of the highest points in the Lower Devonian formation; for instance, near Wiedergrün, Carlsbrunn, Engelsberg, etc., etc., in a N. and S. direction.

Ores.—Gold-bearing pyrites (iron and copper) occur not far from Zuckmantel in Austrian-Silesia. Small crystals of these pyrites occur in the Quartzites and Clay-slates, partly in true veins, partly only as traces diffused through the rock. At some places gold occurs in zinc-blende. Besides gold, magnetic-iron-ore, galena in connexion with zinc-blende, copper-pyrites, iron-pyrites are also found. Hæmatite is likewise worked to a great extent, but not in the Prussian portion of Silesia. Other minerals, as Cyanite, Staurolite, Garnet, Faserquartz, are obtained from the Lower Devonian Quartzites.

Near Würbenthal, in Austrian-Silesia, from whence the stratum was named, fossils were found in the white Quartzite, in all twelve species (p. 14), of which three (the only determinable ones) agree with species from the Lower Devonian formation near Coblenz-on-the-Rhine.

These beds must rest upon crystalline rocks, as Silurian strata are entirely wanting in Silesia.

2. *Engelsberg Grauwacke* rests upon the former bed, and consists of Grauwacke and Clay-slate, striking from N. to S., and dipping E. In the sandstone and slates cleavage can frequently be observed. It covers an area of 192 English square miles in Austrian-Silesia and Moravia. A few traces of fossils (p. 20) were found near Engelsberg. This system is overlain by

3. *The Bennisch beds*, consisting of grey sandstone, clay-slate, and quartz-conglomerate, with amygdaloid diabase and subordinate occurrences of limestone and iron-

[1] Geologie von Oberschlesien. Ein Erläuterung zu der im Auftrage des konigl. Preuss. Handels Ministeriums von dem Verfasser bearbeiteten Geologischen Karte von Oberschlesien in 12 Sektionen, etc., etc. Von Dr. Ferd. Roemer. Breslau, 1870. Royal 8vo., pp. 587. Mit Atlas Taf. 50, karten und profile.

ores. It occurs near Bennisch, eastwards of Frendenthal. Judging by the twelve species of fossils (p. 29), some of which occur also in Westphalia, and also from the stratigraphical position of these beds, it seems probable that they are equivalent to the Upper Devonian formation in Western Germany.

B. *The Devonian Formation West of the Jurassic Hills in Poland* forms small isolated cliffs in the surrounding Muschelkalk, but it is easily identified with the Devonian rocks of the Eifel in Western Germany, by a large number of well-preserved fossils (see pages 33 and 37).

C. *Carboniferous Formation.—A.* Lower group.

Culm.—This consists mostly of grey sandstone and clay-slate of a thickness of several thousand feet. Its strike is from N. to S., it dips East; the strata stand nearly vertical, resting conformably on the Devonian Formation.

It forms to the east and south of the crystalline Altvater, a hilly country, the Niedere Gesenke, of about 800 square miles in extent. The end of the Devonian and the beginning of the Culm formation is very difficult to determine, as the lithological character of the two is very persistent, namely, an alternating succession of Grauwacke and Clay-slates. A long list of fossils (page 54, *et seq.*) follows.

A comparison of the Culm strata of Upper Silesia with that of other countries shows its great resemblance to the Culm formation of the Upper Harz. In both districts sandstones and Clay-slates form the bulk of the formation, and land-plants and marine animals occur in association. Roemer comes to the conclusion that the Culm beds of Upper Silesia were not only synchronous with the upper strata of the Mountain Limestone, but that they represent the whole series of it.[1]

Mountain Limestone was only observed in the most south-eastern part of the Coal-basin of Upper Silesia, in Poland. Near Krzeszowice a considerable number of fossils were obtained (page 59), which identify the stratum as belonging to that formation.

B. Upper group. *Coal-measures.*

The Coal-basin of Upper Silesia and Poland is covered by deposits of Diluvium over nearly its whole area, out of which several isolated portions of the coal-bearing formation crop up. The most extensive of these Coal-measure islands is situated between Gleiwitz and Myslowitz. The Silesian Coal-basin is only part of the vast and extensive Coal-basin which reaches from Hultschin and Mährisch-Ostrau, in Austria, to Siewierz, in Poland, and again from Tenezynek, near Krzeszowice, beyond Gleiwitz. The whole area of this large basin (after the Westphalian basin, the largest on the Continent) amounts to about 1600 English square miles. The formation presents physically a low hilly country, which only in the south-western end of the basin reaches a height of about 1100 feet above the level of the Baltic Sea. Sandstone, of a coarse grain, with large pebbles of quartz and small particles of mica and ordinary Clay-slate, are the principal features of this formation. The latter contains often argillaceous Sphærosiderite, which is worked. The Coal-beds are found throughout the depth of the formation; some of these beds have a thickness of from 45 to 50 feet. The thickness of the whole beds is calculated to be 333 feet, whilst the production of coal in 1867 amounted to 92 millions of cwts. in the Prussian share of the basin.

Amongst the other minerals found in this formation we have Lowigite, Carolathin, Anthrakoxen, Galena, Schaalenblende, Schwerspath, Braunspath, etc., etc.

The stratification of the Coal-basin is almost horizontal, and only shows much disturbance near Mährisch-Ostrau in its south-western extremity.

Then follows a list of land-plants, one species of spider,[2] and 36 species of marine fossils, found in the Coal-measures of Silesia (page 78, *et seq.*).

A comparison of the character of the Silesian Coal-measures and the Fauna with that of other European Coal-basins gives the following results:—

1. That the Fauna of the Coal-measures has much affinity to that of the Mountain Limestone, although it possesses a peculiar character.

2. The remains of marine animals are most frequently met with in the lower strata of the formation.

3. The marine fossils in the Upper Silesian Coal-mines agree not only in the genera, but also in most of the species, with those of Coalbrook-dale, in England, of Chokier-

[1] It may be remarked here, that the Austrian geologists held this opinion long since; it is not, therefore, a novel suggestion.
[2] See Geol. Mag., 1865, Vol. II., p. 468, named by Römer *Protolycosa anthracophila.*

on-the-Maes, and of Werden-on-the-Ruhr, so that it is most likely that the same affinities exist also near the base of the Upper Silesian Coal-basin, which is not, however, known at present. It is, therefore, probable that the sandstones and shales, with thin Coal-beds, which have been found in great thickness below the fossiliferous strata in the shaft of Königshütte at a depth of 2006⅔ feet, do not belong to the true Coal-measures, but most likely correspond to the Millstone Grit of England. The occurrence of marine fossils would serve to determine the extension of Coal-beds downwards.

D. *Permian* (*Dyas*) *formation. Rothliegendes.*—The Limestone conglomerates of Czerna and Paczoltowice consist of pebbles of the Carboniferous series, with red and white sandstones imbedded in it, and fossil remains of *Araucarites Schrollianus.* These are conformably overlain by white Röth-Dolomite, with *Myophoria fallax.* Porphyritic tufa, with Quartz porphyry and Melaphyre and Amygdaloids at the top of the formation, whilst quartzose felspathic porphyry is met with at its base.

The Limestone of Karniowice (white and crystalline) rests on the Red Sandstones, and is covered with porphyritic tufa, which, again, is overlain by Röth-Dolomite, with *M. fallax.* The limestone contained five species of ferns and a fir-cone.

II. Mesozoic Group.—A. *Trias.*

1. The Bunter Sandstein forms only narrow zones at the base of the Muschelkalk, with an average thickness of 200 feet. Roemer distinguishes two horizons :

a. Lower Bunter-Sandstein, brownish-red shales, with sandstones, thickness about 150 feet.

b. Upper Bunter-Sandstein or Röth, red shales, with white Dolomite and marls, containing seventeen species of fossils, amongst them *M. fallax, Amm. Buchii,* etc.

2. The Muschelkalk forms a narrow ridge of hills, of about forty miles length, in Upper Silesia and Poland, which extends from Krappitz-on-the-Oder to Olkusz, in Poland.

3. *Lower Muschelkalk.—A. Equivalent of the Lower Wellenkalk.*

a. Cavernöser Kalk. This bed, only a few feet in thickness, of brown, grey, or reddish crystalline limestone, is full of small cavities, and rests conformably on Röth. It contains no fossils.

b. The Chorzow Beds have a thickness of 280 feet, and consist of a compact grey limestone. Hornstone occurs but seldom. Fossils are abundant (see page 135).

B. Equivalent of the Schaumkalk.

a. Blue "Solestone," thickness 15 feet, greyish-yellow limestone of knotty character, and greyish-red crystalline limestone, sometimes a reddish-white porous limestone. In this bed occurs the first Alpine fauna (see page 137).

b. Gorasdze strata, thickness 80 feet, consisting of a porous white limestone, alternating with a compact one. Hornstone is rare.

c. Encrinites and Terebratulæ Beds, thickness 15 feet. A compact grey limestone, consisting of Encrinites and *Terebratula vulgaris* in great numbers.

d. Mikultschütz strata, 70 to 90 feet in thickness. A yellowish or reddish compact, sometimes porous, limestone, with much hornstone. Numerous Alpine forms (page 140, *et seq.*).

e. Himmelwitz Dolomite, attains a thickness of 40 feet; is a grey or yellow Dolomite. (Fossils, page 143, *et seq.*)

4. *Middle Muschelkalk.* A white or yellowish marly Dolomite, of about 50 feet in thickness, without organic remains.

5. *Upper Muschelkalk, or Rybnaer Limestone,* and Dolomite, from 12 to 40 feet in thickness, with many fossil remains (page 146).

On comparing the Upper Silesian Muschelkalk with that of Western Germany, we find the greatest affinity to exist as regards their fossil remains; there, as well as in Silesia, the Alpine forms appear most frequently in the lower strata, as, for instance, *Rhynchonella decurtata, Terebratula angusta, Retzia trigonella, Encrinus gracilis,* etc., etc. Here also we see, as in Western Germany, the great development of the Lower Muschelkalk, and the thinning out of the middle and upper portion of it.

6. *Keuper.*—This formation covers in Upper Silesia and Poland more than 1600 square miles, with an average thickness of from 500 to 600 feet of rock; the area is

limited in the east by the Jurassic ridge of hills, which extends from Krakau northwards, and to the south and west by the above-mentioned Muschelkalk.

7. *Lettenkohle*, grey and red clay and shales, with brown Dolomite and green sandstone, with few organic remains (page 153). It rests conformably on the Upper Muschelkalk, and is again conformably overlain by

8. *The Middle Keuper*, which consists of reddish brown clay, with embedded white limestone, which contains hornstone. A conglomerate, with fishes and remains of saurians. A greyish-green sandstone with thin beds of coal. Total thickness, 200 to 300 feet. Very poor in fossils (page 162).

9. *Upper Keuper, or Rhætic Group.*

- *a. Wilmsdorfer Beds*, consisting of reddish and greyish-green clay and marl, with argillaceous Sphærosiderite, which contains land-plants (page 178). 60 to 80 feet in thickness.
- *b. Estheria Beds of Hellewald*, resting conformably on the former and consisting of thinly-stratified white sandstone, with mica and shales, sphærosiderite. *Estheria minuta* numerous. Thickness about 60 to 80 feet.

Both the geological structure, as well as most of the species, resemble the typical Keuper of Middle Germany, although not in lithological character, as the marls of Germany are mostly represented in Silesia by limestones.

B. *Jurassic Formation.*—This forms a long ridge of hills between Krakau and Czenstochau; with a few interruptions it extends to Wielun in a north-westerly direction. Beyond this place Jurassic rocks are found isolated in the surrounding Diluvium, as for instance near Kalisch, and even so far north-west as Thorn. Also in the East, on the banks of the Pilica, in Poland, we find a low ridge of hills, which extends South-west, between Kielce and Korytnica. In all, the Jurassic formation covers an area of about 5600 square miles, although it is at some places concealed by Drift.

The strata are very rarely highly elevated, in most cases they slope gently towards the east and north-east. The Jura rest unconformably on Keuper. The average thickness is about 500 feet.

Roemer distinguishes two great groups in the Jura of Silesia: a Lower group, consisting of dark-coloured sandy and argillaceous beds, forming a flat country, or only low hills; and an Upper group of white Limestones and Dolomites, forming mountainous and rugged country. The Lower group represents the brown Jura of Swabia (Dogger), whilst the Upper group resembles Quenstedt's White Jura (Malm). The Lias formation is nowhere developed in Silesia, which is in accordance with all the Jurassic deposits in Eastern Europe.

The subjoined Table gives the sub-divisions of the Jurassic series:—

GROUP.	STRATUM.	BEDS.	GENERAL CHARACTER, STRUCTURE.	EQUIVALENTS.
Quenstedt's White Jura (Malm).	9. Stratum of *Exogyra virgula.*		On the banks of the Pilica, etc., etc. Compact limestone, like the lithographic stone of Solenhofen. *E. virgula* in great numbers.	Kimmeridge beds.
	8. *Nerinea* limestone of Inwald.		Inwald and Roczyny, Galicia. Compact white limestone. Brachiopoda, Lamellibranchiata and Gasteropoda (Nerinæa). Cephalopoda disappear nearly.	Limestone of Plassen, near Hallstadt?
	7. Bed of *Rhynchonella Astieriana.*		Forms the North-eastern extremity of the Jurassic hills, between Pilica and Mstow. White compact limestones with hornstone. Great number of well preserved fossils.	White Jura, E. of Quenstedt. Zone of the *Cidaris florigemma*, Oppel, Upper Oxford.

GRP.	STRATUM.	BEDS.	GENERAL CHARACTER, STRUCTURE.	EQUIVALENTS.
QUENSTEDT'S WHITE JURA (Malm).	6. Bed of *Rhynchonella trilobata.* Upper-Felsen-kalk.		Between Krakau and Wielun. White Limestone, many hundred feet in thickness. *Ammonites polyplocus, Rhynchonella trilobata*, etc., etc.	Lower calcareous grit. —— *Scyphia*, limestone of Swabia.
	5. Bed of *Rhynchonella lacunosa.* Lower-Felsen-kalk.		Between Krakau and Wielun, thickness 150 feet. Porous light grey Limestones. *Rhynchonella lacunosa*, great number of *Planulatæ.*	*Scyphia*, limestone of Swabia.
QUENSTEDT'S BROWN JURA (Dogger).	4. Bed of *Ammonites cordatus (A. Arduennensis).*	2. Bed with the typical form of *Ammonites cordatus.* 1. Bed with a small form of *Amm. cordatus.*	White Limestone with a great number of fossils, white and yellowish marls, and grey earthy limestone, many fossils.	Lower beds of the middle "Oxford," of Oppel.
	3. Bed of *Ammonites macrocephalus.*		Thickness 12–30 feet, Limestone. Great many fossils. Forms of the Etage Bajocien, Bathonien and Callovien, associated in several localities (Balin).	Great Oolith over the *Fuller's earth.* Callovien of England and France. Upper *Dentalium* clay, *Macrocephalus* Oolite of Swabia.
	2. Beds of *Ammonites Parkinsoni* (notOppel's, but the whole of strata, which contain *A. Parkinsoni*).	2. Bed with a small form of *Amm. Parkinsoni.* 1. Lower bed with the typic *Amm. Parkinsoni.*	Dark argillaceous clay, thickness about 100 feet. Grey sandstones, dark shales with Sphærosiderite.	
	1. Beds of *Inoceramus polyplocus.*	4. Clay of Mirow. 3. Dark sandy marl of Lysiec and Siellec. 2. Bed of Kostczelitzer, with undetermined bivalves. 1. Ferruginous brown Sandstone with *Inoc. polyplocus* and *Pecten pumilus*, etc., etc., of Woischnik.		Etage β of Quenstedt.

The Jurassic deposits of Upper Silesia and Poland show the greatest affinity to the Jura of South Germany, especially that of Würtemberg, not only as regards their fauna, but also in the lithological features of the formation, which renders it most probable that the Jurassic seas were in direct communication. But this communication could only have existed as a narrow strait in the Karpathians, through Moravia, in the direction of Vienna, to Regensburg.

A peculiar feature of the Silesian Jurassic formation is the entire absence of Liassic beds; Jurassic beds resting conformably on the Upper Keuper formation. A comparison with the Jurassic deposits in North-western Germany shows the entirely different character of the Silesian Jura; whilst all the Jurassic deposits which are known in Western Prussia, and also in Pomerania, show that the sea in which they were formed must have been in direct communication with the eastern seas of Poland, Russia, and Silesia.

C. *Cretaceous Formation.*—This is found to occur in three groups of strata, which in no way agree in their character with each other.

Group A, forms a part of the Beskides, between Teschen, Skotschau, Bielitz, Kentz, and Wadowice.

Group B, is seen near Oppeln and Leobschütz.

Group C, on the eastern slopes of the Jurassic hills between Krakau and Czenstochau.

A. (*Neocomien.*) The Beskides, which belong to the Karpathians, are nothing else but a continuation of the Alps.

1. Lower Teschen shales (Lower Neocomien after Hohenegger). Grey marly shales, thickness 1200 feet. *Aptychus*, *Belemnites*, etc.
2. Teschen Limestone (Middle Neocomien of Hohenegger). A dark grey limestone, thickness 300 feet.
   a. Lower group, thinly stratified limestone with shaly layers between, which contain a few *Fucoides* and other fossils.
   b. Upper group in thick banks of sandy dark limestone.
3. Upper Teschen Shales and Grodischt Sandstone, black bituminous shining marly shales, with Sphærosiderite. (Upper Neocomien of Hohenegger.)
4. Wernsdorf beds (Etage Urgonien, partly Aptien of Hohenegger). Thickness 400–500 feet. Black marls and shales with Sphærosiderite. This series forms a zone along the northern slopes of the Karpathians. *Scaphites Tranii* (Puzos), *Crioceras Puzosianus* (d'Orb.), *Belemnites dilatatus*, *Aptychus Didayi*, (Coq.), etc., etc.

Roemer differs from Hohenegger, as he does not hold the Aptien is sufficiently proved by one Ammonite and an *Ancyloceras*, but considers the Wernsdorf beds to be Urgonien. The Neocomien strata, on the northern slopes of the Karpathians, show the same character as those of the Alps, but differ greatly from those of North-western Germany.

5. *Gault.*—Hohenegger considers the mighty deposits of Sandstones of the Karpathians and Beskides (up to 4000 feet) as Gault, and calls them Godula Sandstones. The lower portions are generally sandy slates and shales, whilst the upper ones consist mostly of Sandstones, Conglomerates, etc. Although poor in organic remains, these deposits are correctly referred to the Gault, by their position lying conformably between the Wernsdorf beds (Urgonien) and the Istebna Sandstone (Cenomanien).

6. *Upper Cretaceous Series.*—*Baculites* marl of Friedeck and Baschka beds; the first a bluish grey sandy lime marl with *B. Faujasii*, the latter vast beds of fine-grained sandstone containing lime with marls and hornstones. But few fossils, *Inoceramus*, *Aptychus*.

B. Cretaceous rocks of Oppeln and Leobschütz, forming a few islands in the Diluvium.

a. Oppeln.

aa. Beds, belonging to Cenomanien, underlying the Turonien of Oppeln.

1. At the bottom, compact white sandstone.
2. Glauconitic grey or greenish sand.
3. At the top, fine-grained white sandstone.

Ammonites Rhotomagensis, *Turrilites costatus*, etc., etc. (page 290, *et seq.*)

bb. Marl, belonging to the Turonien. Thickness, 70 to 100 feet; white and light grey lime marls, near the base siliceous, and containing many hornstones; near the top, argillaceous. This deposit is very like the Pläner of Saxony, Bohemia, etc., etc.

It lies in a horizontal position, or dipping slightly to the west. It yields Brachiopoda, Lamellibranchiata, Gasteropoda, Cephalopoda, and fishes in great numbers (page 299). Most of the genera afford good evidence that this deposit represents the Pläner of Saxony, Bohemia, and of the hills of Hanover and Brunswick. Possibly, this series in Silesia comprises many zones, as, for example, the zone of *Scaphites Geinitzi*, Stromb., which is most distinctly represented; but at present it is not practicable to divide the stratum into several beds.

cc. Dambraw sandstone (Senonien). Sandstone with much mica and lime. *Exogyra*, *Mytilus*, sp. *Bacalites anceps*, *Callianassa Faujasii.*

b. Leobschütz.

aa. White sands and sandstone, with *Exogyra columba.* Thickness 15 to 50 feet; occasionally hornstones. Stratification horizontal, resting on highly elevated strata of the Culm formation. (List of fossils, page 332.) Most of these agree with forms of the Saxon and Bohemian Quadersandstein, although the latter is separated from Silesia by the crystalline and Devonian rocks of the county of Glatz.

bb. Grey sandy lime marls, with *Ammonites Rhotomagensis.* Thickness, 3 to 20 feet. Horizontally stratified; resting on Culm formation. (Fossils on page 339.) Most probably of the same horizon as the Green Sandstone of Laun, in the Saaz district of Bohemia.

The Cretaceous deposits of Oppeln and Leobschütz show close relationship to Bohemian and Saxon strata, although no relation amongst themselves, or with the Cretaceous deposits of the Eastern Polnian basin.

c. Cretaceous Strata East of the Jurassic Hills of Poland.—These consist partly of sands, partly of lime-marls; the most prominent are the latter, with hornstones. It forms a great part of the late kingdom of Poland, on both banks of the Weichsel.

a. The lower strata consist of grey, white, and green sandstones, with a few grains of Glauconite. (List of fossils, page 351.) Equivalent to the lower strata of Senonien.

b. White lime-marls, with *Belemnitella mucronata;* hornstones; horizontally stratified. The thickness increases towards the centre of the basin, towards east, as, for instance, near Wislica-on-the-Nida the thickness is 600 feet. (List of fossils, page 354.) Most probably this is Upper Senonien.

These Cretaceous deposits of Poland show more relationship to the Cretaceous rocks of Russia, of the Rügen Island, and of the Danish Islands, than with those of North-Western and Middle Germany. The Cretaceous rocks of Poland belong to the great Baltic Chalk basin of North-Eastern Europe, which possesses in the Jura of Krakau a well-defined western boundary, and which does not communicate with the Chalk-basin of Saxony, Bohemia, and Upper Silesia.

III. Cainozoic or Tertiary Group.

Deposits belonging to this system are met with in three entirely different characters:

A. In the Northern Karparthians, as Nummulite rocks.

B. Between the Northern Karpathians and the Muschelkalk of Tarnowitz-Krappitz, as Miocene deposits of the age of the Vienna basin.

C. Oligocene Lignite deposits, northwards of the former.

A. *Nummulitic Deposits. Eocene. Beskides.*—Similar to the Flysch of the Alps, consisting of dark grey, externally brown, micaceous sandstones, marls, and Menilite shales, of a thickness of many thousand feet. The strata are generally much disturbed, raised up and dipping south. These rocks were raised during the same period as the Chalk formation of Silesia. The Miocene strata rest nearly horizontal at the northern slopes of these deposits.

Hohenegger distinguishes:

a. Nummulitic rocks, Lower group. Grey sandstones, Limestone, Breccia, richly coloured clay or shales. The compact Nummulite Limestone is entirely wanting *Nummulina lenticularis* (d'Orb.), *Chondrites Targionii*, *Ch. intricatus*, the same forms as in the Flysch of the Alps.

b. Menilite rocks, Upper group. Richly coloured Clay-shales, thin bed of micaceous sandstones, with beds of Menilite shales. *Meletta crenata* (Heckel).

This deposit forms, according to Ch. Mayer, of Zurich,[1] the youngest stratum of the

[1] Tableau synchronistique des terrains tertiares inférieurs. 1869.

Etage Tongrien (therefore not Eocene), and is equivalent to the Oligocene clay of Boom in Belgium, and, therefore, also with the Septaria clay of Berlin.

Eocene Eruptive Rocks, Teschenite, contains Hornblende, Augite, Nephelin, Anorthite-like-trickline felspar. Accessories to these are Apatite and Carbonate of Lime; Diorite and Diabase; Aphanite and Aphinitic Amygdaloid.

B. *Miocene Deposits.*—These cover the whole south and western part of Upper Silesia, with the exception of the higher elevated country. South, the Cretaceous rocks and Eocene deposits of the Karpathians; West, the Devonian rocks of the Gesenke; East, Jurassic hills of Krakau-Wielun.

This extensive Miocene basin communicates with the basin of Vienna-Moravia, only through the channel of Mährisch-Ostrau, and Prerau, which is only from two to four miles broad. The thickness of these deposits is from 500 to 700 feet. They rest generally on rocks of the Carboniferous formation.

a. Lower group (Marine Clay and Leitha Limestone). Thickness, 500 to 700 feet. Bluish Grey Clay, mixed with quartzose sands, and containing much lime. Equivalent to the Lower Marine Clay of Vienna. Beds of light yellow limestone, very rich in fossils. The latter are of the same age as the Leitha limestone of Vienna. They contain also gypsum and rock-salt (Wieliczka and Bochnia, in Austria). (A list of the fossils is given at pages 375–394.)

b. Upper group. White sands and clay, with iron-ores, near Kieferstädtel and Stanitz. Lignite. Limited to the country between Rybnik and Ujest. Remains of *Prox furcatus*, Hensel, an Indian form. In Upper Silesia are wanting the brackish and freshwater deposits, the *Cerithium* and *Congeria* beds of Vienna.

C. *Oligocene Lignite beds.*—Grey, richly coloured or white plastic clay and white sand, alternating with layers of Lignite and Iron-ores, and freshwater Quartzites many hundred feet in thickness.

Basalt.—Only known west of the river Oder; to be looked upon as the most eastern offshoots of the Basalts of the Eifel, which, beginning at the left banks of the Rhine, strike E. across South Germany, Bohemia, and Silesia. Between the Oder and Ural mountains no Basalt is known.

Diluvium, consisting of the usual sand, gravel, and clay (Löss), covers the greater part of Upper Silesia, with the exception of the highest points. It belongs to the same epoch and fauna as the Diluvium of the Rhine near Basel, etc., etc., with *Elephas primigenius*, *Rhinoceros tichorhinus*, *Bison priscus*, and *Bos primigenius*.

There is a very interesting report by Dr. Runge, of Breslau, on the occurrence and the production of useful minerals of Upper Silesia, with numerous maps and sections, etc., which forms part of Dr. Roemer's book, but which it is not possible to treat with requisite consideration here.

We cannot but express our obligations to Dr. Ferdinand Roemer for his most valuable work.—C. L. G.

REPORTS AND PROCEEDINGS.

Geological Society of London.—May 10, 1871.—Prof. Morris, Vice-President, in the Chair. The following communications were read:—1. "On the Ancient Rocks of the St. David's Promontory, South Wales, and their Fossil contents." By Prof. R. Harkness, F.R.S., F.G.S., and Henry Hicks, Esq.

In the Promontory of St. David's the rocks upon which the conglomerates and purple and greenish Sandstone, forming the series usually called the "Longmynd" and "Harlech Groups," repose, are highly quartziferous, and in many spots so nearly resemble syenite, that it is at first difficult to make out their true nature. The apparent crystals are, however, for the most part angular fragments of quartz, not possessing the true crystalline form of the mineral. The matrix does not exhibit a crystalline arrangement, and contains a very large proportion of silica, much exceeding that which is obtained from rocks of a syenitic nature. These quartziferous rocks form an E.N.E. and W.S.W. course. The arrangement of these rocks, which seem to be quartziferous breccias, is somewhat indistinct.

In the immediate neighbourhood of St. David's they have associated with them irregular bands of hard, greenish, ashy-looking shales, much altered in character, but often presenting distinct traces of foliation. In a ridge running from the S.E. of Ramsey Sound in a north-easterly direction the greenish shales are more compact, and resemble earthy greenstones.

The quartziferous breccias and their associated shales form two anticlinal axes, contiguous to each other, and have on their S.S.E. and N.N.W. sides purple and green rocks.

The order of the rocks from the quartziferous breccias upwards, when not disturbed by faults, is as follows:—

Lower Cambrian.

		feet.
1.	Greenish hornstones on the S.E., and earthy Greenstones on the N.W., forming the outermost portions of the so-called Syenitic and Greenstone ridges.	
2.	Conglomerates composed chiefly of well-rounded masses of quartz imbedded in a purple matrix	60
3.	Greenish flaggy sandstones	460
4.	Red flaggy or shaly beds, affording the earliest traces of organic remains in the St. David's Promontory, namely, *Lingulella ferruginea* and *Leperditia Cambrensis*	50
5.	Purple (sometimes greenish) sandstones	1000
6.	Yellowish-grey sandstones, shales, and flags, containing the genera *Plutonia*, *Conocoryphe*, *Microdiscus*, *Agnostus*, *Theca*, and *Protospongia*	150
7.	Grey, purple, and red flaggy sandstones, containing, with some of the above-mentioned genera, the genus *Paradoxides*	1500
8.	Grey flaggy beds	150
9.	The true beds of the "Menevian Group," richly fossiliferous, and the probable equivalents of the lowest portions of the primordial zone of M. Barrande	550

The discovery of a fauna, specially rich in trilobites, among these rocks of the St. David's Promontory, affords very important information concerning the earlier forms of life of the British Isles. Until the discovery of this fauna, these rocks and their equivalents in North Wales were looked upon as all but barren of fossils. We have now, scattered through about 3000 feet of purple and green strata, a well-marked series of fossils, such as have nowhere else been obtained in the British Isles. In the Longmynds of Shropshire the only evidence of the existence of life during the period of their deposition is in the form of worm-burrows, and in the somewhat indistinct impressions, which Mr. Salter regards as trilobitic, and to which he has given the name of *Palæopyge Ramsayi.* If we assume the purple and green shales and sandstones, with their associated quartz rocks of Bray Head and the drab shales of Carrick M'Reily, county Wicklow, to represent the old rocks of St. David's, they afford only very meagre evidence of the occurrence of life during the period of their deposition in the form of worm-burrows and tracks, and in the very indeterminate fossils which have been referred to the genus *Oldhamia.*

One very prominent feature about the palæontology of the ancient rocks of St. David's is the occurrence of four distinct species of the genus *Paradoxides*; and this is in strong contrast with the entire absence of the genus *Olenus*. On a comparison of the palæontology of the St. David's rocks with those of the Continent of Europe and of America, which seem to occupy nearly the same horizon, we have like features to a very great extent presenting themselves.

With reference to the distribution in time of some of the earlier genera of Trilobites, it would appear that the genus *Olenus* is represented in Britain and Europe by twenty-two species, confined to the Lingula-flags and Tremadoc rocks, and not occurring so low as the Menevian group. The absence of this genus from the Menevian group, and its occurrence throughout the whole of the Lingula-flags, and in the Tremadoc rocks, along with the fact that so far as present observations go, no species of *Paradoxides* ranges higher than the Menevian group, have afforded good palæontological grounds for placing the line of demarcation between Upper and Lower Cambrian at this spot, and for including the Menevian group in the Lower Cambrian, to the bulk of which it is intimately united palæontologically.

Discussion.—Mr. Hughes bore testimony to the admirable work done by Mr. Hicks, who had, almost unaided, worked out the geology of that district. Allowing that many subdivisions and new specific names had with great advantage been introduced into petrology, he defended the Survey nomenclature by reference to the then received definition of Syenite and Greenstone, terms still perfectly understood and applicable to the main mass of the rocks in question, though possibly subsequent closer examination and new sections may have rendered some modification of the boundary lines desirable. He was prepared to allow the metamorphic origin of all rocks of the classes under consideration, but did not think there was sufficient evidence to show that the divisional planes in the Syenite and Greenstone of St. David's were due to original stratification, but might correspond rather to the great joints of most granites. Mr. Hughes pointed out that the conglomerate contained fragments of the hornstone and quartz of this older series, which he considered was probably part of an old ridge or shoal, possibly of Laurentian, but certainly of pre-Cambrian age, and thought that there were slight differences in the lithological character of the beds on either side, such as might be explained on this supposition. He agreed with Prof. Ramsay in thinking that there was evidence of the proximity of land in early Cambrian times, but was not prepared to refer these red rocks to inland seas or lakes as opposed to open sea, the whole seemed rather the deposit of an open sea encroaching during submergence. He did not attach very much importance to the restriction of genera to limited horizons in these older rocks of St. David's. For, as it was reserved for Mr. Hicks to discover these fossils after so many other observers had examined the district, he anticipated that further researches must certainly result in finding links which will connect together more closely beds, the stratigraphical relations of which seem to indicate so clearly an unbroken though varying series.

Mr. Gwyn Jeffreys had been struck by the intercalation of non-fossiliferous beds from time to time among the fossiliferous beds described in the paper. This was the case in beds now in course of formation, and appeared to arise from the great deposits of mud brought down by rivers and redeposited in certain positions in the sea-bed. That this was the case had been proved by recent dredging operations both in the Atlantic, off Spain, and in the Mediterranean.

Mr. Boyd Dawkins called attention to the gap which had been filled by the discoveries recorded in the paper, inasmuch as the Molluscan, Annelid, and Crustacean forms were now carried back far into the Cambrian period, and yet without any trace of their convergence, so that the origin of life might be as far removed from that period as was the Cambrian from the present time. The difference in the colours of the rocks he was inclined to refer to the different degrees of oxidization of the iron they contained, which might supervene in a comparatively short time.

The Rev. W. S. Symonds had, in visiting the spot, been much struck by the rocks, at that time termed Syenite, which he believed might be an extension of those on the Caernarvonshire peninsula, and which he thought supported the whole series of the Cambrian rocks, so that they might after all be the Laurentian, the same as those of Sutherlandshire and Assynt. If this were the case the nomenclature of the Geological Survey would have to be altered, and the rocks of Pistyl and Holyhead no longer termed metamorphosed Cambrian rocks, but Laurentian.

Mr. Hicks, in reply, stated that the quartziferous breccias forming the central ridge contained so many rolled pebbles, and were, moreover, in places so distinctly bedded, that there could be no doubt of their being sedimentary. Other beds, described as Greenstone in the maps of the Geological Survey, were also distinctly laminated. The non-occurrence of fossils in the more sandy beds he attributed to their having been deposited in very shallow water. The fossils occurred principally in fine-grained beds of a flaggy nature.

2. "On the Age of the Nubian Sandstone." By Ralph Tate, Esq., F.G.S.

The author remarked that the sandstone strata underlying the Cretaceous limestones, and resting upon the granitic and schistose rocks of Sinai, had been identified with the "Nubian Sandstone" described by Russegger as occurring in Egypt, Nubia, and Arabia Petræa. In the absence of palæontological evidence, this sandstone has been referred to the Mesozoic group, having been regarded by Russegger as Lower Cretaceous, and by Mr. Bauerman and Figari-Bey as Triassic, the latter considering an intercalated limestone-bed to be the equivalent of the Muschelkalk. The author has detected *Orthis Michelini* in a block of this limestone from Wady-Nasb, which leads him to refer it to the Carboniferous epoch, as had already been done by the late Mr. Salter from his interpretation of certain encrinite-stems obtained from it. The author mentioned other fossils obtained from this limestone, and also referred to species of *Lepidodendron* and *Sigillaria* derived from the sandstone of the same locality. He regarded the Adigrat Sandstone of Mr. Blanford as identical with the Nubian Sandstone.

3. "On the Discovery of the Glutton (*Gulo luscus*) in Britain." By W. Boyd Dawkins, Esq., M.A., F.R.S., F.G.S.

The author in this paper described a lower jaw of the Glutton, which had been obtained by Messrs. Hughes and Heaton from a cave at Plas Heaton, where it was associated with remains of the Wolf, Bison, Reindeer, Horse, and Cave-Bear. He remarked that he could detect no specific difference between the *Gulo spelæus*, Goldfuss, from Germany, and the living *Gulo luscus*, except that the fossil Carnivore was larger than the living, probably from the comparative leniency of the competition for life in post-Glacial times. He referred to the distribution of the Glutton in a fossil state, and argued that its association with the Reindeer, the Marmot, and the Musk-sheep, would imply that the post-Glacial winters were of arctic severity, whilst the presence of remains of the Hippopotamus, associated with the same group of animals, would indicate a hot summer, such as prevails on the lower Volga.

Discussion.—Mr. Hughes indicated the exact position in which the jaw of the Glutton was found, but pointed out that, owing to the excavations of keepers, badgers, rabbits, &c., the earth was so much disturbed in that part that it was impossible to be sure of the original relative position of the bones. He showed that the Plas Heaton Cave was on a hill rising from the top of the plateau, while the Cefn, Brysgill, and Galltfænan Caves were in the gorge cut through that plateau, and therefore that the Plas Heaton Cave was probably formed, and might possibly have been first occupied at a much earlier period than the others. As it appeared to pass under that part of the hill which is overlapped by heavy drift, he thought it quite possible that this may have been a pre-Glacial cave, and that by-and-bye we may find evidence of a pre-Glacial fauna in it.

The Rev. W. S. Symonds mentioned that in some of the pot-holes in the roof of the Cefn cave he had procured silt containing remains of shells determined by Mr. Jeffreys to be marine.

Mr. Hughes explained that these shells had probably been washed in from the superficial marine drift of the district.

Mr. Dawkins, in reply, expressed his belief that though the excavations of the caves in question might have taken place at different periods, yet that their occupation was, geologically speaking, contemporaneous.

CORRESPONDENCE.

TERRACES OF NORWAY.

Sir,—As the translator of Professor Kjerulf's pamphlet, and a visitor to many of the terraces he describes, may I be allowed, in answer to Colonel Greenwood, to occupy half a dozen lines?

The terraces occupy the whole breadth of valleys, often very wide. The upper surface is almost level, save where a groove is cut by an existing stream. They end, as Kjerulf says, in an abrupt slope, often succeeded by another terrace.

I especially recommend travellers to go to Aardal, and ascend by loch and river to see the grandest imaginable fall—the Moïk Pors. In their journey they will see the terrace formation on a very remarkable scale, and I hardly think they will agree with Colonel Greenwood. In fact, few geological problems have so patent a solution.

I shall at any time be happy to sketch out a route, embracing some of the more remarkable terraces, for any traveller proposing to visit them.

Marshall Hall.

New University Club, *May* 9, 1871.

CONCRETIONARY STRUCTURE IN PLASTER.

Sir,—The reference in Notes and Queries of your April number (page 192), to concretionary structure in the plaster of old walls reminds me that years ago, when G. H. K. and myself were colleagues, I used frequently to note it, and he may perhaps remember seeing my rubbings and copies therefrom.

Some of the best of these were obtained in partly ruined buildings, affording a little occupation during showers, etc.

Unfortunately the whereabouts of drawings or notes is now unknown, but I can recollect that these markings were not at all uncommon, and were sometimes very perfect.

The little woodcut given in your April number may be, roughly, a fourth or a sixth of their usual scale, and they appeared to be best observable where partly sheltered, as if showing a certain stage or condition of development or depth of weathering, to which greater exposure was unfavourable, causing the removal of whole patches of the tracery.

The material seemed always to be ordinary mortar, composed of lime, sand, etc.; and upon old walls that had been "puttied," *i.e.*, covered with a thin layer of smoother, and more calcareous, material, they were specially well preserved, the harder laminæ relieved, so that the original surface would have served to print them from; they also occurred in rough plastering and in very old ruins, as well as much more modern structures, on damp-looking internal walls of churches, and such like situations; an almost invariable condition of their existence being some sort of plane-surface, more usually vertical than horizontal, originally given to the composition.

As a consequence of this last observation, probably originated the idea which I have often heard advanced, that the marks were due to the rotary motion of the plasterer's arm causing a mechanical distribution of coarser and finer particles of the plaster, but this is evidently not the case, the old marks of the plastering tool being sometimes seen sweeping in broad curves across the concretionary pattern.

The structure appears to result from segregation or crystallization, or a combination of both, set up among the silicious and calcareous materials of the plaster.

The concentric character of the pattern is frequently quite as perfect as any other concretionary structure, but has much less tendency to interruption by breaks and shifts than is to be observed in agates, etc., of which numerous examples occur in the beautiful plates adorning Mr. Ruskin's contributions to former numbers of your Journal.

It seems strange that I can hardly recall an instance of the occurrence of these markings on the "Chunam" walls of India, and I have never seen them, except in materials of which lime formed a considerable part, nor could I detect anything like signs of commencement, termination, or progressive production of the structure.

MURREE, PUNJAB,
May 1, 1871.

BENWYAN.

MISCELLANEOUS.

SUPPLEMENTARY LIST OF TYPE SPECIMENS OF FOSSIL FISHES IN THE BRITISH MUSEUM.—The following additions to the Type Specimens of Fossil Fishes in the British Museum were purchased after the catalogue published in the May number of the GEOL. MAG., pp. 208–216, was in type. They appear to be of sufficient interest to be noticed in a supplementary note to that catalogue. W. D.

CHONDROSTOMA, Ag.
— *minutum*, Winkler, "Poiss. Foss. d'Oeningen," p. 37, pl. 4, fig. 12. Miocene. Oeningen.
COBITIS, Ag.
— *Bredai*, Winkler, Op. cit. p. 12. ib loc.
ESOX, Linn.
— *robustus*, Winkler, Op. cit. p. 53, pl. 5, figs. 17, 18. ib. loc.
LEBIAS, Ag.
— *crassus*, Winkler, Op. cit. p. 40, pl. 4, fig. 13. ib. loc.
— *furcatus*, Winkler, Op. cit. p. 44, pl. 4, fig. 15. ib. loc.
RHODEUS, Ag.
— *magnus*, Winkler, Op. cit. p. 28, pl. 4, fig. 11. ib. loc.

NOTES ON *DIPLOGRAPSUS*.—Mr. J. Hopkinson, F.G.S., etc., calls attention, in the Annals and Magazine of Natural History for May, to a specimen of *Diplograpsus pristis*, showing reproductive capsules. He considers these reproductive organs to represent the gonothecæ of the recent Sertularian Zoophyte; they are developed almost immediately opposite each other from each side of the periderm, and throughout its whole length. This specimen is of great interest as being the only graptolite with undoubted reproductive organs yet known to have been found in Britain. The presence of these organs throws some light upon the affinities of graptolites. Mr. Hopkinson remarks that it confirms the evidence, which their internal structure has already furnished, of their near alliance with the Hydroida. He adds, that graptolites, having true gonothecæ as well as hydrothecæ, are most intimately allied to that order of the Hydroid Cœlenterata, known as the Thecaphora or Sertularina. The specimen of *Diplograpsus pristis* was found by the Geological Survey of Scotland, at Leadhills, Lanarkshire, along with a series of fossils which parallel the rocks of this locality with those of Moffat, Dumfriesshire, and with the Llandeilo Flags of Wales.

MINERALOGICAL NOTICES.—Prof. N. S. Maskelyne and Dr. Walter Flight contribute some Mineralogical Notices to the Journal of the Chemical Society for January, 1871. These include: 1. On the Formation of Basic Cupric Sulphates. 2. Analysis of Opal from Waddela Plain, Abyssinia. 3. Notes on Francolite from Cornwall. 4. On Epidote and Serpentine from Iona. 5, 6. On some specimens of Vivianite and Cronstedtite found in Cornwall, by Mr. Talling. 7. Notes on Pholerite.

OBITUARY.

WE regret to record the death of George Tate, Esq., F.G.S., of Alnwick, Hon. Secretary of the Berwickshire Naturalists' Club, who died on Wednesday, the 7th of June, 1871, aged 66 years. George Tate was born in 1805 at Alnwick. More than forty years since he became connected with the Mechanics' Institution of his native town, and for upwards of thirty years he filled the post of Hon. Secretary. During that long period the Institution enjoyed a course of uninterrupted and increasing prosperity, and to him more than to any single individual is it owing that it has been the means of conferring such incalculable benefit on the town.

He was thoroughly imbued with the enlightened and progressive spirit of the age, and always held broad and liberal views on the great questions of the day, and as a member of the Common Council, and other public bodies in Alnwick, he never failed to take an honourable, active, and distinguished part in the affairs of the town.

Penetrated with an ardent love of the sciences, he made Geology his particular study, and became the expositor of the geological structure of the Border-country. With equal ardour he gave his mind to Archæology. His learned and interesting treatise on the "Ancient British Sculptured Rocks of Northumberland and the Eastern Borders," and the excellent papers on Geology and Archæology which he has contributed to the "Transactions of the Berwickshire Naturalists' Club," in which society he held the post of Hon. Secretary, must be well known to many of our readers.

But it is as the historian of his native town that he has achieved his chief claim to distinction. The "History of the Borough, Castle, and Barony of Alnwick," the fruit of many years of study and preparation, was completed in 1869, in commemoration of which he was presented with an address, a silver tea and coffee service, and a purse containing 100 guineas, by his fellow-townsmen, aided by many gentlemen connected with the district, and who might be regarded as the representatives of the science of the Border-counties, and also by some few men of high eminence in other parts of the country.

No candid critic will deny the right of this work to take rank amongst the best local histories extant, and as a standard authority that must be resorted to on all subsequent occasions. It is characterized by vast research, conscientious labour, and a sound critical judgment in the weighing of facts and evidence. Its greatest merit is the nobility and independence of soul which is displayed throughout.

Mr. Tate was not only remarkable for versatility of mind, but was gifted with great powers of oratory, and as a lecturer few men were his equal. A man without ambition, happy in public esteem, and imbued with a love for his own native district, having no claim upon it for rank, wealth, or power, he was content to live in it all his life, and to devote himself to the illustration of its history.

In appreciation of his eminent literary and scientific attainments, several learned societies had accorded to him the honorary distinction of Corresponding Member. He joined the Geological Society of London in 1843.

Errata in Geological Magazine, June, 1871, p. 267, lines 43 *et sequi*, *for* "but in the granitic-felstone the rock is often thin, very fine or coarse," etc., etc., *read* "but in the granitic-felstone the rock is often in thin, very fine, or coarse bands, striping the rock, like ribbon, they differing, etc., etc."—At p. 247, line 20 from foot, *for* "; their," *read* ". The".

THE

GEOLOGICAL MAGAZINE.

No. LXXXVI.—AUGUST, 1871.

ORIGINAL ARTICLES.

I.—On Volcanos.[1]

By Henry Woodward, F.G.S., F.Z.S.,
of the British Museum.

IN whatever part of the world we live we can readily discover, by ordinary observation, that there are two great forces constantly occupied in remodelling its surface, from year to year, from century to century.

Little of what they are now doing can be noted by us in our lifetime, or even in the lifetime of our race; but as they have ceaselessly laboured since our planet came into existence, we can, by examining the marks they left long since, find out what each is now doing, and what they can achieve together, for then they are most potent.

These two mighty forces, Upheaval and Denudation, are represented by Fire and Water.

"The gentle rain which cometh down from heaven" is ever occupied in the task of washing away, grain by grain, the dry land, and every brook and river ceaselessly carries on the same task; whilst the Sea, on every coast-line, aims at equality—like a roaring Republican as he is—only, like the ordinary Republican, he seeks "to level himself up" by the degradation of his neighbour, the Earth, till it reaches a level no higher than his own.

Indeed, if water acted as the servant of denudation only, the Earth would have but a poor chance of keeping her head above water; but far down beneath the earth where dwell the dethroned Titans, and where Vulcan forges the thunderbolts for Jupiter (so at least we learnt at school), it seems undeniable that the temperature is so exceedingly high that any water happening to lose its way (as water is apt to do in the dark among so many chinks, crannies, and cracks), and getting down beneath its proper level, is immediately seized by fire, and before it can escape into the bright air it is compelled, as steam, to lift earth-weights, which probably, when all are put together, amount to as much or even more than the drop of water ever did above-ground in the service of denudation.

What do we know of the interior of the earth? How far has man been able to pry into the inside of the great revolving ball upon the outside of which he is being carried around in London at the rate of 600 miles per hour?

[1] A paper read before the Geologists' Association, April 1st, 1870.

Here is a diagram to illustrate and answer this question. (Fig. 1.)

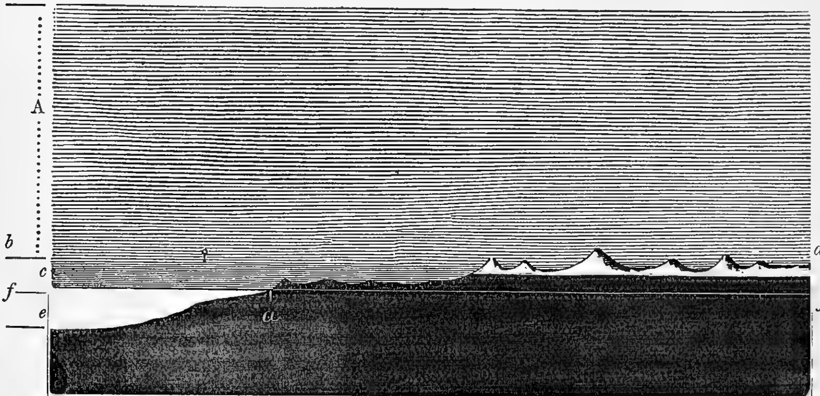


Fig. 1.—Height and Depth.

EXPLANATION OF DIAGRAM.

A. Atmosphere taken at 50 miles.

c. Half the pressure of which is shown at five miles.

d. Mount Everest, the highest known land of the world in the Himalayas, 29,000 feet.

a. Deepest mines, Himmelfürst in Saxony, 2,400 feet; one shaft in Belgium, 2,796 feet; Dukinfield Colliery, 2,820 feet.[1]

b. Highest balloon ascent, Messrs. Glashier and Coxwell, 1862—6½ miles.

e. Deepest sounding in the ocean, Lat. 36° 49′ S., Long. 37° 6′ W. Soundings were found at a depth of 7,706 fathoms, or 8¾ miles. (A. Keith Johnston's Physical Atlas.)

f.f. Sea Level.

From *f.* to *k.* represents a vertical depth of 50 miles.

34 .... Melting point of iron, or 2,786° Fahr., a heat sufficient to fuse almost every known substance. This calculation is founded upon the assumption that the known increase of 1° Fahr. for every 65 feet of depth, is continued downwards for an indefinite distance. Such an assumption would admit of a solid crust upwards of 30 miles in thickness.

[1] E. Hull, F.R.S., Coal-fields, Quart. Journ. Science, January, 1864.

This diagram represents 50 miles only out of the 3,962 miles from the exterior to the centre, which would require a diagram nearly eighty times as long to express. From this we can easily perceive that unless we watch Nature's great agents at work, and take note of her records, we should know next to nothing of the interior of our globe. We are, in fact, reduced to make the same kind of observations which led Columbus to discover the New World; we must watch the waifs and strays thrown up by the tide from this great unknown region, 7,925 miles across, which divides us from the Antipodes.

The evidences afforded of the condition of the earth's interior are derived from—1, volcanic products; 2, thermal springs; and 3, the observations we are enabled to make of underground temperatures.

The rocks at the surface of the earth are everywhere roughly divisible into Igneous and Sedimentary, *i.e.*, produced by the agency of fire and water. Igneous deposits, like sedimentary beds, often show stratification; often, too, they are arranged by currents under the sea; or they may be arranged in layers subaërially.

The Sedimentary rocks are all deposited by water, either in lakes, rivers, or in seas.

All over the world one meets with conical-looking mountains, frequently surrounded, more or less completely, by an outer and larger circle of cliffs, and having a crater formed hollow within. (Fig. 2.)

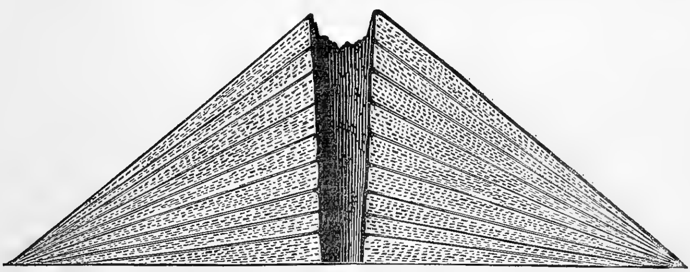


Fig. 2.—Ideal Section of a Volcano.

When we examine their structure, we find they are composed of sloping layers of ashes, cinders, stones, pumice, and other loose materials interstratified with beds of lava and other matter, evidently forced up in a fluid state from within.

Some of these mountains are still active, and by seeing what goes on at their openings one can more readily understand the origin of other similar hills now long since silent.

Taking a map of the world we can trace out upon it roughly the chief volcanic regions where active eruptions are going on or have been seen in historic times.[1]

Upwards of 400 volcanic mountains are known to exist in various

[1] For a world-map of volcanos see Scrope's invaluable work on volcanos; see also Keith Johnston's Physical Atlas.

parts of the earth, more than half of which have given evidence of activity in modern times.

They are distributed over—

	Extinct.		Active.
Europe	7	......	5
Atlantic Islands	14	......	8
Africa	3	......	1
Continental Asia	25	......	15
Asiatic Islands	189	......	110
Indian Ocean	9	......	5
South Sea	40	......	26
America	120	......	56
	407		226

In Europe we have Ætna, Vesuvius, Stromboli, Volcano, and Santorin (active); Ischia and Phlegræan Fields (historic); Auvergne (prehistoric).[1]

In Africa, the Cameroons Mountains, on the West Coast, and others on the Red Sea Coast, and in the Comoro Islands.

India has no burning mountains; but Barren Island, in the Bay of Bengal, Bourbon, and the remote Island of St. Paul, are active volcanos.

In Asia the only volcano is that of Demavend, on the shores of the Caspian Sea, and two reputed volcanos in the Thian-shan, and nine in the peninsula of Kamtschatka.

Through the Asiatic Islands a great volcanic belt extends from Birmah through the Andaman Islands, Sumatra, Java, and Timor, thence turning northwards to Amboyna, Gilolo, and the Philippines, then by Loo-choo Islands to Japan, the Kurile Islands and Kamtschatka.

Here in this region there are above 100 active volcanos.

Through the South Sea Islands, whenever any rock is visible it is of volcanic origin, but in all this great region there are fewer smoking volcanos than on the single island of Java. The active vents occur in the Sandwich Islands, New Guinea group, New Hebrides, and New Zealand, and in the Friendly Islands.

The Western Coast of America, from the Aleutian Islands and the recently ceded Russian American territory to the Southern extremity of the Continent and Tierra del Fuego, presents the most stupendous line of volcanic rocks, cones, craters and other indications of subterranean phenomena in the whole world. One-fourth of the known active volcanos are found in it. No volcanos are found on the eastern coast of America, but in the West Indies there are three active vents in the Lesser Antilles.

Volcanos occur mostly in tropical regions, few exist more than

[1] In Auvergne, on the side of Mount Denise, near Le Puy, two human skeletons were found, together with bones of *Elephas*, *Rhinoceros*, *Cervus*, etc., imbedded in volcanic matter, showing that man in his early state was in the country prior to the extinction of these craters. (Scrope.)

30° from the Equator, but to this rule there are exceptions; for amid Arctic and Antarctic snows blaze forth—

Jan Mayen, at the North Pole	6,874ft.
Hecla in Iceland, "	5,110
Mount St. Elias, North America	17,860
Kamtschatka, in North Asia	15,763
Taranaki, New Zealand, in the South Sea	8,840
New South Shetlands, " "	
St. Paul " "	
Erebus, Antarctic	12,400

The products of volcanic action are most various,[1] and are either thrown into the air by the explosive gases and vapours which accompany a volcanic eruption, and fall as dust, ashes, scoriæ, and stones; or are poured out in a stream of melted rock from the summit, or more generally the flanks of the volcano.

In consequence of the explosive force being directed nearly vertically, and the ashes falling on all sides equally round the aperture, the hills of scoriæ, ashes, etc., accumulated round a volcanic vent are always conical. Whether lava-currents issue from the apex or the side, they merely cause a slight irregularity in figure; but a new explosive vent, opening towards the base of the mountain, may throw up a new hill (see Fig. 4, p. 342). Thus several cones on the flanks of Ætna have been thrown up in the Val del Bove, a great excavation in the side of its cone.

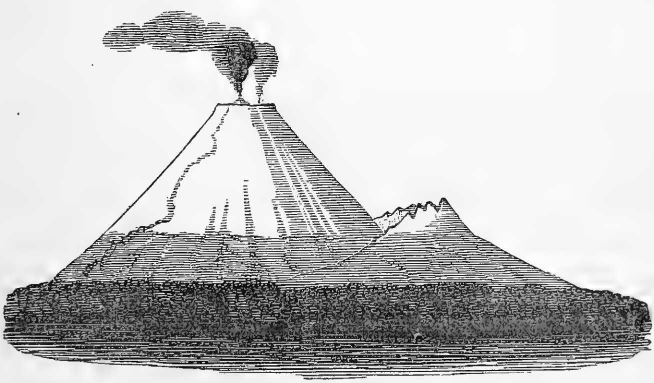


Fig. 3.—Cone of Cotopaxi; seen from a distance of 30 miles.

The cone of Cotopaxi (18,875ft. in height above the sea), in the

[1] The following gaseous and other products have been observed as emanating from volcanos:—

Steam.	Ashes.
Hydrogen.	Pumice.
Sulphuretted Hydrogen.	Sand.
Sulphurous Acid.	Lapilli.
Carbonic Acid.	Scoriæ.
Nitrogen.	Bombs.
Chloride of Sodium.	Vesicular Lava.
Chloride of Potassium.	Obsidian.
Chloride of Ammonium.	Basalt.
Sulphur.	

Andes of Peru (Fig. 3), is an example of this extreme and beautiful regularity on the largest and most striking scale. The drawing from which this sketch is made was taken by Godfrey Vigne, Esq., who visited the spot a few years ago.

Another instance is that of the cone of Mount Wellington, near Auckland, New Zealand (Fig. 4).

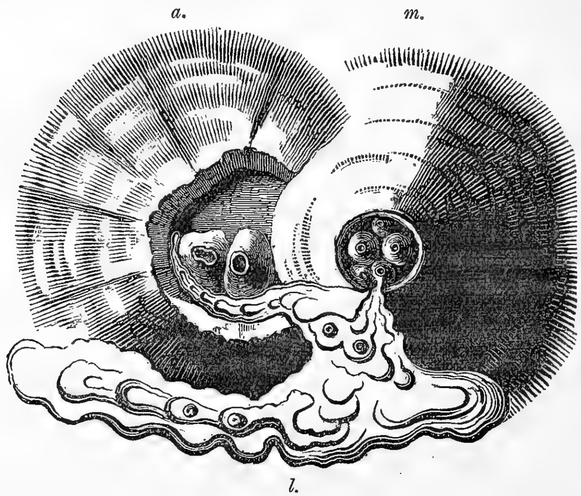


Fig. 4.—Bird's-eye view of Mount Wellington, near Auckland, New Zealand. (From Hochstetter's New Zealand.)

(*a*) Ancient cone, partly destroyed by (*m*) modern cone, which has sent forth the lava-stream (*l*).

But we have many craters without cones. The crater of Kilauéa, in Hawaii (Fig. 5), exhibits, on a much larger scale than any other

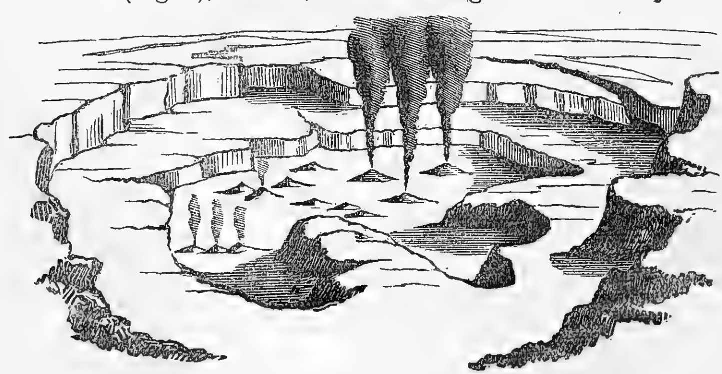


Fig. 5.—View of the Crater of Kilauéa, Hawaian Islands.

active volcano, a lake of liquid lava four miles in diameter, more or less crusted over on the exposed surface, through which at several points volumes of vapour burst upwards with jets of highly viscous matter, which, on cooling, take the form of vitreous filaments or scoriæ. (See woodcut, Fig. 5, page 342.)

This is a flanking-crater to the old volcanic cone of Mauna-Loà. It is 4000 feet above the sea, and about four or five miles in its longest diameter. The whole mass is never agitated, save before a discharge of lava, which rises from a vent eight miles east of the great basin, and descends in a rapid manner for 4000 feet to the sea. In 1840 it flowed at the rate sometimes of five miles per hour! The ordinary rate is less than half a mile.

It boils up in this enormous cauldron-like lake often 15 feet above the rim and cascades over in places; but being very viscid, this seldom occurs. Pools and lakes of fluid lava cover the surface, and craterets 30 or 40 feet high also are seen emitting vapours and lava. The date of the last eruption was 1868.

In visiting Kilauéa in 1864, Mr. T. Brigham writes:—[1]

"As soon as our men came up with the blankets, we engaged guides, and went down into the crater. The descent was steep and winding, and we passed over several terraces, which were the result of a sinking or falling in, as they were inclined and much broken, and came under the grand pali of compact lava. A descent of more than 400 feet brought us to the bottom, and we stepped from a gravelly shelving bank on to a black lava which had broken out last year under the north bank, and overflowed this end of the crater. Where it touched the gravel bank it had glued to its under surface the small fragments of stone, but had not altered their appearance, and all along the edge it was cracked and laid up on the bank as if, on cooling, the lava had fallen about a foot. The surface was covered with a thin scaly vitreous crust, which crumbled beneath the tread, sounding like snow on a cold morning, and thus a very distinct path was made to Halemáumau, the enduring house of the goddess Pélé.

"The lava beneath this crust, however, was so hard as to give out abundant sparks as the nails in my shoes scratched upon it. When hard it was often iridescent, like some anthracite coal, and so closely resembling this mineral that the difference would hardly be detected by a cursory examination. The fresh lava exactly resembled that from Mauna-Loà in the flow of 1859.

"Three-quarters of a mile over this uneven lava, and we came to a long wall composed of fragments of all sizes and shapes, very solid and heavy, and full of small grains of olivine; and this wall, which is concentric with the main wall of Kilauéa, is said to rise and fall, and sometimes disappear, which seems to be a fact, although no one has ever seen it in motion. It is the fragments broken from the edge of the crater by an eruption, and floated out to their present position. An unpractised eye would see no marks of fire on the rough, granite-like masses.

"Caves, cracks, and ridges make the surface very uneven, and after walking two miles we came to several large cracks of great depth, but not more than a yard wide, and then a wall inclosing an amphitheatre, down which we climbed on the loose slabs of lava.

[1] Boston Academy of Natural Sciences, U.S. America.

"When we were near the Halemáumau, we came to a cone formed of spattered lava and cemented scoriæ, some 25 feet high, with a bright light at its apex; this was the first fire we had seen, but we passed by, eager to reach the great lake. This we accomplished after ascending a gradual incline. It was about 800 feet in diameter, and the lava was 50 feet below the cliff on which we stood, covered with a dark crust, which was broken around the edges, and there the blood-red lava was visible, surging against its walls with a dull, sullen sound. The smoke was blown away by the wind, so that we were able to stand on the very verge of the pit, but the heat was so great that we were obliged to hold our hands before our faces.

"The walls on which we stood, and where we intended to sleep, were thickly covered on the side towards the pit with waving woolly Pélé's hair, which we saw forming continually. The drops of lava thrown up drew after them the glass thread, or sometimes two drops spin out a thread a yard long between them, and the 'hair' thus formed either clings to the rough sides, or is blown over the edge, where it catches on any projecting point. The drops are always black, or a very dark green on the surface, but light green within, porous, and excessively brittle, and the thread is transparent, and when first formed of a yellow or greenish colour.

"Occasionally a crack would open across the lake, and violent ebullitions commence at various points of its surface. There were two small islands in the lake, which the lava seemed seeking to destroy. The current would often set in towards the banks, and it appeared as if the whole mass was about to be drawn in, as cake after cake broke off from the surface and disappeared, but it would soon cease, and then run towards another point of the wall, and I could not see that it was oftener on one side than another. As a cake of lava parted from the crust, the red lava rose above the crack, running on the surface, and as the crack grew wider, cooling rapidly, and being drawn out much like molasses or candy.

"Whilst white hot, the lava was as liquid as water, but it rapidly assumed the viscid condition, and then the solid. I threw a stick of dry wood on the surface, which instantly became fixed, after a violent bubbling, and it was ten minutes before any smoke appeared, and it was only when a crack opened under it that it was consumed. The motion was always from the centre, except when the lava was thrown back in spray from the caverns which extended under much of the wall.

"We laid down in our blankets on the eastern edge, where the walls were highest (and the wind drove away the smoke), and here soon fell asleep.

"About nine o'clock I got up and moved to the very edge of the pit to view the molten mass to better advantage, and warm myself, as the wind was quite cold. The moon was up and almost full, but her orb was pale beside the fires of Pélé.

"Finding the place quite comfortable, I lay down and went to sleep. At twelve I awoke with a start, and found myself in the midst of a shower of fiery drops, some of which were burning my blanket. I shook myself and jumped back, looking at my watch to note the time, for I thought a great eruption at hand, and then stood gazing at the strange scene for some time before I thought of calling my companions.

"The whole surface of the lake had risen several feet, and was boiling violently, and dashing against the sides, throwing the red-hot spray high over the banks, causing the providential rain of fire which awoke me to see this grand display. There was no noise, except the dash and sullen roar. When I could think of anything else I called the others, who were asleep several rods from me, but I only succeeded in awakening the guides, and just then a drop came plump on to a greasy paper we had brought our supper in, and it blazed up so suddenly that one of the Kanakas thought it a new jet opening at our feet, and ran off to some distance. Failing to arouse my companions by calling, I threw a handful of small stones at them, but without effect, and I had to climb down and shake them roughly. When they had got to the edge, the action had greatly diminished, and in a few minutes more the dark crust again covered the central portion, and we all went to sleep."

If we compare the Islands of Santorin with those of Hawaii, we shall readily be able to perceive a striking resemblance between the two groups. (Figs. 6 and 7.) Santorin was in active eruption so

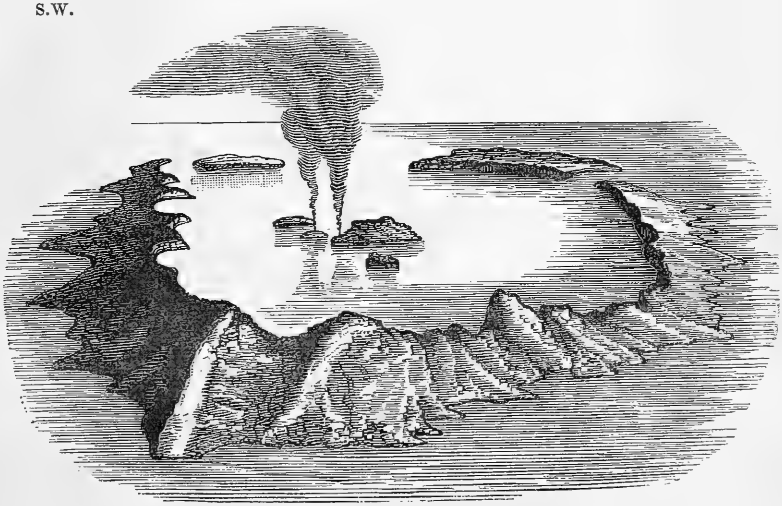


Fig. 6.—Islands of Santorin (after Lyell), with the volcanos on the Islands of Aphroessa and George in a state of eruption, February, 1866.

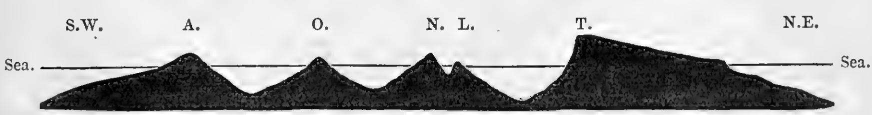


Fig. 7.—Ideal Section of Santorin in a N.E. and S.W. direction.
A. Aspronisi. O. Old Kaimeni. N. New Kaimeni. L. Little Kaimeni. T. Thera.

lately as in 1866. We may also compare the Island of Thera with that of St. Paul.

Graham's Island is another illustration of a sub-marine volcano. This island made its appearance July 10th, 1831, off the South-west coast of Sicily. It was then 12 feet above water; on the 10th of August it had attained the height of 800 feet; but being composed of loose scoriæ and cinders, and having no lava to solidify its cone, it began to be rapidly destroyed and washed away by the sea, and has now entirely disappeared.

The products of volcanic eruptions may be roughly divided into solid, liquid, and gaseous. Of the solid matter thrown out from volcanic vents may be enumerated "Volcanic Bombs," "Scoriæ" (or cinders), "Lapilli" (or gravel), "Pozzuolana" (or sand), "Pumice," and "Ceneri" (ashes).

Of the liquid matter poured out, either from the crater itself or from rents in its sides, we have the substance called "Lava," which, when solidified, may be either Basalt, Obsidian, or Vesicular Lava, depending upon the condition under which it cools, or the temperature at which it is ejected.

Basalt is lava solidified under pressure; it frequently presents the condition of "Columnar Basalt," as in the Auvergne, Staffa, Antrim (Fig. 8), New Zealand, etc.

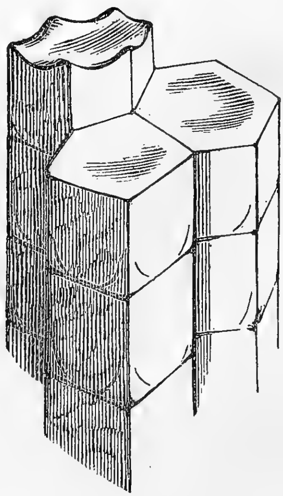


Fig. 8.—Basaltic columns from the Giant's Causeway. In the apartments of the Geological Society, Somerset House.

The most glassy and semi-translucent varieties of lava are known by the name of "Obsidian," or "Volcanic Glass," and occur abundantly in Iceland, the Lipari Islands, Mount Ararat, and Mexico.

Large tracts in Mexico (called Malpais) are covered with "Obsidian," and of it—as did our prehistoric ancestors from the chalk-flints in Britain—the worshippers of the sun manufactured their knives, etc., which were still in use at the time of the Spanish conquest (1518).

Of the gaseous emanations from volcanic vents may be enumerated sulphuretted hydrogen, sulphurous acid gas, hydrochloric acid, nitrogen, and carbonic acid gas.

But water, as steam, is certainly the most abundant substance present, as it is also the most active agent in all volcanic out-bursts, and may even be (as Mr. Scrope has supposed) the cause of the flow of lava streams. We know that, in cooling, lava gives off an immense volume of steam, and also that the vesicular cavities in lava are caused by it.

In all volcanic eruptions water appears to be present also in a liquid state, and is frequently ejected during volcanic eruptions in vast quantities. This may arise from three different causes:—

(1) It may be ejected from the earth's interior with other volcanic matter; or,

(2) From the melting of snows on the sides of the crater; or,

(3) By the discharge of rain-water accumulated in the crater during a period of repose.

The volcano of d'Agua in Guatemala is a perfectly circular cone, more than 11,000 feet high. From it descended, in 1541, a torrent of water (the contents, no doubt, of a crater-lake on the summit), which destroyed the old town of Guatemala, since removed to a new site.

Living fish and alligators were observed in a crater near the lake of Nicaragua, by Dr. C. Carter Blake.

Wherever the tropical rainfall is large, or the height of the mountain condenses the snows upon its sides and crater, an eruption is sure to be preceded by a "mud débacle;" miles of country are thus devastated and destroyed. The volcanos of Kilauéa, Central America, South America, and Java, well illustrate this.

In 1755 Ætna sent a sudden flood of water into the Val del Bove, the volume of which in one mile was estimated at 16,000,000 cubic feet.

Of the magnitude of lava streams, that which burst forth from the Skaptár Jokul in Iceland, in 1783, continued to flow for two years.

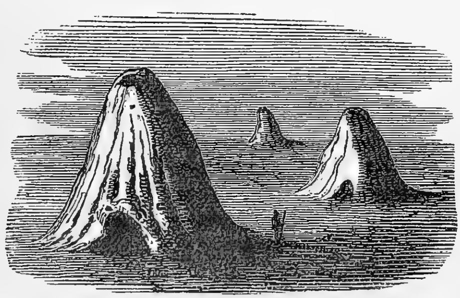


Fig. 9.—Craterets on the lava-stream of 1783. Skaptár Jokul, Iceland.

It filled up the rocky beds of rivers to a depth of 600 feet by 200 feet wide, and spread out in the plains 12 to 15 miles wide, and 100 feet deep! The two principal streams were respectively 40 and 50 miles in length, forming a mass surpassing Mont Blanc in magnitude. The waters of springs being suddenly converted into steam formed craterets over the lava stream 30 feet high. (Fig. 9.)

Heat may be retained in parts of lava streams for a period of twenty years.

From the crater of Galongoon, in Java, in 1822 (after an earthquake shock), was vomited out immense columns of boiling water, mud, steam, brimstone, ashes, and lapilli, in such mass and with such violence as to fall 40 miles distant. The valleys were all filled; 24 square miles were covered to a depth of more than 100 feet (in places) with hot blue mud, burying houses, villages, and people. The second eruption followed (preceded by terrific rains), accompanied by hot water and mud, and great blocks of basalt were thrown seven miles! One side of the crater was rent away, new hills and valleys were formed, and two rivers changed their courses. In one night 2,000 persons were killed; altogether the official return shows 114 villages destroyed, and above 4,000 persons killed.[1]

In January, 1803, all the snows were dissolved off Cotopaxi in one night, causing vast deluges of mud to descend, with great destruction to the region around.

The deluges caused by lake-craters probably exceed in magnitude and destructiveness those of lava-streams.

In 1797 a mud-débacle poured from Tunguragua, in Quito, filled a valley 1000 feet wide to the depth of 600 feet. Many small fish were observed enveloped in the mud. No doubt the fossil fishes and insects found at Oeningen were brought down from an old crater-lake by a Miocene volcano. Similar deposits, also of volcanic origin, rich in fossil fishes, are found at Aix, in Provence.

The volcano of Imbaburu, in 1691, vomited forth so many fishes that it bred fever, from the stench caused by their decomposition, and that of other animals destroyed by the débacle.

The distance to which the sound of volcanic explosions is transmitted, and the fine ashes scattered by the currents of the air, is truly wonderful. "On the night of 30th April," writes Professor Dove,[2] "explosions like those of heavy artillery were heard at Barbadoes, so that the garrison at Fort St. Anne remained all night under arms. On May 1st, at daybreak, the eastern portion of the horizon appeared clear, whilst the rest of the firmament was covered by a black cloud, which soon extended to the East and quenched the light there, and at length produced a darkness so dense that the windows in the rooms could not be discerned. A shower of ashes descended, under which the tree branches bent and broke. Whence came these ashes? From the direction of the wind we should infer that they came from the Peak of the Azores; they came, however, from the volcano of Morne Garou, in St. Vincent, which lies about 100 miles West of Barbadoes. The ashes had been cast up with such force as to enter into the current of the upper trade-wind.

"A second example of the same kind occurred in January, 1835. On 24th and 25th the sun was darkened in Jamaica by a shower of fine ashes, which had been discharged from the mountain Coseguina, 800 miles distant. The people learned in this way that the explosions

[1] Van der Boon Mesch, in Lyell's "Principles of Geology," vol. ii., p. 56.

[2] Dove, Prof. Witterungs Verhaltnisse von Berlin, in Tyndall's "Heat as a Mode of Motion," p. 166.

previously heard were not those of artillery. These ashes could only have been carried by the upper current, as Jamaica lies North-east from the mountain. The same eruption gives also beautiful proof that the ascending air current divides itself above, for ashes fell upon the ship Conway, in the Pacific, at a distance of 700 miles South-west of Coseguina.

"The roaring of Coseguina was heard at San Salvador, a distance of 1,000 miles. Union, a seaport on the West coast of Conchagua, was in absolute darkness for 43 hours; as light began to dawn it was observed that the sea-shore had advanced 800 feet upon the ocean, through the mass of ashes which had fallen.

"The eruption of Morne Garou forms the last link of a vast chain of volcanic actions accompanied by earthquake shocks. In June and July, 1811, near San Miguel, one of the Azores, the island Sabrina rose, accompanied by smoke and flame, from the bottom of the sea, 150 feet deep, and attained a height of 300 feet and a circumference of a mile. The small Antilles were afterwards shaken, and subsequently the valleys of the Mississippi, Arkansas, and Ohio, but the elastic forces found no vent; they sought one, then, on the North coast of Columbia. March 26th began as a day of extraordinary heat in Caraccas; the air was clear and the firmament cloudless. It was Green Thursday, and a regiment of troops of the line stood under arms in the barracks of the quarter of San Carlos, ready to join in the procession. The people streamed to the churches. A loud subterranean thunder was heard, and immediately afterwards followed an earthquake shock, so violent, that the church of Alta Gracia, 150 feet high, borne by pillars 15 feet thick, formed a heap of crushed rubbish not more than 6 feet high. In the evening the almost full moon looked down with mild lustre upon the ruins of the town, under which lay the crushed bodies of upwards of 10,000 of its inhabitants. But even here there was no exit granted to the elastic forces underneath. Finally, on April 27th, they succeeded in opening once more the crater of Morne Garou, which had been closed for a century, and the earth, for a distance equal to that from Vesuvius to Paris, rang with the thunder-shout of the liberated prisoner."

The eruption of Vesuvius in 1794 was the most formidable known in the history of this truly classical crater.[1]

On the evening of June 15th violent earthquake shocks were felt, and a sudden outburst of lava in the Pedimentina, among the remains of the earlier currents, occurred at two p.m. A fissure 2,375 feet long was produced, from which the lava issued for the space of 237 feet in breadth, throwing up four crateriform cones, each of which ejected red-hot stones in quick succession, so as to appear like one continuous outburst. The showers contained really fluid lava (similar to the lava fountains seen in the Hawaian Islands).

[1] A most valuable and interesting account of Vesuvius was read before the Geologists' Association, by the now Honorary Secretary, J. Logan Lobley, Esq., F.G.S., in 1868, giving not only its history, but a description of a personal visit paid during the last eruption. This has since been published in a separate form, by E. Stanford, Charing Cross, with illustrations, and a list of all the minerals both of Somma and Vesuvius.

The lava issued from 15 mouths, and ran towards Portici and Resina in two streams, and the inhabitants of Torre del Greco (whilst sorrowing for their neighbours) rejoiced, and gave thanks in the churches for their own escape. But these two streams stopped short, and the main body, after all, rushed towards the sea, right through the poor town of Torre del Greco (which had hoped to escape), presenting a fiery front of 1,500 feet. It continued, and entered the sea, advancing into it until the 17th inst. The distance from the outlet to the sea margin is 12,961 feet, which was traversed by the lava in six hours.

Sixty-six eruptions of Vesuvius occurred from A.D. 79 to 1868. Of these the first, in A.D. 79, was the great historical eruption when Pliny the elder lost his life, and half of the old crater of Somma was blown away. It was this which destroyed Herculaneum, which now lies buried under six outbursts of ashes, liquid mud, and lava. It is situated under the modern town of Resina, and harder to dig out than Pompeii, which was overwhelmed by an eruption of dry ashes and lapilli. Stabiæ, the furthest distance removed, was buried, but not so utterly destroyed, by an eruption of dry ashes and lapilli only. Pliny the younger witnessed this eruption.

A.D. 472.—Ashes from Vesuvius were spread over Europe as far as Constantinople, causing terror to the inhabitants, who keep up the anniversary on the 8th of November.

A.D. 1631.—Darkness and great agitation of the sea. Ashes fell at Constantinople. Torrents of rain and mud descended, with stones, ashes, and vapour, accompanied by seven streams of lava. Torre del Greco, Resina, Granatello, and Portici, were all destroyed, and 18,000 persons are said to have perished.

A.D. 1822.—Eight hundred feet of the modern cone was blown away, and a great discharge took place of ashes and vapour.

For further accounts of Vesuvius, see Scrope's grand works on volcanos, and Prof. Phillips' and Mr. Lobley's works on Vesuvius.

To these and to Sir Charles Lyell's "Principles" we are largely indebted for most of the facts here recorded.

Any account of volcanos and volcanic phenomena would be incomplete without some reference to Hot or Thermal Springs. These Springs are most abundant in volcanic districts, but are often met with far away from the *foci* of disturbance. Their waters are more voluminous and less variable than those of ordinary springs.

Jets of steam, called by the Italians "Stufas," issue at temperatures far above the boiling point near Naples, and in the Lipari Isles, and are disengaged for ages unceasingly.

In old volcanic regions, as central France, the Eifel in Germany, etc., hot springs are frequent. They all give off abundance of gases, and contain earthy matter in solution in great quantities, corresponding in character with those evolved by volcanos.

The hot well of Bath is an illustration of a thermal spring far removed from any existing focus of volcanic energy, being 400 miles from the Eifel, and 440 from the Auvergne. It gives off 250 cubic feet of nitrogen gas daily, a considerable quantity of carbonic acid gas, sulphates of lime and soda, and chlorides of sodium and magnesium. The discharge of water and mineral ingredients is alike uniform and constant from century to century. The temperature remains constant at 120° Fahr.

These Baths were well known to the Romans, and the old Sanatorium of Aquæ Solis is still marked by many Roman remains.

If the solid matter brought up in solution by the Bath waters could be accumulated for one year, they would form a square column 9 feet in diameter, and 140 feet in height. Yet all this solid matter is conveyed away in a limpid stream to the Avon, and by the Avon to the sea. (Lyell's "Principles," vol. i., p. 398.)

What is the cause of thermal springs? Water descending to deep levels in the strata meets at some point with steam at a high temperature, which, being converted into water by contact, raises the temperature of the water, which in turn, as the store of heat is accumulated, rises by rents and fissures to the surface in the form of thermal springs.

There seems no doubt that hot springs have a direct connexion with volcanos.

1. Hot springs are present in all volcanic areas.

2. Where not connected directly with volcanos, they are found situated, as in the Pyrenees, the Alps and the Himalayas, upon lines of dislocation and disturbance where volcanic force, if not visible at the surface, has been in operation far down beneath.

3. Hot springs distant from volcanic disturbances are nevertheless affected by them. Thus the "Source de la Reine," at the baths of Luchon, in the Pyrenees, was raised suddenly during the great earthquake of Lisbon in 1755, from a tepid spring to 122° Fahr., a heat which it has since retained.

Although springs, as a rule, carry carbonate of lime and sulphate of lime in solution, the hotter thermal springs alone contain large quantities of silica in solution. For example: the hot spring of St. Michael, in the Azores, having a basin 30 feet in diameter, is surrounded by layers of travertin many feet in thickness, composed of siliceous matter deposited on wood, reeds, ferns, etc.

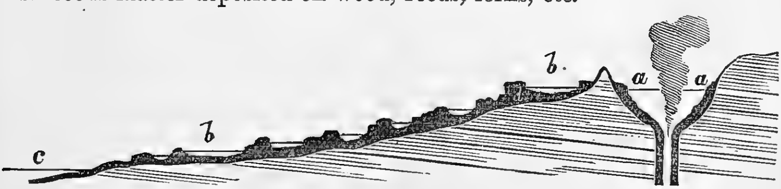


Fig. 10.—Section through Basin and Terraces of siliceous sinter. Hot-springs Te Tarata, Rotomahana, New Zealand. (See Hochstetter's New Zealand, p. 137.)

a. a. Level of water in repose in great Basin.
b. b. Series of Basins into which the overflow water from the great Basin is discharged during eruptions.
c. Level of the river. *d.* Siliceous sinter and travertin deposited by the evaporation of the water.

The hot springs of New Zealand (Fig. 10) are, perhaps, the finest, exceeding even the Great Geyser in Iceland, which also deposits enormous quantities of silica from its waters on cooling, originally held in solution.

The Great Geyser has a cone-like elevation around its basin made up of layers of travertin. The following are its principal measurements:—

Diameter of basin	56 feet.
Depth of tube	74
Diameter of tube	8–10

Professor Bunsen, in 1846, took the temperature of the Great Geyser tube by a thermometer suspended by a string. The results of his observations are given in the annexed woodcut (Fig. 11):—

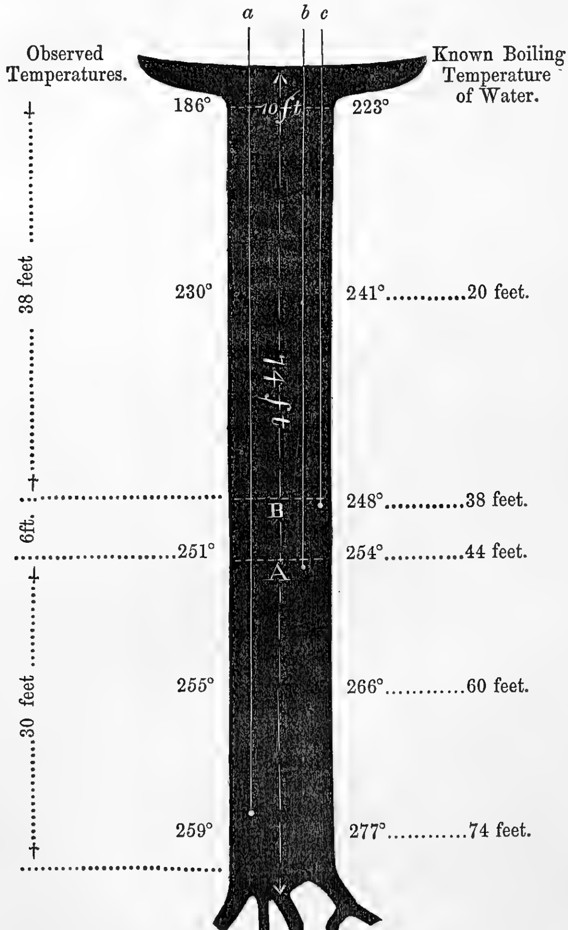


Fig. 11.—Section of Tube of the Great Geyser in Iceland. (After diagram in Prof. Tyndall's "Heat a Mode of Motion," p. 126.)

How does the water rise, under pressure, so much above the ordinary boiling point for water at the surface?—Because, being deprived of air by frequent boiling, it refuses to circulate freely up and down the pipe; therefore, the lower stratum becomes exceedingly heated, and is able at last to overcome the great pressure, and to rise into steam, carrying up with it upwards of fifty tons of water with an eruption 100 feet in height.

In order to ascertain at what depth steam was formed in the tube of the Geyser, Professor Bunsen suspended stones at the ends of cords (Fig. 11, *a*, *b*, *c*), of various lengths, in the tube. When an explosion took place the stone at *c* was found to be blown out, whilst the stones *a*, *b*, remained undisturbed. He thus learnt that it was between A and B that steam was formed; in fact, just at that point in the tube where the observed temperature approaches most nearly the known boiling point for water under the pressure of a column of water of about 40 feet.

Referring the Geyser-action to the crater of a volcano, where steam in a white-hot state under enormous pressure must exist, we can readily see the explanation of the rhythmical explosions which some volcanos constantly keep up.

So long ago as 1825, Mr. Scrope arrived at the conclusion that the mobility of the solid component particles of liquid lava was not due to the mass being in a state of molecular fusion—in which condition it never occurs subaërially—but to the presence of an interstitial fluid disseminated through the mass, and that this fluid was water in a highly comminuted condition. This conclusion he seems to have arrived at from observing that the incandescent lava at the moment of its exposure, and in the act of consolidation, always gave off abundance of steam.

"Water," says Mr. Scrope, "we know is converted into vapour only at temperatures increased in proportion to the increased pressure to which it may be subjected; and when altogether hindered from communication with the atmosphere, as in a Papin's digester or other closed vessel, may be made red-hot, without expanding into vapour.

"The moment, however, that the opening is made in the inclosing vessel (reducing the pressure to that of the atmosphere only), it flashes instantly into steam with explosive violence. The same effect of course must take place in an imperfect liquid or paste composed of water, and any solid matter in mechanical suspension or mixture, such as flour, clay, sand, or any other granular substance." (Scrope, "Volcanos," p. 39.)

The theories as to the source of volcanic heat are many and various; but the one which may be said to claim the largest share of support is that which attributes the phenomena of volcanos and earthquakes to the reaction of the interior of our planet upon its uppermost strata.

A volcano appears always to keep up a permanent connexion between the interior of the earth and the atmosphere, or the sea, either directly or indirectly; sea-water being doubtless the source of many mineral ingredients in volcanic products.

Mr. Hopkins, nearly thirty years ago, and subsequently Archdeacon Pratt and Sir William Thomson, have condemned as untenable and contrary to the known laws of precession and nutation the notion of a globe with a moderately thick crust, and a fluid interior.

In order to produce a complete accordance in the motion of the entire mass, it is necessary, according to these authorities, to assign a solid crust of at least 800 to 1000 English miles in thickness. Can any one believe that lava is pressed up through channels of that length?

M. Delaunay has, however, clearly shown that "there is a fundamental error, not in the mathematical formula, but in the condition assumed, namely, that the interior is filled with a free-flowing liquid rock. The interior fluid can only be of the nature of lava, and that, when examined at the surface, however fresh, is a very intractable mass, flowing indeed as does thick honey, pitch, or slag; incapable of moving, at the very utmost, above a few miles an hour, even on a slope of 30°, and on ordinary slopes only one mile, half a mile, or even thirty or forty feet in an hour. In this condition it would obey perfectly the motions of the solid crust. The problem solved by Mr. Hopkins, looked at in this light, does really not settle anything as to the thickness of the earth's crust." (Phillips, "Vesuvius," p. 332.)

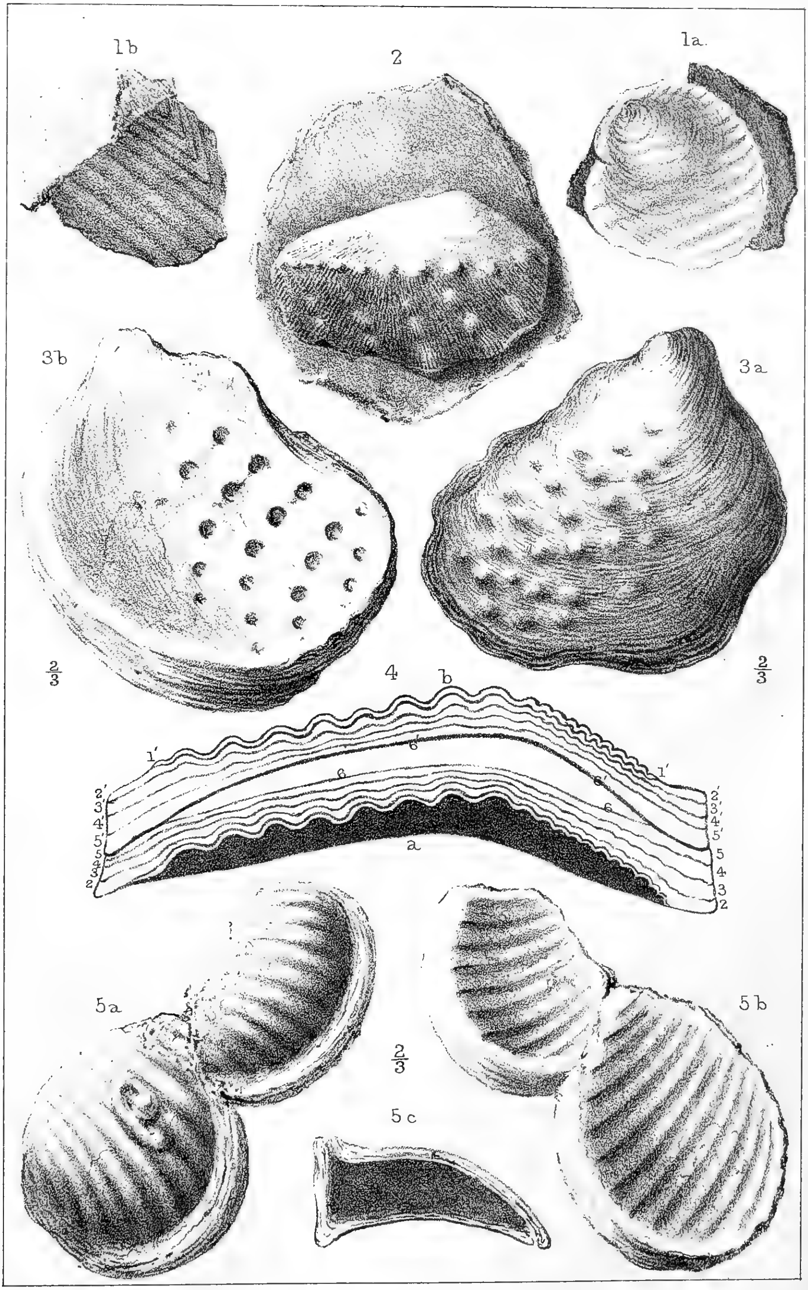
"The globe is continually, though very slowly, losing heat; it grows cooler in a very small degree, and suffers contraction in the same small degree. From what we know certainly of the constitution of the crust of the globe it is of unequal strength to resist change of form in different parts. The weakest part must yield, and if by local yielding the general pressure may be satisfied (which is equivalent to supposing the general pressure determined to a small area), the displacement of small tracts may be extremely great, and the rocks be bent into arches and broken by faults."

"If we are right in our views of the history of the globe, very many epochs would arise, where, first in one region, then in another, lines or areas of relative weakness would be depressed into concave seas, and receive a long series of deposits; and at other times the same areas, or parts of them, might be re-elevated, producing end-pressures and violent local flexures or fractures, resulting in earthquake shocks and volcanic eruptions." (Ibid., p. 335.)

Viewed by the light which volcanic action affords us in other parts of our globe at the present day, the geologist sees the simplest explanation possible by which to understand the upheaval of the sedimentary rocks.

But it is not where volcanic force exhibits itself at the surface, escaping in jets of steam and vapour, or even in lava-flows, that we look for the greatest proof of work accomplished. As well might we study the smoke-stack of a steam-engine to judge of its horse-power. No; it is by the consideration of the elevatory force exerted to raise such vast masses as the Himalayas, or the Peruvian Andes, that we can best appreciate the work achieved by upheaval.

Nay more. Not an inch of land could remain permanently above the sea-level but for its silent yet mighty support. And when we look back through Mesozoic to Palæozoic times we see its active and



G.R. De Wilde del. et lith.

Mintern Bros. imp.

To illustrate Mr. J.W. Judd's paper on the anomalous growth of certain Fossil Oysters.

beneficent agency still in operation—first, in conserving our coal strata by lowering them so as to admit of deposition, to a vast amount, taking place above them; and again in uplifting them so as to bring them, and indeed every other economic stratum of our island, within easy access to meet our varied and ever-increasing needs.

II.—On the Anomalous Mode of Growth of Certain Fossil Oysters.

By John W. Judd, F.G.S.

(PLATE IX.)

In that rich storehouse of fossils, the Cornbrash, there occur, as all geologists who have been in the habit of collecting from it are aware, several species of the genus *Ostrea*, two of which are large and conspicuous shells. One of these is the everywhere abundant and very characteristic plicated form known as *O. Marshii*, Sow. (*O. flabelliformis*, Lamk.?); the other, which is far less common, but by no means rare, is flat and smooth, and sometimes considerably elongated in form. This latter species does not appear to have received a name in this country, but it may not improbably be identical with the *O. exarata* of Goldfuss (Petrifacta Germaniæ, Theil ii. z. 5, tab. 72, fig. 9), a shell first obtained from the *Unter-oolith* of Gräfinberg.

If we look over any collection of specimens of this Cornbrash Oyster, we shall almost certainly be struck with the appearance of some detached upper valves, which exhibit on their outer surfaces markings very different from those belonging to any known species of Oyster, and unmistakably resembling those which characterize totally different classes of shells. The interiors of these valves, however, exhibit no peculiarity whatever, but have the smooth surface with the impression of the single adductor muscle, which characterizes that group of the Mollusca to which the Oysters belong. Occasionally the markings on the outer surfaces of these oysters appear to be nearly as distinct and sharply defined as those of the shells which they imitate. The shell of which the markings appear to be most frequently copied in this manner is a clavellate *Trigonia*, itself a tolerably abundant fossil of the Cornbrash, and known as *T. Scarburgensis*, Lycett; but specimens of the oyster bearing the markings of *Ammonites Herveyi*, Sow., and other common Cornbrash shells, are by no means rare.

Of course the first suggestion which offers itself to the mind, in attempting to account for these appearances, is that the oysters are merely impressed with the features of the objects to which they happened to grow attached. But a moment's consideration suggests a fatal objection to this explanation; we are required to account for the production, not of a *cast*, but of a *facsimile* of the shell copied. In the case of a remarkable oyster in the British Museum, which bears the markings on the back of an Ammonite of the group of the

Ligati, an attempt to meet this difficulty has been made by the suggestion that the oyster had grown on the *inside* of a dead Ammonite shell. Setting aside the inherent improbability of this explanation, it is evident that it will not serve us in the case of oysters taking the markings of *Trigonia*, as the inner surfaces of these latter bear no resemblance whatever to their outer.

So remarkable is the appearance of shells of one genus bearing the *superficial* markings of those of a totally different group, but otherwise retaining all their essential characters, that I was at one time even tempted to speculate whether we might not have here in the Oolitic rocks an actual case of *mimicry*, possibly for protective purposes, similar to those which obtain so frequently among many living animals. The collection and careful examination of a large series of specimens, while it has dispelled this idea, has led to the true explanation of the phenomenon—an explanation which is not a little curious and interesting.

Among the thin-shelled *Ostreidæ* (*Anomia, Placunopsis, Placuna, Plicatula*, etc.), we frequently find specimens that have grown attached to shells or other foreign bodies in which, owing to its tenuity, the whole organism, lower valve, animal and upper valve, has become moulded on to and taken the markings of the surface on which it lies. In Plate IX. two examples illustrating this are shown. Fig. 1*a*, 1*b*, represents the upper and under sides respectively of a specimen of *Placunopsis Jurensis*, Mor. and Lyc., which has grown attached to the side of *Goniomya V-scripta*, Sow. This specimen, which was obtained from the Cornbrash of Scarborough, by the late Mr. Bean, is now in the British Museum. In Fig. 2 is shown a still more curious specimen; it was obtained by Dr. Lycett from the Inferior Oolite of Rodborough Hill, near Stroud, and is in the Museum of Practical Geology, Jermyn Street. This specimen is a *Placunopsis*, of a species not yet described, which has grown upon a clavellate Trigonia; the surface of its upper valve exhibits the peculiar markings of the Placunopsis in combination with those of the Trigonia.

If we were to find the upper valve of a Placunopsis, like either of those we have been describing, lying detached in the rock (which we seldom or never do), it would resemble, in the character of its outer surface, the oysters to which we have referred; but its inner surface would differ altogether by following all the foldings and wrinklings of the outer, instead of being perfectly smooth.

Occasionally we find specimens of our Cornbrash oyster with both valves preserved. A good example of this is shown in Plate IX., Fig. 3. The specimen which is in the British Museum was collected by W. Cunnington, Esq., at Weymouth. 3*a* shows the upper valve displaying very distinctly the characteristic tubercles of the Trigonia; 3*b*, the lower valve, in which precisely the same markings are exhibited in reverse or as a cast. On separating the two valves, we find the interiors quite smooth, and exhibiting no trace whatever of the prominent markings of the exterior.

If we consider the characters presented by this specimen, at the same time bearing in mind the features presented by the attached thin-shelled *Ostreidæ,* like *Placunopsis,* and also the mode of growth of the shell in the oysters by the deposition of successive laminæ from the mantle of the animal, we are led to realize the exact manner in which the singular examples to which we have referred have been produced.

This we have illustrated by the ideal section, Fig. 4, which represents a Trigonia shell (*a*), upon which an oyster (*b*) has grown. At an early stage of its growth the valves of the oyster would be represented by 1–1, 1′–1′; these being then nearly in apposition, and the animal like them extremely thin, and partaking of all the undulations of the surface of the Trigonia. In this state the oyster would exactly resemble the specimen of *Placunopsis* represented in Fig. 2. The subsequent growth of the oyster was almost entirely confined to an increase of the thickness of the shell. The two first-formed laminæ, 1–1, 1′–1′, would not be in any way altered by the shell's subsequent growth, though they would be thrust gradually farther and farther apart. The successively deposited layers of shelly matter would naturally be less and less conformed to these exterior laminæ, and thus these markings becoming continually fainter on the interior of the shell, would at last be obliterated altogether. The successive stages of growth of the two valves are represented in the diagram by the lines 2–2, 2′–2′; 3–3, 3′–3′; 4–4, 4′–4′; 5–5, 5′–5′; and 6–6, 6′–6′. Of course, as the animal increases in thickness as well as the shell, an excessive deposition of shelly matter will have to take place at the edges of the valves, and this is always observed to be the case in the specimens of which we are speaking.

That this is the true explanation of the remarkable appearances to which we have directed attention in this note is confirmed by an examination of sections of these oysters, and also by the successive removal (by the aid of dilute acid) of the several laminæ of which the shells are composed.

It is evident that the oysters which present these mimetic markings over nearly the whole of their surfaces must, in their early stage of growth, have increased very slowly vertically, but rapidly laterally, like *Placunopsis,* so that the shell must have attained almost its full diameter before it began to increase greatly in thickness.

As an example of the singular objects which are sometimes produced in consequence of the peculiar mode of growth of these oysters, we have figured a specimen obtained by the late Dr. Porter from the Cornbrash, near Peterborough. In this case two oysters have grown side by side on the back of a large example of *Ammonites Herveyi,* Sow., and at last have so pressed upon each other that they have become united at their edges. The curvature of the Ammonite shell, with the markings of its surface, have been reproduced on this double specimen, the ribs of the former appearing as casts on its under side (5*b*) and in relief on its upper side (5*a*); 5*c* represents a section of this singular specimen.

Besides the species to which we have been referring, other oysters exhibit, in a greater or less degree, a tendency to this mode of growth. Conspicuous among these is the well-known *O. deltoidea*, Sow., of the Kimmeridge Clay. In the British Museum (Northern Gallery, Room V., Table Case 2) there is exhibited an interesting series of these shells from Boulogne, which have grown upon different portions of several species of Ammonites.

Other oysters, which are only attached during a short portion of their existence, sometimes display the characters we have been describing in the portion of the shell first formed. Thus the plicated *O. gregaria*, Sow., of the Coral Rag, sometimes exhibits on the central ridge of its attached and free valves respectively, the cast and facsimile of the surface of a coral to which it has been attached.

That the Gryphoid oysters, which normally become free at a very early stage of their existence, sometimes remain attached during a considerable portion of their life, is well known, and has been referred to by Mr. Jones in his interesting paper, "On *Gryphæa incurva* and its Varieties," in the Proceedings of the Cotteswold Club, vol. iii., p. 81. The aberrant forms thus produced have even been mistaken in some cases for distinct species of oysters. These *Gryphææ*, with large surfaces of attachment, sometimes strikingly exhibit the phenomenon which we have described in this note. In the British Museum there are two specimens of *Gryphæa dilatata*, Sow., from the Oxford Clay of Weymouth, each of which has grown on the outside to a Trigonia, till it has attained about one-half of its diameter. The portion of the shell formed during the period of attachment shows clearly the markings of the Trigonia in cast and facsimile, while the interior is quite smooth. In another example we find a small Trigonia shell with its outer surface still embedded in the incurved beak of a Gryphæa; on the inner surface of the attached valve of this latter there are no traces of the markings of the Trigonia, but these are beautifully reproduced on the exterior of the free valve.

Although Goldfuss has figured some specimens of oysters with the markings of other shells, such anomalous objects are generally excluded from the plates which illustrate palæontological treatises. An exception is found in the magnificent "Der Jura" of Professor Quenstedt, a work which is the result of the most patient, minute, and exact observation, and which may be quoted as the most faithful delineation of the characters of a single formation in a given area with which geological science has as yet been enriched. In this work we find figured under the name of *O. falcifer* (Atlas zum Jura, tab. 37, fig. 1) an oyster from the Upper Lias, which exhibits the sigmoidal markings of the shell of *Ammonites falcifer*, Sow. Prof. Quenstedt does not appear to have noticed the remarkable character of the smooth surfaces of the interior of these oysters; but he remarks that the animal was probably very thin, and in this respect allied to that of *Placuna*. In the same work, tab. 6, fig. 9, tab. 11, fig. 9, and tab. 23, fig. 6, there are represented other examples of Ostreiform shells which have taken the markings of the shells to which they have grown attached.

EXPLANATION OF PLATE IX.

Fig. 1*a*, *b*. Upper and under side of *Placunopsis Jurensis*, Morris and Lycett. Cornbrash, Scarborough.
Fig. 2. *Placunopsis*, sp. nov. Inferior Oolite, near Stroud.
Fig. 3*a*, *b*. Upper and under side of *Ostrea*, sp. Cornbrash, Weymouth.
Fig. 4. Ideal section of *Ostrea*, showing growth (see page 357).
Fig. 5*a*, *b*, *c*. Upper and under side, and section of *Ostrea*, which has grown on the back of *Ammonites Herveyi*. Cornbrash, Peterborough.

III.—Notice of Soundings executed in the Lake of Como, with a view to determine the Form of its Bed.

By John Ball, F.R.S.

(PLATE X.)

THOSE who have taken part in the recent discussions as to the origin of lake-basins are well aware that one of the chief causes which has retarded a settlement of the controversy is the ignorance prevailing as to the true form of such basins. Even as to the Swiss and Lombard lakes, constantly visited as they have been by men of science, the data are extremely scanty and no way reliable. A few soundings made by myself in the Lake of Como, in 1863, and referred to in a paper published in the *Philosophical Magazine* in the following December, increased my conviction of the importance of instituting careful and exact measurements of the form and dimensions of the beds of lakes, if we were to reason securely as to their origin. I expressed that conviction at the time to an active local naturalist, Don Baldassare Bernasconi, residing at Laglio. In 1865 Signor Gentilli, one of the engineers of the Lombardo-Venetian Railway, being for some months on the Lake, proposed to undertake a regular survey of the bed of the Lake by means of a complete series of soundings, and devised an instrument for measuring the distances traversed horizontally in a boat, corresponding to each cast of the sounding line. Signor Gentilli found two active coadjutors in the persons of the above-named ecclesiastic, and of Dr. Guiseppe Casella, also resident at Laglio, on the Lake.

The results were published by Signor Gentilli in a paper inserted in the second volume of the Memoirs of the "Società Italiana di Scienze Naturali," and also in a little tract, entitled "Cenni Orografici sul Lago di Como," by MM. Casella and Bernasconi, both dated in 1866.

It is apparent that the authors of the second paper found cause for complaint as to the form adopted by Signor Gentilli for the publication of results which had been mainly obtained through the labour and perseverance of his coadjutors.

An examination of the plans and sections contained in both papers displays a general agreement in the results, showing that they are derived from identical materials, along with some discrepancies easily accounted for when we recollect that some of the sections are executed independently, and do not follow the same line exactly.

To a fourth contributor—Signor Ferdinando Stoppani—are due most of the measurements in the Lecco branch of the Lake.

Geologists in foreign countries will feel little interest in the personal question here referred to, but they cannot fail to attach importance to the results of such a work, which appears to have been carefully and efficiently conducted. The mode adopted for measuring the horizontal distances between the point where soundings were made, does not seem to have been free from objection; but the errors, if any, could not be considerable enough to affect the general result.

It is remarkable that these measurements should have remained unknown to many geologists, even among those who take a special interest in the subject, and that they are not referred to by so careful a writer as Professor Rütimeyer in the important memoir, "Ueber Thal- und See-bildung," in which he has fully discussed the disputed question of the origin of Alpine Lakes. On this account I believe that the plans and sections accompanying the present paper, being reduced copies of those published by the original observers, will be full of interest to all who have attended to this subject.

Very little comment is necessary to the full understanding of the accompanying plans. Most travellers are familiar with the form of the Lake of Como. Filling the bottom of a great valley that extends southward from near Chiavenna, at the foot of Splügen, to Bellagio, it forks at that point. What is called the Lecco branch extends S.S.E. beyond the town of Lecco, and sends the Adda to carry the drainage of the lake-basin to the Po, across the plain of Lombardy. The Como branch, about equal in length to that of Lecco, is more sinuous, but the general direction is S.S.W. from Bellagio. At the south end it is closed by a barrier of solid rock that rises behind the city of Como to a height of about 200 feet above the Lake.

The original bed of the Lake, as thus roughly sketched, has been extensively modified by the action of Alpine torrents that continually pour vast masses of detritus into the basin. At its northern extremity the Mera, draining the valleys of San Giacomo and Bregaglia, has filled up the original bed of the Lake for a distance of nearly five miles, and the shore is first reached at the hamlet of Riva, nearly half-way from Chiavenna to Colico. Still more considerable changes have been effected by the Adda. In a course of over seventy miles this receives numerous affluents from the lateral valleys of the Rhætian and Lombard Alps, until it enters the lake near Colico in the form of a turbid stream, heavily charged with glacial silt and coarser detritus. It is very probable that an arm of the Lake, long since filled up, once extended to Morbegno in Valtellina; but it is at all events certain that the Adda has completely barred the main channel of the Lake, forming a wide delta that stretches from shore to shore, and cutting off the northern part of the ancient Lake—now called Lago di Mezzola—from the main basin.

At the opposite end of the Lake, where there is every reason to suppose that the original bed was comparatively shallow, several rapid torrents have carried masses of Dolomitic debris into the Lake at Lecco, and again at Olginate, so that at each place the channel is

OUTLINE MAP AND SECTIONS OF THE LAKE OF COMO   To Illustrate Paper by John Ball Esq. F.R.S.

narrowed to the dimensions of a river, and the soundings cease to give any secure indication of the original form of the lake-basin.

From these statements it will be inferred that the portions of the lake-basin, where alone it is possible to obtain an approximation to its original form, are those lying between Gera and Lecco, along with the entire line of the Como branch, the distances being nearly 24 miles, if we measure from Gera to Lecco, and more than 31 miles from the former village to Como. Future observers, may perhaps, ascertain what amount of transporting power is exercised by currents setting in the direction of the stream through the deeper parts of a lake-basin; but for the present it seems safe to assume that this is but inconsiderable, and that nothing but fine glacial silt can be transported to any considerable distance from the point where a stream enters the Lake. Detailed measurements of the "cones of ejection" formed by the deposit round the mouths of streams are wanting to establish this securely, but some evidence is given in the annexed plans. The promontory on which stands the village of Mandello is the upper portion of the "cone of ejection" formed by the Neria torrent, an impetuous stream laden with the Dolomitic debris of the Grigna mountain, the remainder of the cone being prolonged under the surface of the Lake. The section from Santa Anna to Mandello (Fig. 14) does not cut the front of the cone at an exact normal; but it shows that at the utmost this does not extend more than about 1150 yards from the shore, or about half-way across the present (contracted) bed of the Lake, with a slope of more than 1 in 10. The section made from Onno (see Fig. 1), more nearly opposite the point of the same promontory, showing a maximum depth of only 90 yards, has not been published, but as it indicates a slope of at least 30 in a horizontal distance of 875 yards, measured along what is probably a tangential section crossing the base of the cone, it confirms the inference as to the comparative steepness of the subaqueous portion of such a "cone of ejection."

With such materials as I possess for forming a judgment, I am disposed to think that the cone of ejection of the Adda does not at the utmost extend beyond the line connecting Domaso with Montecchio, the fact being that in modern times the river falls into the Lake of Mezzola, and its detritus serves to fill up that portion of the original Lake of Como. It is probable that a thin stratum of glacial silt covers the bed of the Lake throughout its northern half; but even this can scarcely be present in the southern branches, and especially in the Como branch of the Lake. This is in every way remarkable. It is a closed basin except where it joins the main body of the Lake opposite Bellagio, and throughout a coast-line exceeding 40 miles in length it receives but two unimportant torrents—at Como and Argegno—and it may safely be said that there are no existing causes that tend materially to alter the form of its bed. How singular this is may best be learned by studying the annexed sections (Figs. 8, 9, and 10), which, be it remembered, are drawn to true scale. The object of this paper is to supply facts, and not to discuss their interpretation; and it is sufficient here to call attention to the very remarkable section given in Fig. 9. Every one who has attended to the subject will desire additional information as to the nature of the lake-bottom, which fills the almost perfectly level space between the perpendicular cliffs at either side. The superficial deposit brought up by the sound from a depth of 447 yards, is a greenish grey mud of impalpable fineness, which was examined under the microscope by MM. Casella and Bernasconi. It appears to be exclusively composed of organic matter, consisting mainly of Diatomaceæ and Confervaceæ either in an entire or fragmentary condition.

Signor Gentilli appears to adhere to the theory of lake excavation by glaciers, but declines to discuss the application of that theory to the facts disclosed in respect to the Lake of Como. He makes one remark, however, which appears to me to be absolutely at variance with them. Supposing the rocks on either side to be of equal hardness, and similarly stratified, it is safe to affirm that if they had been hollowed out by glacial action, or by aqueous erosion, the slope would be steepest on the concave side of the bend in those parts of the Lake where the glacier stream was turned aside from its previous direction. Three such bends are conspicuous in the map of the Lake (Fig. 1), and correspond to the positions of Castello di Musso, Argegno, and Riva Palanzo. The erosion theory leads one to expect at each of those places a much more rapid slope than on the opposite side, and Signor Gentilli refers to the section between Argegno and Cavagnola as confirmatory of the theory. I do not find this assertion to be justified by the section, copied accurately from Signor Gentilli's memoir, given in Fig. 8. It is true that if we divide the section into two equal parts the average depth is rather greater on the Argegno side, but the deepest sounding of all lies on the opposite side, and, what is more important, the declivity of the bed, near the lake-shore, is actually steeper on the Cavagnola side. A depth of 190 yards is there found at a distance of 100 yards from the shore, while it is necessary to go 120 yards from the Argegno shore to obtain an equally deep sounding. If there be any doubt in regard to this section, there can be none as to that between Castello di Musso and Olgiasca (Fig. 5). There are some important differences between the section here referred to, extracted from the paper of MM. Casella and Bernasconi, and that given by Signor Gentilli, doubtless because not made exactly between the same points, but they agree completely in showing that for a distance of several hundred yards from the shore on either side the slope is twice as rapid on the east side as on the opposite shore, being the exact contrary of the result required by the erosion theory.

The details of the section between Carate and Riva Palanzo have not been given to the public.

When the beds of other Alpine lakes shall have been surveyed with the same care that has been bestowed on that of Como, geologists will be able to reason much more securely than they have hitherto done on the causes that have given them their present form.

EXPLANATION OF PLATE X.

Fig. 1.—Outline map of Lake of Como, with the names of the places between which transverse sections have been taken. The numbers inserted show the maximum depth in yards of the Lake at each transverse section.

Fig. 2.—Longitudinal section of the lake from Gera to Ponte, near Lecco, the numbers affixed to the vertical dotted lines showing the maximum depth of the Lake in yards at each point where a transverse section has been made, and the numbers written parallel to the surfaces showing approximately the horizontal distance in yards between one transverse section and the adjoining one. The vertical distances showing the depth are exaggerated as compared with the horizontal distances in the ratio of five to one.

Fig. 3.—Longitudinal section of the Lake from Gera to Como, the numbers corresponding to those in Fig. 2, and being identical so far as the portion between Gera and the section from Menaggio to Varenna.

Fig. 4.—Transverse section between Domaso and Montecchio. The numbers written horizontally denote approximately the distances in yards from the western or left hand shore at which each sounding was taken, and the numbers written vertically the corresponding depth in yards. In this and all the succeeding transverse sections the vertical and horizontal distances are drawn to the same scale.

Fig. 5.—Transverse section between Castello di Musso and Olgiasca.

Fig. 6.—Transverse section between Rezzonico and Dervio.

Fig. 7.—Transverse section between Villa Ricordi and Bellagio.

Fig. 8.—Transverse section between Argegno and Cavagnola.

Fig. 9.—Transverse section between Torriggia and Corno.

Fig. 10.—Transverse section between Lucisino and Torno.

Fig. 11.—Transverse section between Villa Capriccio and Geno.

Fig. 12.—Transverse section between Villa Serbelloni and Fiumelatte.

Fig. 13.—Transverse section between Bellagio and C. Cicogna.

Fig. 14.—Transverse section from S. Anna to Mandello.

IV.—On the Co-relation of the Carboniferous Deposits of Cornbrook, Brown Clee, Harcott, and Coalbrook-dale.

By Daniel Jones, F.G.S.

It has not hitherto been clearly made out in what way these Carboniferous patches are related to each other. Some have considered it doubtful whether the three former are in any way represented in the Coalbrook-dale Field. The prevailing impression is, I believe, that the Clee Hill Fields are quite distinct in point of age from any of the Coal tracts surrounding them, and were formed in a depression sufficiently low to receive the Millstone Grit which we find to be wanting in the extensive Coal-fields to the East and North-east, except, let me observe, along the Western margin of the Coalbrook-dale district, where it is not well developed, but still represented. Eastward of that margin, however, it thins out rapidly, and gives way to the Silurian flooring of that Coal-field.

I propose to show the following co-relations :—

a. Between Cornbrook and Brown Clee Hill;
b. „ Cornbrook and Harcott;
c. „ Harcott and Coalbrook-dale;

taking fixed horizons, and tracing the Coals and Ironstones within them through the whole of these districts.

That the Cornbrook basin was once connected with the Coal patches on the Brown Clee seems to be accepted by most Geologists, but I have not yet found that any one has attempted the co-relation of the strata. The points of nearest contact are not more than three miles and a half apart.

The Cornbrook deposits may be conveniently divided into the following horizons, leaving out the Jewstone capping, which has nothing to do with the question before us :—

CORNBROOK DEPOSITS.—Section A.

1.	Base of Jewstone to Pennystone			27ft.	0in.
2.	Pennystone Measure			6	0
3.	From Pennystone to Great Coal			153	0
4.	Great Coal			5	6
5.	Three Quarter Ironstone			3	0
6.	Three Quarter Coal			2	0
7.	Clumper (Blackbind with Ironstone concretions) ...			9	0
8.	Smith Coal			3	6
9.	Coal-measures			9ft. to 28	0
10.	Four-feet Coal			3	0
11.	Measures			404	0
12.	Gutter Coal,—				
	Coal	0ft.	11in.		
	Clunch	15	0		
	Coal	3	4		
	Foul Coal	0	3		
	Coal	0	6		
	Foul Coal	0	3		
	Under-clay... ...	1	4		
	Shale	6	0		
	Coal	3	0		
				30	7
13.	Measures variable			10ft. to 20	0
	Millstone Grit			200ft. to 300	0
	Old Red Sandstone where the Carboniferous Limestone is absent.				

The Brown Clee Hill deposits rest upon Millstone Grit, though I do not think it is more than 50ft. thick. The following section will explain their character, and we shall see there is a considerable difference in the lower portion from that of Cornbrook. Here we leave out the Jewstone cap, and below it we have—

Section B.

1.	Jewstone Black Coal,—				
	"Tops"	1ft.	2in.		
	Black Shale and Fire-clay ...	1	0		
	"Handful" Coal	0	4		
	Clod	0	1½		
	"Bottoms"	1	4		
				3ft.	11½in.
2.	Thick Tough. Light grey Clod, containing Ironstone in lower part, varies in thickness from 6 to 12ft., say			9	0
3.	Black Bessie's Eyes (Lumpy, hard, grizzly stuff, with black markings, rather rocky than cloddy) ...			2	0
4.	Dark-coloured Clod			2	0
5.	Three Quarter Coal,—				
	"Tops"	4 to 6 in.			
	Clod	3			
	Bottoms	1ft.	9		
				2	6
6.	Poundstone			2	0
7.	Clumpers			3	0
8.	Big Bat			1	6
9.	Clod			1	3
10.	Batty Coal,—				
	"Handful" Coal	0ft.	4in.		
	Tile Piece	0	1		
	"Tops" (Sweet Flaming Coal) ...	1	6		
	Cloddy Bat	0	10		
	"Bottoms" (good for Blacksmiths)	2	6		
				5	3
11.	Coal-measures to Top Rock			21	0
12.	Top Rock to Level Rock			21	0
13.	Level Rock to Bottom Coal			21	0
	About 9 feet above the Bottom Coal, in some places, is a rider of Coal, called "Foot" Coal, where it				

	proves workable. In a Clod about 3ft. 6in. lying within this 21 feet, is the Ironstone which was formerly so extensively wrought. The nodules vary from a few pounds to half a ton in weight.	
14.	Bottom Coal	2ft. 4in.
	Sometimes rests upon the Millstone Grit, and in other cases is separated from it by a few feet, or as much as five or six yards of Coal-measure.	
15.	Measures as described above, say	12 0
16.	Millstone Grit, say	50 0
17.	Old Red Sandstone.	

Now it is obvious that these measures and Coal-seams cannot be compared with the "Gutter Coal" of Cornbrook, which we have seen lies within a few feet of the Millstone Grit, although they themselves are found lying on or within a few feet of the same grit; but we find every element of comparison with a zone of Coal-measures 400 feet above the Gutter Coal at Cornbrook.

Thus I consider the Jewstone Black Coal to be the equivalent of the Great Coal, differing only by its being divided by a few inches of Clod, and we shall notice that all the Brown Clee Coals show the same tendency to "split up." Beneath the Jewstone Black is a Clod containing Ironstone in the lower part, and this is the same as the Cornbrook "Three Quarter Ironstone," and the "Three Quarters Coal" of each locality is the same. The "Clumper Beds" which lie between it and the Smith Coal of Cornbrook are not wanting between the Three Quarters Coal and Batty Coal of Brown Clee, and we must consider the Batty Coal to be the same as the Smith Coal. This view is supported not only by the "Clumpers" and Three Quarter Coal overlying it, but from its very quality as fuel. One portion is described as a "Sweet Flaming Coal," another as "good blacksmiths' Coal," the same properties which gave rise to its being called "Smith Coal" at Cornbrook. We observe that it is divided into three seams by their Clods. At the Watsell pit, in Cornbrook basin, which is the nearest point to the Brown Clee at which I have any shaft section, the "Smith Coal" is thus divided:

Tops	0ft. 9in.
Clod	1ft. 9in.
Coal	2ft. 6in.

Thus showing a tendency to divide in the direction of the Brown Clee.

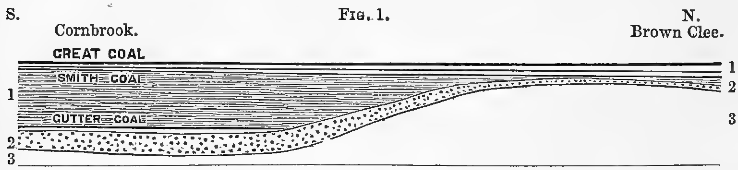
The Bottom Coal with its overlying Rider must represent the Four-feet Coal of Cornbrook, though it is separated from the overlying Coal by sixty-four feet of measures. This ground seems variable, for

At Cornbrook it is	9ft.
At Watsell Pit	13ft.
At Knowlbury	28ft.

The important deposits of Ironstone in the lower part of this ground are noteworthy. In the Watsell pit no Ironstone is shown at this horizon, yet in the Cornbrook Pit, still further South, we have in this place a six-feet "Shale, with balls of Ironstone." The Bottom Coal, as I have said before, rests *upon* the Millstone Grit, except where a few feet of Clods intervene.

It is obvious, then, from the foregoing, that Cornbrook was the site of a much lower surface than the Brown Clee surface at the time the Four-feet Coal was deposited. If the Millstone Grit were originally deposited at an average thickness of 250 feet over the whole district, there may have been an upheaval of it to the extent of about 600 feet, previous to the deposition of the Four-feet and other Coals in the same horizon. Two hundred feet of it having been denuded, the "Four-feet Coal" was then deposited, covering the accumulated Coal-measures of the lower ground, and rising high enough to rest upon the Millstone Grit at Brown Clee (vide Fig. 1). Now this explains to us the anomaly of the same Coals resting upon Old Red Sandstone, as at Harcott.

Fig. 1.



1. Coal-measures. 2. Millstone Grit. 3. Old Red Sandstone.

Harcott Coals and Cornbrook.—I had examined these Coals some months since when working in the forest of Wyre. Seeing that there was a distance of 420 feet of Coal-measure, and 200 to 300 feet of Millstone Grit, lying between the main Coals of Cornbrook and the Old Red Sandstone, whereas at Harcott the Coals were within thirty feet of the Old Red Sandstone, I could never have supposed they were identical. The Harcott pits are sunk in the valley cut by the brook-course flowing by Farlow Factory at the N.E. end of Clee Hill Common towards Kinlet. They are near to the Western margin of the forest of Wyre Coal-field. In sinking there, and at Billingsley, they pass through the Sulphur Coals of the Younger Coal-measures, and at various distances below them come upon important Coals and Ironstones, which might be very naturally supposed to belong to the Clee Hill basin from its being so near, but there was the difficulty before mentioned of having no lower Coal-measure and no Millstone Grit; and again there was no sort of comparison to be made with the lowest or Gutter Coal. I therefore concluded they were either connected with the Coalbrook-dale district, or were formed in a small depression marginal to the great deposits of Coal-measure to the East and North-east.

The section of the Harcott Pit shows the following features:—

Section C.

1.	Coal-measures	157ft.	0in.
2.	Blue Bind	6	0
3.	Coal	1	0
4.	Measures	26	0
5.	Black Shale	1	0
6.	Measures	100	0
7.	Coal	1	3
8.	Measures	12	0
9.	Black Parting	0	6
10.	Measures	5	0
11.	Sweet Coal	4	6
12.	Ironstone and Rock	3	0
13.	Coal	0	9
14.	Clod	0	6
15.	Coal	1	8
16.	Black Clod and large balls of Ironstone	5	0
17.	Coal	6	0
18.	Clod	2	6
19.	Coal	2	6

Now if we turn back to the Cornbrook section, distinguished as Section A, we shall find that the following relations subsist with that of Harcott, or Section C, so far as the Lower and Sweet Coal[1] deposits are concerned. We shall refer to the relationship of the strata above those Coals later on:

A 4	=	C 11.
A 5	=	C 12.
A 6	=	C 13, 14, 15.
A 7	=	C 16.
A 8	=	C 17.
A 9	=	C 18.
A 10	=	C 19.

Considering that the sections are from points between six and seven miles apart, it appears to me both pass through the same geological horizon to the extent of the foregoing strata.

How, then, does it happen that at Harcott we have no lower Coal-measures and no Millstone Grit? The answer is, that previous to the deposit of A 10, the Millstone Grit had been upheaved, probably at the same time as that of Brown Clee. It was then denuded, not partially as at the Brown Clee, but from top to bottom, leaving the Old Red Sandstone exposed; upon this A 10 was deposited, and the others above it in order (vide Fig. 1).

It appears to me that this upheaval was not confined to one or two points, but that it extended away to the North for many miles, for in the Coalbrook-dale field we see that the Little Flint Coal (the equivalent of A 10), as I shall presently show, is no great distance from the representation of the Grit.

Harcott and Coalbrook-dale.—As a preparatory step, it becomes necessary to revise the nomenclature of the Coal-seams in the Southern part of the Coalbrook-dale district, and to make out a clear co-relation between them, and those in the Northern portion.

We are led into endless confusion by new names being given to old and well-defined beds, as well as to the divisions of some of the thicker seams caused by "splitting up." Then an examination of this kind prepares us for certain changes which we find developed more and more as we proceed southward, changes which have been maintained even as far south as Cornbrook, where they are so great that we never could co-relate those deposits with Coalbrook-dale, unless we fully established that they are in proportion to the distance going south from the North of the Coalbrook-dale Field.

The Penny-measure, though changing from 31 feet thick at Lodgewood, to 6 feet at Madeley, maintains its name all through the district. The following names of Coals are constant over the whole Northern district:—

Sulphur Coal.	Best Coal.
Upper Clunch Coal.	Randle Coal.
Clunch Coal.	Clod Coal.
Two-feet Coal.	Little Flint Coal.

In the Puddley Hill Pit we find the Clunch Coal for the first time as we go South called Sill or Silk Coal. In the Madeley Pits we find the Sulphur Coal divides, and the lower portion is called

[1] The expression Sweet Coal is commonly used to distinguish it from Sulphur Coal, which prevails in the Forest of Wyre Coal-field.

Viger Coal. In the Madeley Meadow Pit section we have a "Sill Coal" and a "Bottom Coal" shown *above* the Pennystone. In the same section we find "Two-foot" Coal, and below it "Ganey" Coal. Now the "Two-foot" here so called is the "Sill Coal" underlying the "Viger Coal," and the real "Two-foot" is the Ganey coal, for it overlies the Best Coal which is the proper place for the Two-foot Coal in all the sections.

In the Castle Green Trial Pit we actually have the Sill Coal immediately below the Sulphur Coal, and *below that* the Viger Coal. We then have the Two-foot, here called Ganey Coal, in its proper place over the Best Coal. The Best Coal having with it the Linseed Earth, which almost invariably lies just below it.

The term Middle Coal seems to be used in cases where the Randle Coal is divided, or where the name Randle is not given. Thus in the Castle Green Trial Pit we have "Middle and Clod Coal Gob" underlying the Best Coal. Again, in the Lodge Pit, Madeley, the "Middle Coal" is shown lying between the Best and Clod Coal, which is the place for the Randle Coal, there improperly called Middle Coal. The terms "Sulphur," and "Main Sulphur Coal," in the southern part of the district, are very confusing to the inexperienced. The Sulphur Coal of the older deposits is always known by having the Penny-measure above it, whereas the Sulphur Coals of the younger series are very numerous, and, with the exception of one which has the Spirorbis Limestone overlying it at about 13 to 20 yards, I know of no associated stratum sufficiently persistent to enable me to fix their horizon in the measures. However, by the "Main Sulphur Coal" is meant, in the South, the Younger Sulphur Coal, having the Spirorbis Limestone within 13 to 20 yards above it. Indeed, it is *there* much thicker than the Sulphur Coal which underlies the Penny-measure. That, like the Pennystone, seems to be subject to the same law of attenuation as we proceed southward.

We have in the Madeley Meadow Pit a "Bottom" Coal, four feet thick, above the Pennystone; it is the same as in every other case is called Upper or Big Flint Coal.[1] The following table will show the true relationship of these Coals.

North.		*South.*
Sulphur Coal		Sulphur. Viger.
Upper Clunch, Lower Clunch	Sill Coal	Upper and Lower.
Two-feet Coal		Little Ganey. Ganey.
Best Coal		Best Coal.
Randle Coal		Middle Coal.
Clod Coal		Clod Coal.
Little Flint		Little Flint.

We shall now know of what Coals we are treating, whether the name be borrowed from the North or South.

Now as to the law of attenuation affecting the Penny-measure, Sulphur Coal, and the Clunch Coals, as we go from North to South,

The Pennystone decreases in thickness from 31 feet to 6 feet;
Sulphur Coal from 5 or 6 feet to two seams, 1 ft. 4 in. and 1 ft. 3 in.;
Clunch Coals together 3 ft. 6 in. to 1 ft. 6 in.

[1] The Rider Coal is the Double Coal.

Another law which prevails is that the distance from the Pennystone to the Best Coal is increased as we proceed from North to South, as will best be shown by the following measurements in the several sections there mentioned :—

	ft.	in.	
Granville Pit	16	2	
Lodgewood	22	9	
Wombridge	22	6	
Lawley New Works	30	6	
Little Wenlock	17	6	very much to the West.
Lightmoor	34	5	
Castle Trial Pit	47	4	
Lodge Pit, Madeley	60	5	
Meadow Pit, ditto	65	6	
Yew Tree Pit (Calcut Field)	74	0	

The distance from North to South over which these observations are made is about six miles. Now suppose the Coal-field, instead of being cut off by Symon ground (*i.e.*, denudation)[1] to the south o f Caughley, was continued, say as far as Harcott, which is still further south about 12 miles, did this law still prevail the distance between these two horizons of Penny-measures and Best Coal would be so much more increased. Indeed, the argument would be that, as in six miles the thickness had increased 58 feet, it would be increased by 116 feet more at 12 miles further south, and as the total thickness at the Yew Tree Pit is 74 feet, at Harcott it would be $74 + 116 = 190$ feet.

I hope, presently, to show that this is approximately the case, as proved by the Harcott section, which is sunk through what I believe to be a patch of the older Coal-measures, which, like Shirlot, Brown Clee, and Cornbrook, are islands of Coal-measure which have escaped the denudation by which they have been isolated from the parent field. In the first place we will see how far the Lower Coals of Harcott compare with those in the Southern part of the Coalbrook-dale field. Before I had discovered that there was any relationship between the Clee Hills and Harcott, I had seen that they were undoubtedly the representatives of the Best, Randle, Clod, and Little Flint Coals of Coalbrook-dale. It will be observed that Ironstones set in between the Clod and Little Flint Coal south of a line drawn, say from Ironbridge to Cuckoo Oak. There we have them described as "Clod Coal Pennystone" and "Large nodules of Ironstone." It would appear, then, that as we proceed southward, not only do the changes before mentioned take place, but this new feature sets in, and is not only maintained, but considerably increased, as shown in the Harcott section. The following sections are from Hills Lane Pit, the Meadow Pit (Madeley), and Amies in the Coalbrook-dale district.

Meadow Pit.—Section D.

	ft.	in.
1. Best Coal	2	8
2. Clod (very hard), 1ft. 8in., Clod (very soft) 2ft. 10in.	4	6
3. Middle Coal (very indifferent)	2	8
4. Clod	0	10
5. Clod Coal (very good)	1	10
6. Pricking, 7in., Poundstone, 2ft. 1in.	2	8
7. Little Flint, Coal Flint, very hard and full of large Ironstone	13	10
8. Little Flint Coal	3	4
9. Crawstone measure and Crawstone	2	5
10. Coal under Crawstone	0	6

[1] Vide Geol. Mag., May, 1871, On the Denudation of the Coalbrook-dale Coal-field.

Hills Lane.—Section E.

		ft.	in.
1.	Best Coal	2	5
2.	Basses	0	7
3.	Randle Coal	2	8
4.	Clunch	1	0
5.	Clod Coal	1	4
6.	Clod Coal Clunch	4	0
7.	Clod with Ironstone (large nodules of Ironstone)	2	6
8.	Hard Rock	0	4
9.	Little Flint Coal	0	4
10.	Rock in the Coal	5	3
11.	Lower Little Flint Coal	2	6

Amies (*Broseley*).—Section F.

		ft.	in.
1.	Best Coal	3	4
2.	Middle Coal	3	0
3.	Clod Coal	1	8
4.	Pricking	1	0
5.	Clod Coal, Pennystone	3	0
6.	Black Clod	2	3
7.	Hard Stone	3	0
8.	Flint Coal	3	0

If we turn back to Section C, which is that of Harcott, and compare it with the foregoing, I think we shall find an unmistakable similarity which we may most readily express as follows:

C 11 = D 1, E 1, F 1.
C 13 = D 3, E 3, F 2.
C 15 = D 5, E 5, F 3.
C 16 = D 6, 7, E 6, 7, 8, F 4, 5, 6, 7.
C 17 = D 8, E 9 and 11, F 8.

C 19 must be a greater development of the Lower Flint Coal or the Crawstone Coal. I have drawn these out to a scale, and find a very satisfactory comparison.

The strata above these Coals, though they are not so obviously continuations of the Coalbrook-dale strata, yet in connexion with the same strata at Cornbrook there is much to be said about them.

I have shown before how the ground between the Best Coal and the Pennystone might at Harcott be 190 feet thick, or even more at Cornbrook. Now, at Cornbrook we find at 153 feet above the representative of the "Best Coal," there is a stratum of Pennystone 6ft. thick. At Watsell pit it is 135 feet between the two. The Pennystone is not shown in the Brown Clee, because, as at Shirlot, it has been denuded. At Knowlbury, a little south-west of Cornbrook, the Penny-measure is not recorded in the section; but 150 feet above the Great Coal is a stratum of Bind 6 feet thick, lying between a White Rock 14 feet thick above and a hard White Rock of 42 feet below. At 90 feet above the Bind is "Measure containing large nodules of Pure Ironstone," but I am not inclined to think it is the equivalent to the Pennystone. I will not say it may not be the equivalent of the Ball Stone, but of this I am quite doubtful, as there is no means of accounting for the absence of the Coals, which are so thick and numerous in this horizon in the Coalbrook-dale Field. I am inclined to think that the Bind holds the place of the Pennystone, and if Ironstone is not mentioned, it is because the whole stratum degenerates in thickness and Ironstone. We observe that at Cornbrook and Knowlbury there are no Coals to represent the Sulphur, Viger, or Sill Coals. Indeed when we find that at Madeley Meadow Pit the Sulphur Coal is only 1ft. 4in., the Viger 1ft. 3in., and this in obedience to a law of Southerly attenuation, I do not think we can be much surprised if they are absent altogether at fifteen or sixteen miles further South.

At Harcott, however, which is twelve miles South of Madeley, it seems to me that we have some representative of them. The Coal No. 7, in Section C, which lies 17 feet above the Coal No. 11, Section C, is probably the Ganey Coal. At 100 feet above this Ganey Coal is a Black Shale, No. 5, Section C, which I consider to be the representative of the Viger Coal; and 25 feet above this is No. 3 Coal (Section C), only one foot thick, which I take to be the Sulphur Coal. Upon this is a Blue Bind, five feet, which is probably the Pennystone Measure, without any Ironstone in it, as at Knowlbury. Now from No. 11, Section C, which represents the Great Coal to this Bind, No. 2 (Section C), is 150 feet, about the same as at Cornbrook. I admit the case is not so strongly in favour of the upper measures as of the lower.

In the Billingsley Engine Pit Section we have two small Coals of ten inches each at seventy feet below the zone of productive Coal-seams. These may represent the Lancashire Ladies' or Crawstone Coal of Coalbrook-dale.

If the co-relation is thus established, many curious and interesting inquiries will spring out of it, as to the denudation of the Coal-measures to the South of the Coalbrook-dale field, and as it would appear by the same process as channelled out the valley of the Symon fault as far North at least as Prior's Lee, leaving the Coal-brook-dale field in fact an isolated Coal-patch, as we have shown the Clee Hills, Harcott and Shirlot to be from the main Coal deposits of the Midland counties, unless it be connected with them somewhere to the North of Prior's Lee.

NOTICES OF MEMOIRS.

I.—Report of the Chief Commissioner of Mines for the Province of Nova Scotia, for the Year 1870. 8vo. pp. 66. (Halifax, 1871.)

THIS report of Mr. Roberston, the Chief Commissioner, supplemented by that of the Inspector of Mines, Mr. Rutherford, shows the gold and coal mining operations that have been carried on in the various districts during the past year. As regards gold mining, the districts of Stormont, Wine Harbour, and Sherbrooke, have each returned more gold than in the year 1869, and Tangier, Oldham, and Montagu, more than in any year previous. The other districts show a falling off, but on the whole there has been a considerable increase in the quantity of gold obtained. Better modes of mining and amalgamating are wanted, and until these are introduced, gold mining cannot be carried on in any but the richest places.

As for the coal mines, it is stated that there are a number so well managed, that they would be a credit to any country, and could now supply any demand that is likely to be made upon them for some years.

II.—On the Cause of the Motion of Glaciers.

By John Ball, F.R.S.

[*Philosophical Magazine*, February, 1871.]

In the Geological Magazine for December last we gave a short notice of a paper by Mr. Croll, in which he endeavoured to prove the motion of a glacier to be molecular. To this Mr. Ball replies in the paper now before us. He questions whether the ordinary theory, which affirms that a glacier descends by its weight through the processes of fracture and regelation, has been overthrown by the arguments and observations opposed to it by Canon Moseley, and which, according to Mr. Croll, successfully show the insufficiency of the theory. These opinions are combated by Mr. Ball, who then proceeds to explain the cause of glacier-motion as it appears to him to be most consistent with the facts. He remarks that glacier-ice is a substance which at the temperature of freezing is capable of yielding, very slowly, to moderate pressure, and that a portion of the motion of all glaciers is due to this cause, and is effected independently of fracture and regelation. Glacier-ice, though imperfectly solidified, is yet rigid enough to transmit very considerable pressure; but there is a limit at which pressure upon the ice (which has a fixed internal temperature of 32° Fahr.) has the effect of reducing it to the liquid state. At any given moment of the progress of a great glacier, especially in summer, certain points are subjected to enormous pressure. The effect may either be that fracture ensues at that point, and so continues further; or else the pressure liquefies a portion of the ice: and the water, even if it cannot escape, occupies less space than it did before; so that the effect of transferring the maximum pressure from one point to another is accomplished. It is this process which Mr. Ball has compared to the progress of a huge snake, whose movements are effected not by simultaneous effort at every point, but by the transmission of muscular energy from one point to another.

III.—The Spirorbis Limestone in the Forest of Wyre Coal Field.

By Daniel Jones, F.G.S.

[A paper read before the Manchester Geological Society, 20th December, 1870.]

Mr. Jones brings forward some additional information respecting the occurrence of Spirorbis Limestone in the Forest of Wyre Coal-field, occupying a district lying between the Abberley Hills and Bridgenorth. This limestone, which occurs in the Upper Coal-measures, has been described by Sir R. Murchison in the Shrewsbury Coal-field as being about seven feet thick, and divided into two beds, the uppermost of which is a compact cream-coloured rock, slightly argillaceous, with a splintery conchoidal fracture and dull lustre; the lower is a cellular limestone, the cavities being filled with calc-spar and black bitumen. Singularly enough these two beds are still developed in the Forest of Wyre, where the formation is of much less thickness. It was originally pointed out in this area by Mr. Binney, to whose observations Mr. Jones has been enabled to add several new facts regarding its distribution.

IV.—Ernest Favre on the Geology of the Alps.[1]

THE group of mountains which forms the subject of this little work lies between Châtel-Saint-Denis and the valley of the Sarine; it is composed of Niremont and the Corbettes, of the Moléson group, and of a part of the Verreaux chain.

The work is divided into two parts: the first is devoted to a geological description of the area, illustrated by plates of sections; the second, to a special study of the strata and of the organic remains found in them.

The structure of Niremont is shown to be that of an inverted fold, the crown or apex of which does not occur at the highest part of the mountain, and this is also the case with Corbettes, which presents two inverted folds. The Moléson group forms an elongated mass, stretching in a north-east and south-west direction, and isolated from the surrounding mountains; its structure is very regular. On whatever side one climbs, one reaches from the base to the summit more and more recent beds of Jurassic and Neocomian age, which dip on either side (north-east and south-west) towards the centre. Further to the east, at the foot of the mountain mass, the lie of the strata is different. Here Rhætic and Triassic beds are met with, highly inclined, and, indeed, plunging beneath the mountain mass. These beds are repeated further East, owing to an anticlinal. The Verreaux chain forms an abrupt escarpment to the West, the beds dipping gently to the East. Jnrassic and Cretaceous strata form this ridge.

The author then turns his attention to the palæontology of the beds, which include the Triassic, Rhætic, Liassic, Oolitic, Neocomian, Cretaceous, and Tertiary strata.

REVIEWS.

I.—The Phosphate Rocks of South Carolina and the "Great Carolina Marl Bed." By F. S. Holmes. pp. 87. (London: Trübner & Co., 1870.)

THE object of this pamphlet is to give a popular and scientific view of the origin and geological position of the Phosphate rocks, to point out their chemical and agricultural value, and to record the history of their discovery and development.

The "Great Carolina Marl Bed" is regarded as of Eocene age. It is extensively developed on the Ashley and Cooper Rivers, where

[1] Etudes sur la Géologie des Alpes. Par Ernest Favre. I. Le Massif du Moléson et les Montagnes environnantes dans le Canton de Freibourg. 8vo. pp. 48. Geneva et Basle, 1870. Tiré dçs Archives des Sciences de la Bibliothèque Universelle, tome xxxix.

it is mainly composed of Polythalamia; numerous fish remains, and bones and teeth of Cetaceans, are also met with in it. On the Santee River another bed of Eocene marl occurs, older than the beds of Ashley and Cooper rivers, and composed principally of shells and corals. The Marl beds attain a thickness of seven hundred feet in the Artesian Well at Charleston. They yield from 55 to 95 per cent. of Carbonate of Lime. Mr. Holmes also describes a "Buhr-stone" or Millstone Grit of Eocene age, originally a marl bed, which has been subsequently silicified. The silica has been obtained from superincumbent sand beds, and as hot water will dissolve silica largely, he thinks it "not a wild supposition that the waters of the Tertiary sea may have been at one time heated, and thus facilitated the solution of the silica." We should have been glad to see some evidence in support of this statement, although it is indorsed by Professor Tuomey.

The Phosphate rocks are of Post-Pliocene age, derived, according to Mr. Holmes, from the Eocene Marl-bed, which is the foundation of the whole of the sea-board country of South Carolina. These nodular fragments of Eocene rocks are composed (like the parent rock from which they are derived) entirely of marine remains. Mingled with them are the bones of large land animals, such as the Mammoth, Mastodon, Rhinoceros, Megatherium, and the gigantic reptile Hadrosaurus, etc.

The author describes the formation of these Phosphate beds on a coast-line of shallow water, where irregular and undulating sand-banks rested upon the surface of the great Marl-bed. The surface of this bed where exposed was worn into cavities and holes, indeed, Mr. Holmes remarks, into a coarsely honey-combed surface, from which fragments were continually broken off, rolled, and finally deposited in the hollows and basins below the ocean level.

A great elevation of the country subsequently ensued, and the basins remained as so many salt-water lakes, having their bottoms covered with a layer of the nodular fragments of Marl-rock. It was after this elevation that the bones and teeth of the Post-Pliocene animals became mixed with the nodules. Then the gigantic quadrupeds "which roamed the Carolina forests, repaired periodically to these Salt-lakes, and during a series of indefinite ages were engaged first sipping brine, then licking salt, and depositing their fæcal remains, and ultimately their bones and teeth, in fact their dead bodies, in these great open *crawls* or pens."

To account for the 60 per cent. of Phosphate of Lime which these nodules contain, the author devotes but a small space. Their conversion from a Carbonate to a Phosphate he considers to be due to a dissolution of the Carbonate of Lime by water holding Carbonic acid, and the Phosphoric acid was obtained from the animal remains associated with the nodules.

That the economical part of this work will prove useful we have little doubt; we are sorry we cannot say so much for the theoretical or purely scientific portion. The work, we should mention, is illustrated with five gorgeous plates.

II.—The Existence of Man in the Tertiary Epoch.

By Alphonse Favre.

[De l'Existence de l'Homme à l'Epoque Tertiaire. Tiré des Archives des Sciences de la Bibliothèque Universelle, Février, 1870.]

THE aim of this paper is to bring down the Stone age to the Tertiary period. The author observes that so far as the climatal conditions of Tertiary times are concerned, no difficulty presents itself, as they were favourable to the existence of man. If he did exist at so remote a period, he would have been associated with a fauna and flora very different from those of the present time, and he must then be classed with those genera that have existed during two successive geological epochs. We must not therefore be surprised at the caution of scientific men in receiving these new views; the scientific man is nothing unless sceptical.

Passing on to the facts of the case, M. Favre mentions that so long ago as 1863, M. Desnoyers communicated to the Academy of Sciences some observations made at Saint-Prest, near Chartres, in which the occurrence of human works in Pliocene deposits was pointed out. M. Desnoyers found a large number of bones in stratified sand of fluviatile appearance, and mixed with flint-gravel. The bones, as determined by M. Lartet, are the following: *Elephas meridionalis, Rhinoceros etruscus, Hippopotamus major* (?), *Equus Arnensis, Cervus Carnutorum* and two other species of *Cervus, Bos,* and *Trogontherium Cuvieri.* These fossils and the sands in which they were embedded have been classed as of Upper Tertiary or Pliocene age. M. Desnoyers observed on the surface of these bones certain scratches, varying in form, length, and depth, and passing over the edge, which he thought could not be accidental, and led him to imagine that they had been made by flint-blades, and, in fact, by the hand of man. From these facts he concludes that man co-existed with the *Elephas meridionalis,* and other Pliocene species. The age of the deposits is undoubted, but not so the cause of the markings found on the bones. Sir Charles Lyell gave some bones to pigs to gnaw, and found the markings made by their teeth to be very similar to these alleged human scratches, and he therefore concluded that they were made by the great Beaver, or some other animal.

However, some more unequivocal evidence than the scratched bones was soon found; for in 1867 M. l'Abbé Bourgeois announced to the Academy that he had found in these sands of Saint-Prest worked flints, such as lance or arrow-heads, stampers, scrapers, etc. These flints were much more rudely worked than those of Amiens or Abbeville. Soon after, M. Bourgeois announced the discovery of worked flints, not only in Miocene marls, but also below the Beauce limestone, which is older. He found these flints in nearly all the beds separating this ancient deposit from the Alluvium, as can be seen in a section at Thenay, near Pont Levoy, Department of Loir-et-Cher.

Many scientific men refuse to believe that these flints are of human workmanship. On the other hand, many assert that they are genuine implements, and this idea is supported by MM. Hamy, Cotteau Marquis de Vibraye, Dupont, de Mortillet, and De Worsæ.

To sum up, the evidence of man in the Tertiary epoch seems to rest upon the evidence of the scratched bones, marked, according to M. Desnoyers, by man; according to Sir C. Lyell, gnawed by some animal; and upon the stronger evidence in the shape of rudely-fashioned flint implements, which is supported by many high authorities, but rejected by others. F. J. B.

III.—A Visit to Sydney and the Cudgegong Diamond Mines. By Angus Mackay. 8vo. pp. 64. (Melbourne, 1870.)

THIS is an interesting sketchy narrative of Mr. Mackay's visit to the Cudgegong Diamond Mines. Commencing with an account of his journey from Melbourne to Sydney, he gives a notice of the present state of the latter city and of the changes it has of late years undergone. Then he visits the Lithgow Valley Coal-field, and afterwards takes coach to Mudgee, a thriving town, pleasantly situated in an open level country, through which the Cudgegong or Mudgee river flows. The nearest diamond workings are at a place called Two Mile Flat, twenty-two miles distant to the westward; two or three miles from this hamlet is the head-quarters of the Mudgee Gold and Diamond Washing Company. It is a portion of the ancient river-bed, considered to be of Older Pliocene age, thirty or forty feet above the present channel of the river, which has been found to be rich both in gold and diamonds,—indeed, the gold alone should give excellent returns if the ground be worked with ordinary skill. The gold is derived from the Upper Silurian rocks. The great question of interest, however, is, Whence come the Diamonds? Upon this point opinions are at variance. Judging from the facts that the diamonds found in the ancient Drift are almost without exception perfectly formed and unabraded, whereas those found in the present river alluvium show marks of the ill-usage they have met with among the pebbles and boulders, it is inferred that the diamonds were formed in the older Drift after its deposition. On the other hand, the diamonds may have been brought with the disintegrated rocks which supplied the Drift. Further observations are needed before a definite conclusion on the subject can be arrived at. Meanwhile, it is interesting to have an account of the processes carried on in these gold and diamond workings, which Mr. Mackay has set forth in a popular manner in the little pamphlet now before us.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I. May 24th, 1871.—Prof. John Morris, Vice-President, in the Chair. The following communications were read:—1. "On the principal Features of the Stratigraphical Distribution of the British Fossil Lamellibranchiata." By J. Logan Lobley, Esq., F.G.S.

In this paper the author showed, by means of diagrammatic tables, what appears to be the present state of our knowledge of the general stratigraphical distribution of the fossil Lamellibranchiata in Britain. As a class, the Lamellibranchs are sparingly represented in the Lower, and more numerously in the Upper Silurian group, and fall off again in the Devonian; they greatly increase in number in the Carboniferous, become scanty in the Permian and Trias, and attain their maximum development in the Jurassic rocks. They are also largely represented in the Cretaceous and Tertiary series. The stratigraphical distribution of the two great subordinate groups, the Siphonida and the Asiphonida, corresponds generally with that of the class; the Siphonida predominate over the Asiphonida in Tertiary formations, whilst the reverse is the case from the Cretaceous series downwards. Nearly all the families of Lamellibranchs are represented in the Jurassic and Carboniferous rocks, and in the former very largely. The author remarked especially on the great development of the Aviculidæ in Carboniferous times.

Discussion.—Mr. Etheridge, after noticing the importance of the paper, remarked that possibly the great difference observed in the proportions of the Lamellibranchiata in different formations might to some extent be due to our want of knowledge. Of late years, in the Caradoc and Lower Silurian series, the number of species had been nearly doubled, principally through the persevering industry of one single observer, Lieut. Edgell. The same was to some extent the case in the Carboniferous rocks, owing to the collections of Mr. Carrington. Much was also being done for the Oolitic series, in connexion with which the names of Mr. C. Moore, Mr. Sharp, and Dr. Bowerbank ought to be mentioned. Mr. Griffiths and the Rev. Mr. Wiltshire were doing the same work for the Gault. What the late Mr. S. P. Woodward had done as to the distribution of the different species of mollusks through time, Mr. Lobley was doing on a larger and more extended scale.

Prof. Ramsay was glad to find that Mr. Lobley was, to some extent, doing the same for the Lamellibranchiata as Mr. Davidson had done for the Brachiopoda. He did not know how the case might be with the Silurian and Devonian formations, but in the Carboniferous strata the Lamellibranchiata were obtaining a preponderance over the Brachiopoda. He accounted for their comparative absence in formations of other ages, especially between the Upper Silurian and Rhætic beds, by the best known areas of those periods having been mainly continental, or containing principally freshwater or inland sea remains, so that the true marine fauna was absent. In Carboniferous times, possibly the true relative proportions of the two forms had been preserved in the deposits.

Mr. Judd was doubtful as to the safety of placing too great reliance upon figures. He questioned whether some of the conclusions as to the great increase of Lamellibranchiates between the Carboniferous and Jurassic periods could be substantiated. Much depended on the amount of the rocks present in different countries, and the study bestowed on each. The conditions also for the preservation of the fossils might be more favourable at one time than another.

Mr. Carruthers considered the tables as of the greatest value, as indicating the present state of our knowledge. He called attention to the difference of conditions under which different deposits had accumulated, which must have to some extent affected the proportion of Lamellibranchiates preserved in the different formations.

Mr. Charlesworth remarked on the occurrence of *Trigonia* in the Australian seas, and on there being varieties of form among specimens of existing species so great, that if they were found fossil they might be regarded as of several species.

Mr. Hughes considered that the data were too incomplete to justify the generalizations of some of the previous speakers. It had been pointed out that whenever the Tables showed a very large number of Lamellibranchs from any formation, that formation had been carefully worked out by local observers; and therefore he would like to know in each case, the proportion the Lamellibranchiata bore to the total number of fossils found. It had been shown also that a larger proportion of Brachiopoda had been found in the older rocks, and of Lamellibranchiata in the newer. But in the older rocks whole genera of Lamellibranchs are confined to horizons and localities which are not cut off by stratigraphical breaks, such as would allow us to think it at all probable that they can be characterized by peculiar genera. He thought the scarceness and irregular occurrence of Lamellibranchs in the older rocks could be best explained on the supposition that those portions of the older deposits which were least favourable to Lamellibranchs happened to be those now chiefly exposed to our search, and that those few portions are only in part worked out.

Mr. Jenkins observed that in thick deposits there was a far greater likelihood of numerous forms being present than in thin, for thickness meant time, and time meant variation.

Prof. Morris dissented from this view, as in thin littoral deposits an enormous number of shells might be present, while in beds formed in deep sea they might be almost entirely absent.

2. "Geological Observations on British Guiana." By James G. Sawkins, Esq., F.G.S.

In this paper the author gave a general account of his explorations of the Geology of British Guiana when engaged in making the Geological Survey of that colony. He described the rocks met with during excursions in the Pomeroon district, along the course of the Cuyuni and Mazuruni rivers, on the Demerara river, on the Essequibo and its tributaries, on the Rupununi river, and among the southern mountains. The rocks exposed consist of granites and metamorphic rocks, overlain by a sandstone, which forms high mountains in the middle part of the colony, and is regarded by the author as probably identical, or nearly identical, with the sandstone stretching through Venezuela and Brazil, and observed by Mr. Darwin in Patagonia.

Discussion.—Prof. Ramsay remarked upon the barrenness, from a geological point of view, of the district investigated by Mr. Sawkins, and especially called attention to the absence of fossils in the stratified rocks. He referred briefly to Mr. Sawkins's labours in Trinidad and Jamaica, and to his discovery of metamorphosed Miocene rocks in the latter colony exactly analogous to the metamorphic Eocene rocks of the Alps. He was glad to see that the author had brought forward examples of cross-bedding in metamorphic rocks, and considered that the results adduced were favourable to those views of the metamorphic origin of granite which he had himself so long upheld.

Mr. D. Forbes, on the contrary, considered that the facts brought forward by Mr. Sawkins were confirmatory of the eruptive nature of the granites observed. He added that cross-bedding was common in igneous rocks and even in lavas.

Mr. Tate remarked that in the country to the north of the district described in the paper metamorphic rocks abound. He considered that the series of metamorphosed Jurassic rocks extends across the whole north of South America, and perhaps into California. Similar sandstones to those described occur in the basin of the Orinoco, and contain fossils which show them to be of Miocene age. Mr. Tate did not consider these sandstones as the equivalent of the Patagonian sandstones, as from the shells contained in the latter they would appear to be Pliocene or Pleistocene.

Mr. Sawkins, in reply to a question from Mr. Tate, stated that the only gold found in the country had probably been carried down from the well-known gold district of Upata. He also entered into a few additional details connected with the chief points in his paper, dwelling especially upon the physical features of the country, in illustration of which several landscape drawings were exhibited.

II.—June 7, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—1. "On the persistence of *Caryophyllia cylindracea*, Reuss, a Cretaceous Coral, in the Coral-fauna of the Deep Sea." By P. Martin Duncan, M.B. Lond., F.R.S., F.G.S., Professor of Geology in King's College, London.

The author first referred to the synonyms and geological distribution of *Caryophyllia cylindracea*, Reuss, which has hitherto been regarded as peculiar to the White Chalk, and as necessarily an extinct form, inasmuch as it belonged to a group possessing only four cycles of septa in six systems, one of the systems being generally incomplete. The distribution of the *Caryophylliæ* of this group in the Gault and the Upper Chalk, the Miocene, and the Pliocene, was noticed, and also that of the species with the incomplete cycle. The falsity of this generalization was shown to be proved by the results of deep-sea dredging off the Havannah, under Count Pourtales, and off the Iberian peninsula under Dr. Carpenter and Mr. Gwyn Jeffreys. The former dredged up *Caryophyllia formosa* with four complete cycles, and the latter obtained, from depths between 690 and 1090 fathoms, a group of forms with four complete and incomplete cycles. This group had a Cretaceous facies; one of the forms could not be differentiated from *Caryophyllia cylindracea*, Reuss; and as a species of the genus *Bathycyathus* was found at the same time, this facies was rendered more striking. The representation of the extinct genera *Trochosmilia, Parasmilia, Synhelia*, and *Diblasus*, by the recent *Amphiheliæ, Paracyathi*, and *Caryophylliæ* was noticed, and it was considered that as the Cretaceous forms throve under the same external conditions, some of them only being persistent, there must be some law which determines the life-duration of species like that which restricts the years of the individual. It was shown that deep-sea conditions must have prevailed within the limits of the diffusion of the ova of coral polyps somewhere on the Atlantic area ever since the Cretaceous period.

Discussion.—Mr. Gwyn Jeffreys remembered that at the spot where the coral in question was dredged up the sea-bottom was extremely uneven, varying as much as fifty fathoms within a quarter of a mile. It was also not more than forty miles from land. The species of mollusca dredged up were extremely remarkable, and many were totally different from what he had previously seen. They were, however, living or recent; none of them were Eocene or Miocene, much less Cretaceous, like *Terebratula caput-serpentis*. He quoted from Mr. Davidson other instances of the persistence of forms, especially of the genus *Lingula* from the Silurian formation. The persistence of this species of coral, as well as that of Foraminifera, from the Cretaceous to the present time, was therefore not unique, and other cases of survival from even earlier times might eventually be recognized.

Dr. Carpenter, after commenting on the reductions that extended knowledge enabled naturalists to make in the number of presumed species, could not accept the mere identification of species as of the highest importance in connecting the Cretaceous fauna with that of our own day. The identity of genera was, in his opinion, of far more importance. He instanced *Echinothuria*, and *Rhizocrinus*, as preserving types identically the same as those of a remote period, and as illustrating the continuity of the deep-sea fauna from Cretaceous times. The chemical and organic constitution of the deep-sea bottom of the present day was also singularly analogous to that of the Chalk sea. The low temperature at the bottom of the deep sea, even in equatorial regions, was now becoming universally recognized, and this temperature must have had an important bearing on the animal life at the sea-bottom.

Prof. Ramsay thought that there was some misapprehension abroad as to the views held by geologists as to continuity of conditions. They had, however, always insisted on there having been an average amount of sea and land during all time; and the fact of sea having occupied what is now the middle of the Atlantic since Cretaceous time would create no surprise among them. If, however, the bed of the Atlantic were raised, though probably many Cretaceous genera, and even species, might be found, there would on the whole be a very marked difference between these Atlantic beds and those of the Chalk.

Mr. Seeley had already, in 1862, put forward views which had now been fully borne out by recent investigation. His conviction was that, from the genera having persisted for so long a time, the genera found in any formation afforded no safe guide as to its age, unless there were evidence of their having since those formations become extinct.

Mr. Etheridge maintained that the species in different formations were sufficiently distinct, though the genera might be the same. Recent dredgings had not brought to light any of the characteristic molluscan forms of the Cretaceous time; and it would be of great importance to compare the results of future operations with the old Cretaceous deep-sea fauna.

Prof. Rupert Jones, with reference to the supposed sudden extinction of chambered Cephalopods, remarked that Cretaceous forms had already been discovered in Tertiary beds in North America, and also that cold currents could not have destroyed them, seeing that icebergs came down to the latitude of Croydon in the Chalk sea.

2. "Note on an *Ichthyosaurus* (*I. enthekiodon*) from Kimmeridge Bay, Dorset." By J. W. Hulke, Esq., F.R.S., F.G.S.

In this paper the author described the skeleton of an *Ichthyosaurus* from Kimmeridge Bay, agreeing in the characters of the teeth with the form for which he formerly proposed the establishment of the genus *Enthekiodon*. The specimen includes the skull, a large portion of the vertebral column, numerous ribs, the bones of the breast-girdle, and some limb-bones. The first forty-five vertebral centra have a double costal tubercle. The coracoids have an unusual form, being more elongated in the axial than in the transverse direction, and this elongation is chiefly in advance of the glenoid cavity. The articular end of the scapula is very broad. The paddles are excessively reduced in size, the anterior being larger than the posterior, as evidenced by the comparative size of the proximal bones. The species, which the author proposed to name *I. enthekiodon*, most nearly resembles the Liassic *I. longirostris* and *I. tenuirostris*. The length of the preserved portion of the skeleton is about 10 feet; the femur measures only 2 inches, and the humerus 2·7 inches.

3. "Note on a Fragment of a Teleosaurian Snout from Kimmeridge Bay, Dorset." By J. W. Hulke, Esq., F.R.S., F.G.S.

In this paper the author described a fragment of the snout of a Teleosaurian obtained by J. C. Mansel, Esq., F.G.S., from Kimmeridge Bay, and which is believed to furnish the first indication of the occurrence of Teleosaurians at Kimmeridge. The specimen consists of about 17 inches of a long and slender snout, tapering slightly towards the apex, where the præmaxillæ expand suddenly and widely. The nostril is terminal and directed obliquely forwards; the præmaxillæ ascend 2·5 inches above the nostril, and terminate in an acute point; and each præmaxilla contains five alveoli. The lateral margins of the snout are slightly crenated by the alveoli of the teeth, of which the three front ones are smaller than the rest; most of the teeth have fallen out, but a few are broken off, leaving the base in the sockets.

Discussion.—Mr. Seeley thought it likely that Mr. Hulke would eventually be led to re-establish his genus *Enthekiodon*. He remarked on the peculiar characters presented by the specimen, and referred especially to the coracoids, which were unlike those of *Ichthyosaurus*, but presented a close resemblance to those of *Plesiosaurus*. He considered that there were indications of its having been connected with a cartilaginous sternum. The scapula furnished an important character in its widening, which formed a distinct acromion process. Mr. Seeley remarked that double-headed ribs occur only in animals with a four-chambered heart; and that, considering this and other characters, there was no reason for placing *Ichthyosaurus* lower than among the highest Saurians. He considered that the Teleosaurian snout differed from all known types.

Dr. Macdonald believed that what is called the coracoid has nothing to do with the shoulder-girdle, and thought it might be a part of the palate.

Mr. Mansel stated, in answer to the President, that the fossils were obtained from about the middle of the Kimmeridge Clay.

Mr. Etheridge suggested that it would be desirable to ascertain whether the horizon of the *Ichthyosaurus* described was the same as that of the specimens from Ely.

Mr. Gwyn Jeffreys inquired as to the food and habits of the *Ichthyosaurus*.

Mr. Hulke, in reply, stated that, from the presence of a stain and of numerous small scales under the ribs, the food of the *Ichthyosaurus* probably consisted of Squids and small fishes. He showed that the so-called coracoid was clearly a part of the shoulder-girdle.

CORRESPONDENCE.

THE GEOLOGICAL SURVEY OF VICTORIA.

Sir,—You have been good enough to draw attention to my paper on the present condition of the Geological Survey of Victoria, and although I might well let pass, without comment, the just and fair account which you have given of it, I think it right to offer one or two observations on the subject, which you may publish if you think fit. Whilst Mr. Selwyn was Director-General of the Geological Survey of Victoria, I stated, when giving my evidence before a Royal Commission, in what manner I differed from him as to the mode in which a Geological Survey should be conducted in a new and partially explored country, but I always recognized his abilities as a Geological Surveyor, and I never hesitated to express publicly my opinion of his services. My scheme for the continuation of the Survey was offered in the hope that it would be accepted if nothing better presented itself. That there should be one geologist in the field who would continue the survey after what I conceive to be a better method than that of Mr. Selwyn, appeared to me preferable to its being abandoned as a national work.

In naming the sum of £1,500 per annum as the probable cost of the Survey, I should have stated, for the information of those not acquainted with the economy of the government departments of this Colony, that it was not intended to include in it the cost of drawing maps and sections, the preparation of coloured lithographed maps, or the printing of reports. These costs I intended should be borne by the Mining Department and the Department of the Government Printer, where skilful lithographers and engravers and printers are employed. Some small costs for preparing tracings and plans for the officer in the field would necessarily be chargeable to the sum I set down. It was not proposed to pay the officer in the field a smaller salary than was paid to the chief officers who acted as field geologists under Mr. Selwyn, and there is an analyst attached to the

Department of Mines who would examine the minerals and ores collected by the field geologist without much extra expense.

With reference to your suggestion—that we should rather work steadily on than map out in detail more or less isolated areas—I may remind you that in our Colony there is a wide band of Palæozoic rocks stretching from west to east; that both on the north and on the south that band is bordered by Tertiaries; and that the wide expanse of basaltic and volcanic rocks, which lies between the river Plenty and the river Glenelg, is scarcely in any part broken by the protrusion of any large masses of granite or sedimentary rocks except on the margins, and that a broad line carried across any one formation would serve for a connexion, as well as if the boundaries of that formation were carefully laid down.

In other words, I conceive it is not necessary to delineate exactly and completely the boundaries of a large mass of granite which may lie between two gold-fields in order to connect these fields. I would survey a sufficient extent of the boundary, and I would leave the rest for future explorations.

Undoubtedly the plan advocated by you is preferable, and I would gladly adopt it if there were a large staff to make it practicable, and if the delays which it would necessitate would not prejudice the interests of the miners. But when it is considered that at this moment the prosperity of one great gold-field, Ballarat, is checked, and the enterprize of the miners paralyzed by the want of knowledge of the connexion and course of the deep auriferous *leads;* that a wide area in the vicinity of our richest reefing district, Sandhurst, cannot be prospected by the miner with any hope of advantage, because he has no map to guide him; and that in North Gipps Land there are two hundred square miles of country covered by basalts and lavas with intercalated beds of auriferous gravel, respecting which little or nothing is known; I may be pardoned for recommending a method of survey which, as regards the results, shall be of an immediate benefit to the miner.

My scheme embraces also the regular publication of drawings and descriptions of the fossil flora and fauna of the Colony. The first plate and description, which I send herewith, prepared by Dr. von Mueller, C.M.G., our Government Botanist, will satisfy you that much credit will redound to the Colony if the work be continued as it has been begun.

Though the Geological Survey was continued under Mr. Selwyn's direction for about fourteen years, I think you will find, if you examine his reports, that there has not been published in this Colony one plate or description illustrative of the fossil fauna of our Silurian rocks, rich as they are in organic remains and with many forms quite new to science.

The assistance which I stated would be given by gentlemen in the country had reference to such observations as would be made by Mr. Thomas Couchman, the Chief Mining Surveyor of the Colony; Mr. A. W. Howitt, the Explorer; Mr. John Lynch, Mining Surveyor at Smythesdale; and Mr. Reginald Murray, Mining Surveyor at

Sandhurst; gentlemen who have proved that they are qualified to give accurate descriptions of the topography and geology of the country.

R. Brough Smyth.

Melbourne, 18*th May*, 1871.

CONCRETIONARY STRUCTURE IN PLASTER.

Sir,—The concretionary structure in plaster noticed by your correspondent Benwyan has been frequently noticed by me, as it must have been by many. I do not think that the explanation given by him, that it results from segregation or crystallization, can be the true one ; for if that were so, the nuclei of the concretions should be *inside* the plaster; whereas I think they will be observed to be external. The concretions resemble saucers nested, rather than spherical shells nested. I have been used to attribute the appearance to the habit that plasterers have of casting the mortar on with a dash, so that it spreads from a central spot in concentric waves around. Thus the particles of the mortar are arranged in shallow saucer-shaped layers. And possibly, owing to some mechanical law in the distribution of the pressure from the central spot towards the periphery of the lump thrown on, the density of the mortar may alternately be greater and less in successive layers; and it is even possible that an arrangement of the particles analogous to cleavage may be produced. The subsequent passage of the smoothing tool over the whole obliterates the structure superficially, but time reveals it again by the process of weathering.

O. Fisher.

DENUDATION OF THE SHROPSHIRE COAL-FIELD.

We are favoured by Mr. John Randall, F.G.S., of Madeley, Salop, with a lengthened criticism upon a paper by Mr. Daniel Jones, F.G.S., " On the Denudation of the Coalbrook-dale Coal-field," published at p. 200 of our May number.[1] Mr. Randall states that the conclusions arrived at by Mr. Jones are identical with those of Mr. Scott, Sir R. Murchison, and himself as unmistakably shown by the sections published by Mr. Scott (Quart. Journ. Geol. Soc., 1861, vol. 17, p. 457), and that Mr. Purton has since figured the same thing (see Geological Magazine, 1865, Vol. II., p. 515).

Mr. Randall always held the opinion " that denudation took place prior to the general elevation of the Coal-field and the great faults by which it is intersected." The quotation from Mr. Randall's letter to the *Mining Journal*, given by Mr. Jones, refers to " one particular case on the eastern boundary of the Shropshire Coal-field, showing evidence of denudation and disturbance combined."

" The case refers exclusively to the Coals in the Halesfield and Kemberton pits, and not to the general question."

[1] Its earlier appearance has been delayed from want of space, and, indeed, we cannot now give Mr. Randall's criticism in full.

Mr. Randall equally objects to the section given by Mr. Jones (Fig. 1, p. 206), purporting to illustrate his views. Mr. Randall says: In this section "Mr. Jones leaves out altogether the Upper Coal-measures of which I had been speaking all along, but introduces them in another (Fig. 2, p. 206), which he says represents his own views."

Between the two paragraphs quoted by Mr. Jones from the *Mining Journal*, Mr. Randall says, "The following sentence has been omitted, which throws altogether a different light on the subject:—'At several places they, that is the Permians, may be seen overlying the younger members of the Coal-measures south of the Old Coal Field, also the latter group where the younger are denuded.'" —Edit. Geol. Mag.

THE SUBMERGENCE OF IS.

Sir,—There is a curious work on the subject of Mr. Lebour's interesting paper,[1] which, if it be unknown to him, he, with others, may be glad to read. It contains a number of statements with reference to the subsidence of Brittany, some of which are so startling that one views them with a little suspicion. Perhaps the unworkmanlike style of making references, too common in French books, increases this feeling. The author maintains that in the thirteenth century Jersey was yet united, or almost united, to France. The book is "Les Mouvements de la Mer," by M. Quenault (Coutances, 1869. pp. 68). My attention was called to it by a review from the pen of Mr. Whitaker in "Nature," vol. i., p. 381.

T. G. Bonney.

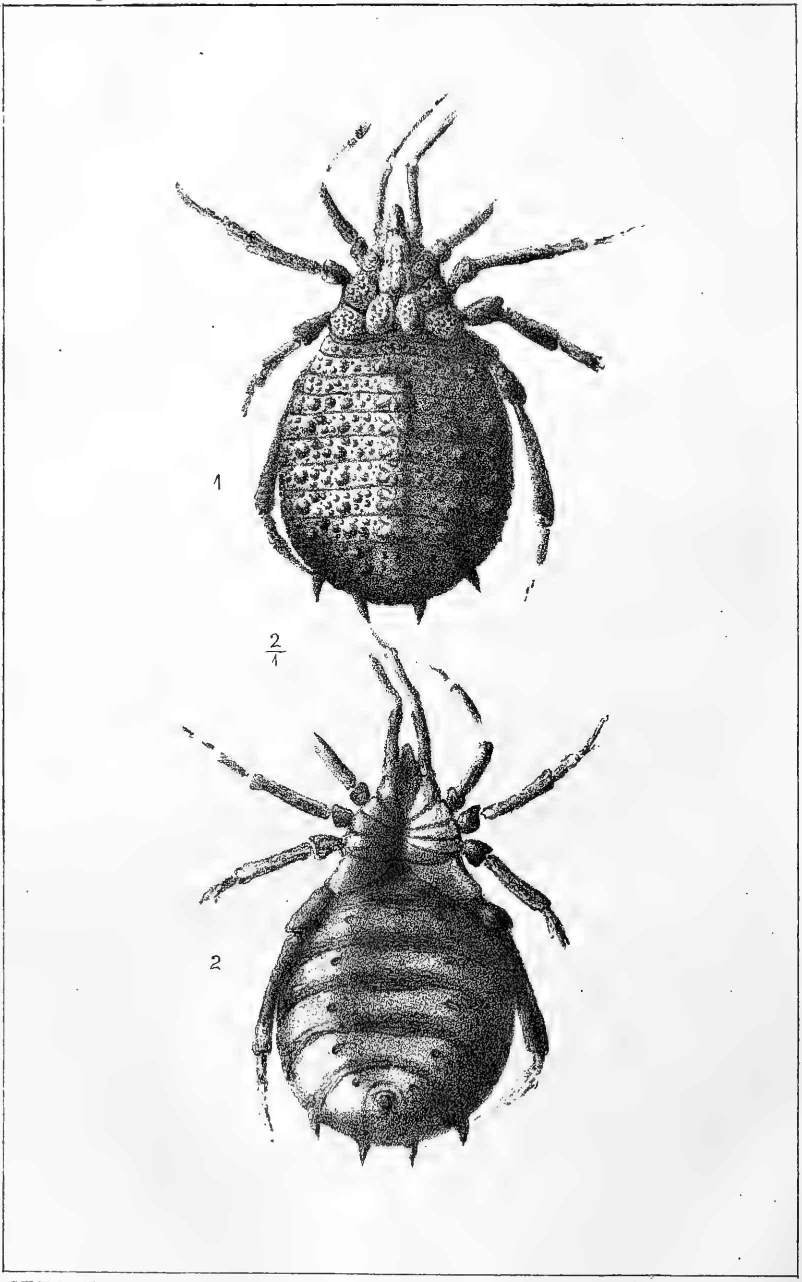
St. John's College, Cambridge.

MISCELLANEOUS.

Chair of Geology, College of Physical Science, Newcastle.—The Executive Committee of this new and promising institution have just completed the list of Professors, and we learn that Dr. David Page, alumnus and hon. LL.D. of the University of St. Andrew's, F.R.S. Edinburgh, F.G.S, etc., has been selected to fill the Chair of Geology. Dr. Page is well known as the author of numerous Geological Text-books, which have a very wide circulation; he has also published a very useful Glossary of Geological Terms. The subscriptions announced on behalf of the College now amount to £23,700.

Erratum.—Geol. Mag. for July, p. 333, in Mr. Marshall Hall's letter on "Terraces in Norway," *for* "Moïk Pors," *read* "Mörk Foss."

[1] Published in the Geol. Mag. for July.



G. R. De Wilde del. et lith. Mintern Bros. imp.

Eophrynus Prestvicii Buckland sp. Iron-stone
Coal Measures. Dudley

THE

GEOLOGICAL MAGAZINE.

No. LXXXVII.—SEPTEMBER, 1871.

ORIGINAL ARTICLES.

I.—On the Discovery of a new and very perfect Arachnide from the Ironstone of the Dudley Coal-field.[1]

By Henry Woodward, F.G.S., F.Z.S.,
of the British Museum.

(PLATE XI.)

THE "Pennystone Ironstone" Nodules of the Coalbrook-dale Coal-field have long been celebrated for their fossil contents yielding, when split open, impressions of Fern-leaves, fruits of Lepidodendron, King-crabs, and the more rare remains of Insects.

Nor have the similar concretions of the Dudley, Manchester, and Glasgow Coal-fields proved less productive; whilst the recent investigations of Messrs. Meek and Worthen in the Coal-measures of Grundy Co., Illinois, U.S., have brought to light an even larger series of new and interesting forms.

A short time since I was favoured by receiving from E. Hollier, Esq., of Dudley, a series of these nodules containing examples of *Bellinurus trilobitoides*, and one specimen, which proved upon examination to be a most beautiful and perfect insect inclosed in the centre of a nodule of clay Ironstone, which, happily, had split at exactly the right spot, and, what is not a little singular, has exposed two entire views—one of the upper or dorsal surface (Plate XI. Fig. 1), the other of the under and ventral aspect (Plate XI. Fig. 2)—of the very same insect, each view being as nearly perfect as it is possible to conceive.

Turning to "Buckland's Bridgewater Treatise," I at once identified Mr. Hollier's beautiful specimen with an insect figured on pl. 46″, fig. 2, from the Pennystone Ironstone of Coalbrook-dale. Dr. Buckland makes the following remarks upon (fig. 2), and upon another specimen (fig. 1), with which latter, however, the fossil under consideration has nothing to do.

"Figs. 1 and 2 belong to the family *Curculionidæ*, of which the Diamond-beetle is a familiar example. They were discovered by Mr. Wm. Anstice in nodules of Ironstone from the Coal-formation of Coalbrook-dale.

[1] Communicated to the British Association (Section C.), Edinburgh, August 8th, 1871.

"Fig. 2. (writes Dr. Buckland) Mr. Samouelle considers this extinct fossil species to approach most nearly to the *Brachycerus apterus* of Africa."

Dr. Buckland then proceeds (vol. ii., p. 76), to give a minute description of the fossil, which, from its imperfectly preserved state, had been mistaken for a *Curculio,* and concludes by naming it *Curculioides Prestvicii,* in honour of Joseph Prestwich, Esq., F.R.S., the Geological historian of the Coalbrook-dale Coal-field (see Trans. Geol. Soc., 1840, second series, vol. v., p. 413), and the present President of the Geological Society of London.

An examination of the very perfect specimen found by Mr. Hollier shows it to be an Arachnide, and not a Coleopterous insect at all; the dorsal surface (only a fragment of which is seen in Mr. Anstice's specimen), being quite perfect in Mr. Hollier's example, shows at once that it is not furnished with elytra, as supposed by Mr. Samouelle, whilst the insect, as a whole, is divided into cephalothorax and abdomen, as in spiders, instead of into three parts, head, thorax, and abdomen, as in beetles. Four pairs of ambulatory legs and a pair of palpi are preserved. The dorsal surface of the abdomen is ornamented with numerous smooth rounded tubercles, the largest of which are arranged in five principal lines, the median one forming pentagonal groups of tubercular ornaments down the centre of the body.

There is evidence of nine somites on the dorsal, but only seven are visible on the ventral aspect, the others being probably concealed beneath the broad basal joints of the posterior pair of limbs. The ventral surface is destitute of ornamentation, but is marked by about six pairs of stomata or tracheæ placed in a linear series down each side.

The dorsal surface of the cephalothorax is very tumid, and its centre is marked posteriorly by two, and centrally by three raised lobes covered with minute tubercles; the front of the head is somewhat prolonged, so as to form a rostrum. The lateral border is deeply indented, forming three rounded lobes on each side, which are finely granulated on their surface. The legs are also seen to be minutely scabrous on their upper surface.

The posterior border of the abdomen bears four short stout spines, two on either side the ultimate segment, which bears on its ventral aspect the efferent orifice.

The cephalothorax on its ventral aspect is much indented, and exhibits the very broad basal joints of the last pair of appendages, and the wedge-shaped basal joints of the three anterior pairs of ambulatory limbs.

The palpi appear to be long, slender, and, so far as we can judge, not chelate, as in *Thelyphonus,* although their extremities may have been furnished with spines, as in the genus *Phrynus,* with which latter it appears to be more nearly comparable. I have not been able to detect the ocelli.

I propose to name this new and interesting type of "false-scorpions" *Eophrynus Prestvicii,* the genus *Curculioides* being retained for *C. Ansticii*, which there is good reason to believe may belong to the *Rhynchophora*, although I have not as yet obtained a sight of the original specimen figured by Dr. Buckland.

The subjoined is a list, so far as I have been able to gather them, of the Palæozoic insects :

ARACHNIDA.—I. *Scorpionidæ*.

1. *Microlabis Sternbergi*, Corda, Coal M. Bohemia.
2. *Cyclophthalmus senior*, Corda, do. do.
3. *Mazonia Woodiana*, M. & W. Coal M. Illinois.
4. *Eoscorpius carbonarius*, M. & W. do. do.

II. *False-Scorpions*.

5. *Architarbus rotundatus*, Scudder Coal M. Illinois.
6. *Eophrynus Prestvicii*, gen. nov., Coal M. Coalbrook-dale and Dudley.

III. *Araneidæ*.

7. *Aranea*, sp. Coal M. Bohemia.
8. *Protolycosa anthracophila*, Rœmer, Coal M. Silesia.

MYRIAPODA.

9. *Xylobius sigillariæ*, Dawson, Coal M. Glasgow, Huddersfield, and Nova Scotia.
10. *Euphoberia armigera*, M. & W. Coal M. Illinois, U.S., and Nova Scotia.
11. ,, *Brownii*, H. W. do. Glasgow.
12. ,, *major*, M. & W. do. Illinois, U.S.
13. ,, *anthrax*, Salt, sp. (?) do. Coalbrook-dale.

COLEOPTERA.

14. *Curculioides Ansticii*, Buckl., Coal M. Coalbrook-dale.
15. *Scarabæus*, sp. do. Saarbruck (a fossil fruit ! Rœmer).
16. *Troxites Germari*, F. Gold. do. do.

ORTHOPTERA.

(*Blattidæ*) 17. *Blattina primæva*, F. Gold. Coal M. Saarbruck.
,, 18. ,, *Lebachensis* ,, do. do.
,, 19. ,, *gracilis* ,, do. do.
,, 20. ,, *anaglyptica*, Germar. do. Westphalia.
,, 21. ,, *anthracophila* ,, do. do.
,, 22. ,, *didyma* ,, do. do.
,, 23. ,, *flabellata* ,, do. do.
(*Locustidæ*) 24. *Gryllacris lithanthraca*, F. Gold. do. Saarbruck.
(*Termitidæ*) 25. *Termes Heerii*, ,, do. do.
,, 26. ,, *formosus* ,, do. do.
,, 27. ,, *Decheni* ,, do. do.
,, 28. ,, *affinis* ,, do. do.
,, 29. *Acridites* sp. Germar. do. Westphalia.

LEPIDOPTERA ?

30. *Tinea* sp. Fabr. Coal M.

NEUROPTERA.

31. *Dictyoneura anthracophila*, F. Gold. Coal M. Saarbruck.
32. ,, *Humboldtiana*, do. do. do.
33. ,, *libelluloides*, do. do. do.
34. *Miamia Bronsoni*, Dana. do. M. Grundy Co. Illinois.
35. ,, *Danæ*, Scudder do. do. do.
36. ,, *Chrestotes lapidea*, ,, do. do. do.
37. *Mantis ?* ,, do. do. do.
38. *Mylacris anthracophila* ,, do. do. do.
39. *Megathentomum pustulatum* ,, do. do. do.
40. *Euphemerites simplex* ,, do. do. do.
41. ,, *gigas* ,, do. do. do.
42. ,, *affinis* ,, do. do. do.
43. *Haplophlebium Barnesii* ,, do. Cape Breton.
44. *Corydalis Brongniarti*, Mantell do. Coalbrook-dale.

DEVONIAN.

1. *Platephemera antiqua* Scudder Devonian New Brunswick.
2. *Homothetus fossilis* ,, do. do.
3. *Lithentomum Harttii* ,, do. do.

DEVONIAN—*continued.*

4.	*Xenoneura antiquorum*	Scudder	Devonian	New Brunswick.
5.	*Gerephemera simplex*	"	do.	do.
6.	*Dyscritus vetustus*	"	do.	do.
7.	*Archimulacris acadicus*	"	do.	do.
1.	*Eugereon Bœckingii*,	Dohrn,	Permian,	Birkenfeld.

Arachnida ...	...	8
Myriapoda ...	...	5
Coleoptera ...	...	3
Orthoptera ...	...	13
?? Lepidoptera ...	...	1
Neuroptera ...	...	14

44 Coal-measures.
7 Devonian.
1 Permian.

Total Number of Palæozoic Insects ... 52

EXPLANATION OF PLATE XI.

FIG. 1. Upper side of } *Eophrynus* (*Curculioides*) *Prestvicii*, Buckl., sp., enlarged.
FIG. 2. Under " " }
From the Ironstone of the Coal-measures, Dudley. Length of specimen 14 lines, greatest breadth of abdomen 8 lines.
(Drawn from the original specimen in the Cabinet of E. Hollier, Esq., Dudley.)

II.—ON "WANTS" IN IRONSTONE SEAMS[1] AND THEIR CONNECTION WITH FAULTS.

By ROBERT L. JACK, F.G.S.,
of the Geological Survey of Scotland.

OF all the "troubles" that afflict the Ironstone miner, few are more perplexing than those known as "wants." It sometimes happens that in the course of the working a "face" is being carried forward into the ironstone seam, when the miner finds that he has taken out what is apparently the last piece of "stone," and looks with astonishment at "the blaise where the stone should be."

The ironstone seam has not thinned out, for it is found that it continues of its normal thickness up to the face, where it abruptly ends. There is no fault or step, for the miner, carrying on his working, finds that in a dozen feet or so the ironstone "takes on again" as abruptly as it ended off, and may observe that he has had one and the same shale bed all the way for his floor. The roof has simply settled down upon the floor, and the ironstone which should have come between them *is not.* Such wants are generally found to take the shape of long stripes, inclosed by lines nearly parallel, and about as straight as lines of fault usually are.

The task before us is to explain why there should be long gaps in strata which without doubt were laid down continuously. The obvious commercial importance of such wants, and the perplexity which seems to prevail regarding their geological origin, lead me to offer the following observations.

As a matter of fact, wants have hitherto been observed for the most part (and perhaps exclusively) in districts where the strata are much

[1] Only clay-band and black-band Ironstones interstratified with Carboniferous rocks are here referred to.

disturbed by faults. If it can be shown that faults must necessarily produce wants in certain strata, the solution, or at least a solution, of our problem will have been obtained.

To demonstrate the connexion between wants and faults, it is necessary to premise some facts regarding the latter.

A single fault, disturbing hitherto unbroken strata, must begin in two zero points, one at each end of the line. The dislocation must reach its maximum somewhere between the two zero points.

Let us suppose (as is, indeed, generally the case) that only the strata on the downthrow side of the fault have been displaced; the edge of any particular bed which has been affected by the movement will, on the side of downthrow, "bag" or lie along a curved line; and, on the other side, along a straight line. The curved line will represent a portion of the bed originally of the length of the straight line between the two zero points, but now stretched out to a greater length. For example: a fault whose two zero points are one mile (1760 yards) apart, has a maximum downthrow midway between those points of 220 yards.[1] In this case, strata measuring 1760 yards along the so-called "upthrow side" of the line of fault must be stretched out to not less than 1833 yards, *or broken.*

Few rock masses after consolidation are, strictly speaking, elastic, at least to such an extent that they can be stretched 73 yards in a mile. The source of the capability of being stretched,[2] possessed by a set of various stratified beds, as a whole, has to be sought for in the unequal widening (by separation of the solid parts, not by waste), of the vertical joints with which strata of different composition are endowed. Any one who has examined the jointing of Carboniferous shales in a natural section will readily understand how the mass might be, as it were, pulled out horizontally, so as to occupy a greater space, without losing its continuity. Each bed of the shales, as seen from above, is cut by an irregular network of joints into pieces like broken slates in a slate-yard, and only remains in its place in consequence of its resting on lower beds, similarly jointed, although the joints of one bed do not accurately underlie or overlie those of the neighbouring beds. Seen in a cliff, or other vertical section, the pieces of shale, into which the joints have divided the mass, overlap each other in the manner represented in the diagram (Fig. 1). A glance at the diagram will show that by slightly widening each joint the whole mass of the shales might be stretched out so as to occupy a greater space without losing its continuity.

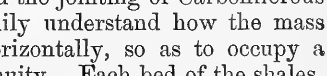


Fig. 1.—Portion of a cliff of Carboniferous Shales, showing the arrangement of the joints.

Other strata alternating with shales in the Carboniferous Limestone series, such as Sandstone, Coal, Limestone, or Ironstone, have systems of jointing peculiar to themselves, which vary, however,

[1] Faults sometimes increase with remarkable rapidity. The above example is not a hypothetical one.

[2] As neither "elasticity" nor "flexibility" expresses the meaning to be conveyed, I am compelled to use this roundabout phrase.

in consequence of differences in thickness, or in fineness of material, of individual beds, and other causes. Generally speaking, the joints cut each bed, of whatever material, from top to bottom. A bed of, say ironstone, a foot in thickness, is cut up by the system of joints peculiar to it into parallelepipeds, separable from each other (named "lunkers" by the miners), something like paving-flags. In the bed of shale above or below the ironstone there are probably a score of joint planes for one in the ironstone; while in a thick bed of sandstone or limestone there is probably not one joint for a thousand in the shale. If a number of beds of ironstone, sandstone, or the like, lie together, they will no doubt be capable of being stretched as a whole (though clumsily and with difficulty), in the same manner as a number of shale-beds. But in the case of a single stratum of such material (jointed from top to bottom) occurring in the midst of a thickness of shales, it is evident that as the stretching of the latter goes on, the single stratum—which cannot be stretched—must *yawn* along one or more of the joints which cut it in lines forming angles (probably right angles) with the line along which the pulling force is exerted. When the pulling force is the weight of the strata let down by a fault, it is of course exerted along the line of the fault; and the yawning in the stratum which cannot be stretched will take place along a line forming an angle with the line of fault.

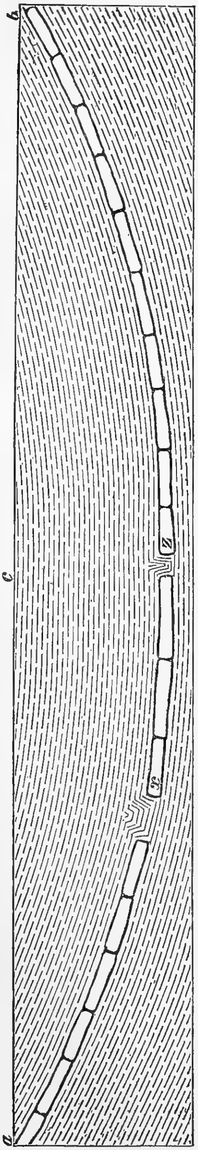


FIG. 2.—Section on Downthrow Side of a Fault, showing Wants in Ironstone Seam filled up with Shales.

a and *b*. The zero-points of the Fault—1760 yards apart along the line *a b*, as measured on the "upthrow" side.
c to *z*. The maximum downthrow of 220 yards.
x and *z*. Two Wants in the Ironstone seam, amounting to about 73 yards, being the extent to which the Shales have been stretched.
Note.—The thickness of the Ironstone is necessarily exaggerated in the woodcut, being about 50 *feet* by the scale.

It is hardly necessary to remind either the miner or the geologist who hunts for fish-teeth that by far the greatest number of the workable ironstones in the Carboniferous Limestone series occur as isolated seams among considerable thicknesses of dark Carbonaceous shales. The vast heap of "blaise" which has to be excavated as "holing" is almost as familiar an object at the pit mouth as the engine-house itself.

Wants in ironstone seams are, therefore, the gaps necessarily formed in strata incapable of being stretched, which occur among strata *capable* of being stretched by the weight of a mass of rock displaced by a fault. Fig. 2 is intended to show two wants, amounting together to about 73 yards, caused by the fault above mentioned, which had a maximum downthrow of 220 yards; its zero points being one mile distant.

It is by no means asserted that even in the case of shales the capability of being stretched is without limit. In every case after the limit is reached, the fault can only increase its downthrow by increasing in horizontal length (*i.e.* adding to the distance between its two zero points), or by producing on its downthrow side one or more faults along lines of weakness forming angles with its own line. Such lines of weakness, destined to become faults, will be found in the largest wants in the thickest strata. Faults which disturb stratified deposits of varying composition are very frequently filled with a "hash" of the softer strata only, such as shales and fire-clays; and this circumstance may be due in some cases to the fact that the fault has been made (during the increase of a master-fault) along a line from which the harder beds—of sandstone or the like—had been previously withdrawn.

When a master-fault, after exhausting the capability of being stretched possessed by the strata displaced, produces smaller faults, the latter will have their downthrow on the side towards which the master-fault increases. The superincumbent strata will settle down along the lines of the master and smaller faults till the gap which would otherwise have existed is filled up.

III.—On the Mollusca of the Crag-formation of Iceland.

By Dr. O. A. L. Mörch, For. M. R. Soc., Edin.; For. Corr. Z. S., Lond.; Acad. Sc., Philad.

THE fossils of the volcanic Islands of the Atlantic Ocean, St. Helena, Madeira, Teneriffe, and Iceland, have a special interest, as giving dates relative to the supposed Atlantic Continent. The fossil land-shells of St. Helena and Madeira appear to belong to a period corresponding to the Crag-formation of England. The marine fossils of the Canaries, on the contrary, belong to a somewhat more ancient period.

In Iceland beds of fossils are found in several places, but belonging to very different geological ages. The most celebrated formation is the Surturbrand, containing a fossil flora, chiefly known from the description of Prof. O. Heer of Zürich, from the collections of Prof. Steenstrup, etc. It contains about thirty-seven species of plants, chiefly belonging to *Araucarites* (*A. Sternbergi*, with stems from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet in thickness), *Betula*, *Corylus*, *Alnus*, *Vitis*, *Lyriodendron*, *Ulmus*, *Rhamnus*, *Rhus*, *Quercus*, etc. A wing of a *Carabus* is the only trace of animals. The author considers this formation to be of Miocene age, but belonging to two different periods.

The fossil shells belong to a more recent period; but as they are never found in the same place in superposed strata, it is difficult to indicate their relative age with security. From zoological reasons it is however evident that some of the beds are of a more recent date; whilst others, especially the beds of Husavik Hallbjórnastadir-camb,[1] the best-known formation, is the oldest, and probably corresponds to the older Crag of England and Belgium. The following authors have contributed to the investigation of this subject:—

1. *Eggert Olafssen og Biarne Povelsen.* Reise igjennem Island, 1752-57. Sorö, 1772.—In vol. i., pp. 126 and 153, is described a layer of fossils in bluish clay, 7 to 10 feet thick, in the border of the Leyraa and Laxaa (two rivers), containing *Pecten Islandicus*, L., with the colours well preserved, and *Cyprina Islandica*, L.—In vol. i., p. 410, it is stated that fossil shells are found in several localities in Bardestrands and Isefjords Sysseler, close by the shore, from between one and two to four fathoms above high-water mark, and in several other places in South Iceland, but not afterwards investigated, so far as I know. It is mentioned that near many of the houses are found large heaps (*middings*) of shells of *Cyprina* and *Mya*, eaten by the inhabitants, but which are not to be mistaken for fossils, any more than are the shells and sea-urchins the ravens have left on the rocks far inland.—In vol. ii., p. 936, several localities for fossil shells are mentioned, on the authority of the inhabitants. A hill close to Soget contains shells in a bluish very soft stone, which are washed out by this rivulet, viz., *Cardium Islandicum, Cyprina Islandica,* and especially *Tellina calcarea*, Chem. At another place, in a very hard rock, is found *Pecten Islandicus*, with the colours of the shell preserved. All these localities seem only to yield shells exactly like those *now living* on the coast of Iceland. The following locality contains the greatest number of shells, many of which differ from those now living in the seas of Iceland.—Vol. ii. p. 665. Fossil and partly mineralized (crystallized) shells are found in a hill called Hallbjórnastade-Kamb, 140 feet high, situated close by the shore, in the vicinity of Husavig harbour, on the Eastern part of the North coast of Iceland. The mineralized (crystallized) shells are only found on one spot; they are mostly shells of *Cardium, Venus* (*Cyprina*). The following shells are indicated: *a. Astarte; b. Cardium ciliatum?; c. Pecten Islandicus; d. Mya truncata; e. Buccinum undatum; f. Littorina; g. Fusus Olavii,* Beck; *h. Natica clausa,* and perhaps *N. aperta*, Lovèn.

2. *Olaus Olavius.* Œconomisk Reise igjennem de nordvestlige, etc. Kanter af Island. 1780.—In vol. ii. p. 572, is a plate with shells from Halbjarnastadirkamp. The figures are very bad, but the plate gives a very good idea of the abundance and position of the fossils. *Tellina, Cyrtodaria, Nassa, Trophon, Pleurotoma, Natica, Bittium?* The best figure represents an *Astarte*, very like to *A. castanea*, Say.

3. Voyage en Islande et aux Grónland, executé pendant les années 1835 et 1836, sur la corvette la Récherché, commandé par M.

[1] "*Hallbjarnarstada-Kamb*" is the official way of spelling this locality, but the various authors referred to wrote more or less in Danish or old Icelandic; this will sufficiently explain the diversity in writing this name in the various works here quoted.—O. A. L. M.

Trehouart, publie sous la direction de Mr. Paul Gaimard. Mineralogie et Geologie, par E. Robert. 1840.—P. 283, "Les coquilles fossiles de Husavik Hallbjarnastadarkambur sont d'une abondance extrême dans ce terrain, et admirablement conservées, ce sont d'aprés Mr. Deshayes, qui a constaté leur identité avec celles qui vivent encore dans ces mêmes lieux, notamment les *Cyprina Islandica, Mya arenaria, Tellina solidula* (*T. ovata,* Sowb. ?), *Tellina tenuis* (probably *T. calcarea,* Ch.), *Natica clausa, Cardium* voisin de *ciliatum, Solen vagina, S. ensis ? Buccinum* voisin de *Buc. reticulatum.*" It is stated that the great specimens of *Cyprina* contain chambers filled with a blackish matter, probably being part of the animal (perhaps the stomach). "Au dessus de ce gissement, les coquilles sont entassées pêle mêle comme dans un falun ; le tufa se divise alors en plaque et renferment principalement des petites bivalves." Mr. Robert figures as *Cyprina Gaimardi* a shell which Mr. Deshayes considers a very inflated variety of *Cyprina Islandica,* L.

4. *G. G. Winkler.* Island der Bau seiner Gebirge und dessen geologische Bedeutung. München, 1863.—The fossils of Hallbjarnarstadir are for the first time stated to belong to the Crag-formation. Twenty-seven species are enumerated. Through the favour of the author, I have received some sketches of the new species, which enable me to give the following observations:—*Tapes virginea,* Forb., is *Tellina calcarea,* Ch. ; *Astarte Hjaltalini,* Winkl., is, as the the author himself supposes, *A. crebricosta,* Forb. ; *Natica Steenstrupiana,* Winkl., is *Natica aperta,* Lovèn. ; *Planorbis spirorbis,* Müll.,[1] is probably mis-written for *Spirorbis borealis,* Daudin ; *Patella lævis,* Winkl., appears not to differ from *Patella pellucida,* L., *Cyrtodaria Heerii,* Winkl., is perhaps *C. angustata,* Nyst. The following true Crag-fossils are named:—*Cyprina rustica,* Sowb. ; *Tellina ovata,* Sowb. ; *Corbulomya complanata,* Sowb. ; *Cyrtodaria siliqua,* Spgl. ; *Natica varians,* Duj. ; *Natica hemiclausa,* Sowb. ; *N. occlusa,* Wood. At p. 211 the following species are named as occurring at Fossvogur, which may be considered of a more recent period :—*Mya truncata,* L. ; *Buccinum undatum,* L., var. *vulgatum ; Balanus,* sp. ; *Tellina,* sp. From Arnabäuli, p. 212, which appears to belong to the same period :—*Cyprina Islandica,* L. ; *Astarte borealis,* Chem. ; *Mya truncata,* L. ; *Pholas crispata,* L. ; *Pecten Islandicus,* L. ; *Buccinum undatum,* L., var. *vulgatum.*

5. *C. W. Paykull.* Bidrag till Kännedommen om Islands Bergsbygnad. (Kgl. svenska vetenskaps Akademiens Handlingar. 7 Band. 1867. Stockholm.) At p. 47 is given by the late author a description of the fossiliferous layers of Hallbjarnastada, and at p. 49 a list of species named by the present author.[2] The specimens are partly in the Museum of Copenhagen, partly in Stockholm. At p. 48 the layer of Fossvogur, between Reykiavik and Hafnarfjord, is more specially described. It contains—*Saxicava rugosa,* L. ; *Mya truncata,* L. ; *Tellina sabulosa,* Spgl. (*T. calcarea,* Ch.) ; *Nucula tenuis,* Mtg. ; *Balanus,* sp. These species indicate a more recent period

[1] Wood, 1848, p. 9, tab. 1, fig. 11.
[2] Quoted in the Catalogue as Mörch-Paykull's List.

than the Crag. The Crag is not found in Greenland, but a formation probably corresponding to the layers of Fossvogur and Arnabäuli. In the following paper I have given a list of thirteen species of shells from Pattorfik, in the Omenaksfjorden. They are still living in the seas of Greenland, except *Cyrtodaria siliqua*, Spgl., a Newfoundland species, and *Panomya Norvegica*, Spgl. (the form *P. arctica*, Lam.), found on the north coast of Iceland and in the Cattegat.

6. *H. Rink.* Om den geographiske Beskaffenhed af de danske Handelsdistrikter i Nordgrónland tilligemed en Udsigt over Nordgrónlands Geognosie, 1852. (Kgl. danske Videnskabernes Selskabs Skrifter, 5 Række, 3 Bind.)

The Crag-formation of Hallbjarnastadir is characterized by the following fossils:—1. Species not found living but fossil in England and Belgium:—*Corbulomya*, two or three species; *Actæon Noæ*, Sowb.; *Natica varians*, Duj.; *N. hemiclausa*, Sowb.; *N. occlusa*, Wood; *Littorina littorea*, the Crag variety, *Buccinopsis crassum*, Nyst.; *Nassa monensis*, Forb.?; *Voluta*, sp.; *Trochus*, two sp.; *Cyrtodaria Heerii*, Winkl.; *Mactra*, two or three sp.; *Tellina obliqua*, Sowb.; *Tellina prætenuis*, Leathes; *Cyprina Gaimardi*, Robert; *C. rustica*, Sowb.; *C. Islandica*, L., var. *pumilio; Mytilus hesperianus*, Lam.

2. The following species are found living in the arctic regions, and are found fossil in the Crag of England: *Natica Grœnlandica*, Beck; *N. clausa*, Sowb.; *Tritonium Grœnlandicum*, Chem.; *Tr. undatum*, var. *pumilio; Fusus propinquus*, Ald.; *Fusus fornicatus*, Fabr.; *Pleurotoma turricula*, Mtg. (but very large); *Pl. rufa*, Mtg.; *Pl. Treveylliana*, Turt.; *Admete viridula*, Fabr.; *Patella pellucida*, L.; *Teredo*, sp.; *Solen siliqua*, L.; *S. ensis*, L.; *Saxicava Norvegica*, Spgl.; *Cyrtodaria siliqua*, Spgl.; *Mya truncata*, L.; *M. arenaria*, L.; *Tellina calcarea*, Chem.; *Cyprina Islandica*, L.; *Astarte crebricosta*, Forb.; *A. compressa*, L.; *Cardium Grœnlandicum*, Chem.; *Modiolaria nigra*, Gray; *Mytilus edulis*, L.; *Cardium echinatum*, L.

The following species only are found living: *Acrybia lutea*, Gould; *Littorina Grœnlandica*, Chem.; *Tritonium Tottenii; Tritonium scalariforme*, Beck.

At present the north coast of Iceland is quite arctic, but in the Crag-period the temperature must have been much milder, at least as at present on the west coast by Reikiavik. The following genera, which indicate a southern climate, are still found on the west coast of Iceland: *Actæon, Trochus, Patina, Nassa, Mactra* (*elliptica*), none of which are arctic; *Littorina littorea, Solen ensis, S. siliqua, Cardium echinatum*, none of which are arctic shells, have not been yet discovered in Iceland, but may possibly be found there hereafter. The change of the climate of the north coast of Iceland to one of a true arctic nature probably has resulted from an elevation of the land in that part which prevented the free passage northwards of the great equatorial current.

Natica aperta is considered by Prof. C. Mayer to be a tropical form, but this species is, on the contrary, a true Glacial form. Prof. Winkler believes that the dwarf variety of *Cyprina Islandica* indicates a warmer climate, like that of the Baltic near the coast of Mecklenburg, where a small variety is said to exist. The size of the specimens of the Crag-formation of Iceland is in general not remarkable, except the following species, which may be considered dwarf varieties: *Fusus Olavii* (perhaps dwarf variety of *F. gracilis*), *Cyprina Islandica pumilio, Cardium Grœnlandicum, Tritonium Grœnlandicum*, Ch., *Tritonium undatum pumilio*.

The following species may be considered very large in the Crag-formation of Iceland: *Actæon Noæ, Natica aperta, Pleurotoma turricula, Corbulomya,* two or three species, much larger than any specimen known to me from England. The three species of *Mactra* may be considered large in comparison with the species now living in the North Sea.

The dwarfed condition of certain species may depend on various causes. The North Sea shells all become smaller when they enter the Cattegat and the Baltic, diminishing in size according to the decrease of the saltness of the water. The freshwater shells, as *Neritina* and *Lymnœa,* decrease, on the contrary, in the same proportion as the water becomes salter.

List of Mollusca found in the Crag-formation of Iceland at Hallbjarnastadir.

(The species marked with * are not known to me from autopsy).

1. *Actœon Noœ,* Sowb., Min. Conch., tab. 374.
   Tornatella Noœ, Nyst, Coq. Foss. de Belgique, p. 424, tab. 37, fig. 22.
   One specimen 16 mm. long, and 10 mm. in diameter; and another smaller: Suturis depressis, subcanaliculatis, labro intus sulcato.
2. *Acrybia lutea,* Gould.
   Natica aperta, Lovèn.
   Natica Steenstrupiana, Winkler, l.c. p. 209.
   Bulbus apertus, Lovèn, Mörch, apud Paykull.
   Tungabakker Tjörnæs. The largest specimen is 32 mm. long and 25 mm. in diameter.
3. *Natica (Lunatia) Grœnlandica,* Beck.
   Natica catena, D. Costa, Wood, Winkler, p. 208.
   Mamma et Lunatia Grœnlandica, Mörch, apud Payk.
   Common (Winkler, Paykull).

*4. *Natica (Lunatia) varians,* Dujardin.
   Natica varians, Wood, p. 142, tab. xvi., fig. 6.
   Natica borealis, Gray?
   Two specimens; 30 mm. long, 25 mm. in diameter; aperture, 21 mm. long, 13 mm. in diameter.

*5. *Natica (Lunatia?) hemiclausa,* Sowb., tab. 479, fig. 2.
   Natica hemiclausa, Winkler, l.c. p. 209.
   Rare (Winkler).

*6. *Natica occlusa,* Winkler.
   Natica occlusa, Winkler.
   Common (Winkler).

7. *Natica clausa,* Sowb.
   Natica clausa, Sowb., Winkler, p. 209, w. 5, Mörch, Payk.
   Common (Winkler, Paykull.)
8. *Natica (Neverita ?).*
   One specimen, 29 mm. long, 25 mm. in diameter; aperture, 20 mm. Perhaps the *N. hemiclausa* of Winkler.

*8. *Littorina littorea*, Linn.

Litorina littorea, L., Wood, p. 118, tab. x. fig. 14.

One specimen exactly corresponding to the variety figured by Wood, smooth and banded; 16 mm. long, circ. 15 mm. in diameter. Paykull.

9. *Littorina Grœnlandica*, Chem.

The nucleus of some specimens. (Gudman.)

10. *Tritonium Tottenii*, Stimpson.

Buccinum undatum vulgatum, Wood, tab. 3, fig. 12*c*.
" " " Winkler, p. 210.

Probably only a variety of *Buccinum undulatum*, Möller.

11. *Tritonium Grœnlandicum*, Chem.

Buccinum undatum, var. *læviusculum*, Wood, p. 111, tab. 3, fig. 12*a*.
Tritonium undulatum var. *Grœnlandicum*, Mörch, Payk.

Fragmentum *T. lævis*, with the epidermis; 20 mm. in diameter, from Paykull. This species is mostly a dwarf variety of the preceding.

12. *Tritonium undatum*, L. (var. *pumilio*).

circ. 36 mm. long; 20 mm. in diameter, plicis obliquis suturalibus prominentibus. Three specimens.

13. *Tritonium scalariforme*, Beck.

circ. 25 mm. long.; 12 mm. in diameter; 13 mm. long spiræ. One specimen, Gudman.

14. *Buccinopsis crassa*, Nyst.

Buccinum crassum, Nyst, p. 569, tab. 44, fig. 7.
Buccinum Dalei, Sowb. M.C., tab. 488, fig. 12 ?
Buccinopsis Dalei, Sowb., var. Mörch, Payk.

One specimen measures 39 mm. in length, and 20 in diameter. Several specimens from Gudman and Paykull. It reminds one of a dwarf thick-shelled *Fusus antiquus*.

16. *Fusus* (*Sipho*) *Olavii*, Beck.[1]

Testa *Fus. gracili* affinis sed parva tenuiuscula, sutura profunda, spira abbreviata. Mammilla apicalis obliqua Littorinam obtusatam non absimilis. Long. speciminis majoris, 35 mm., diam. 17 mm. Long. speciminis minoris, 16 mm., diam. 9 mm.

Fusus gracilis, Wood, var. *a*, tab. vi. fig. 10*a*, non absimilis.
Fusus Olavii, Beck, Mörch, apud Payk.

Var. *Spira longa*, 38 mm. long, 16 mm. in diameter.

Trophon gracilis, Wood, tab. vi., fig. 10*b*.; var. *β* non absimilis.

*17 *Fusus* (*Sipho ?*) *propinquus*, Alder; var. *Spira elongata*.

Fusus propinquus, Ald., Mörch, Payk.

Among Paykull's collection, now in the museum of Stockholm, I believe there is a specimen of this species. It is certainly found in the Crag of Belgium. I have seen several specimens, with well-preserved apices, corresponding in shape to the figure given by Nyst.

18. *Fusus* (*Neptunea*) *fornicatus*, Fabr.

Fusus antiquus, Wood., tab. xi. fig. 4*a*–*k* (Winkl.).
Fusus despectus, L., var. Mörch, Payk.

Common (Winkler). I have only seen a well-preserved fragment. 43 mm. in diameter.

[1] Not the *Fusus Olavii*, Beck, in Eichwald Urwelt Russlands, 1842, p. 141.

20. *Nassa monensis*, Forb., Jeffr., *verbotinus*.

Testa conica, anfr. planiusculis conferte costatis; costæ circiter 29 in anfr. ultimo, bifidæ obsoletæ arcuatæ; spiraliter liratæ unde interstitiis costarum foveolatis. Long. 12 mm., diam. 5½ mm.; spiræ 7 mm. long.

Nassa labrosa, Wood, tab. 3, fig. 8, quoad formam sed non sculptura.
Nassa Cuvieri, Payr. non *absimilis*.

I have compared four specimens from Mr. Gudman, and from Spengler's collection one specimen. I consider it very different from *N. monensis*, Forb., which I, however, do not know from autopsy.

21. *Pleurotoma* (*Ischnula*) *turricula*, Mtg.

Clavatula turricula, Wood, tab. viii., fig. 13, Winkler, p. 211.

Very large specimens, 20 mm. long, 8 mm. in diameter; spiræ, 10 mm.

22. *Pleurotoma* (*Ischnula*), sp.

Clavatula concinnata, Wood, p. 61, tab. vii., fig. 11, aff. vel. *C. nebula*, fig. 10.

One specimen is 19¾ mm. long, 8 mm. in diameter; spiræ, 11 mm. long.

23. *Pleurotoma* (*Bela*) *rufa*, Mtg. Wood.

13½ mm. long, 5½ mm. in diameter; spiræ, 7 mm. long.

24. *Pleurotoma* (*Ischnula*) *Treveylliana*, Leach.

Circ. 11 mm. long; 5 mm. in diameter; anfr. ult., 5 mm. long.

25. *Admete viridula*, Fabr.

One specimen, 10 mm. long.

26. *Voluta*, sp.

Fragmentum spiræ. Anfr. tres primi solum adsunt: anfr. 2 primi lævigati, mamillam formantes; anfr. tertium undatim plicato-costatus. Sutura profunda. Diam. 3 mm.

Cancellaria coronata, Wood, tab. vii., fig. 18, gives an idea of it.

27. *Trochus amphibola*, nov. sp.

Testa subperforata conica obtuse-angulata. Anfr. convexiusculi, quadrilirati, interstitia lirarum lirulis 2–3 intercalantibus. Labio subreflexo incrassato liris 2–3 obsoletis. Periomphalum declivi angusto. Striæ incrementi regularibus membranaceis. Axis, 8 mm.; long, 13 mm.; diameter maj., 12 mm.; min., 10 mm.

(*Gibbula*) very like *Margarita cinerea*, Couth., but decidedly a *Trochus*.

28. *Trochus* (*Gibbula*).

Testa convexo conica, imperforata, carina subprominula acutiuscula. Anfr. declivi planiusculi supra carinam liris 5 bipartitis; basis conferte lirulata interstitiis lirarum carinam versus lirula intercalante. Striæ incrementi confertæ, obliquæ, regulares, filiformes. Axis, 5 mm.; long, 8 mm. diameter maj. 9 mm.; min. 7 mm.; alt anfr. penult, 2½ mm. Allied to *Tr. divaricatus*, L. One specimen.

*29 *Patella* (*Patina*) *pellucida*, L.?

Patella lævis, Winkler, l.c. p. 211.

The surface is, according to Dr. Winkler, smooth, the concentric lines of growth are scarcely to be seen by the lens. Length 9½ mm., and 6 mm. broad.

ACEPHALA.

30. *Teredo*, sp., tube about 9 mm. in diameter. In a fossil piece of wood. Paykull indicates exactly the layer in which it is found, p. 42. *d*.

31. *Solen siliqua*, L. ?

In the Spenglerian collection is found a fragment 27 mm. long, and 14 mm. high.

32. *Solen ensis*, L. *minor*, Nyst, l.c., tab. 1, fig. 4.

In the same collection a fragment 18 mm. long, 7½ mm. high.

33. *Cyrtodaria siliqua*, Spgl.

Glycimeris angusta, Nyst, p. 55, tab. 11, fig. 1*a*. (Winkler).

Well preserved, often with the ligament.

*34. *Cyrtodaria Heerii*, Winkler, l.c. p. 208.

According to a sketch by Dr. Winkler, this species is established upon a rather incomplete specimen. It is 45 mm. long, and 19 mm. high, under the umbo only 13 mm. It looks to me very like *Cyrtodaria angusta*, Nyst.

*35. *Saxicava* (*Panomya*) *Norvegica*, Spgl.

Panopœa Norvegica, Spgl. Winkler, l.c. p. 208.

36. *Corbulomya complanata*, Sowb.

Corbula complanata, Sowb., M.C., p. 86, tab. 362, fig. 7, vix 8.
Corbulomya complanata, Nyst, Coq. Foss., p. 59, tab. 2, fig. 2 (Winkl.).
Corbula complanata, Bronn. Leth. T., 11, p. 69, tab. 37, fig. 8.
Corbulomya complanata, Mörch, Payk.

Several specimens exceedingly thick in the shell, 23¾ mm. long, 13 mm. alt.

37. *Corbulomya Winkleri*, Mörch.

Corbulomya complanata, Winkler, p. 206, non Sowb.
Corbulomya, sp. Mörch, Payk.

Testa tenuis postice angustata juxta umbones ochracea. Long. 29 mm., alt. 15 mm.

38. *Corbulomya*, sp.? var. *Abbreviata præcedentis ?*

39. *Mya arenaria*, L.

Mya arenaria, L., Winkler, p. 205, Mörch, Payk.

Rather common, Winkler, Paykull.

The largest is 72 mm. in length, 40 mm. high.

40. *Mya truncata*, L.

Paykull. One specimen 70 mm. long, 48 mm. high.

41. *Mactra* (*Spisula*) *procrassa*, S. Wood.

Mactræ solidæ, aff., Mörch, Payk.

42 mm. long, 35 mm. alt.

Cyprina Islandica, var. without lunula or area. Winkler, p. 201, belongs perhaps to this.

42. *Mactra* (*Spisula*) *arcuata*, Sowb., 1817, tab. 168, fig. 1. Long. 55 mm.; alt. 43 mm.

43. *Mactra* (*Trigonella*), sp.

Mactra stultorum, L., S. Wood? Mörch, Payk.

This species closely resembles *Cardium Grœnlandicum*, Chem.; it is however easily distinguished by the want of the impressed lines outside for the reception of the ligament.

44. *Tellina* (*Macoma*) *obliqua*, Sowb., M.C., tab. 161, fig. 1.

Tellina obliqua, Nyst, p. 107, tab. 15, fig. 2.
Tellina ovata, Sowb., Winkler, p. 203, Mörch, Payk.

I give here the measure of some individuals—

Long. 36 mm.; alt. 33 mm.
" 28 " " 23 "
" 33 " " 28 " Wood, tab. 7, fig. 1.

45. *Tellina (Macoma) calcarea*, Chem.
Tapes virginea, Forbes, Winkler, p. 203, ex figura.
Tellina sabulosa, Spgl., Mörch, Paykull.

Rather common; 28 mm. long, 19 mm. alt.

46. *Tellina (Macoma?) prœtenuis*, Leathes.
Tellina prœtenuis, Wood. p. 238, tab. 21, fig. 2.
Tellina, sp. Mörch, Paykull.

Husavig, Spgl., Paykull.

47. *Cyprina Islandica*, L.
Cyprina Islandica, L., Mörch, Paykull.

The large form is rather scarce. I give here the measures of three individuals.

Long. circ. 98 mm.; alt. 85; crassities testæ, $4\frac{1}{2}$ mm.
" 70 " " 69 " " 4 "
" 66? " " 65 " " 3 "

48. *Cyprina*, sp.
Cyprina Islandica, Nyst, p. 145, tab. ix., fig. 1.
" " Wood, p. 96, tab. 18, fig. 2.
" " Winkler, p. 200.
Cyprina Gaimardi, Robert, Mörch, Paykull.
Cyprina Islandica, Deshayes.

In immense banks. The valves are always united and closed, often with the ligament preserved, and with crystals of calcspar. I am very much inclined to consider it a distinct species. A similar dwarf form is found in Odensefjord, Fyonia, and, according to Winkler, on the coast of Mecklenburg. Long. 73 mm., alt. 60 mm.

*49. *Cyprina Gaimardi*, Robert.
Cyprina Gaimardi, Robert, l.c. p. 285, fig. 51.

Probably the same as the following.

*50. *Cyprina rustica*, Sowb.
Cyprina tumida, Nyst, p. 148, tab. 10, fig. 1*a–c*.
Cyprina rustica, Wood, l.c. p. 197, tab. 18 fig. 1*a*.

The right valve partly preserved. The length is about 45 mm. and the breadth nearly the same; diameter, 40 mm.; the thickness of the shell 4–5 mm. *Cyprina Lajonkairii*, Goldf., p. 237, tab. 148, fig. 9, quoted by Dr. Winkler; seems to me not to belong to this species.

*51. *Astarte crebricosta*, Forbes.
Astarte Hjaltalinii, Winkler, l.c. p. 204.

According to Dr. Winkler's drawing not sufficiently distinct a sp.

52. *Astarte compressa*, L.
Astarte elliptica, Brown.

A fragment seems to me to belong to this shell.

53. *Cardium echinatum*, L.
Cardium echinatum, Winkler, p. 202, Mörch, Payk.

Long. testæ circ. 55 mm.; costæ fere, 3 mm. latæ.

Dr. Paykull's specimen, with a part only of the shell preserved, indicates a very thick-shelled variety.

*54. *Cardium*, sp.

A small distinctly ribbed form, not determinable. Winkler, p. 203.

55 *Cardium* (*Serripes*) *Grœnlandicum*, Chem., var.

Cardium Grœnlandicum, Wood, tab. 3, fig. 1*a*, Winkler, p. 202.
Serripes Grœnlandicus, Chem., Mörch, Payk.

Rather common, long. 42 mm.; alt. 35 mm. circ.
Spm. jun. „ „ 9 „ „ 8 „

This variety looks most like to the variety from Spitzbergen, called *C. Fabricii* by Deshayes.

Old specimens are rather difficult to distinguish from *Mactra* without the hinge. The *Mactra* is, however, easily recognized by the want of the impressed lines for the reception of the external ligament of *Cardium*.

56 *Modiolaria nigra*, Gray.

The nucleus of a rather large specimen.

57. *Mytilus edulis*, L.

A few young specimens, the largest 32 mm., from Paykull.

58. *Mytilus hesperianus*, Lam., Wood.

Mytilus densatus, Wood, Cat.

Tungubakkar paa Tjörnæs. The largest specimen is 80 mm. long and 35 mm. high.

59. *Lepralia auriculata*, Hen., Smitt.

60. *Balanus sulcatus*, Brug.

61. *Balanus ovularis*, Lam.?

IV.—Notes on Metamorphism of Strata in the Mendip Hills.

By Horace B. Woodward, F.G.S.,
of the Geological Survey of England.

Although the Mendip Hills have received a large share of attention from geologists since the beginning of the present century, and particularly from Buckland and Conybeare, Weaver, De la Beche, Ramsay, and Moore, there are still many points of great interest that require to be worked out.

The object of the present communication[1] is to re-direct attention to some instances of silicification which are to be met with in certain formations on the Mendip Hills, and to offer some theoretical remarks on the origin of this metamorphism.

General Description.—On Harptree and Egar Hills, in the neighbourhood of Chewton Mendip, and also near Emborrow, reposing on the Dolomitic Conglomerate, the Mountain Limestone, and the Old Red Sandstone, there occurs a peculiar siliceous deposit. In the upper part it is a compact chert containing shells, lower down come sandy beds; sometimes the chert appears conglomeratic, or rather brecciated, for the fragments contained in it are angular. The entire deposit must attain in places a thickness of 30 feet, but in the

[1] I should mention that my observations were made in 1868 and 1869 when engaged with my colleagues, Messrs. W. A. E. Ussher and J. H. Blake, in re-surveying the Mendip Hills, under the superintendence of Mr. H. W. Bristow, F.R.S.

absence of any clear section this estimate is merely approximate. The molluscan remains, of which the species collected by the Geological Survey were determined by Mr. Etheridge, show that the Rhætic and Lower Lias formations are here represented.[1] The fossils are changed like the rock in which they are imbedded; occasionally the shells have been dissolved away, leaving cavities. Associated with the Dolomitic Conglomerate there often occur in the same vicinity cherty beds somewhat similar in character to the above-mentioned deposits; they may be seen by the road-side at Eastwood House, near East Harptree, and on the hill above this spot, and near Green Down Cottage.

Previous Observers.—These deposits have attracted much notice; but, from the earlier observers having confounded the two, some confusion at first arose. Thus Mr. Weaver[2] referred them both to the Greensand; the Rev. W. D. Conybeare,[3] pointing out the fossil remains found in the cherty beds at one place, and the association of chert with the Magnesian (Dolomitic) Conglomerate at another, referred the whole, though with hesitation, to the Magnesian Limestone. Later he and Dr. Buckland[4] placed them with the Dolomitic Conglomerate. In the Geological Survey Map, Sheet 19, the fossiliferous beds were included with the Lower Lias, those of Keuper age were mapped with the Dolomitic Conglomerate, or with the New Red Marl.[5]

Details of Liassic Beds.—The surface of the ground at Harptree Hill is covered with hollows, some sunk to obtain ochre from thin clayey beds interstratified with the chert, others to obtain calamine from the Dolomitic Conglomerate beneath the chert, while, again, a few are undoubtedly natural hollows or pot-holes due to dissolution of the Mountain Limestone where it underlies the chert. These pits, being generally covered with a loose talus, rarely afford any section of the beds. The best exposure is seen in a pot-hole, about 60 feet in diameter, east of the road, and about half-way between East Harptree and the "Castle of Comfort." The beds shown, to a depth of nearly 20 feet, consist almost entirely of massive chert, in layers, from one to three feet in thickness, separated by thin clayey partings (probably of subsequent subaërial formation), and standing out sharply, but sometimes weathering sandy (at the exterior). Lower Lias fossils occur in the top beds, while very probably the lower beds represent the White Lias, but in these no fossils were detected. In places, indeed, some beds have a curious resemblance to the Sunbed, or top limestone of the White Lias in Somersetshire, which usually has a flinty appearance and conchoidal fracture. Beneath

[1] Mr. Sanders, F.R.S., has collected a series of fossils from these beds, which he has placed in the Museum at Bristol. They have also been briefly alluded to by Mr. C. Moore, Quart. Journ. Geol. Soc., vol. xxiii., p. 492, and Mr. E. B. Tawney, *ibid*, vol. xxii., p. 79. Lists will be published in the official explanation which will accompany the new edition of Sheet 19 of the Geological Survey Map.

[2] Trans. Geol. Society, second series, vol. i. p. 364.

[3] Geology of England and Wales, p. 304.

[4] Trans. Geol. Society, second series, vol. i. p. 294.

[5] The former were alluded to by De la Beche, Mem. Geol. Survey, vol. i. p. 277.

these beds of chert, according to Weaver, comes the Conglomeratic bed, which is probably of Rhætic age.

Near the cottage at Harptree Hill is a pit dug in hardened reddish-brown sand ("rock-sand") crowded with *Pullastra arenicola*, while in hollows hard by loose blocks of sandstone containing this shell, together with *Avicula contorta* and *Pecten Valoniensis*, are to be found. These Rhætic sands show no other alteration from their original character than induration. They are of very local distribution, and occupy a position above the grey Rhætic marls; they are not exposed along the escarpment to the north, but here the ground is much obscured by detritus. The lowest beds of the Rhætic, the grey marls, pass downwards into the red marls of the Keuper at the East Harptree Lead Mines, and show no alteration in character.

Around Green Down Cottage the ground is very complicated, and here there is a quarry exposing the ordinary argillaceous limestones and clays of the Lower Lias and a portion of the White Lias.

South of the cross roads at Egar Hill are beds of Lias Limestone.

These facts show the partial nature of the silicification, and also as regards the Lower Lias and the White Lias, that there was no gradual change in sediment from limestone and clays to an arenaceous beach deposit, which is an explanation that suggests itself.

Keuper Beds.—The Chert beds associated with the Keuper occupy very variable positions; they can be traced sometimes above, at others below, the Red Marl or Dolomitic Conglomerate, which latter occasionally appears silicified. On the borders of the Mendip Hills it is well known how these beds dovetail one into the other. The question is, whether these beds be altered red marls, or whether they were originally arenaceous, and have been subsequently compacted. I am inclined to think the former supposition the correct one, because in this immediate neighbourhood, where sections of unaltered beds are obtained, as in the lane leading from Compton Martin Church up Keighton Hill, and also in the gorge between Noah's Ark and West Harptree, marls and conglomerates alone occur. In the quarries at East Harptree, where the beds are worked for road-metal, they appear much broken up, and there are no lines of stratification apparent. These beds are described by Messrs. Buckland and Conybeare as sandstones "of so fine and compact a grain as to assume the character of chert." They have a peculiar baked appearance, and are quite unlike the ordinary sandstones of the Keuper series, the only representatives of which in the neighbourhood are some calcareous sandstones or cornstones found near Chew Magna, etc., and which are quarried for building purposes.

Character of Change.—It is clear, then, that the Cherty beds have suffered a great change since their original deposition, and that only local patches of rock have been metamorphosed. What now was the agency that produced this change? We look in vain for any suggestion in the district itself, and therefore seek information elsewhere. Turning to Jukes's Manual,[1] we learn that the Lias of Portrush has been converted by contact with a large mass of greenstone

[1] New (second) edition, 1862, p. 166.

into a smooth, hard, brittle, splintery rock, that might be called Hornstone, and in which the fossils are still perfectly preserved. This notice led us to seek Major-General Portlock[1] for particulars, as it seems we have here a parallel case of change. It is the calcareous clays of the Lower Lias, as seen at Ballintoy, that have been altered into the Portrush rock. He gives some analyses made by Dr. Apjohn, which roughly show the character of the change to consist in a loss of carbonic acid and of a great deal of lime. They prove it to be on the whole a molecular change rather than one of replacement.

We append an analysis given by De la Beche[2] of the Red Marl at Aust, and which shows but little variation from the analysis of the Ballintoy marls :—

	Ballintoy Marls.	Portrush Rock.	Red Marls Aust.
Silica	56·90[3]	57·44	48·69
Protoxide of Iron	—	—	4·79
Peroxide of Iron	7·43	10·16	9·09
Alumina	1·76	23·48	8·77
Lime	19·02[4]	5·94	8·68
Magnesia	3·94[4]	2·68	0·94
Carbonic acid		—	8·56
Soda, Potash, etc.	—	99·70	6·23
Water and loss	10·95		4·25
	100·00		100·02

We have not met with any analyses of the Somersetshire Lias,[5] but its general composition (the clays and limestones being taken together) would doubtless be similar to that of these marls. Accurate analyses of the beds would have been interesting, but they are not, however, essential to the argument.

Cotta[6] mentions that in Germany the name of "Hornfels" is given to certain rocks, the product of transmutation of argillaceous deposits, found adjoining to plutonic rocks, to which they probably owe the change they have undergone.

Origin of Change.—We may, therefore, conclude that some similar agency to that which has affected the Lias of Portrush has been instrumental in altering the beds in Somersetshire.

Unfortunately we have no traces of igneous rock at Harptree; indeed, the nearest point at which trap is exposed is distant about eight miles, namely, at Wrington Warren. There are also dykes at Downhead and Bleadon Hill. They do not seem to have effected any great change on the rocks with which they are seen in contact, nor does it appear that they were erupted at one period.

The large basaltic dyke discovered by Mr. Moore,[7] and found by Mr. Ussher to extend from Tadhill House, Downhead, to near Long

[1] Report on the Geology of Londonderry, etc., pp. 97, 98, 140, 150, etc.

[2] Mem. Geol. Survey, vol. i. p. 254.

[3] This is given as Matter insoluble in Hydrochloric acid.

[4] These are Carbonates.

[5] Save one of the Lower Lias of Downside, near Shepton Mallet, the equivalent of the Sutton Stone.—*Ibid*, p. 276.

[6] Rocks Classified and Described. Edited by P. H. Lawrence. p. 350.

[7] Quart. Journ. Geol. Soc., vol. xxiii., p. 451.

Cross Bottom, with a breadth of about a quarter of a mile, is regarded by the former as evidence of the mighty agent which formed the Mendip anticlinal, at "a time not far removed from the deposition of the upper beds of the Trias," or perhaps, we might suggest, in Permian times.

The trap rock of Bleadon Hill was described by the Rev. D. Williams, soon after the completion of the railway cutting at Uphill.[1] The rock is exposed at the base of the section beneath the Mountain Limestone, which is much altered by it. Mr. Williams points out the change to be one of crystallization, and that the Limestone has altered in colour and become very crisp and brittle.[2] Mr. Sanders[3] subsequently described the section, and stated, without going into particulars, that he differed very materially from Mr. Williams. He regarded the igneous rock to have caused the extensive faulting which is shown in the section, where the Lias is brought abruptly against the Mountain Limestone. And therefore this eruption is probably of the same age as that which, as we believe, affected the Secondary beds at Harptree.

Siliceous Mountain Limestone.—The Mountain Limestone is in some places very siliceous, particularly in the neighbourhood of Banwell, and also north of Priddy, where I remember using pieces of the rock to strike a light for my pipe. The silicification, I need not say, has nothing to do with the black chert bands which cut across the beds in all directions.

Elevation and Depression.—We must now look to support from other considerations to account for the metamorphism of the Secondary beds. We know that considerable changes, apart from denudation, have affected the configuration of the district since the deposition of the Jurassic rocks, for the Lias, Rhætic, and Dolomitic Conglomerate occur on some of the highest parts of the Mendips, between Charterhouse Warren and Egar Hill, and considerably above the vales and plains on either side of the range where these beds occur in force. Irregularity of sea-bottom, or the higher position of beach deposits over those formed away from the coast, cannot be adduced to account for these; unequal elevation in Post-Liassic times is clearly the explanation.

We say unequal elevation, because there is no doubt that portions of the Mendip area were above water during the Triassic and Liassic periods. Indeed, Mr. Moore is of opinion that as an island it constituted a barrier against the incursion of beds immediately to the north, where the Keuper and Liassic, *though not the Rhætic beds*, show a considerable thinning out.[4]

We cannot tell the precise period when the higher patches of Lias and Dolomitic Conglomerate, including a portion of the cherty beds, were elevated into the positions they now occupy.

[1] Proc. Geol. Soc., vol. iv., p. 293.

[2] I have an impression that it was rather siliceous. But Dana observes that in the metamorphism of limestone the carbonic acid is not given out if the material is under heavy pressure.—Manual of Geology, 1863, p. 705.

[3] Rep. Brit. Assoc., 1846. Trans. of Sections, p. 60.

[4] Quart. Journ. Geol. Soc., vol. xxiii., p. 449.

Professor Ramsay[1] has shown that throughout the period occupied by the deposition of the New Red Marls and Lias, the general tendency of the area was one of depression, and that after the deposition of the Lias the general tendency was for a lengthened time one of elevation, the successive Oolitic deposits accumulating in a diminishing area.

The beds in question may, therefore, have been upheaved into their present relative position, and altered in Oolitic times.

This was attended by much faulting, as is apparent when a survey of the ground is made. Indeed, the neighbourhood of these cherty beds is much affected by faults, which are probably more numerous than can be ascertained with certainty.

Metamorphic Agents.—Elevation we know to be due to igneous agency, and, therefore it is to the presence of igneous matter that we attribute the alteration of these Secondary strata. While, however, we attribute the metamorphism to igneous eruption, it is only as a promoting cause, for we are led from the absence of any traces of igneous rock at the surface to infer that the heat which produced the change was applied through the agency of water.

Dana[2] has pointed out how sub-marine beds are saturated with water, and how, when an eruption should occur, and the molten rock is forced up through fissures, the interspersed or permeating waters, as well as those superincumbent, are heated, and they convey the heat far into the rock, and produce metamorphism. In this way he explains how certain soft clays have been changed to a bluish chert.

These heated waters would, as Dana remarks, contain much silica in solution which they have taken from the siliceous materials at hand. So that any addition of this substance to the metamorphosed rock is satisfactorily accounted for.

The patchy nature of the metamorphism, which is not due to denudation, although the beds have suffered considerable erosion, may be partly accounted for by local igneous protrusion, partly by the facts that metamorphism is greatly influenced by mineral character, so that sets of beds which are altered and not altered in turn have been observed.[3]

In introducing such theoretical notions to explain the origin of the metamorphism of these Secondary beds, in the area to which they have been applied, little else but negative evidence can be adduced in their support; the only apology that can be made for such temerity is that in so doing, we have endeavoured to show how much still remains to be done in elucidating the geological history even of a district so much studied as the Mendip Hills.

[1] Mem. Geol. Survey, vol. i., p. 297.

[2] American Journal of Science, vol. xlv.

[3] A great many valuable facts relating to metamorphism have been brought together in a paper by Dr. J. J. Bigsby, Edin. New Phil. Journ., new series, April, 1863.

V.—Further Remarks on the Sequence of the Glacial Beds.

By Searles V. Wood, jun., F.G.S.

THE paper of Mr. Hull, "On the General Relations of the Drift Deposits of Ireland to those of Great Britain," in the July number of the Geological Magazine, induces me to recur to one by myself on the Sequence of the Glacial Beds, Vol. VII. p. 17 of the same Magazine.

In that paper I adverted to what seemed to me to be illusory in the classification of the Glacial beds, viz., the intercalation of a formation of sand or gravel between an under and an overlying Boulder-clay (Vol. VII. p. 20, foot-note); and I endeavoured to show that, though to be received with due care, the evidence of organic remains should have its weight, and go hand in hand with the physical evidence in this classification; and attention was called to the antagonism that seemed to exist between the molluscan evidence afforded by the Middle Sands of the North-west of England and that afforded by the Middle Sands of the East. Since then this antagonism has come out more distinctly; for while Mr. Harmer and I have made considerable additions to the fauna of the Middle Glacial Sands of East Anglia, the former took the opportunity, when attending the British Association Meeting in 1870, of collecting from the Middle Sands of Blackpool Cliff; and Mr. T. M'K. Hughes (who sent me all he could collect) has tried to obtain the same molluscan evidence at St. Asaph; down to which place, and over the northern portion of Wales, it would seem (from the observations of Mr. Hughes around St. Asaph, and of Mr. H. F. Hall about Llandudno), the Lancashire arrangement of an Upper and Lower Boulder-clay, divided more or less by sand, prevails.

In the paper referred to, I ventured to suggest with some confidence that a parallelism might perhaps be found between the fauna of the East Anglian sands and that of the so-called Crag gravels of Aberdeenshire, described by Prof. Jamieson; but this also has failed, as Prof. Jamieson kindly sent the specimens he had obtained up to me for examination; and they proved to be derivatives in the gravels in question, many of them being filled with a matrix foreign to this gravel, which had been rolled with the shells prior to their deposit in it; and although they clearly showed that some bed of Crag, or, more probably, of very early Glacial age, had existed in the North-east of Scotland (and been destroyed probably by the ice-grind of some later Glacial epoch), yet they threw no light on the relation of the Aberdeenshire gravel to the East Anglian Mid-glacial.

Last year Mr. Harmer and I made a superficial examination of the Glacial beds from Yorkshire (which was the northernmost limit to which our field knowledge of those beds previously extended) as far north as Inverness and Cromarty; and the conclusion we came to was that these so-called Crag gravels of Aberdeenshire were but a part of the great expansion of Boulder-bearing sand and gravel which, overlapping (and about Inverness resting on) the Red Boulder-clay of Cromarty, occupies a great part of the maritime borders of the counties of Inverness, Nairn, Moray, Banff, and Aberdeen, on the North-east of Scotland, and penetrates the Highland valleys in all directions, down to Perthshire and to Argyllshire on the West; inosculating with and passing into the gritty obscurely stratified (and sometimes *un*stratified) Boulder Drift of the mountain region; and that their overlay on the Aberdeenshire coast by red clay—a feature which we did not detect throughout the mountain districts—is probably one of those peculiarities which seem to us incidental to Glacial deposits, without possessing any classificatory value. These Highland sands seemed to us to be probably the same as those alternating with clays at Gamrie, on the Banffshire coast, which yielded Mr. Prestwich some shells that were all of living species, and were described by him in the Transactions of the Geological Society upwards of thirty years ago;[1] all these sands, etc., appearing to Mr. Harmer and myself to belong to the latest part of the Glacial sequence, and to have been accumulated after the land-ice had disappeared from Britain, and when the mountain districts of Scotland and Wales formed a snow-clad archipelago of mountain tops which was beset with floe ice; and it is to the same period, I think, that the sands of Moel Tryfaen, and those at high elevations (and possibly those also at low elevations that intervene between Boulder-clays) in the North-west of England and Wales, belong.

Mr. Binney adheres to the opinion originally advanced by him, that although sand extensively intervenes between Boulder-clay in Lancashire, that arrangement is not structural, but accidental; and he has recently published some notices of borings to corroborate this view. The same opinion is entertained by Mr. Rome, Mr. Harmer, and myself, respecting the sand and gravel beds in the Purple-clay of Yorkshire; and Mr. J. W. Judd (late of the Geological Survey), who has quite recently been at work in the counties of Lincoln, Rutland, and Leicester, also tells me that the sands and gravels in those counties pass horizontally into Boulder-clay; and he repudiates altogether any classification based upon the alternation of Boulder-clay with sand; while Mr. Wilson's description of the drift about Rugby (Quart. Journ. Geol. Society, vol. xxvi. p. 192) seems to suggest a similar conclusion.

Under these circumstances, I should have begun to entertain a doubt of the propriety of the classification of the Glacial beds into Lower, Middle, and Upper, which I have for some years been endeavouring to substantiate, were it not for the distinct evidence of this division upon far more striking grounds than the intervention of sand between Boulder-clays, which the Survey of Essex, Suffolk, and Norfolk, made by Mr. Harmer and myself (now, I am glad to say, almost finished), has led us; for this Survey has shown us that the Lower Glacial formation of East Anglia (which is mainly not Boulder-*clay* at all) was, prior to the accumulation of the sands and gravels, which we term Middle Glacial, enormously denuded and swept away, the part remaining being furrowed into valleys, some of them

[1] More shells from this locality have been since obtained, and are given in Prof. Jamieson's lists.

150 feet deep, which then had their inception, and down into which these sands and the subsequent great Chalky Boulder-clay of the Eastern and Midland Counties have gone.

As this denudation seems to us to have been due, not to an elevation of the Lower Glacial sea-bottom, but to an extension of the land-ice over it, by increment of cold; and the accumulation of the Middle Glacial sands in these troughs, and generally over the denuded area, to have been permitted by a melting back of this ice (due either to a material increase in subsidence, or else to an augmentation of temperature), the deposit of these sands seems to us to mark a great change in the conditions of North-western Europe, which is worthy of a distinctive appellation; and we cannot, we think, better make this than by preserving the appellation I have for several years past applied to it, of "Mid-glacial," while, at the same time, rejecting any classification based merely upon the intervention of sand or gravel between Boulder-clays.

Further, I may add, that though we do not venture to assert its absence, yet we cannot at present see anything indicating that the Lower Glacial formation of East Anglia is represented elsewhere in the British Islands; and although we repudiate the hypothesis of the formation of either the Scotch or the North of England Boulder-clay on a terrestrial surface, believing it to be all of submarine deposit (though produced by land-ice), yet, for the purpose of contrasting the Lower Boulder-clay of Mr. Hull's tabular classification with the East Anglian beds, let this be admitted; and then see how the two sides of England would agree. Mr. Hull describes his lower division, that of the Lower Boulder-clay of Scotland, of the North of England, and a large portion of Ireland, as of the period of greatest elevation; *portions of existing seas being then land,* and covered by ice; but it is apparent to even a casual observer that the pebbly sands (containing *Mya truncata,* with its valves united and in vertical position, as it lived), the stratified Till, and overlying contorted drift, which Mr. Harmer and I group together under the term Lower Glacial, and which are exposed in a section of twenty-two miles' length along the Cromer Coast, were there accumulated under the sea; since, where not contorted, even the contorted drift is finely stratified, and contains marine shells,[1] and where contorted presents clear evidence, from the included masses of marl almost invariably associated with the contortions, of having been a sea-bottom ploughed up by grounding bergs, which brought and left in the contorted mud masses of an entirely different material, viz., marl or ground-up chalk. Such evidences appear to Mr. Harmer and myself to negative the possibility of England at that time standing even at so high, far less a higher, level than the present. We obtain evidence, first in the fluvio-marine fauna of the pebbly sand forming the base of the Lower Glacial formation—a fauna showing a very slight departure from that of the Upper Crag beds, on whose denuded surfaces this

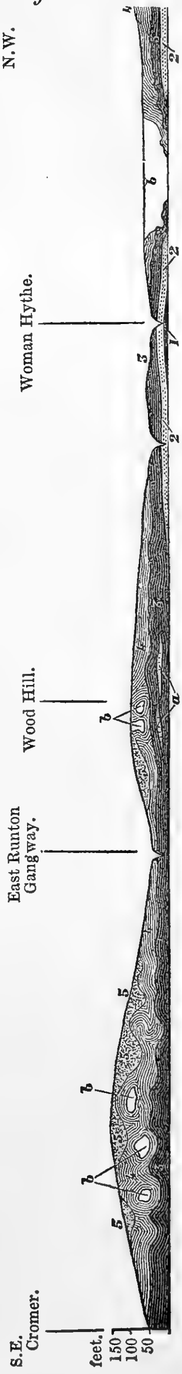
[1] From the centre of one of these contortions, Mr. Harmer and I took a perfect valve of *Tellina Balthica.*

pebbly sand reposes—and afterwards in the deeper water deposit of contorted drift which forms the top of the Lower Glacial formation, that on the East side of England the period of the Crag was followed, and the Glacial period was commenced, not by an elevation, but by a gradual subsidence; which first giving rise to a littoral and fluvio-marine deposit of rolled pebbles and sand, was rapidly succeeded by a submergence sufficient to float bergs over the area previously occupied by these pebbly sands. The extent to which that subsidence reached before the denuding land-ice to which I have adverted pushed over this sea-bottom, may be approximately inferred from the circumstance that one of these intruded marl masses (immediately North-west of Woman Hythe) is 800 feet and upwards in length, and 60 in height, and has been so tranquilly intruded into the contorted drift, that it has sunk through it down to the fundamental Chalk, squeezing out the stratified beds on either hand. It must be obvious that in order to float a berg adequate to such a marl-freight as this, many hundred feet of water is necessary. The accompanying section of three miles of the Cromer Cliff will show the position of these beds, of some of the included marl masses, and in particular of this enormous transported mass, of which there are, inland from this cliff, many examples to rival it, in which lime-kilns and marl-pits are worked over North-east Norfolk.

In order to call the attention of the Geologists of Lancashire to the divergence of the faunas, Mr. Harmer and I read a paper at the British Association in 1870, pointing out the facts as far as then

THREE MILES OF THE CLIFF WEST OF CROMER.

(Vertical Scale about $4\frac{1}{2}$ times the Longitudinal.)



1. Peaty Freshwater Bed of Cromer Forest Age. 2. The Pebbly (or Weybourne) Sand. 3. The Stratified Till.
4. The Contorted Drift. 5. The Middle Glacial Sand and rolled Gravel, with shells too corroded for extraction.
a. Sheets of Chalk in the Till. *b.* Masses of Marl in the Contorted Drift.

N.B.—The Fundamental Chalk appears on the Beach at Low Water.

(No part of the great chalky Boulder-clay that we term Upper Glacial comes nearer to this section than Winterton and Somerton on the South-east, and Reepham and Cawston on the South-west.)

obtained. As some additions to this fauna have since been made, and in order to render the particulars of it better known, it may be useful to enumerate the satisfactorily identified specimens here; omitting several others to whose identification any uncertainty is, from their imperfect condition, attached.[1] *Cypræa Europæa, Buccinum undatum,* var. *tenerum, Trophon muricatus, T. antiquus* (dextral form), *T. scalariformis,* two new small species of *Trophon, Purpura lapillus,* ditto var. *incrassata, Nassa incrassata, N. granulata,* and a new Crag species of *Nassa* not yet named, *Mangelia turricula, M. linearis,* and a new Crag species of *Mangelia* not yet named, *Natica clausa, N. helicoides, N. Alderi, Scalaria Trevelyana, S. Grœnlandica, Turritella incrassata, T. terebra, Cerithium tricinctum, Cerithiopsis tubercularis, Chemnitzia internodula, Odostomia unidentata, Rissoa semicostata* (of Woodward, non Mont.), *Littorina littorea, L. rudis, Margarita undulata, Trochus cinerarius, Capulus Ungaricus, Tectura fulva, Calyptræa sinensis, Dentalium dentale, Anomia ephippium,* ditto var. *aculeata, A. striata, Pecten opercularis, P. pusio, P. varius, Mytilus edulis, Pectunculus glycimeris, Limopsis pygmæa, Nucula Cobboldiæ, N. tenuis, Leda oblongoides, L. lanceolata, Cardium edule, Cardita scalaris, C. corbis, Loripes lacteus, L. divaricatus, Lucina borealis, Woodia digitaria, Astarte borealis, A. sulcata, A. compressa, A. Burtinii, A. Omalii, Erycinella ovalis,* a new Crag species of *Lasea* not yet named, *Montacuta bidentata, Cytherea rudis, Cyprina Islandica, Venus fluctuosa, V. fasciata, V. ovata, Tellina obliqua, T. calcarea, T. Balthica, T. crassa, Scrobicularia piperata, Mactra ovata, Panopæa Norvegica, Mya arenaria, Saxicava arctica* (smooth small form), *Solen ensis, Pholas crispata, Corbula nucleus, C. contracta* (Say.), and *Pandora inæquivalvis.* Of these the new Trophons, *Nassa, Mangelia,* and *Lasea, Cerithium tricinctum, Rissoa semicostata* (of Woodward), *Nucula Cobboldiæ* (which is very common), *Astarte Burtinii, A. Omalii, Erycinella ovalis,* and *Tellina obliqua,* are not known living; while *Nassa granulata* (if indeed it be living), *Turritella incrassata, Chemnitzia internodula, Dentalium dentale, Limopsis pygmæa, Cardita Corbis, Woodia digitaria,* and *Cytherea rudis,* are known living only in the Mediterranean, the Azores, the Canaries, or in abyssal recesses of the Atlantic; and *Cardita scalaris* (as *C. ventricosa* of Gould) lives only on the Pacific Coast. All of them, except the new Trophons, *Venus fluctuosa, Tellina Balthica,* and *Loripes lacteus,* are shells of either the Coralline, Red, or Chillesford Crags.

Now, contrasted with the above, the only species that I have been able (from papers of Mr. Binney, and from the collecting of Mr. Harmer and of Mr. Hughes) to ascertain have occurred in the Middle Sands of Lancashire are the following 25 species, viz., *Nassa reticulata,** *Buccinum undatum, Fusus Bamffius,** *Aporrhais pespelicani, Murex erinaceus, Turritella terebra, Purpura lapillus, Littorina littorea, Mangelia turricula, Dentalium dentale* (or else *D. tarentinum*), *Natica catena?* (*monilifera*), *Patella vulgaris? Venus*

[1] The specimens having all been re-examined in reference to the forthcoming Supplement of the Crag Mollusca, one or two names will be found to differ from those in the list published in the British Association Reports, 1870.

striatula * (*gallina*), *Astarte borealis, Artemis* (*exoleta*?*) *Mactra subtruncata, M. solida, Cardium edule, C. tuberculatum*?* *C. aculeatum*?* *Corbula nucleus* (*inequivalvis*), *Tellina Balthica, Psammobia Ferrœnsis, Ostrea edulis* and *Mytilus edulis.* All of these shells inhabit common ordinary depths of British or contiguous Arctic seas, and those which have an asterisk placed against them have not occurred in the Crag.

I have not included the shells from the Moel Tryfaen or Macclesfield sands (see Mr. Darbyshire's Article in Vol. II. of this Mag., p. 293) in the above list, because it has not been satisfactorily shown that these sands are identical with the Middle Sands of the Lancashire Coast; but however that may prove, these shells, like the others, all inhabit ordinary depths of British or contiguous Arctic seas.

I have also carefully compiled from the best authorities I can find, including papers of Prof. Jamieson, with lists of shells identified by Mr. Jeffreys, and papers by Messrs. Crosskey and Robertson[1] and by Mr. Peach, a list of the mollusca from all the Glacial or so-called Glacial beds of Scotland, including the localities of Invernettie, Ellishill, Ednie, Annochil, Auchleucries, Belhelvie (all in Aberdeenshire), King Edward, and Gamrie (both in Banffshire), Montrose (in Forfarshire), Errol, Tyrie, and Elie (in Fifeshire), Fort William (in Inverness-shire), the Kyles of Bute, Dalmuir, Loch Gilp, Cumbrae, Paisley, and other localities on or near the Clyde, and the Boulder-clay of Caithness. This list comprises about 130 species of mollusca, and the whole of them are still living at *ordinary depths* in that part of the ocean which, lying North of the 50th parallel of North latitude, is bounded by the East coast of America on the one side, and the North-west coast of Europe on the other; while about one-fifth of them are not found in any part of the Crag. How much this fauna of 130 species contrasts with the East Anglian Mid-glacial one of 80, especially if the Scotch species (the names of which I have not set out) be considered with the Mid-glacial ones above named; and how much it negatives the probability of any of the Scotch beds which yield molluscan remains (inclusive of the Caithness Boulder-clay)[2] belonging to a period as remote as the East Anglian Mid-glacial, with its Crag-like fauna, those familiar with the mollusca of the Newer Tertiaries and (so-called) Post-tertiaries of Britain will, I think, appreciate.

I have made efforts in various quarters to get at the mollusca of the Wexford gravels, and so far as I can learn there is nothing from these gravels to point to any period so ancient as the East Anglian Mid-glacial, or even as the Bridlington bed, with the exception of a

[1] The lists of the late James Smith, of Jordan Hill, are not, except so far as they have been confirmed by Messrs. Crosskey and Robertson, altogether reliable.

[2] Those who (unlike myself) believe in Mr. Croll's ice-filled North Sea, and in its having brought the shells of the Caithness Boulder-clay from some anterior sea-bottom into that clay, will perceive that any such sea-bottom, as well as the Caithness clay, must, from these Caithness shells belonging to the category mentioned in the body of the paper, be, according to palæontological probabilities, newer than the East Anglian Middle Glacial.

fragment of *Nucula Cobboldiæ,* to which some doubt is attached, all the rest of the Wexford shells being living species of ordinary depths, and of not distant shores. If *Nucula Cobboldiæ,* however, be really present in them (not of course as a derivative, as it is in the Aberdeenshire gravel), it would suggest a greater antiquity for those sands than any Glacial bed of the North-west of England or of Scotland seems to possess.

If any of the readers of this MAGAZINE have the opportunity of collecting from the Wexford beds, I should esteem it a favour if they would send anything they can find by post (duly secured against injury) to me at the subjoined address, when they would be carefully examined by my father and myself, and promptly returned to the sender.

In conclusion, I should add that the possibility of the shells from the East Anglian Mid-glacial being derivative has been duly weighed; and for several reasons, intrinsic and extrinsic, which I have not space to set out, that possibility has been rejected as inadmissible.

BRENTWOOD, ESSEX.

VI.—ON THE GLACIATION OF THE NORTH-WEST OF ENGLAND.

By C. E. DE RANCE, F.G.S.,
of the Geological Survey of England and Wales.

IN bringing the last of a long series of papers on the Surface Drifts of the Lake District of Cumberland and Westmoreland to a close, Mr. Mackintosh sums up the general results at which he has arrived. All will agree with the first of his conclusions, "that land-ice *may* have planed, smoothed, polished, and striated rock surfaces, and pushed loose débris forward. . . ." But I cannot see his reason for adding, "to the nearest *protected* situations," for one would expect to find a terminal moraine at the *open* entrance of a valley, on a plain, or even on what can be proved to have been a true sea-bottom.

Thus, Mr. Lamont, F.G.S., described in 1861 a glacier in Deeva Bay that was separated from its terminal moraine by two miles of water, mostly covered with "fast ice;" the moraine being three and a half miles long, 200 to 400 yards broad, and twenty to thirty feet in height. As Mr. Lamont observed in this bay bones of the whale, of apparently no great age, at an elevation of forty feet above the sea, the whole of this moraine would appear to have been formed under the sea, being pushed along the sea-bottom by the backward weight of the glacier, which formerly extended further than at present, and filled up what is now the space between the "island moraine" and the land. And, in another instance, he observed a glacier extending *into the sea*, and actually in the process of pushing before it "a huge moraine of mud and débris, the base of which is washed by the sea, ..." which becomes muddy "for several miles around."

All scratched and polished surfaces of rock *in sitû,* now covered by deposits, which, from stratification, the presence of marine shells or of rounded boulders, can be proved to be *marine,* I consider to have been formed beneath *low-water* mark, either by the grounding of icebergs, or by the seaward prolongation of glaciers, which, on retreating, left a vacant space, afterwards filled up by Boulder-clay, with or without subsidence of the sea-bottom. Mr. Mackintosh states[1] that "one of the fundamental principles of geology" is, "that the sea preserves the most delicate marks on rocks in *areas of deposition*," and accuses me of overlooking it, in affirming that the Grange rôche moutonnée has not been touched by the sea since its formation.[2] It appears to me, if we assume these rocks to have been rounded under the sea, and the associated mounds to be of marine origin, that as they are now *above* the sea (and, in fact, above Derwentwater), their movement betwixt land and water must have been in an *upward* direction, and that Mr. Mackintosh must, therefore, prove another fundamental principle (?) in geology, "that the sea preserves delicate marks on rocks in *areas of elevation*." If the striæ were made under the sea, as they are now above it, they necessarily, in process of elevation, must have been exposed to the action of the waves on the tidal or littoral zone, and when so exposed must have suffered denudation.

Mr. Godwin-Austen, F.R.S., has shown,[3] "that the tidal zone[4] is capable of division into two belts, an upper, composed of clean shingle, and a lower, seldom broken up, and covered with sand and mud, with various species of plants and animals growing on the isolated stones. He has also shown that the greatest movements of pebbles on a beach take place on the upper zone, especially at its upper edge. I have generally found the lower sub-belt to commence a *little below* neap-tide high-water mark, ending at the lowest water margin, the upper sub-belt terminating at the highest limit of breaker action. It is along this edge, or upper margin, that the sea exerts its denuding agency; for in the lower portion it merely causes a movement of pebbles, in the direction of the "flow-tide," but in the seaward sub-belt, stones of only two or three pounds weight will remain, when the coast slopes at a low angle, for weeks and even months, in the same position: delicate *Confervæ*, and numerous, but slightly prehensile marine organisms, remain unscathed, and the fine striæ of glaciated stones and boulders retain the sharpness of their sculpturing. It follows, (1) that should a rock-surface be glaciated above the sea-level, and be afterwards submerged beneath the waves, it will necessarily suffer denudation on passing the upper edge of the tidal or marginal zone; (2) should a surface of rock be glaciated in the lower belt of the tidal zone, say by land-ice, and then submerged, and never again elevated to a higher level, than it had when first glaciated, it will retain its striations and smooth surface; and (3), similarly, rock-surfaces

[1] Geol. Mag., Vol. VIII., p. 305.

[2] *Idem*, "On the Two Glaciations, etc."

[3] Quart. Journ. Geol. Soc., and "On the Valley of the English Channel," vol. vi., 1850, p. 69.

[4] The "littoral zone" of Forbes and Audouin, and the "marginal zone" of Godwin-Austen.

striated under the sea by projecting glaciers, or by icebergs, and afterwards covered with marine drift, will retain their striations on elevation above the sea, and the glaciated surface be preserved on passing the tidal zone, provided they are elevated above it, at a greater rate than the waves can denude, the precise thickness of overlying and protecting Boulder-drifts; but this marine drift will have been deposited during either subsidence or entire cessation of movement of the sea-bottom. In Lancashire, it is often a great thickness. I have had a recent instance, north of Wigan, of its attaining a depth of 180 feet in a flat country.

I, therefore, for these reasons, cannot admit Mr. Mackintosh's dictum, "that it is a fundamental principle in geology, that striæ are preserved in areas of depression," nor its converse, "in areas of elevation;" and, further, I believe that it is the former alone, almost without exception, that are areas of *deposition* of true sedimentary rocks. Mr. Darwin, F.R.S., states on this point, "I am convinced that nearly all our ancient formations, which are throughout the greater part of their thickness *rich in fossils*, have thus been formed during subsidence. Since publishing my views on this subject in 1845, I have watched the progress of Geology, and 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."[1] And he further shows that, though vast quantities of sediment may enter a sea, from muddy rivers and eroded coasts, around a rising continent, and littoral and sub-littoral deposits may be formed, these must be infallibly gradually worn and denuded away, as they are successively brought up to the action of the waves by the slow and gradual rise of the land.

If the sands and shingle occurring between the two marine Boulder-clays have been deposited as sand-banks, similar to those now found in the estuaries of rivers, and on coasts with small soundings,—as I have endeavoured to show in my paper on the "Glacial Phenomena of Western Lancashire and Cheshire,"[2] and which Mr. Mackintosh does not appear to question,—it appears to me to be impossible that they could have been thrown down, as he states, "during elevation," for each sandbank as it rose would be exposed to the action of the breakers, and, at the least, be denuded and re-deposited as a flat surface; while everywhere, from Carnarvonshire to Cumberland, I have observed the surface of these sands to have a curved, flowing outline, the hollows of which have since been filled in with Upper Boulder-clay.

The observations of Mr. Lamont, F.G.S., in the seas of Spitzbergen, on the changes of direction in the currents of the sea at different times of the year, have an important bearing on many of the phenomena of the Glacial drift. Thus, he shows that the Gulf Stream has little or no influence to the north and east of Black Point (Spitzbergen) and the Thousand Isles, as the ice is always travelling south-west, but immediately it is driven past that promontory, so as

[1] "Origin of Species," 5th ed., pp. 358–9.
[2] Quart. Journ. Geol. Soc., vol. xxvii.

"to come within the influence of the Gulf Stream, it is rapidly dissolved, that is, during June, July, August." After this month the arctic currrent bears back the remnant of the Gulf Stream, and the "polar ice, aided by the increasing cold, comes down in such quantities as to defy the efforts of the now vanquished Gulf Stream to dissolve it." It sweeps round the coast, meets another polar current from the other side, and wraps the island during the winter in an impenetrable barrier of ice. Regarding the warm episode in the Glacial epoch, during which the Middle Sand was formed, as an extended summer, it is easy to explain the fact, that though both of the Boulder-clays contain northern erratics, yet in the Middle Sand fossils and pebbles from the south often occur. Thus in 1861 I found in the sands of Leamington, in Warwickshire, Corals from the Lias of Cheltenham, Pectens and other fossils from the Red Crag, and a Nautilus from the London Clay. And in the neighbourhood of Crewe Mr. Taylor, F.G.S., has recorded the presence of a great number of chalk flints, though possibly these, like those from Blackpool, may come from Antrim.

In Lancashire the Middle Sands are invariably current-bedded to the south-east; and as I believe that they were thrown down during the *flow-tide*, it follows that it moved from the north-west, but in the south it may possibly have moved in the opposite direction, the meeting of the tides being then in Warwickshire, instead of in Morecambe Bay, as now. In the Upper Boulder-clay the north-west currents no doubt moved nearly as far south as the Thames.

It is clear from the descriptions of Drs. Brown, Sutherland, Kane, Rink, and Lamont, and other arctic travellers, that land-ice can make its way for a considerable distance into the sea, scratching and striating the rock-surface, and forming true moraine mounds, not only in the sea, but rising above it, forming islands, the sea-margins of which being exposed to the waves will be slightly denuded, and re-deposited at lower levels; in fact, the moraine mound may be *faced*, so to speak, with a marine deposit, composed of re-assorted land-ice débris. And, further, that these marine beds fill up and render seas shallow in the neighbourhood of the embouchure of large glaciers, forming Boulder-clay similar to that of the north-west of England, lying upon and graduating into moraine matter, and resting upon glaciated rock-surfaces, such as we find in the Lake District; and it is clear that, on the retreat of the glacier and the subsidence of the sea-bottom, the sea-belt occupying the space between the moraine island and the land would also become gradually filled up with marine deposits.

In the Upper and Lower Boulder-clays, as I have endeavoured to show,[1] the included stones and clayey matrix are almost invariably from different sources, formations, and localities. In the Middle Sand, on the contrary, the pebbles are composed of fragments of the neighbouring and surrounding rocks, and where it rests on the Lower Boulder-clay, of such erratic pebbles as may occur in that deposit at the particular locality.

[1] Quart. Journ. Geol. Soc., vol. xxvii., "On the Glacial Phenomena, etc.'

In the Till, or land-ice Lower Boulder-clay, the matrix and included fragments have often the same origin, and the pebbles and boulders are invariably angular or sub-angular, glaciated, and scratched, and comparatively local.[1] In North Wales I have described it as being eroded, denuded, and overlain by the ordinary marine Lower Boulder-clay, but in Lancashire the latter is absent at high levels, and the former does not generally occur at low levels, though in going north its level gradually descends.

Mr. Mackintosh mentions a "blue clay" under the Lower Boulder-clay, and states that it may be inferred from the facts given in his eight papers that it was formed in a "shallow sea and denuded (if not upheaved and again depressed) before it was overlaid by the Pinel"; and, further, in his "Drift-Deposits of the West Riding of Yorkshire," describes the sea as acting at a level principally between 300 and 600 feet above the present sea, during a period of subsidence. If this clay be really marine, as he states, and deposited when the land stood at 650 feet lower than at present, then it follows that the true Lower Boulder-clay, which in Lancashire, Cheshire, Cumberland, and Carnarvonshire, often occurs *below* the present sea-level, must have been formed in water of 650 feet depth, and when the Lake District and Lancashire were submerged under the sea to that amount. Unless it can be proved that an *elevation* of at least 600 feet took place between the depositions of the two clays, of which he gives no proof,—and as it is clear that the parent rocks from which all erratics found in the Lower Boulder-clay must have been, with the rarest exceptions, *above* the sea-level,—no Boulders should be found in it that occur *in sitû* at an elevation of less than 600 feet; but an examination of the stones and boulders of the Lower Boulder-clay of Lancashire has convinced me, that at least eight to ten per cent. are derived from portions of hills to the north, *under* 300 feet in height.

I, therefore, see no reason to change the opinion, stated in my paper on the "Glacial Phenomena of Western Lancashire, etc.,"[2] that the Lower Boulder-clay was deposited when the land forming the sea-bottom was not more than 100 *feet lower* than at present, and that the movement of subsidence continued during the Middle Sand period, so that the shells found near Macclesfield at 1200 feet, and on Moel Tryfaen, are newer than those of Blackpool at 50 feet above the sea, by the period of time which the land took to subside that amount.

If, as Mr. Mackintosh states, these sands were formed during an elevation, it follows that the Moel Tryfaen and Macclesfield are older than those of Blackpool, and that the country was submerged twelve or thirteen hundred feet before the deposition of the Lower Boulder-clay ceased, and that of the sands in the high districts commenced; and it therefrom follows that before the sands of Western Lancashire

[1] For my descriptions of this clay in North Wales, see *Nature*, vol. ii., p. 391; in Lancashire, Quart. Journ. Geol. Soc., vol. xxvii.; Geol. Mag., Vol. VIII., pp. 108, 116, and 310.

[2] Quart. Journ. Geol. Soc., vol. xxvii., part i., p. 652.

were deposited, the land must have been elevated to a level only 50 feet lower than at present. But, unfortunately for that argument, the sands at Blackpool, and all over the North-west of England, are overlaid by *marine* Upper Boulder-clay, at all levels up to 800 or 1,000 feet above the sea.[1] If, therefore, his theory be true, the country must have subsided a second time more than a 1,000 feet for the Upper Boulder-clay to be deposited, which I at present see no grounds for supposing.

Mr. Mackintosh takes exception to the statement in my paper,[1] on the "Surface Geology of the Lake District," that 1st, those lakes deliver as well as receive their waters, and 2nd, "that considering the immense depths of the lakes, the deep chasms in which they lie, it is impossible to say that *immense* quantities of detritus do not lie concealed beneath their placid waters," in opposition to those that hold that the limited excavating power of the Lake-district rivers "is proved by the small quantity of detritus they have yet been able to deposit." He states that he "ascertained from various persons, who were thoroughly acquainted with all the *ins and outs* of the Lake, that none of the detritus, or *sediment* brought in by the Brathay river, can find its way through the lake to the sea." But I am still perfectly unconvinced of any error in my statements; for (1) were the "various persons" competent judges, and (2) admitting that they were, the question to be decided is not "the ins and outs of the lake," but of the quantity of matter held in chemical solution and mechanical suspension, and pushed along at the bottom of the stream at the *point of outlet;* (3) that sediment is brought into the lake, not only by the Brathay, but by other streams, and by a portion of every rain-shower that falls upon the surrounding hills; that (4) granting that a deep current moving to the north is generated by the S.W. wind, this would aid the movement of sediment in all the lakes north of the great watershed, including all the chief lakes of the district, with the exception of Windermere and Coniston mere; and that (5) though in my paper in 1869,[2] I took especial care to point out the enormous lacustrine deposits, which no doubt exist at the bottom of these lakes, I cannot admit, with him, that even in "*Lake* Districts," that "Lacustrine deposits, which have all resulted from the action of fresh-water, afford the only *true measure* of sub-aërial denudation since the Glacial period."

In the first portion of his last paper Mr. Mackintosh states, in regard to Wastdale Screes, that the "idea at first suggested itself that a great stream of land-ice may once have tumbled over the Screes escarpment, and smoothed the above rocks (between Greendale and Wastwater) in its passage across the dale. Mr. De Rance has expressed a similar idea, but I do not think it can be reconciled with attentive consideration of the physical geography of the district." But unfortunately he omits to give the result of his own considerations on the subject. In his section, however (Fig. 3), through the roches moutonnées, west of the lake, he clearly shows

[1] Quart. Journ Geol. Soc. vol. xxvii., part i.
[2] Geol. Mag., Vol. VI.

that the glacial agent came from the east, *i.e.* the high ground of Sca Fell and neighbourhood, and thus supports my position by the evidence of a tract of country which I have not had the opportunity of visiting; for it is clear that the ice-cascade, after falling over the Screes and digging out the deep eastern side of the Lake Wastwater (which, however, is not shown in his section), gradually made its way westward to the sea, over the various hills on the other side.

In regard to the Boulders in Peel Park, Salford, of which Mr. Mackintosh gives an analysis, it would be interesting to know, 1st, on what principle they were selected from the clay-pits, etc.; and, 2nd, in what manner the 100 specimens were chosen from this selection? For instance, if another 100 specimens had been taken, would it also have included one per cent. of Criffell granite?

In Mr. Mackintosh's list I notice a much higher number of granites and igneous rocks than in the per-centages of the Boulders of the Manchester Dift given by Mr. Binney, F.R.S., and Prof. Hull, F.R.S., as shown in the following table:

Mr. Mackintosh.			Mr. Binney. (Trans. Mem. Lit. Phil. Soc., vol. x., p. 133.)		Prof. Ramsay. (given by Prof. Hull. Mem on Oldham.)	
Felspathic Trap and Porphyry	50	70	....	21	... 39	43
Eskdale Fell Granite............	19		Igneous Rocks...		... 6	
Criffell Granite	1		....		...	
Silurian Grit and Local Sandstones	30		Silurians and Slates	31	....	37
			Carboniferous ...	55·33	....	17
			New Red	2·66	....	—

Mr. Mackintosh likens the conditions prevailing during the British Glacial epoch to those now holding in Labrador, but from what I have read in the works of my friend Prof. Youle Hind, M.A., of Montreal, the first white man to penetrate its central savage wilds, and from what he told me in the beginning of last year, I consider that those conditions do not at present nearly reach that degree of glacial severity which formerly existed in England; conditions now only met with in Greenland, Spitzbergen, and within the Antarctic circle.

I cannot here refrain from mentioning the observations of Mr. W. Bradford, of New York, the artist and companion of Dr. Haynes, who in his recent lecture at the Royal Institution, described the Sermitsialik Glacier in Greenland, which debouches into the sea at the head of a fiord three miles and a half in width, the ice extending from side to side, rising 275 feet above the surface of the sea, and extending 510 feet below it, resting on the rock bottom; the glacier steadily rising inland, and joining the Mer de Glace, *overtopping* the hills on either side of it. The heat of the rock melts the base of the ice, which flows out in a stream, producing a current running five miles an hour, which makes the sea coloured and muddy for a distance of many miles.

NOTICES OF MEMOIRS

I.—British Association for the Advancement of Science. Forty-first Meeting. Edinburgh, 1871. Papers Read or sent in to be Read in Section C. (Geology.)

President.—Professor Archibald Geikie, F.R.S., F.G.S.

Address by President:—Sketch of the Geology of Edinburgh and Neighbourhood.

J. Thomson, F.G.S.—On the Age of the Stratified Rocks of Isla.

Dr. J. Bryce, F.R.S.E., F.G.S.—Third Report of the Committee on Earthquakes in Scotland.

H. Woodward, F.G.S.—Report on Fossil Crustacea.

Prof. W. C. Williamson, F.R.S.—On the Structure of Dictyoxylon.

G. J. Grieve—On the Position of Organic Remains near Burntisland.

W. Carruthers, F.R.S.—On the Vegetable Contents of Masses of Limestone occurring in Trappean Rocks in Fifeshire, and the conditions under which they are preserved.

W. Pengelly, F.R.S.—Seventh Report on Kent's Cavern Explorations.

Rev. W. S. Symonds, F.G.S.—On the Contents of a Hyæna's Den on the Great Doward, Whitchurch, Ross, Herefordshire.

L. C. Miall—Further Experiments and Remarks on Contortion of Rocks.

Prof. Ed. Hull, F.R.S., and *W. A. Traill*—On the Relative Ages of the Granitic, Plutonic, and Volcanic Rocks of the Mourne Mountains, Down, Ireland.

R. Daintree—On the General Geology of Queensland.

Rev. Dr. Hume—On the Coal-beds of Panama, in reference mainly to their Economic Importance.

T. Moffat, M.D.—On Geological Systems and Endemic Diseases.

Rev. J. F. Blake, M.A., F.G.S.—On the Yorkshire Lias and the Distribution of its Ammonites.

H. Woodward, F.G.S.—Relics of the Carboniferous and other Old Land Surfaces.

James Thomson, F.G.S.—Report on Sections of Fossil Corals.

Sir Richard Griffith, Bart., F.R.S.—On the Boulder Drift and Esker Hills of Ireland; and likewise on the Position and Composition of Erratic Blocks in that Country.

Dr. J. Murie, F.G.S.—On the Systematic Position of *Sivatherium giganteum.*

W. Boyd Dawkins, F.R.S.—On the Relation of the Quaternary Mammalia to the Glacial Period.

Prof. Williamson, F.R.S.—On the Structure of Diploxylon, a Plant of the Carboniferous Rocks.

C. Lapworth and *J. Wilson*—On the Silurian Rocks of Selkirk and Roxburgh.

C. Lapworth—On the Graptolites of Gala Group.

D. J. Brown—On the Silurian Rocks of the South of Scotland.

D. J. Brown—On the Upper Silurian Rocks of the Pentland Hills and Lesmahago.

John Henderson—On the Age of the Felstones, Conglomerates, and Sandstones of the Pentland Hills.

Prof. Dr. P. M. Duncan, F.R.S., F.G.S.—Report on the British Fossil Corals.

Prof. Archibald Geikie, F.R.S., F.G.S.—On the Progress of the Geological Survey of Scotland.

John Miller, F.G.S.—On the so-called Hyoid Plate of the Asterolepis.

P. W. Stuart Menteath—On the Origin of Volcanoes.

Prof. Harkness, F.R.S.—To exhibit one of the earliest forms of Trilobites.

H. Woodward, F.G.S.—On a new Arachnid from the Coal-measures of the Dudley Coal-field.

Dr. Bryce, F.R.S.E.—Note on certain Fossils from the Durine Limestone, N.-W. Sutherland.

Rev. W. S. Symonds, F.G.S.—To exhibit a new Onchus Spine from the Lower Old Red Sandstone of Hay, Breconshire.

Professor Traquair—Additions to the Fossil Vertebrate Fauna of Burdiehouse, near Edinburgh.

C. W. Peach.—Additions to the List of Fossils and Localities of the Carboniferous Formation in and around Edinburgh.

D. Grieve—Fossiliferous Strata at Lochend, near Edinburgh.

W. Milne Home—Notice of a Scheme for the Conservation of Remarkable Boulders in Scotland, and for the Indication of their Position on Maps.

Rev. J. Gunn, F.G.S.—On the Agency of the Alternate Elevation and Subsidence of the Land in the formation of Boulder-clay and Glaciers, and the Excavation of Valleys and Bays.

J. E. Taylor—On the Later Crag Deposits of Norfolk and Suffolk.

L'Abbé Richard—On Hydrogeology (in French).

W. S. Mitchell, M.A., F.G.S.—Leaf-beds of the Lower Bagshot Series.

R. H. Scott, M.A., F.R.S.—Mesozoic Deposits of Ombiak, North Greenland.

Robert Brown, Ph.D.—On the Geology of the Noursoak Peninsula and Disco Island in North Greenland.

W. S. Mitchell, M.A., F.G.S.—Some further remarks on the Denudation of the Bath Oolite.

J. Curry—On the general condition of the Glacial Epoch, with suggestions on the Formation of Lake Basins.

G. Busk, F.R.S.—Report on the Fossil Elephants of Malta.

*** The following Papers were announced, but not read in Section C.:

D. J. Brown—Notice of a small Glacial Moraine in the Pentland Hills.

G. A. Lebour, F.G.S.—On the value of Palæontological evidence in correlating distant (so-called) Contemporaneous Deposits.

G. Maw, F.G.S.—On the Geological Structure of the Atlas Mountains.

H. P. King—Remarks on Silver Islet, Lake Superior.

G. A. Lebour, F.G.S.—On the Age of the Coal-bearing Rocks of Chili.

T. L. Phipson—On the Gold Ore of Nova Scotia.

II.—On the Relative Ages of the Granitic, Plutonic, and Volcanic Rocks of the Mourne Mountains and Slieve Croob, Co. Down, Ireland.[1]

By Professor Edward Hull, F.R.S.; and William A. Traill, B.A., of the Geological Survey of Ireland.

After remarking on the bold and interesting physical features of the district, which in some respects resemble those of Arran, and which had already been objects of investigation by Griffith, Berger, and Bryce, the authors observed that there were, as in Arran itself, two varieties of granite. These had been shown by the Rev. Professor Haughton to differ both in composition and origin; the soda granite of Slieve Croob (consisting of quartz, orthoclase, and mica) being of metamorphic origin, and the potash granite of Mourne (consisting of quartz, orthoclase, albite, and mica) being irruptive. The relative and (as far as possible) the actual ages of these granites remained to be determined; and, in the absence of stratified deposits newer than the Lower Silurian in immediate contact with the granite, the authors considered they had approximately determined these points by considerations connected with the basaltic and felstone-porphyry dykes by which the district had, on several occasions, been invaded; the conclusions thus derived being that the granite of Mourne was newer than that of Slieve Croob by a long interval of geological time, and that while the former was probably of Mesozoic, the latter was of Palæozoic age.

This distinction might be otherwise expressed thus: that the metamorphic granite of Slieve Croob was formed out of the Lower Silurian Grits and Slates with which it is associated, while the granite of Mourne was forcibly irrupted amongst the Silurian rocks, which now inclose and surmount it in several places. These differences in manner of formation were clearly shown by the effects of the two granites on the surrounding stratified rocks.

The granite of Mourne at its margin in some places passes into quartziferous porphyry, and sends offshoots of this rock in the form of dykes into the surrounding Silurian strata, as may be very clearly determined by several examples in the vicinity of Newcastle. Hence the authors inferred that the dykes of quartz-porphyry and felstone which traverse the older granite of Slieve Croob might be referred to the age of the newer granite of Mourne.

Trap Dykes.—The trap rocks of the district were classed mineralogically as follows:—

(*a*) Quartz-porphyries and highly silicated felstones; (*b*) Diorites; (*c*) Basalts or Dolerites of two ages.

Considered with reference to relative ages of formation, the following was the order of succession:—

(1.) *Older Basalts and Dolerite Dykes.*—These form by far the most numerous of all the trap rocks of the district, occurring in great numbers along the coast south of Newcastle, and amongst the in-

[1] Communicated to Section C., British Association, Edinburgh, with the sanction of the Director-General of the Geological Survey.

terior of the Mourne mountains, as at Slieve Muck and Pigeon Rock Mountain and others.

Their age with reference to the granite of Mourne was placed beyond question by a large number of examples in which these dykes, after traversing the Silurian rocks, are abruptly terminated at the margin of the granite, evincing a higher antiquity than the granite itself.[1]

These older basalts were found to traverse the Silurian rocks in well-formed dykes within vertical (or nearly vertical) walls, and are generally undistinguishable from those of newer Tertiary age. Sliced specimens showed under the microscope the composition to be augite, triclinic felspar, and titano-ferrite.

(2.) The next in order of age are the quartz porphyries and felstones, which (as already stated) branch off from the main mass of the Mourne granite, and are unquestionably of the same age as the granite itself, and often strongly resemble it in its more compact form.

Dykes of these rocks are also found traversing the older granite of Slieve Croob. They consist of a felspathic base, with crystals of felspar grains and crystals of quartz, and sometimes mica or hornblende as accessories in small quantities.

(3.) The diorite dykes are few in number: the finest example occurring at Rostrevor, where a large dyke traverses the older basalt dykes contained in the Silurian beds. It consists of a crystalline granular aggregate of reddish felspar and hornblende well developed.

(4.) Besides the older basaltic dykes, which are cut off by the granite, there are a few which traverse both the Silurian rocks and the granite of Mourne itself. These are, therefore, newer than those previously described.

In general aspect there is no decided difference between the older and newer basaltic dykes; they have all the external appearance of the Tertiary dykes which abound along the margin of the basaltic plateau of Antrim, and in the west of Scotland; and had it not been for their different relations to the Mourne granite, they might have all been included in the same category.

It might have been supposed that microscopical examination would show some distinction in the basalts of these geological ages, but recent investigations by Zirkel, D. Forbes, Allport, and others, tend to show that there is no criterion of age amongst the constituents of basalt, dolerite, or melaphyre; and the presence of olivine—once supposed to be distinctive of Tertiary basalts—has been detected amongst those even of Carboniferous age.[2] Nor can the bearing of these dykes form any basis of distinction, as in the Mourne district the older basaltic dykes run in all directions; the easterly and westerly dykes, however, appear to cut those bearing North and South.

Age of the older basalts.—The geological age of these older

[1] Sir Richard Griffith has informed one of the authors that he was already aware of this fact, but had not published his observations.

[2] Mr. S. Allport, Geological Magazine, Vol. VI., pp. 115 and 159.

basalts can only be approximately determined. They are newer than the Carboniferous Limestone which they are seen to traverse at Cranfield Point, Carlingford, and elsewhere. Recollecting the abundant evidences of contemporaneous volcanic action which the Carboniferous rocks of Scotland and the North of England and Staffordshire present, the authors are disposed to refer these older basalts to the Carboniferous period; and, having regard to the prodigious number of these dykes traversing the rocks at intervals along the coast from Dundalk Bay to Dundrum Bay, they suggest the former existence of one or more volcanic vents in their vicinity during later Carboniferous times, such as has been inferred to have existed in the vicinity of Carlingford by Dr. Haughton.[1]

Sequence of Granitic, Plutonic, and Volcanic Rocks in the Mourne District.—The following may be regarded as the order of succession of these rocks, with their approximate ages, in the district north of Carlingford Bay, all being more recent than the age of the Caradoc beds of the Silurian epoch; commencing with the oldest we have—

(*a*) Metamorphic Granite of Slieve Croob, Castlewellan and Newry; *Pre-Carboniferous: Post Silurian.*
(*b*) Older Basaltic dykes of Mourne and Carlingford; *Upper Carboniferous.*
(*c*) Diorite dykes; later than the *Carboniferous.*
(*d*) 1. Granite of Mourne, 2. Felstone and Porphyry dykes penetrating the Granite of Slieve Croob and the older Basaltic dykes; *Post Carboniferous.*
(*e*) Newer Basalts of *Miocene Tertiary Age.*

Judging by the comparative scarceness of the newer Tertiary dykes in the district of Mourne, the authors draw the conclusion—that it may be considered as the southern limit of the region affected by the volcanic outburst of the Miocene Period, which have left such grand monuments of active force over the districts of the north-east of Ireland and extending into the Inner Hebrides; while, on the other hand, it was the seat of active volcanic energy during an earlier period, which, in all probability, was identical with the later Carboniferous.

III.—On the Silurian Rocks of the Pentland Hills and Lesmahago.

By D. J. Brown.

THE author showed that in the Pentland Hills both the Wenlock and Ludlow divisions of the Silurian Rocks are represented, and that the Lower Old Red Sandstone formed no part of these beds. Also, that these Pentland beds are not the equivalent of the Lesmahago, but that these latter are a higher portion of the Ludlow series than any found in the Pentland Hills.

IV.—On the Silurian Rocks of the South of Scotland.

By D. J. Brown.

IN this paper the author endeavoured to show that the Silurian rocks of the South of Scotland, as developed in Dumfriesshire

[1] Quart. Journ. Geol. Soc. vol. xii., p. 193.

and Peebleshire, do not all belong to one geological epoch, as has been hitherto supposed, but belong to two different epochs, a lower one represented by the Moffat rocks, well known by their beds of Anthracite shales, and Graptolites, and an upper series of later age, which lies unconformably on the Moffat rocks. These beds have been long known at Wrae and Glencotho, and more recently at Galashiels, through the exertions of Messrs. Lapworth and Wilson.

V.—On the Age of the Felstones, Conglomerates, and Sandstones of the Pentland Hills.

By John Henderson.

THE author described two sections through these hills, and showed that the Pentland Felstones cut through, indurate, and inclose angular fragments of rocks belonging to the upper portion of the Lower Carboniferous formation, and that the so-called Old Red Conglomerates contain limestone pebbles inclosing Carboniferous fossils.

REVIEWS.

I.—Introductory Text-book of Meteorology. By Alexander Buchan, M.A., F.R.S.E., etc. 8vo. pp. 212. (Edinburgh and London: Blackwood and Sons.)

THE science of the weather has naturally occupied attention from the earliest times, and in the form of proverbs the leading facts and inferences of Meteorology have, longer than those of any other science, been familiar to the people. But not until the invention of meteorological instruments in the seventeenth century could it be said to rank as a science, since which it has made such rapid advances that it has tended as much as any other science to the benefit of mankind. That its study has been much neglected, and does not form a subject of general education, may in some measure be due to the want of a concise hand-book, wherein the facts and principles of Meteorology are stated in a simple and connected form. If this be so, the little volume before us will, we think, remove the impediment; it furnishes an excellent class-book to the student, while at the same time the general reader will find in it as much information as he would desire, and this in an attractive style. The author describes the various meteorological instruments, and points out the methods of using them. The work is illustrated with numerous woodcuts, and with eight charts, showing the mean pressure of the atmosphere, the prevailing winds, the mean temperature of the earth at different periods, etc.

A study of Meteorology is of great importance to the geologist, in the explanations it gives of the climates of different regions, for the causes which originate changes in them, and the influence they would have in modifying the different forms of life, are questions of the highest interest.

II.—The bottom of the Gulf-stream and Atlantic Ocean near the Coast of North America. By L. F. Pourtales.[1]

POURTALES first tells us of the great share which the Government of the United States took in the exploration of the deep sea through the Coast Surveys, which first (1844) were under the superintendence of the late Professor A. D. Bache, and during the last three years under the direction of Prof. B. Peirce, who gave permission to the above publication. Pourtales first describes two important instruments, which are used for deep-sea explorations, namely, the sounding cups of Lieutenants Stellwagen and Sands. Each sounding is carefully put away in bottles, which bear the date, the longitude, latitude, and the depth in fathoms. The number of such samples is already 9,000. The undertaking, which has not nearly concluded its task, was confined only to the Atlantic Coast of North America, between Cuba and Cape Cod in Massachusetts, that is to say, between the 20th and 40th degrees of latitude.

Pourtales distinguishes principally two kinds of deposits in this part of the ocean, namely, a siliceous deposit and a lime deposit. The first runs along the coast from Cape Lad to Cape Florida, the latter as Coral lime occurs on the Coast of Cuba and off the Bahama banks, as well as to the South of Florida, and as Polythalamia lime in greater depths.

It is remarkable that the siliceous deposits begin with the cold northern current, whilst the lime deposits are confined to the warm southern current. It is probable, however, that the organic life which produced this lime deposit depends more on the depths, than on the temperature, which continues constant in greater depth, and is independent of the temperature at the surface of the sea.

Somewhat east of Long Island we find a muddy sea-bottom; this mud originated apparently from the former extension of the Tertiary deposits, whose remains now form only a few cliffs at scattered localities along the Coast of Massachusetts. The siliceous deposit reaches as far down as 100 fathoms, and slopes gradually towards the deeper parts of the ocean. It consists of yellow sand, and in the Gulf of Mexico of pure white quartz, mixed with a few grains of hornblende and felspar, but seldom of pebbles of old sedimentary rocks. Near the Bay of New York this sand is much mixed with glauconite and casts of *Polythalamiæ* from the greensand of New Jersey. They are easily seen with an ordinary magnifying glass. The region nearest the coast, of a depth of from 10 to 12 fathoms, affords only very few and small *Polystomella,* owing to the constant movement of the water. The next zone contains several species of *Miliolidæ,* but seldom at a depth of more than 40 fathoms. Beyond this zone they are found, but very rarely. *Truncatulina advena,* d'Orb., is not rare in depths of from 25 to 70 fathoms. In this region begins the fourth zone, which reaches down to 100 fathoms, and affords the larger types of the *Marginulinæ* and

[1] Petermann's Mittheilungen, vol. xvi., 1870, xi.

Cristellariæ. In the fifth zone, in depths of 60 fathoms and upwards, the sand is very much mixed with *Globigerinæ,* which in depths of 100 fathoms become so frequent that they actually form the entire mass. This continuation of zones shows the same character as far down as Cape Florida. Limestone of Tertiary age occurs only at a few places, forming small banks and cliffs, affording a suitable habitat to species of corals. The neighbourhoods of these banks are generally richer in fishes. But the small islands between Cape Florida and Cape Sable are all formed by coral limestone; the siliceous bottom which begins at the latter point is there much mixed with lime from the coral banks.

It is remarkable to observe how the littoral fauna changes with the condition of the sea-bottom. Many forms common to the coast of Carolina disappear at Cape Florida, and reappear at Cape Sable, as, for instance, the oysters, which at Florida are driven away by the West Indian Coral-fauna. The mud-bottom contains only few *Guttulinæ* (*Polymorphinæ*), whilst the lime-bottom is exclusively of organic origin, consisting either of Corals or of *Polythalamiæ.* Cape Florida is the most northerly point to which corals extend; the coral reef there does not show the same steep incline as the coral islands of the Pacific, or like the Bahama islands close by. Between this reef and the depth of about 100 fathoms, the bottom consists only of remains of shells, pieces of corals and such like, showing rolled edges. The following semicircular region, inclosing the former, called the plateau of Pourtales, gradually deepens to about 300 fathoms; it consists of a hard, dark-brown limestone, whose surface is animated with corals and a large fauna of all classes of Invertebrata, Crustacea, Mollusca (two Brachiopoda and *Voluta Junonia*), Echinoderma, Ophiura, Asteria, Holomacea. The sea-bottom near Cuba is also similar, but forms a steep inclination, which (at 400 fathoms) bears a fauna totally different from that near Florida. The steep banks of Bahama are covered with soft white lime mud. The lime-bottom, which consists almost entirely of Polythalamia, covers in greater depths the entire channel of Florida. This formation extends without interruption over the whole bed of the Gulf-stream in the Gulf of Mexico, is continued along the Atlantic coast of America, and most probably also extends over the greater part of the Atlantic basin. The commonest genera met with in this deposit are *Globigerina, Rotalia cultrata,* in large numbers, several *Textilariæ, Marginulinæ,* etc., etc. Besides these, small free corals, *Alcynoidæ, Ophiuræ,* Mollusca, Crustacea, small fishes, etc., etc., are found living in these depths. *Rhizocrinus lofotensis* was often met with, and was also found near the coasts of Norway, Great Britain, and the Azores, always within the reach of the Gulf-stream. The whole sea-bottom appears to be covered with a vast deposit of white chalk still in formation, whilst in the littoral and deep-sea region, the corals and shells of mollusca afford material for Oolite coral limestone and conglomerates.

Between Georgia and South Carolina, in depths of from 50 to 100 fathoms, almost at the line of demarcation of the siliceous and lime deposits, a number of isolated places were observed where a deposit of greensand is still going on.

Pourtales' researches include depths of 700 fathoms, with rich faunas, others often with very poor ones, which seems to show that the fauna is certainly more influenced by the condition of the bottom than by the depth, as the abundance of animal forms suddenly disappears, where stony bottom changes into Polythalamia deposits. The animals live there at a temperature of only a few degrees above zero, and with a small amount of light. The oysters, Annelida and Mollusca, possess developed eyes, rather larger than their relations of the littoral region.

One of the most important results of the researches of the expeditions of 1867 and 1868, is the fact that the Corals and Echinoderma of the deep-sea region possess the entire facies of the Tertiary and Cretaceous faunas.[1]—C.L.G.

REPORTS AND PROCEEDINGS.

Bath Natural History and Antiquarian Field-Club.—At a meeting of this Club held on the 15th February, 1871, the Rev. H. H. Winwood, M.A., F.G.S., read a paper on the Rhætic section at Newbridge Hill, on the new (Midland) Railway between Bath and Mangotsfield.[2] This section has been noticed by Mr. C. Moore in his paper, "On the Abnormal Conditions of the Secondary Deposits of the Somersetshire and South Wales Coal Basin," but since his observations were made the banks have been worked back, and greater facilities afforded for the examination of these beds. The Rev. Mr. Winwood has made a careful section of the beds exposed in this cutting, which include a thin representative of the bone-bed, the black shales, the Cotham Marble and the White Lias of Rhætic age, while resting upon these come the *Ostrea* and *Angulatus* beds of the Lower Lias, which are mostly wanting in this neighbourhood, the *Lima* and *Bucklandi* series, as Mr. Winwood remarks, generally resting unconformably upon the White Lias. Numerous species of fossils are mentioned as occurring in the beds.

Geological Society of London.—June 21, 1871.—Joseph Prestwich, Esq., F.R.S., President, in the Chair. 1. "On some supposed Vegetable Fossils." By William Carruthers, Esq., F.R.S., F.G.S.

In this paper the author desired to record certain examples of objects which had been regarded, erroneously, as vegetable fossils. The specimens to which he specially alluded were as follows:—Supposed fruits on which Geinitz founded the genus *Guilielmites*, namely, *Carpolites umbonatus*, Sternb., and *Guilielmites permianus*, Gein., which the author regarded as the result of the presence of

[1] See Dr. Duncan's remarks on a New Coral, Reports Proceedings Geol. Soc. June, Geol. Mag. for August, 1871, p. 378.

[2] Published in the Proceedings of the Bath Nat. Hist. and Antiq. Field-Club, vol. ii. no. 2, 1871, p. 204.

fluid or gaseous matter in the rock when in a plastic state; some roundish bodies, which, when occurring in the Stonesfield slate, have been regarded as fossil fruits, but which the author considered to be the ova of reptiles, and of which he described two new forms; and the flat, horny pen of a Cuttlefish from the Purbeck of Dorsetshire described by the author as *Teudopsis Brodiei*, sp. n.

Discussion.—Mr. Seeley remarked on the compressed spheroids found in so many rocks, that there was a difficulty in accepting the view of their originating in fluid vesicles, though he was unable to suggest any other theory by which to account for them. He observed that the eggs from the Stonesfield slate closely resemble those of birds, and that it was of the highest interest to find such eggs in strata containing so many remains of ornithosaurian forms, such as *Rhamphorhynchus* and *Pterodactylus*. of which genus probably these were the eggs.

Prof. Rupert Jones fully recognized the ingenious explanation of the bubble-formed limited slickensides, that looked so much like possible fossil fruits, and Mr. Carruthers's masterly treatment of the other specimens. But he wished that the author would take up the subject exhaustively, and define the nature of other supposed vegetable fossils, such as the so-called fucoids, *Palæochorda*, *Palæophyton*, *Oldhamia*, etc., many, if not all, of which Prof. Jones thought to be due to galleries and other tracks made by Crustaceans.

Prof. Ramsay had known many instances of such blunders as these pointed out, made, not by experienced geologists, but by those unacquainted with the science. Though he had never regarded the flattened spheroids as fossils, he was unable to account for their presence in the clay-beds of different ages.

Mr. Hulke inquired whether Mr. Carruthers considered the limited slickensides common in the Kimmeridge shales as due to gaseous origin. He remarked on the rarity of Pterodactylian remains as compared with those of other Saurians in the Wealden beds, in which the presumed eggs of Pterodactyle were found.

Mr. Seeley did not regard the Wealden egg as being that of a Pterodactyle.

Mr. Carruthers, in reply, remarked that the local slickensides mentioned by Mr. Hulke differed in character from those to which he had referred.

2. "Notes on the Geology of part of the County of Donegal." By A. H. Green, Esq., F.G.S.

In this paper the author described the geological structure of the country in the neighbourhood of the Errigal Mountain, with the view of demonstrating the occurrence in this district of an interstratification with mica-schist of beds of rock, which can hardly be distinguished from granite, the very gradual passage from alternations of granitic gneiss and mica-schist into granite alone, and the marked traces of bedding and other signs of stratification that appear in the granite, to which the author ascribed a metamorphic origin. He also noticed the marks of ice-action observed by him in this region, and referred especially to some remarkable fluted bosses of quartzite, and to the formation of some small lakes by the scooping action of ice.

Discussion.—Mr. Forbes stated that none of the facts of this communication were new, but he dissented altogether from the conclusions arrived at by the author in regarding these rocks as originally of sedimentary origin, and for the following reasons:—(1) That this district had been studied in detail by Mr. Scott and Prof. Haughton, who declare the rock to be undoubtedly intrusive, as it not only sends out veins into the neighbouring strata. but also incloses fragments of the rocks through which it has broken. (2) Because the author starts from the idea, that if such rocks are found to lie conformably on beds of undoubted sedimentary origin, it is a proof of their being themselves sedimentary or stratified,—a conclusion which is totally unwarranted, since there are innumerable instances, not only of beds of lava or other igneous rocks being conformable to fossiliferous strata, but of their also being found intercalated with such beds even for considerable distances. (3) The strata, so far from being proved by him to be truly of sedimentary origin, are of a most questionable origin, since they are neither in themselves fossiliferous, nor can they be correlated with any containing fossils as proofs of true sedimentary deposition; and the description of his section is sufficient to show this; for although it looks well on paper on a scale of three feet to the mile, the author has so little confidence in it that he is not even certain as to which is the top or bottom of the section on which so much generalization is based. (4) That a parallel structure equally, if not better, developed than any occurring in the gneiss of Donegal is common to many volcanic rocks, as in a specimen laid before the meeting, in which this parallel foliated structure, due to crystallization-layers, is so well developed as to make it appear exactly like a stratified rock, and even split along these lines, and this, although the product of volcanos still active is found for great distances both overlying conformably and intercalated between beds of the Cretaceous and Oolite formations.

Mr. Scott was unwilling to accept the section given by the author as satisfactory. He agreed, however, as to the bedded appearance of the granite, and to the masses lying in general conformably with the lines of stratification of the country. The nearest spot at which fossiliferous rocks occurred was separated from the beds described by the whole width of the county of Tyrone, though some presumed Eozoonal forms had been found at a less distance. He was not prepared to believe in the original absolutely fused condition of granite, nor in there being two distinct forms under which it occurred.

3. "Memoranda on the most recent Geological Changes of the Rivers and Plains of Northern India, founded on accurate surveys and the Artesian well-boring at Umballa, to show the practical application of Mr. Login's theory of the abrading and transporting power of water to effect such changes." By T. Login, Esq., F.R.S.E. Communicated by Alfred Tylor, Esq., F.G.S.

The author commenced by referring to the general conditions of the surface of the country under consideration, and to the evidence afforded by it of a great decrease in the amount of rainfall, and a great change in the nature of the rivers. His object was to show that the superficial deposits of the plains of India were formed by the action of mountain streams, the deposits being irregular transversely, but exhibiting a uniform section longitudinally, in a curve which the author believed to be a true parabola, as indicated by Mr. Tylor. The connexion of this with the author's theory as to the transporting power of water was indicated. The author also showed that the beds of the large Indian rivers are rising rather than being lowered, and pointed out that this was in accordance with his theory.

CORRESPONDENCE.

DENUDATION OF THE SHROPSHIRE COAL-FIELD.[1]

SIR,—I regret to find that I have read the passages contained in Mr. Randall's letter to the *Mining Journal* in a sense which the author had not intended; and I hope he will acquit me of any desire wilfully to misrepresent his views. I am well satisfied to find there is really no difference of opinion between us on the general question whether the denudation took place before or after the main faults of the Coal-measures. He refers, however, to a local instance of faults having protected the Coals at Halesfield. I think it would help forward the scientific inquiry if he would kindly furnish us with the data which have led to this impression—or rather opinion—that

[1] GEOL. MAG., 1871, Vol. VIII., p. 200.

such is the case at Halesfield. Should it be so, it would establish the fact of there being two systems of faults in point of age affecting the Coal-measures in this Coal-field, which has not, I think, been pointed out by any previous writer upon the subject. I had not supposed that my conclusions were different from those of most other geologists; but I have fallen into the error of supposing that Mr. Randall thought in any way differently on the general subject. The reference, however, to a local exception, is equally new to me; and therefore I should be obliged for information on the subject. It will be necessary to show that there are faults in that neighbourhood which affect the older Coal-measures, without affecting the younger, which fill the denuded valley. I take this opportunity of saying that I am indebted entirely to Mr. Scott for the lines showing the denudation of the several groups of Coal-seams from near the Hem pit northwards. DANIEL JONES, F.G.S.

ON THE SUBMERGENCE OF THE WEST COAST OF BRITTANY.

SIR,—In connexion with Mr. Lebour's paper on the submergence of the western coast of Brittany (see above, p. 300), and the Rev. T. G. Bonney's reference to M. Quenault's book treating of the subsidence of the coast of Normandy (see above, p. 384), I beg to call your attention to the elaborate and conscientious collection of "physical and historical evidences of vast sinkings of land on the north and west coasts of France and south-western coasts of England within the historical period," by Mr. R. A. Peacock, C.E. (8vo., Spon, London, 1868.) Although the western coasts of Brittany (comprising Is) are not specially treated of, yet a vast amount of relative information is afforded by Mr. Peacock's work, and some of M. Quenault's labours, alluded to by Mr. Bonney, are given in detail at pages 131–133.

Mr. Peacock's "collected evidences prove that within the last nineteen centuries, and even so late as the beginning of the fifteenth century, large tracts of land and sea-bottom have sunk, even more than a hundred feet at some places, along the coasts of Western Prussia, Holland, and Belgium, from the Elbe to near Nieuport; along the coasts of North Somerset, and of Devon and Cornwall, north and south; in the bed of the English Channel; amongst the Channel Islands; along the coasts of Normandy and Brittany, from the Seine to Portrieux; on the north coast of Brittany, from about Lannion to the north-west angle of Brittany; around the Isle of Sein, on the west of Brittany; and probably also along the French coast in the Bay of Biscay. Whilst possibly the land around Rochelle has risen a few feet since the commencement of the twelfth century." (Phil. Mag. for May, 1869.)—Yours, etc., RUSTICUS.

TERRACES OF NORWAY.[1]

SIR,—I have endeavoured to follow Mr. Marshall Hall's advice (GEOL. MAG., July). But I found that there were many Aardals in Norway. I have been to that a little north of Stavanger. I found plenty of terraces, and my walk up the valley ended at a magnificent

[1] See GEOL. MAG., 1871, Vol. VIII., p. 75.

waterfall. But I believe that it was called Hjaa Foss. I could not hear of Mr. Hall's Mörk Foss, so I presume that I have been to the wrong Aardal. Half the bridge below Hjaa Foss had been swept away, which brought me to a full stop. So as I sat and gazed on the fall, I transferred my deck-load of luncheon to the hold, and then retraced a walk of loveliness, such as of itself alone would have repaid me for my journey from here by Hull to Stavanger.

In my letter (GEOL. MAG., April) I have agreed with all Professor Kjerulf's facts, and with all his theories, except that I think that the level of the terraces depended, not on the level of permanent "water-surfaces," but on the level at which the river which carried the materials overflowed on to the *land.* I do not, however, think with the Professor, that we need suppose the rising of the land which placed the *marine* terraces above the overflow of the river to have been *sudden* and "with several shocks." As the land rose gradually, the river gradually deepened its channel, and not only ceased to overflow and deposit on its Delta, but in floods cut away the banks which it had formerly built, which it drove to the hill-side in the form of two parallel terraces. The existing slopes of the sides and ends of these terraces, on which the Professor founds his theory of "sudden shocks," are not the slopes at which they rose from the sea thousands or millions of years ago. These slopes have been receding from atmospheric erosion during all this period, and they are receding now. But they retain universally the angle at which their incoherent materials will rest—an angle not very unlike that taken by the sands of an hour-glass. For these materials, like those of the Scottish Kames, the Irish Eskers, and (query) of every terrace on earth, are simply sand and pebbles; and where they are accidentally bared of herbage, you sink ankle-deep in going up or down the slopes.

The Delta which the river is forming now at Aardal is not at the level of the sea, or even of the unflooded river, but, like every other Delta in the world, above both. The great universal mistake is to suppose that Deltas formed by rivers in the sea, or in lakes, cease to rise when they reach the water-level. Can any one point to a Delta at the level of the sea or of a lake? Deltas universally rise by overflow of the rivers above the water-level, and they continue to rise as long as the land and water maintain the same relative level; though all Deltas slope downward to the end at the water's edge. All alluvial flats formed on land by the annual overflow of rivers are just as level as the Deltas which are formed above the sea-level or lake-level.

On the new Delta at Aardal there are a number of terraces at different levels, and the boundary of any one which is not overflowed by any particular flood is swept by the escaping flood-water. Six terraces may be counted on the left bank of the river at the bridges. These may probably, by unusually high floods, be cut back against the hill-side in the form of one high terrace, and then supposed to have been thrust up at one "shock." The correspondence of terraces in number, on opposite sides of the river, will often vary from this destruction of terraces by unusual floods.

As I have said in the last chapter of "Rain and Rivers," amid the apparently hopeless irregularity in all Deltas, there is this one *general tendency*, that the entire overflow is from a central channel or channels, and the entire escape of the overflow to the sea is by the two side channels. These two sides and the sea-side form the triangle, or Greek Delta, from which these formations receive their name. Besides the earlier deposit of the heaviest materials, this side-escape of the flood-water causes the slope downward from centre to side of Delta deposits. Inland deposits frequently slope the contrary way, from side to centre. For besides that the flood-water has no side-escape, but returns to the river over the same surface which it has traversed, the erosion of the hill-sides and of old terraces tends to heap from the side to the centre. Sometimes, however, channels are cut by the return water. In this case, a slope from centre to side may be observed even in inland alluviums.

The Rev. Mr. Bonney, in your May number, applies my theory for the formation of *inland* terraces (Geol. Mag., May, 1867) to the formation of *marine* terraces, to which it is wholly *in*applicable. I agree with that close observer and accurate thinker, Professor Kjerulf, in thinking that inland and marine terraces result from causes totally distinct.

Brookwood Park, Alresford, *3rd August*, 1871. George Greenwood, Colonel.

MISCELLANEOUS.

We understand that there will shortly be published a Geological Atlas of England, by Mr. W. Stephen Mitchell, M.A., LL.B., F.L.S., F.G.S. The Atlas will contain the following Maps:—1. Cambrian (of Survey); Lower Cambrian (of Sedgwick). 2. Lower Silurian (of Survey); Middle and Upper Cambrian (of Sedgwick). 3. Upper Silurian (of Survey); Silurian (of Sedgwick). 4. Old Red Sandstone; Devonian. 5. Carboniferous Limestone; Yoredale Beds. 6. Millstone Grit; Coal Measures. 7. Permian (of Survey); Pontefract Group (of Sedgwick). 8. New Red Sandstone; Rhætic (Penarth). 9. Lias. 10. Lower Oolite. 11. Middle Oolite. 12. Upper Oolite. 13. Wealden; Neocomian. 14. Gault; Upper Green Sand; Chalk and Chalk Marl. 15. Eocene. 16. Crag. 17. Alluvium. 18. Bone Caves. 19. Metamorphic (?) 20. Igneous.—The Maps will be printed in colours, each Map exhibiting only the range of one formation, and the names of places on the formation. In some few cases, where it is requisite, as a clue to the locality, to introduce the names of places near, but not on the formation, these will be printed in a different type. The Maps ($11\frac{3}{4}$ in. by $9\frac{1}{4}$ in.) are based on a photographic reduction of the last edition of the Greenough Map, which is published under the direction of a Committee appointed by the Geological Society. In all cases where, through researches more recent than this last edition, any changes have been adopted in the grouping of the beds, this Atlas conforms with the latest alterations. The revision of the proofs of particular Maps has been kindly promised by W. Boyd Dawkins, Esq., M.A., F.R.S., W. Whitaker, Esq., B.A., F.G.S., H. Bauerman, Esq., F.G.S., J. W. Judd, Esq., F.G.S., Charles Moore, Esq., F.G.S., W. T. Aveline, Esq., F.G.S., and others.—Letter-press will accompany each Map, giving in a tabulated form the subdivisions of the formations, the origin of the names of the groups of beds, their lithological characters, thickness, range, etc., with a historical notice of the various classifications that have been at different times employed.—The Lists of Fossils will be arranged on a new plan, showing in a tabulated form for each formation the genera that first appear, those that last appear, and those that are numerically abundant in that formation. Separate tables give the characteristic species. These lists are prepared expressly for this work by R. Etheridge, Esq., F.R.S., F.G.S., etc., Palæontologist to Her Majesty's Geological Survey of Great Britain.

THE
GEOLOGICAL MAGAZINE.

No. LXXXVIII.—OCTOBER, 1871.

ORIGINAL ARTICLES.

I.—On the Contents of a Hyæna's Den on the Great Doward, Whitchurch, Ross.[1]

By the Rev. W. S. Symonds, M.A., F.G.S., of Pendock.

The hill of the Great Doward rises above the right bank of the river Wye to the N.W. of the well-known limestone escarpment of Symonds Yat. The section of the Great Doward, geologically considered, is best seen by ascending the hill from the Monmouth road, a quarter of a mile from the village of Whitchurch. The basement beds consist of Upper Old Red Sandstone, which thins out considerably in its Southern strike from the Brecon Vans; and we pass upwards over the Old Red Conglomerate, and the Passage beds of the Upper Yellow Sandstones, while the hill itself is capped by the Lower Limestone shale and the Carboniferous Limestone.

View of the Wye from the roof of King Arthur's Cave looking towards Monmouth. Height of the cave above the level of the river, 300 feet. (From a photograph.)

On the summit of the Great Doward are the vestiges of an ancient encampment known as "King Arthur's Hall," and on its western slope is a cavern called "King Arthur's Cave." A short distance to the westward is the "Little Doward Camp," where the remains of an old encampment are very conspicuous, and where, according to Gibson's Camden, "broad arrow-heads have been found;" and in a place which seemed to have been arched over, an almost entire human skeleton was discovered, "whose joints were pretended to be twice the length of those of the present race."

[1] Read before the British Association, Edinburgh, August, 1871.

A remarkable feature in the geology of the district is owing to the fact that the channel of the Wye now runs between the gorge of Symonds Yat and Whitchurch, and cuts off the Doward Hills, and Coppet Wood Hill, which thus may be said to be outliers of Carboniferous Limestone, from the great mass of Carboniferous strata which constitute the area of the Forest of Dean. There is evidence, as we shall see, that the Wye once flowed at a much higher level than now. For ages it has been deepening its channel, and dark craggy cliffs of Mountain limestone, clothed with the foliage of numerous trees, now rise high above its waters.

King Arthur's Cave does not open out upon the river Wye, as many of the caves and fissures do in the limestone escarpments, but opens at right angles to the flow of the river, and the entrance looks towards Monmouth, and the hill of the Little Doward on the west. Some years ago, when visiting this cave in company with a hermit cave-dweller known as "Jack the Slipper," I was struck with the accumulation of cave earth in the interior, and endeavoured to obtain leave to make some excavations, but without success. In the mean time the site on which this cave is situated became the property of the Crown; and in 1870, some miners engaged in the search for iron ore had removed a good deal of the surface soil and upper cave earth in the interior of the cave. During these excavations several fossil bones were discovered; and a tooth of the fossil horse (*Equus fossilis*) was forwarded to me by Mr. Fryer, of Coleford, who was thus the first person who detected the existence of fossil bones in King Arthur's Cave. During the summer, Sir James Campbell visited the excavations, and forwarded a number of bones to London for examination by Prof. Owen, who at once pronounced them to be the relics of Mammoth, Rhinoceros, and Horse; also, that it was evident, from the state of the bones, that the cave had been the resort of hyænas, as many had evidently been dragged in and gnawed. This information I communicated last year at the Meeting of the British Association at Liverpool. It now remains to state briefly what has been done in the excavations I have superintended during the present summer of 1871.

Having obtained permission through Sir James Campbell, the Gaveller of Dean Forest, to whom I am also indebted for kind assistance in furthering the explorations, and furnished with funds by the Malvern Field Club and a few personal friends, we commenced operations on the 7th of June, and on successive occasions careful examinations have been carried on.

At our first meeting we were accompanied by Mr. Boyd Dawkins, well known for his osteological researches; and he was soon enabled to determine many bones, jaws, and teeth as they were exhumed from the cave earth, and which belonged to the great Carnivores and Ruminants which once inhabited the country round the cave.

I soon found, however, that, owing to the disturbance of the soil in the interior of the cave by miners, it would be necessary to institute a series of excavations and cuttings in order to arrive at any definite result as to the true position of the cave deposits. In carrying out these investigations, I have to thank Mr. Ward, of Coleford, for his superintendence and assistance; Mr. Scobell, for his careful search for specimens; and Henry Jones, the Woodman of Dean Forest, and the men employed under him, for their hearty co-operation in my endeavours to arrive at a truthful determination.

Having carefully examined the remotest corners of the cave during the last two visits in July, I directed several excavations in one recess of the cave where it appeared to us that the debris had been little disturbed. This work had to be carried on by candle light, but the investigations were as careful as possible, and every barrow-full of earth and debris was carefully examined by daylight at the entrance.

The following is the order of deposition of materials in the cave:

1st. Fallen debris from the roof which had been shifted, and loose stalactitic matter forming a superficial soil containing pottery, which Mr. John Evans, who has been so good as to examine the human relics from the cave, informs me is probably Roman; also human bones in a recent and unfossilized condition. This superficial soil is black and peaty, inconsiderable in thickness, and at the base of it we found, in the inner cave, a thin band of decomposed stalactitic matter, which had probably once formed a thin stalactitic floor. This was the only separation between the debris and an upper cave earth; but I have no doubt this decomposed stalagmite was once hard and solid when more covered by debris.

2nd. *Cave Earth, No.* 1.—This accumulation of cave earth is, in the inner cave, about three feet in thickness. It contained, both in the inner cave and in the outer cave, near the entrance, flint flakes and chips, with three human instruments of stone, and of unmistakable character. These instruments are not of flint. Two are of a black chert, and have evidently been formed from rolled pebbles; the third is apparently manufactured from a pebble of some lower Silurian rock. The core of chert from which flakes have been struck, and the pale grey instrument, I excavated with my own hands. The core was lying in close approximation to the canine tooth of a Hyæna. The second cherty instrument was found by Mr. Scobell close to the molar tooth of a young Mammoth. The remains of the animals found in this upper cave earth consist of the teeth, jaws, and bones of numerous Mammalia, of which several species are altogether extinct, and others which no longer inhabit the continent of Europe. Thus we have, in beautifully perfect condition, the teeth and jaws of the Cave Lion (*Felis spelæa*), the Cave Bear (*Ursus spelæa*), and the Hyæna (*Hyæna spelæa*). With these are remains of the teeth and bones of the Mammoth (*Elephas primigenius*), the long-haired Rhinoceros of the Glacial period (*Rhinoceros tichorhinus*), and numerous remains of the fossil Horse (*Equus fossilis*). In the inner cave, below the cave earth No. 1, with bear and hyæna remains, and flint flakes, we found a thin stalactitic floor resting on a mass of stratified red sand containing rolled pebbles, which I believe to be an old river deposit.

3rd. *Old River Bed.*—This deposit consists of stratified red sand

and silt three or four feet in thickness, and out of it, when digging a trench, in order to discover its physical position to the cave earths, Mr. Scobell and myself picked up five pebbles, and Mr. Fitton a greenstone pebble, all of which I have preserved and exhibit. It appears to me that this stratified red sand and silt containing these pebbles tells its own history as the deposition of an ancient Wye.

It is true the present Wye flows at 300 feet below the mouth of King Arthur's Cave; but those who know anything of the geology of that river will recognize these pebbles as belonging to the silt of an ancient stream which had its source, like the present, in the heights of Plynlimmon, and flowed through the Lower Silurian rocks and interbedded traps of Rhayader and Builth. Every one of those pebbles out of that red sandy deposit must have been derived from Silurian and Trap rocks, which are not to be found *in situ* until after we have traversed the long tract of Old Sandstone through which the Wye passes between Coppet Wood Hill, near Ross, and Trewerne, above Hay, in Breconshire, a distance, by the river, of 70 or 80 miles.

4th. Below this river sand and pebbles we cut a section, showing that the sand and pebbles rested upon a thick floor of Stalagmite, covering a second deposition of cave earth.

5th. *Cave Earth, No.* 2.—This thick floor of Stalagmite, which underlies the red sand, nearly misled us on our first visit, for we thought we had arrived at the limestone floor of the cave. On breaking through it, however, we found cave earth separated every few feet by layers, or thin floors, of stalagmite. This second cave earth afforded many animal remains, and here and there we disinterred some flint flakes, principally from the upper layers. Two of these I saw disinterred myself from below the thick stalactitic floor. No other human relic was discovered, save a hone or whetstone, which was thrown up by the workmen from the deep pit in the presence of Mr. Scobell just before my arrival on the 20th of July. Mr. Scobell did not see this whetstone *in situ,* and the workmen threw it out as a piece of common stalagmite. On forwarding this specimen to Mr. John Evans, he favoured me with the following remarks:—"The whetstone has far more the appearance of being neolithic than palæolithic, and is very different from anything I have seen from the French or English caves. It has much the appearance of having served for grinding the edge of polished stone celts. Does there seem any possibility of its having been of more recent introduction than the teeth of hyæna? The men who used it cannot well have been joint tenants of the cave with the hyænas." In reply to Mr. Evans's question I may say that several persons also questioned the antique age of this whetstone, and it has been supposed that it was surreptitiously introduced for the sake of a hoax by the workmen, or some other person when the workmen were away. For my own part I dismiss the idea of the workmen having done anything of the kind, as they were one and all nearly as interested as myself in the search for truthful results; and I have a strong objection to believing that any Herefordshire man would have attempted thus to deceive. Still Mr. Evans's opinion is of the greatest consequence on such subjects, and for that reason I sent the whetstone to him, believing myself at the time that it it came from the lower cave earth. On thinking the matter carefully over I believe the history may be thus explained. When the whetstone was thrown out of the bottom of the pit it was directly after I had directed the removal of a quantity of debris from the side of the fissure, outside the cave, in order to get at more relics from the upper cave earth, on which a mass of rock had fallen. The pit in the lower cave earth lay right in the way of the fall of some of this upper debris from the side of the cave, and this whetstone may have fallen in from the debris. I prefer this solution to that of the hoax and the lie! and, therefore, place the whetstone in the same category as the pottery, and the recent human bones; so even if it was a hoax, the hoax has failed!

Still we must not forget that the disinterment of flint flakes from the lower cave earth is as convincing a proof of the existence of man, and of his frequenting the cave at the time of the deposition of this earth, as would be the discovery of 20,000 whetstones; as well as of his contemporaneity with the extinct animals.

One or two of the flint flakes I discovered *in situ* myself imbedded with the bones of the extinct mammalia. They are completely whitened by their long interment in the cave earth. I would also remark that the flakes, teeth, and bones do not show the faintest sign of being rolled or acted upon by water. The fangs and edges of the teeth are as sharp as when in the jaws of the living animal. The lower cave earth was introduced gradually and by degrees, probably by the wash of rain and melting of snow through crevices in the limestone. It is separated continually by thin layers of stalagmite, in many instances coated with the *album græcum* of hyænas, proving that for a time each layer of stalagmite formed the floor of the cave, and that during such periods there was no influx of water save by the drippings from above. The very idea of this cave earth having been washed in by a flood, or floods of water, is simply preposterous nonsense to those who worked it, and examined it, as we did, inch by inch, and foot by foot. The animal remains are those of the cave Lion, Hyæna, Rhinoceros, Mammoth (three sizes and ages), the Gigantic Irish Deer, the Horse, the Bison, and the Reindeer; but no Bear was found in the lower earth.

From the foregoing facts it appears safe to draw the following inferences:—

1st. That long ages ago King Arthur's Cave was a deep fissure in the rocks of the mountain limestone, which was gradually silted up by the introduction of the lower cave earth, by the wash of rain and water through crevices and fissures; and that during that period it was a Hyæna's den, and, also, the occasional haunt of ancient Herefordian men, who left there their manufactured weapons and sharpened tools. These implements are all foreign to the district, for the flints, the cores, and the more modern whetstone have all been imported from long distances. A thick floor of stalagmite seals this lower earth in the fissure which was quarried to the depth of 17ft., and bored to the depth of 20ft.

2ndly. Above the thick stalagmite we found there rested stratified sand and gravel of considerable thickness. It is my belief that this deposit was washed into the cave by an ancient Wye, which flowed 300ft. above the level of the existing Wye, and when the land was higher than at present, before it was so much degraded by the atmospheric denudation of ages, and before it had assumed its present aspect of deep valleys and glens. It is probable that the soft Old Red strata, north of the Great Doward, once rose higher than the harder limestones of the Dowards, and that long ages of atmospheric wear and tear have reduced their height since the land was occupied by ancient man and the cave animals. And here I may mention that my friend Mr. Lucy, who has done so much in Gloucestershire for the elucidation of the Drifts, thinks it possible that the drift sand and pebbles in Arthur's Cave may have been derived from the washing in of the materials by the agency of melting snow and ice from higher sites and previously deposited gravels. The only reason why I object to this opinion of Mr. Lucy's is that I recognize in these pebbles a *river drift*, the deposit of some ancient stream which flowed as the present Wye flows, viz., through the Lower Silurian rocks of Rhayader and Builth.

Years ago I showed that the Drift of the higher lands, as on the platform above Symonds Yat, is a true Boulder-clay, containing large rounded and unrounded erratics, such as the Machen Boulder, near Symonds Yat, and in which I have never seen such river pebbles. I therefore prefer the hypothesis I arrived at from a study of the district, viz., that these pebbles were washed in by the stream of an ancient Wye, before the excavation of the mountain limestone gorge to its present depth, 300 feet below.

Be this as it may, there rests that sand and pebbles, sealed by a stalactitic floor, the droppings of the cave roof upon its stratified layers, and separated from a lower cave earth by a mass of stalagmite more than two feet thick. In that lower cave earth are associated the remains of ancient Men and the extinct Mammalia; and what with the evidence of the old river-bed and the stalagmites, I doubt if there be better authenticated evidences of the antiquity of Man in the records of cave history.

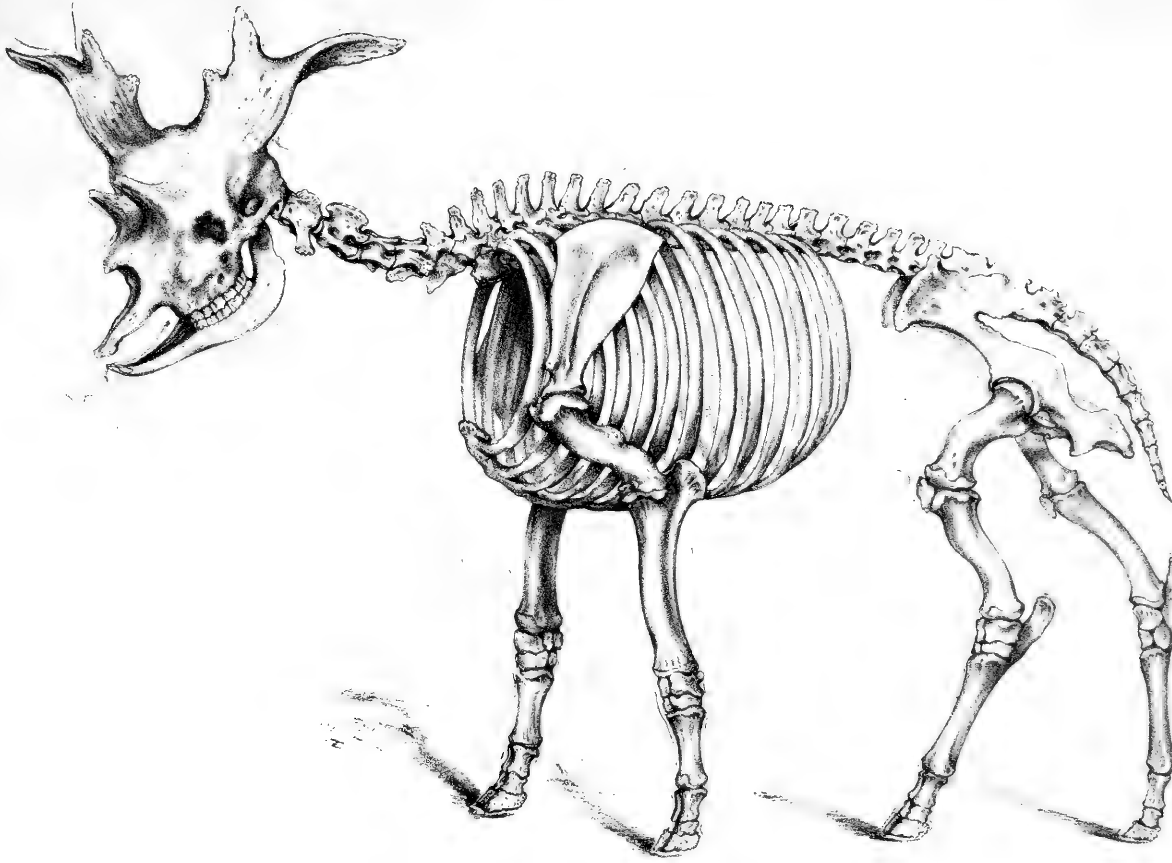
II.—On the Systematic Position of the *Sivatherium giganteum* of Falconer and Cautley.[1]

By Dr. James Murie, F.G.S., F.L.S., etc., Lecturer on Comparative Anatomy, Middlesex Hospital, and late Prosector to the Zoological Society.

(PLATES XII. AND XIII.)

1. *Introductory.*—The fragmentary evidence attesting the presence of former tenants of our globe is just sufficiently tantalizing to permit of glimpses of bygone forms to be evoked; and what is lacking in the relics themselves is supplied by the imagination or reasoned out

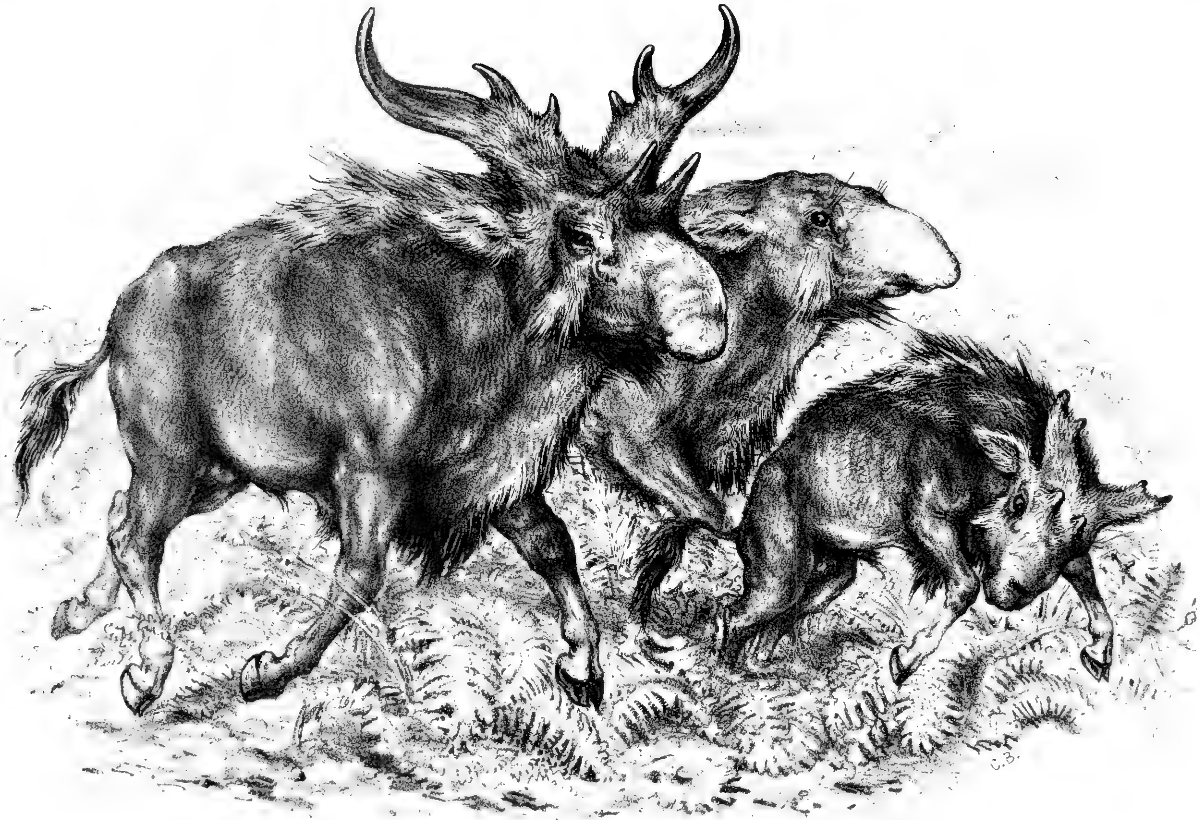
[1] Read at the Meeting of the British Association, Edinburgh, 1871.



C. Berjeau. del et lith.

SIVATHERIUM GIGANTEUM. Falc. & Caut.

J. Murie



[illegible] ♂, ♀ et juv.

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by the aid of existing forms. Palæontology, in truth, is based as yet on a narrow but solid foundation of fact, propped up by much that is uncertain or unstable, which future time must test, try,—accept, or reject. For this reason all adventitious drapery thrown around the remnants of the departed requires to undergo a close scrutiny of its genuineness; and no seeming fittingness can save it from the ruthless hands of succeeding inquirers should any counterfeit be detected.

The very singular animal which I purpose treating of in this paper is one of the magnificent series of fossil forms excavated from the Valley of the Murkunda, in the Sewalik branch of the Sub-Himalayan Mountains.

The indefatigable discoverers of the ancient fauna of the Sewalik range, the late lamented Dr. Hugh Falconer and Capt. Sir Proby T. Cautley (also deceased), first made known and described the remains of the extinct *Sivatherium giganteum*, in a very lucid communication in the Asiatic Researches, vol. xix., p. 1 (1836).[1]

The main deduction may be gathered from the following passage of these authors:—

"The isolated position, however, of the Giraffe and the *Camelidæ* make it probable that certain genera have become extinct which formed the connecting links between them and the other genera of the family, and further between the Ruminantia and the Pachydermata."

"In the *Sivatherium* we have a ruminant of this description connecting the family with the Pachydermata, and at the same time so marked by individual peculiarities as to be without an analogue in its order."

Dr. Falconer's description[2] of the individual bones obviates any lengthened remarks on my part further than what pertains to their supposed taxonomic value. Whilst my observations in some respects support the verdict arrived at by the above-mentioned palæontologist, they nevertheless differ materially as to their ultimate tendency, pending the attempted restoration of the animal.

2. *Form and structure of the horns.*—As regards these, the remarks of the authors of the "Fauna Sivalensis" are so appropriate, and convey so much truth in their deductions, that I do not hesitate to quote their words. Afterwards I shall add what new light my studies enable me to evoke. They observe:—

"Now what was the character of the horns? Were they cores of hollow horns, as in the *Bovidæ*? or branched antlers, as in the *Cervidæ*? or were the front the former and the rear the latter?

[1] A number of figures of the cranium are to be found in the "Fauna Antiqua Sivalensis," xci. and xcii., and in unpublished proof-plates of same, now in the Geological Department of the British Museum. Also in Royle's "Illustrations of the Botany of the Himalayas," vol. ii., pl. vi. See likewise Journ. Asiatic Soc., vols. iv., v. and vi., for descriptions and figures of various bones. Lastly, consult Dr. Charles Murchison's edition of the "Palæontological Memoirs and Notes" of the late Hugh Falconer, M.A., M.D. (Lond., 1868), vol. i., pp. 247-279, where the original paper above mentioned and copious MS. notes are published, accompanied with eight figures, plates 19, 20, and 21.

[2] I refer both to the original paper and the posthumous MS. notes printed in Dr. Murchison's collected edition of his palæontological labours.

"About the front ones there can be no doubt. They are conical, rise rapidly to a point, are smooth, have no burr, are hollow at their base, and are formed of large cells throughout; no ruminant had ever antlered horns of this sort.

"They must, therefore, have been cavicorned cores. Besides, no ruminant with antlers was ever seen with four bases to the horns.

"With regard to the rear ones, their structure is most perplexing, the main branch is hollow, as in the *Bovidæ*, they have no burr, or appearance of articulation; but, at the same time, they give undoubted proofs of having had two branches, the distinct bases of which are seen, and there is every reason to believe they had a third. No cavicorned core is known to be branched in this way, after the manner of the solid antlered horns of the *Cervidæ*, but, at the same time, they have no burr, as all the *Cervidæ* have. They are smooth, they are not solid, as all the *Cervidæ* are, but hollow; at least, the central and outer ones are so. The horns in the *Cervidæ* always come off from the forehead, much in advance of the occipital, with long parietals between. In the *Bovidæ*, they come off exactly overhanging the occipital; so do these. In the specimen the plane of the occipital is exactly as in the *Bovidæ;* there are no distinct parietals, the frontals run up to the occipital crest, and there give off these cores. Therefore, both from structure and analogy, the rear horns of the *Sivatherium* were at least three-branched, and, at the same time, cavicorned."

When the above was penned, the writers were unaware of the existence of a living ruminant whose horns present some of the bizarre construction which so puzzled them: leaving doubts whether the *Sivatherium* was a deer or an antelope. The weight of their evidence leans chiefly towards the *Antilopidæ*. Still the palmate horns, the reverse of antelopes, offered difficulties not easily accounted for.

Recent researches on the interesting North American Prongbuck (*Antilocapra*) reveal the fact that this cavicorned ruminant actually sheds its horns annually, as do the *Cervidæ*. In Dr. Canfield's concise paper,[1] the manner of shedding, and the nature of the horns themselves, is sufficiently lucidly told. The patent facts are: the presence of a forked, flat, hollow horn, annually deciduous, and no burr at the base of the bony pedicle.

To all intents, at least as far as shape, shedding, and renewal are concerned, the Prongbuck's horn might be looked upon as a kind of antler. Still even in the above-mentioned peculiarities it is no antler, but strictly a bovine horn, subject to a periodical removal of its investing sheath.

It is not to be forgotten that *Sivatherium* differed from *Antilocapra* in the possession of four, and not two, horns. This, after all, is only of minor importance, as what may be said of the anterior is in many ways applicable to the posterior horns. The living Indian antelopes (*Tetracerus*) have all four horns conical, and the rearmost pair situate much further forwards than obtains in *Sivatherium*.

[1] Proc. Zool. Soc. Lond., 1866, p. 105.

The enigmatical part of the problem in the *Sivatherium,* palmation and absence of burr, is therefore thoroughly explained in *Antilocapra;* for the core of the Sivathere's hinder horns agrees with it, and does not do so either with the antelope, deer, or giraffe.

Knowing, as we do from the fossil specimens, that the *Sivatherium* had four bony horn-cores, it becomes an interesting question, What surmounted these, to constitute the fully-developed horns? For of the covering, whatever that may have been, no trace has as yet been discovered. Of the front horns it will be readily admitted these may have been similar to those of *Tetracerus* and other straight-horned antelopes.

The hind horns are the most difficult ones to appreciate as regards their casing. One or other of the following conditions necessarily existed.

1. Each posterior horn sheath may have consisted of one deciduous mass of agglutinated hairs, with corneous extremity, as obtains in the living Prongbuck; or this may further have split up at the forks on being cast off.

2. The sheath may have consisted of semi-detached pieces corresponding to the snags, shedding taking place by partition.

3. The core covering might be made up of soft epidermal hairy material, such as clothes the reindeer's horns, and this exfoliate, as in that animal, by shreds when the periodical cessation of its growth had occurred.

4. The front horns, and probably the hinder ones also, were, like those of the giraffe, covered with an investment of true skin, and never cast off.

5. Lastly, both front and rear horns might, as in the *Bovidæ,* have had firm corneous envelopes, not subject to shedding, but persistently retained through life, save when accidentally injured.

Analysis of the above five reasons removes a certain amount of equivocation as to their nature. Admitting, for argument's sake, that the covering of the front horns may have consisted entirely of a horny sheath, as in buffaloes and other *Bovidæ,* it does not follow the hind ones were similarly clothed. Indeed, by force of reason, from their flatness, snags, etc., it could not be so. Hence necessarily follows separation from that family.

It is quite as unlikely they resembled, nay, it may be affirmed that they did not agree with, those of the modern giraffe. The median fore-horn of the giraffe is epiphysial, and springs from the frontal suture. The surface of the bony eminence shows impressions indicating a skin covering. These are absent in *Sivatherium.*

The hind horns of the giraffe, again, are not flat, and branched as in the fossil genus compared; and the osseous surface exhibits cuticular markings. The hind horns of *Sivatherium* are unlike those deer with flat palmate antlers clothed with a hairy membrane; and furthermore, as before mentioned, are devoid of burr; therefore separate from all *Cervidæ.*

Lastly, then, it alone in its entirety agrees with the Prongbuck. I have mentioned the possibility of each snag possessing its own separate covering, though this presents difficulties in the way of the sheath being fastened in separate areas.

By far the most sensible view of the subject, and, indeed, the only satisfactory one which accounts for shape, and absence of suture and burr at the base, is the theory that they must and only could be analogous to those of *Antilocapra.* A horn with certain external aspects peculiar to those of deer; a horn likewise possessing attributes belonging to antelopes and the *Bovidæ;* a horn differing in every respect from that of the Cameleopards.

3. *Peculiarities of the facial bones.*—The imperfect closure of the nostrils by bone, the nasals being of most diminutive size, and apparently unconnected either with the maxillaries or premaxillaries, gives a most aberrant character to the *Sivatherium.*

Its discoverers truly noted its resemblance to the Pachyderms. As a matter of induction, they were led to believe in the probability of its possessing a trunk. A proboscis in a ruminant they considered to be a most anomalous circumstance. Certain genera of the bovine section, *Bos* and *Bubalus,* have shortened nasals, barely impinging on the premaxillaries. Other genera, *Bison, Ovibos,* and *Budorcas,* etc., have nasals which do not reach the premaxillaries, a condition met with in few, if any, deer, except *Alces,* and only occurring sparsely in antelopine genera, notably, in *Saiga, Panthalops,* and *Rupicapra.*

Excepting in the *Saiga,* however, the nostrils and muzzle of the genera mentioned depart little from the ruminant type generally.

Not only does *Sivatherium* and *Saiga* assimilate in the entire separation of the nasals from the maxillary bones, and great saliency of the former, but with true proboscidean feature, have a great scooping out of the bones surmounting the intermaxillaries and maxillaries.

Pallas, long ago,[1] depicted the trunk-like character of the *Saiga's* nose, and recent researches demonstrate the same thing even more fully than he has done.[2]

That the *Sivatherium* had a huge long proboscis, tactile and prehensile, as in the Elephant, or to a lessened extent as in the Tapir, does not seem to be established. Falconer and Cautley, from the structure of the facial bones, infer as much. The bones of the face of the *Sivatherium* and *Saiga* assimilate closely in pattern, and individually correspond; and, as in the latter, we have a soft, flabby, enlarged patulous nostril of moderate dimension, it follows, as a matter of probability, that the same existed in the former, as in the Elk and others. For it is to be borne in mind, when we attribute a pachyderm's trunk to the *Sivatherium,* that the animal had large heavy horns, occipital and prefrontal, a circumstance vastly different from the Tapir and Elephant tribes.

4. *Formation of the base of the skull.*—To Mr. H. N. Turner the merit is due of first appreciating trenchant shades of distinction in

[1] "Spicilegia Zoologica." Berlin, 1777.

[2] *Vide* Proc. Zool. Soc. 1870, pp. 451, 503, figs. 4, 5, 8, and 12 respectively.

the inferior base of the skull of ruminant tribes and other Mammalian groups.[1] He demonstrated salient characters for classifying, in the foramina and relative disposition and development of the bones.

The fossilized condition of *Sivatherium* crania precludes much being drawn from the foramina. The contour of the basal surface of the skull is a most unusual one for a ruminant, the area posterior to the palate and teeth being remarkably broad and quadriform. The length occupied by the teeth is short, and about equal to that posterior to it. This portion of the palate is of moderate breadth; that anterior to it, comprising portions of the maxillaries, is relatively very narrow. Unfortunately, the fore part of the palate is not preserved, but I presume it to have been comparatively narrower than what obtains in the ordinary antelopes. In the basi-occipital we have an element for judging the affinities of the animal. In sheep and goats the bone in question is broadish throughout, and distinguished by what Turner has denoted as anterior and posterior tubercles of the basi-occipital. In the antelopes there is a greater tendency to narrowing forwards of the basi-occiput, but the anterior tubercles are full and prominent. In *Cervus* the said bones are broader posteriorly, but narrow forwards, which gives them a decided wedge-shape; the tubercles, fore and aft, are less marked than in the preceding forms; the posterior tubercles especially almost running, as it were, into the condyles. Nearly the same characters distinguish the oxen, but with this difference, that the median furrow betwixt the tubercles is shallower.

The basi-occiput of *Sivatherium*, as far as I can judge from the fossil specimen, may be said to be intermediate between these two families. It is of triangular form, narrow anteriorly, and with very moderate elevations, representing posterior tubercles. The occipital condyles are very large and wide, and so set backwards as in a great measure to hide the foramen magnum when the skull is viewed from below.

The posterior nares appear rather short and with no great width crosswise. The tympanic bullæ are small and, I presume, laterally compressed, but the mastoid and ex-occipital regions have a considerable breadth, though flat. The glenoid surfaces are very large, and, as Falconer remarks, truly ruminant in character. The result of the characters of the base of the skull with the proviso of a certain amount of obscurity or indefiniteness from deposition of stony matrix, inferentially demonstrate the skull's basis as a modification between that of the deer and ox tribe, with tendencies quite as much to the latter as the former.

5. *The Nature of the Teeth.*—It has been conjectured on good grounds that the *Sivatherium* had no upper incisors nor canines. This necessarily excludes it from the ruminant groups possessing these. As to the molar series, these have one attribute peculiar to a limited section of the ruminants, viz., the enamel exhibits rugose

[1] In three communications laid before the Zool. Soc., respectively published in Proc. 1848-9-50.

reticulations; a mark of giraffe alliance, but one also met with in the fossil *Bramatherium* and *Megacerops*.[1] The next point of importance is the manner of folding of the enamel ridges. "The inner crescent, instead of sweeping in a nearly simple curve, runs zigzag-wise in large sinuous flexures somewhat resembling the form in *Elasmotherium*."[2] Finally, the last true molar, as Owen[3] observes, presents in the *Megaceros* (*M. Hibernicus*, the extinct gigantic Irish Deer) and *Sivatherium* a deeper central enamel island or fold, which also characterizes the smaller third lobe in the giraffe. In short, the construction of the teeth, like that of the horns and fore face, borrow from or assimilate to several incongruous mammalian forms.

6. *Considerations applicable to the neck, chest, and limb bones.*—The remains of seven neck vertebræ are tolerably complete. They show, from their magnitude and strength, that great fleshy masses overlying them must have conduced to the support of the massive head. The atlas is chiefly remarkable on account of the shape of its transverse process, which is concave towards the body, and this, according to Falconer's opinion, distinguishes it from that of other ruminants. The peculiar features of the atlas, as far as I can make out, approach those of the Saiga, save in greater magnitude and relative shortness. The other cervical vertebræ partly resemble those of the buffalo, the ox, and the eland. The spinous processes of the third and fourth are apparently imperfectly developed, and the ends of the posterior ones being broken off, renders it difficult to say what might have been their natural length. The transverse and inferior processes are also incomplete; but doubtless they, as well as the spinous processes, were very strong. Falconer and Cautley in their original paper suggested "that the vertebræ were condensed as in the elephant, and the neck short and thick, admitting of limited motion to the head, circumstances indirectly corroborating the existence of a trunk." The specimens in the British Museum, however, show them to have been truly ruminant cervicals fairly proportioned. Much cannot be inferred concerning the dorsal vertebræ because of their mutilation. They were indeed powerful, and the spines of the first and second at least, long and strong.

The sternum in the antelope and deer groups in general is flat and moderately shallow. Its very great depth and narrowness in *Sivatherium* removes it from these groups, and shows affinity with the stouter-chested oxen. As Falconer's posthumous notes attest, it agrees closely with *Bos urus*, but it differs from this as well as from other ruminants in its complete ossification.

There is a camel-like tendency in the glenoid segment of the scapula.

The humerus in pre-eminence of the deltoid crest trends to equine character. But the general massiveness of the bone altogether ap-

[1] This North American form, the *Megacerops Coloradensis*, has been determined and named by Dr. Linz from fragments described by him at the Meeting of the Acad. of Nat. Science, Philadelphia, Jan. 1870.

[2] Fauna Antiqua Sivalensis.

[3] "Odontography," p. 535.

proaches that of the bullock. Falconer (MS.) avers, "the fore arm presents a sort of transition from the ruminants to the pachyderms." To his able descriptive remarks thereon I can but acquiesce. The carpus is fashioned as is that of a buffalo, and the other bones of the fore limb evince considerable resemblance to those of the same animal.

What has been said of the anterior limb applies in a great measure to the posterior one. Both long and short bones dividing their characters somewhat betwixt the Camelidæ and Bovidæ. The middle shaft of the femur has not been discovered, so that the precise length of this bone is unknown. With this deficiency, it may be said broadly that all four limbs have not the delicacy of pattern of the antelopes; nor are they by any means equivalent to the giraffes in length. Furthermore, they present a greater comparative stoutness relative to length than is found either in sheep, goats, or deer. As has been hinted, with some faint resemblance to camels, they most nearly assimilate to the heavy-limbed cattle tribe, a dawning of pachyderm-like structure being intermingled.

7. *General taxonomic inferences, etc.*—Revising, as I have done, the data from which Falconer and Cautley drew their inferences, and incorporating such new facts as science has furnished, it devolves upon me to elucidate the creature's alliances, and suggest its probable appearance, with hints as to habit.

The most recent division of the ruminants into families gives the grouping as follows[1]:—1. *Camelidæ*; 2. *Giraffidæ*; 3. *Antilocapridæ*; 4. *Bovidæ*; 5. *Cervidæ*; 6. *Moschidæ*; 7. *Tragulidæ*.

The first and two last mentioned for obvious reasons may be excluded as apart from our horned Sivathere, they being deficient in such appendages.

To the antlered *Cervidæ* the *Sivatherium* only approximates in seeming aspect. Its horns, while deciduous, being hollow and differently situated, as has been proved. The *Sivatherium* again is no cerf, inasmuch as the fossil skull shows no supra or ant-orbital fissures. Neither does the co-adaptation of lengthened nasals to maxillæ and premaxillæ at all agree with what is the rule in all true deer. Although the back of the skull and its base show a tendency to cervine type, yet is the line of demarcation sufficiently distinct to strengthen separation. Of cranial features, fleshy and bony, the Elk (*Alces*) is almost the only deer exhibiting likeness to what obtains in *Sivatherium*. But even it is trenchantly separate.

The form of the lower jaw, and the dentition of *Sivatherium*, are those points which best ally it with the *Cervidæ*. Nevertheless, it is possible that some extinct forms may have existed bridging over the line of separation spoken of.

Although the *Giraffidæ* can only boast of a single living species, yet this family in geological epochs undoubtedly was a numerous

[1] *Vide* respectively Drs. Gray and Sclater, Ann. and Mag. Nat. Hist., 1866, pp. 326, 401, and a previous paper by the latter, Brit. Assoc. Report, 1866.

one, and presented many variations which would stop the gaps now existing between it and other ruminants. The giraffe is but a modified deer; yet withal it differs from the latter tribe very materially. It is tricorned, and the horns are persistent, etc. The length of its fore and hind limbs, and even of such of the fossil species that are known, are disproportionate to each other, the former far exceeding those of all other ruminants. In the teeth alone does the *Sivatherium* incline to the *Giraffidæ*.

Coming to the *Bovidæ*, as has been demonstrated, the *Sivatherium* affines itself to oxen in the stoutness of its limbs, sternum, and vertebræ, and also in some parts of the skull structure. It is further removed from the goats and sheep, albeit some *Ovidæ* have four horns.

In the fact of all antelopes having persistent horns, and from other points of skeletal structure heretofore mentioned, the *Sivatherium* in strictness cannot belong to that group. Yet, as I have enunciated, the strange Saiga, which wavers between sheep and antelopes, possesses several facial features strikingly brought out in relief in the remains of the extraordinary *Sivatherium*. But thus far likeness ceases, and the *Sivatherium*, with its deciduous hollow horns, clings most strongly to the unique Prongbuck (*Antilocapridæ*). This latter animal, notwithstanding its singleness of structural organization, exhibits deer-like proclivities in several points, and notably in the existence of ant-orbital fissures.

The fossil *Bramatherium* and *Megacerops* link themselves with *Sivatherium* in greatness of dimensions, in being quadricavicorned, and in similitude of dentition; though these attributes must be used with caution, from the paucity of the fossil remains.

The *Sivatherium*, through the Saiga, as I have mentioned, veers towards pachyderms in nasal conformation, and the splitting of the lower limb bones adds to *Perissodactyle* character.

To not one of the families spoken of does the *Sivatherium* consistently belong. According as we accept horns, skull, teeth, or bodily framework, so does the *Sivatherium* ally itself to the different ruminant families. The strongest expression of character weighs towards *Antilocapridæ*. Admitting as naturalists do that the horns are a guiding wand of taxonomic value, the *Sivatherium*, though not agreeing in all respects, must truly be classed under the family *Antilocapridæ*. But I go further than this, and look upon the *Sivatherium* as a type of a group, and which may be termed the *Sivatheridæ*. Radiating from it can be traced differentiation of structure allying it to the *Bramatherium* and *Megacerops*. Diversely, links lead through the Prongbuck towards the deer, giraffe, and camel; on the other hand, configurations point undoubtedly to the Saiga, and again its affinities are, as it were, split into lines directed towards the antelopes, goats, sheep, and oxen, and even foreshadowing pachydermate conformation. The accompanying diagram illustrates such views, and shows at a glance by what varied tracts we can trace paths from the *Sivatherium* winding and connecting it with nearly all the ruminants besides the thick-skinned *Perissodactyla* and *Proboscidea*.

By such chains of consanguinity are the observations of the

Palæontologist strengthened.[1] After a study of this remarkable form, the *Sivatherium*, one is readily inclined to admit the existence in ages past of generalized forms, towards which the specialized and existent fauna can be traced back.

There is a charm in speculating on the appearance and habits of bygone forms. In the case of the *Sivatherium*, no attempt heretofore has been made to restore it, as has been done to many reptilian, feline, ruminant, and other groups. Witness Dean Buckland's, Mantell's, Waterhouse and Hawkins's, etc., efforts. Plate XIII. gives my ideal of the creature (*vide* descriptive remarks). I have attempted likewise to put together the skeleton on the grounds noticed in the description of Plate XII. How far these are successful must be left for others to judge.

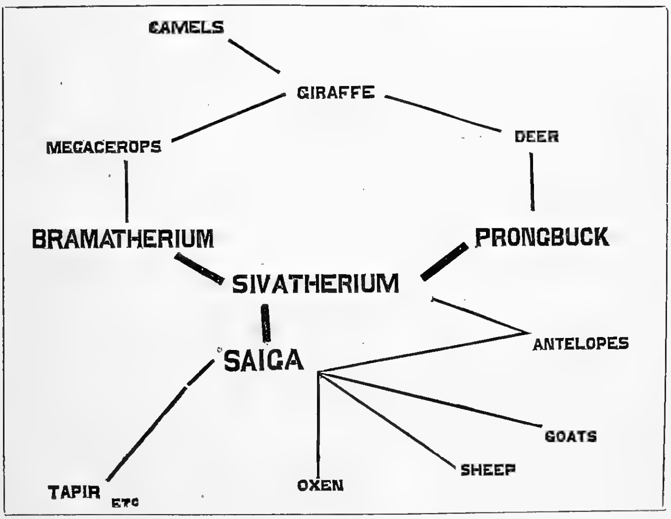


Diagram designed to express the probable relationship of *Sivatherium* with other Mammalian families.

Concerning habits, Falconer threw out the startling doctrine that this ruminant may have possessed and used a proboscis in the manner of the elephants and tapirs. He, moreover, from its dental characteristics, states—"It may hence be inferred that the food of the *Sivatherium* was less herbaceous than that of existing horned ruminants, and derived from leaves and twigs; or that, as in the horse, the food was more completely masticated, the digestive organs less complicated, the body less bulky, and the necessity of regurgitation from the stomach less marked than in the present ruminantia." Only in one of these points am I inclined to give my unqualified adhesion, viz., the probability of its food being coarse and ramal.

[1] Witness the remarks, and genealogical tabular views in the "Animaux Fossiles de l'Attique" of M. Albert Gandry (Paris, 1862): also Rütimeyer's "Beitrage pal. Gesch. der Wiederkauer," Basel, 1865, and various other late writers.

I have already given reasons for believing the nose of *Sivatherium* resembled that of *Saiga*, and remotely the Elk, and was therefore not prehensile. Comparing the same forms, there seems no reason why the digestive organs should not have been as complex as in them and other horned ruminants, and the act of rumination also corresponding. I believe the body to have been quite as bulky as that of cattle and deer, and much more so than in the ordinary antelope group. My conception of the animal I depict and the features tell their own tale, to wit, a creature with several herbivorous traits combined.

I might surmise more regarding this strange animal, and conjure a picture[1] rivalling modern Eastern tales; but with imperfect data haziness, like distance, lends enchantment to the view.

EXPLANATION OF PLATE XII.

Restoration of the skeleton of the *Sivatherium giganteum*, Falc. and Caut.

This is based on the remains deposited in the British Museum, and partly on Dr. Falconer's figures and descriptions of the several fragments in the Calcutta Museum and elsewhere.

The under-mentioned bones, and portions of bones, are separately illustrated in the published and unpublished parts of the "Fauna Sivalensis."

Cranium ♂ and ♀ different views.
Several portions of the horns.
Cervical vertebræ separate and *in situ*.
Dorsal vertebræ, 1st, 4th, and a few joined together, numbers unknown.
Fragments of the sternum, and glenoid, and of scapula.
The fore limb bones nearly complete.
Portions upper and lower end of femur; the entire tibia, calcaneum, astragalus, and scapho-cuboid bones.

The remainder of the skeleton, chiefly ribs, vertebræ, and pelvis, are constructed on a comparative study of similar parts in kindred ruminants.

EXPLANATION OF PLATE XIII.

Design to illustrate the probable appearance of the living form of the *Sivatherium*, male, female, and young. It shows the *Prongbuck*-like horns, *Saiga*-like snout, and other features appertaining to diverse kinds of existing *Herbivores*, which were combined in this extinct form.

III.—On the Relative Ages of Igneous Rocks.

By S. Allport, F.G.S.

In the last number of the Geological Magazine there is an abstract from an interesting and important paper by Prof. Hull and Mr. Traill on the relative ages of certain igneous rocks of Co. Down, Ireland. In that paper there is one paragraph on which I should like to offer a few remarks, as it refers to a previous communication from myself, and relates to a subject in which I take a special interest. The paragraph is as follows:—"It might have been supposed that microscopical examination would show some distinction in the basalts of these geological ages, but recent investigations by Zirkel, D. Forbes, Allport, and others, tend to show that there is no

[1] I refer the reader to Dr. Malcolmson's Geological Deductions, etc., Geol. Trans. ser. 2, vol. v., p. 570; Journ. Bombay Geograph. Soc. 1841–44, p. 371; and Falconer's criticism thereon in his "Fossils of Perim Island."

criterion of age amongst the constituents of basalt, dolerite, or melaphyre."

In the first place, I think Mr. Forbes will object to be placed in this connexion, as he has not long since expressed a very decided opinion that "eruptive rocks of identical mineral constitution have made their appearance or intrusion into the earth's crust at similar geological epochs;" and, conversely, that "when the geological epochs of the appearance of two or more intrusive or eruptive rocks are known to differ, these rocks will then also be found to differ essentially in mineral constitution."[1] Then with respect to Prof. Zirkel, I am not aware that he has anywhere stated that the old melaphyres and more recent basalts are mineralogically the same; in fact, in his work on the basalts, published in 1870, he says, in an appendix on melaphyre,[2] "the structure and mineralogical constitution of these apparently compact rocks still remains in the greatest obscurity;" and then gives the results of the examination of a few specimens, reserving definite conclusions on their composition, etc., till further evidence is forthcoming. It is clear, however, that he perceived a close resemblance between the two series.

Now it would appear from the above quotations, that my investigations have led me to conclusions completely at variance with those arrived at by Mr. Forbes, and I am not aware that others have shown that there is no essential difference between eruptive rocks of different geological epochs. I arrived at this conclusion more than three years since, as the result of a microscopic examination of very many sections prepared by myself, and I am under the impression that I have been the first to ascertain the fact.

I have abundant evidence that melaphyres of undoubted Carboniferous age, and basalts of Tertiary age, have not only the same mineral constitution, but also that both present the same structural varieties.

A highly characteristic structure in many basalts is that in which the various constituents form a close net-work of crystals in actual contact with each other, without any intervening cement; in others, there is a vitreous, or semi-vitreous base, in which the crystals are imbedded; or, in many, the rock is composed of a mass of very minute crystals, in which larger ones are porphyritically imbedded.

Now it is an interesting fact, that these varieties of texture are equally common in the older melaphyres, affording, I think, additional evidence that both were formed, not only of similar materials, but also under like conditions. There is, in fact, no lithological or petrological difference whatever between them, for both agree completely in composition, texture, and modes of occurrence.

The statement that there is no mineralogical difference, will, of course, be understood to apply to the least altered portions of the older rocks, for the latter have generally undergone a very considerable amount of alteration; but the difference thus set up between them is one which may be readily recognized as due to chemical or

[1] Researches in British Mineralogy, Phil. Mag., vol. xxxiv. p. 336.
[2] Untersuchungen über die Basaltgesteine, p. 198.

other metamorphic action subsequently to their formation. In order to acquire a knowledge of such facts, it is necessary to make a careful study of rocks in various stages of alteration,—a study of great interest, and of quite as much importance as the examination of specimens supposed to be unaltered; in fact, to select a typical specimen, and make a single section of it, is to leave off at the beginning of the work. By making a number of thin sections from well-selected specimens, a series may be obtained in which all the minerals are to be seen in various stages of alteration; and as some of the changes are very characteristic, it becomes possible to recognize the original composition of a rock, although it may now differ completely in appearance from its original state.

Since I first discovered the invariable presence of olivine or its pseudomorphs in the old basaltic rocks (melaphyres) of the Midland Counties, I have extended my inquiries to the Scottish Coal-fields and to other formations, and have obtained ample confirmation of previous observations, as well as many additional facts. The evidence appears to indicate very plainly that there is no essential original difference between the true eruptive rocks of early geological periods and those of recent or Tertiary age; the later glassy and trachytic rocks are closely analogous to the older pitchstones and porphyrites, while the occurrence in Skye and other places of granites and syenites of Tertiary age affords equally strong evidence in the same direction.

Satisfactory methods of investigation have been so recently employed, that very much remains to be done; but it is already tolerably clear that the difference now found to exist between the so-called *Plutonic* and the volcanic rocks is due to the metamorphic action to which the former have been exposed during the long periods which have elapsed since their original formation.

IV.—The Butley Crag Pits.

By Alfred Bell.

In the July Number of the Geological Magazine a well-known geologist[1] has endeavoured to prove the existence of sands of the Chillesford age in the Crag Pits near Butley, referring more especially to that on the Neutral Farm, near the Oyster Inn; and as I cannot agree with this opinion, I venture to lay before the readers of the Magazine some of the notes upon which I ground my dissent.

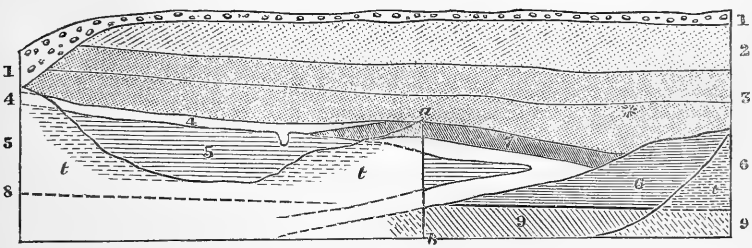
The accompanying figure represents the section now presented by the excavation in question, which has been cut into a gently rising slope for nearly 300 feet in length, by about 35 feet in its deepest part. From the extreme right of the figure the side of the excavation returns at nearly a right angle to the road, thus showing a cross section.

The top of the pit is covered with drift sand (full of minute particles of quartz), containing a large number of rolled stones

[1] The Relation of the Red to the Norwich Crag, by J. E. Taylor, F.G.S., Geol. Mag., July, p. 314.

(No. 1). Below this are reddish sands passing downwards into yellow (2), then into red again (3), and, lastly, a vein of fine white sand (4), the latter extending rather more than half way across the pit. At * a large mass of brownish clay, full of casts of the common mussel, and well-preserved Trochi (*T. cinerarius*), was to be seen. The remains of this fell down a few days ago while I was there, presenting to view the red sand above mentioned. These sands, etc., are about 18 to 20 feet thick, and are nearly, except where in contact with the Crag, *totally devoid* of organic remains. Finely comminuted shells occur at the lines of junction.

Below these sands are the Crag beds, the two main portions (5 and 6) being separated by a singular deposit of sand (7), the upper side of the angle of the sandy division becoming slightly fossiliferous and false bedded. The beds (5 and 6) themselves are composed of nearly horizontal layers of shells, with intercalated beds of sand. A series of layers of fine sand and shells, having a rapid dip, being the lowest deposit seen. Unfortunately, the Crag beds are largely covered by a talus of fallen sand.



SECTION OF PIT ON THE NEUTRAL FARM, BUTLEY, SUFFOLK.

1. Black sand with rounded water-worn stones.
2. Red sands passing gradually down into
3. Yellow sands.
4. Pure white sand.
5. Red Crag, full of shells.
6. Red Crag, also full of shells.
7. Unfossiliferous sand, partly false-bedded at the top, separating 5 and 6.
8. Line of Freshwater shells.
9. Red Crag, with shells.

t, t, t = talus, cut off artificially at the line *a, b,* to the right of which the lower part of the section is exposed.

The cross section gives traces of considerable erosion, bed 6 being worn away several feet (behind the talus), and then suddenly rising to a height of 17 or 18 feet above the level of the lowest Crag exposed on the floor of the pit, and then sinking till it is not more than 5 feet in thickness. The summit of this pinnacle is composed of horizontal layers of finely comminuted shells, with a few perfect valves, double and single, of *Mactra ovalis.*

Mr. Taylor remarks upon the absence of the Red Crag shells and the thorough Chillesford facies of the Upper deposits. I am not aware that in any deposit hitherto assigned to the Chillesford pre-Glacial stage, any of the following species, which are strikingly Red Crag forms, have been found: *Cardium venustum, C. interruptum* and *C. angustatum, Nucula lævigata, Gastrana laminosa, Cancellaria scalaroides, Cypræa avellana,* or *Ovula spelta.* These are but a few amongst the number (see list). Secondly. The Fusi, if washed out of an older bed, would have suffered the loss of their apices. Thirdly. Of the seven species quoted as being undoubtedly Norwich Crag forms, all are common in the oldest Red (or Middle) Crag beds, and three occur in the Coralline (Lower) Crag also.

The condition of the shells is against the presumption that they have suffered from being rolled about; they are in general very perfect, except towards the extreme right of the pit, where the greatest amount of comminution obtains.

After the Crag bed (6) had been deposited or beached up, the fine sand (7) was thrown down, this passing under the Crag bed (5). In this Crag bed occurs a remarkable horizontal layer, about one foot thick (No. 8), of fossils, composed of land and freshwater forms interspersed amongst others purely marine. At present it is covered by the sandy talus. From this, and an overlying mass of red sand, several species were procured (see list), many of which range into the *topmost* layers of shelly matter.

The greater part of the Molluscan fauna are of recent forms, as they also are at the adjacent pits at Butley Mill, and the Chillesford Stackyard. This latter pit contains *Scrobicularia piperata* towards the top, upon which the *true* Chillesford sand is superimposed. This shell does not occur to my knowledge at Butley, and its presence in abundance implies a change in the depth and condition of the then sea.

Lastly. To compare the fauna of the Chillesford sands at Chillesford and Sudbourn Church Walks with those of the Butley Neutral Farm, and Mill Pits, the large form of *Mya truncata*, *Lucinopsis undata*, *Leda lanceolata* (except a large fragment), and *Scalaria Turtonis*, have not yet been obtained at either of the Red Crag pits mentioned; but if the whole series of Chillesford shells are collated with those of the earlier deposits, it will be found that *Scalaria* and *Lucinopsis* are the only shells out of nearly 130 species, peculiar to the Chillesford beds, and one *Echinus* (*E. lividus*). These cannot therefore be said to have a facies *peculiarly their own*.

Of the 192 species in the following list, not more than 20 are unknown in a recent state, and a comparison of this with the Chillesford fauna will best explain the reason why I consider the Butley pits do not contain deposits of Chillesford age.

Fossils from the Crag Pits at Butley, Suffolk.

† Peculiar to the "Neutral Farm" Pit.
* Peculiar to the Pit near the Mill.

The unmarked species are also found in some other Red Crag Pits.

PISCES.
Raia (not *antiqua*).
Lamna.
Platax Woodwardii.
ANNELIDA.
Ditrupa gadus.
CRUSTACEA.
Cancer pagurus.
Balanus crenatus.
„ *Hameri.*
„ *porcatus.*
RADIATA.
Echinocyamus pusillus.
* *Toxopneustes Dröbachiensis.*
MOLLUSCA.
† *Planorbis complanatus.*

† *Limnœa palustris.*
† ,, ,, var. *Holbollii.*
† ,, *pereger.*
† ,, *truncatulus.*
† *Helix hispida.*
† *Pupa marginata.*
Melampus pyramidalis.
Terebratula grandis (a much worn valve).

Anomia ephippium.
,, *patelliformis.*
Ostræa edulis.
Pecten maximus.
,, *opercularis.*
,, ,, (var.) *gracilis.*
,, *tigrinus.*
Pinna rudis.
Mytilus edulis.
Modiola modiolus.
Arca lactea.
,, *tetragona.*
Pectunculus glycimeris.
Nucula lævigata.
,, *nucleus.*
,, *tenuis.*
Acila Cobboldiæ.
* ,, *Lyallii.*
† *Yoldia hyperborea.*
,, *lanceolata.*
† ,, *myalis.*
Cardium angustatum.
,, *lævigatum ?*
,, *edule.*
,, *interruptum.*
,, *nodosum.*
,, *venustum.*
Serripes Grœnlandicus.
Lucina borealis.
Loripes divaricatus.
Diplodonta trigonula.
,, *rotundata.*
Kellia ambigua.
Scacchia elliptica.
Cyprina Islandica.
Astarte compressa.
,, *incrassata ?*
,, *obliquata.*
,, *Omalii.*
Woodia digitaria.
Cardita corbis.
,, *chamæformis.*
,, *scalaris.*
,, *sulcata.*
Venus fasciata.
,, *ovata.*
Cytherea rudis.
Artemis exoleta.
Mactra constricta.
,, *elliptica.*
,, *ovalis.*
,, *subtruncata.*
Tellina calcarea.
,, *obliqua.*
,, *prætenuis.*
,, *crassa.*
Gastrana laminosa.
Syndosmya alba.
Solen siliqua.
Mya arenaria.
,, *truncata*, (var.) *pullus* only.
Corbula gibba.
Corbulomya complanata.
Saxicava Norvegica.
,, *rugosa.*
Glycimeris angusta.
Pholas crispata.

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† *Murex erinaceus.*
,, *tortuosus.*
,, *Lachesis.*
Cancellaria varicosa.
Admete viridula.
Fusus altus.
,, *antiquus.*
,, *contrarius.*
,, *costifer.*
,, *gracilis.*
,, *Sarsii.*
Trophon muricatum.
,, *Barvicense ?*
,, *scalariforme.*
Buccinopsis Dalei.
Buccinum undatum.
,, *ciliatum.*
,, *Grœnlandicum.*
Nassa granulata.
,, *incrassata.*
,, *labiosa.*
,, *propinqua.*
,, *monensis.*
,, *pygmæa.*
,, *reticosa.*
,, *variabilis.*
,, *Ascanias.*
Ringicula ventricosa.
Purpura lapillus.
,, *tetragona.*
Columbella sulcata.
,, *abbreviata.*
Defrancia reticulata.
,, *linearis.*
,, *purpurea.*
Pleurotoma bicarinata.
,, *Bertrandii.*
,, *contigua.*
,, *costata.*
,, ,, (var.) *coarctata.*
,, *exarata.*
,, *harpularia.*
,, *mitrula.*
,, *nebula ?*
,, *nobilis ?*
,, *pyramidalis.*

Pleurotoma rufa.
,, *turricula.*
,, *violacea ?*
Voluta Lamberti.
Cypræa Europæa.
,, *avellana.*
Ovula spelta.
,, *Adriatica.*
Amaura candida.
Natica borealis.
,, *catena.*
,, *catenoides.*
,, *affinis.*
,, *occlusa.*
,, *Grœnlandica.*
,, *Alderi.*
,, *Montacuti.*
,, *Islandica.*
,, *millepunctata.*
,, *hemiclausa* (=*N. macilenta*).
* *Odostomia*, sp.
Chemnitzia internodula, and var. *conica.*
,, *plicatula.*
† ,, *communis.*
Cerithium borealis (*granosum*, S. W.).
,, *tricinctum.*
,, *reticulatum ?*
Aporrhais pes-pelicani.
Turritella incrassata.
Vermetus subcancellatus.
Scalaria clathratula.
,, *Grœnlandica.*
Littorina littorea.
Lacuna subaperta.
Rissoa pulchella (S. Wood, not Philippi).
Paludestrina pendula.
Trochus Adansonii.
,, *cinerarius.*
,, *granulatus.*
,, *Montacuti.*
,, *occidentalis.*
,, *subexcavatus.*
,, *tumidus.*
,, *villicus.*
Fissurella Græca.
Emarginula fissura.
Calyptræa Chinensis.
Capulus Hungaricus.
Tectura virginea.
Lepeta cæca.
Dentalium dentale.
Actæon tornatilis.
,, *subulatus.*
Cylichna cylindracea.
POLYZOA.
Cellepora compressa.
Eschara sinuosa.
Fungella multifida.
ACTINOZOA.
Balanophyllia calyculus.
Sphænotrochus intermedius.
PROTOZOA.
Cliona celata.

In a former paper, "On the English Crags, etc.," GEOL. MAG., June, 1871, the Butley Crag was considered to be a shallow water deposit of the Upper Crag, and that near Shottisham Creek, by the river Deben, to be a deep water one; and in comparing the fauna, the latter, I think, should be contrasted with that of the Chillesford stage, which I consider to be indicative of much deeper water than either the Butley or Chillesford (*Scrobicularia*) pits. The following species do not occur in the shallow water deposits, and are from the Shottisham Creek pit.

d. = double bivalves.

d. *Terebratula grandis* (var.)
d. *Rhynchonella psittacea.*
Pecten pusio.
Cardium Parkinsoni.
Cyprina rustica.
Mactra arcuata.
Syndosmya obovalis.
Gastrochæna dubia.
Fusus Largillierti.
,, *cordatus.*
,, *Turtonis.*
Purpura incrassata.
Terebra inversa.
Cassidaria bicatenata.
Columbella Borsoni.
Pleurotoma striolata.
,, *pygmæum ?*
Pleurotoma galerita.
Pleurotoma valvula.
Conopleura crassa ?
,, *elegans ?*
Erato lævis.
,, *Maugeriæ*
Cypræa retusa.
,, *Angliæ.*
,, *Dertonense.*
Cerithiopsis tuberculare.
Scalaria subulata.
,, *varicosa.*
Trochus multigranus.
,, *ziziphinus.*
Capulus unguis.
,, *militaris.*

Hornera infundibulata.
Lunulites conica.

P.S. While I am upon the Crag formations, I shall beg leave to refer to the Palæontology of two papers in the September Number of the GEOLOGICAL MAGAZINE by Dr. Mörch, and Mr. S. V. Wood, jun.

I. Dr. Mörch's paper on the Mollusca of the Crag-formation of Iceland.

No. 4. *Natica varians.* The Crag shell so named I am inclined to refer to Brocchi's *N. helicina,*[1] on the authority of the Marquis Monterosata, to whom I submitted some Italian shells corresponding with those of the Crag. It is not *N. borealis* of Gray, which is a high Arctic form of *N. Grœnlandica,* and a Crag shell. (See Butley list.)

No. 5. *Natica hemiclausa,* Sow., except in size, cannot be distinguished from a living Mediterranean shell, *N. macilenta,* Phil.

No. 6. *Natica occlusa,* S. V. Wood, *not* Winkler.

No. 16. *Fusus Olavii,* Beck., var. *Spira longa,* is probably the shell for which I have suggested the name *F. cordatus.*

No. 20. *Nassa monensis,* Forbes. The figure of the type shell was not given, and the type specimen itself is lost. The determination of the species in the English Crag rests upon Forbes's identification. The Crag shell is not unlike some forms of Philippi's polymorphous *N. variabilis.*

Dr. Mörch is in error in assigning to the English Crags the following forms: *Patella pellucida, Cyrtodaria siliqua, Astarte crebricosta.* and *Modiolaria nigra.*

From the matrix of several specimens of Icelandic Crag (?) fossils kindly given me by Dr. Mörch, and the fact that most of the species recorded in his list, which are not fossil in the English Crags, such as *Natica aperta, Tritonium Tottenni, T. scalariforme, Cyrtodaria siliqua,* etc., are Northern forms, I am inclined to refer this very interesting deposit to a much later period than the age of any of our English Crags.

II. Mr. S. V. Wood, jun., Sequence of Glacial beds.

Nucula Cobboldiæ and *Astarte Omalii,* quoted as both extinct species. The former is an inhabitant of the Japanese seas, and is described by Dr. Gould (Otia. Conch. p. 175) as *N. insignis.* The opportunity of comparing the Japanese and the Crag shells I owe to the kindness of Mr. Jeffreys.

Astarte Omalii=*A. undulata,* Gould, living in Massachusetts Bay, etc.

Cardita corbis is a native of N.W. America. P. P. Carpenter.

Lastly. Does not the presence of *Melampus pyramidalis, Turritella incrassata,* and *Nassa semistriata* (or *labiosa*) in the Wexford drift, point to an age nearer the Chillesford pre-Glacial stage than to a later period.

[1] The *N. helicina* of Brocchi is assigned to *N. catena* by Mr. Jeffreys, and to *N. sordida* by some Italian naturalists. Michelotti figures a specimen of *N. millepunctata* as *N. helicina,* and Philippi also figures another (?) species under Brocchi's name!

V.—On the Silurian Rocks of the Counties of Roxburgh and Selkirk.[1]

By C. Lapworth and Jas. Wilson.

For the last three summers we have devoted the greater part of our leisure time to the examination of the Silurian Rocks that lie more immediately between the Moorfoot Hills and the English border. Our investigations have been attended with a fair amount of success, and we thought that a short summary of what we have accomplished would not be wholly uninteresting to the Geological Section. As these old Silurian strata of the South of Scotland have only been once alluded to in the papers already read at the Meeting—namely, by the Chairman in his eloquent address—we may be pardoned if we say a few preliminary words concerning them.

These Silurians fill up almost the whole extent of Scotland that lies to the south of the great central Carboniferous basin, and stretch uninterruptedly from sea to sea, forming the largest area of unaltered Silurian in the British Isles. The investigation of these rocks is attended by almost insurmountable difficulties. In the district to be described, the beds are folded and contorted in the most remarkable manner, so that it is possible to walk for a mile across the dip where the rocks are well exposed—as, for instance, in the beautiful glen of the Yarrow, below the old peel of Newark—without ascending or descending more than three hundred feet in the order of the beds, and this, when the rocks are pitching at angles, varying from 80° to the perpendicular. All these old strata have pretty much the same lithological character throughout; there are no limestones, scarcely any conglomerates, and only one constant easily recognizable bed among them; and not only so, but previous to our labours, scarcely any fossils had been discovered, except in a few isolated spots, from which the age of these ancient sediments could be determined. With all these difficulties in the way of their investigation, there can be no wonder that these rocks have been neglected by geologists for the younger and more promising formations, and that the Government Geological Survey have been forced to colour all the beds of this district already surveyed of a uniform purple tint. Nevertheless, much has already been done, and well, and the well-known names of Murchison, Nicol, Harkness, and Geikie, are only the first of a long array of those who have laboured long and devotedly among them.

Small portions of the district more particularly examined by us were described by Professor Nicol, in papers read before the Geological Society of London, and published in volumes iv. and vi. of their journal.

He discovered *Graptolites Griestonensis* (Nicol), *G. Sedgwickii* (M'Coy), and *G. priodon* (Brown) in the Grieston Slates, and a peculiar form he called *Graptolites laxa* in the Thornilee Quarry. He mentioned the fact of dark schists with carbonaceous markings

[1] Read before Section C of the British Association, Edinburgh.

occurring in the flanks of Ernton Fell in Liddesdale, and, arguing from lithological characters alone, considered that some of the beds to the south of Hawick were of Upper Silurian age; but in a section exhibited by him at the meeting of the British Association at Belfast in 1852, and afterwards published in Sir Roderick Murchison's Siluria, he relinquished this opinion, and held that the Southern beds were of the age of those associated with the Moffat Anthracite.

The Geological Survey of Scotland published maps and explanations of much of the northern portion of the district. In Berwickshire, *Graptolites priodon* was discovered at Byrecleuch, in Headshaw Burn black shale with *Dip. pristis*, and also on the sides of Browbeat Rig, in Peeblesshire. No evidence was, however, obtained by which the strata could be split up, and the whole of the Silurians mapped were coloured in one uniform tint.

This is the sum of what was known of the district before we began our investigations, and that which is additional in this paper is mainly the result of our own labours.

In an able, and at that time exhaustive paper on the Silurians of South Scotland, by Professor Geikie, published in the third volume of the Transactions of the Geological Society of Glasgow, the following sub-divisions of the strata were recognized:—

1. The purple schists of Eskdale-muir.
2. The thin bedded flags of Glenkiln, etc.
3. The greywackes and shale of Moffat.
4. The thick grits of the Broad Law and Innerleithen.
5. The Wrae and Winkstone beds.
6. The blue grits and shales bordering the great Carboniferous basin.
7. The Girvan beds.
8. The upper Silurians of Kirkcudbright.

Our divisions are in effect the same as those of his. Our plan, however, has been to name the several groups of strata after the towns near which they attain their greatest development, and thus we have in our country:—

1. The Hawick rocks.
2. The Selkirk beds.
3. The Moffat series.
4. The Gala group.
5. The Riccarton beds.

Nos. 1, 2, 3, answer to Professor Geikie's divisions 1, 2, and 3 respectively. The Gala group embraces his divisions Nos. 4, 5, 6, and possibly also the greater part of No. 7, while the Riccarton beds are the exact equivalent of his No. 8.

It is well known that these Silurian beds of South Scotland dip away from an anticlinal line that runs in a N.E. direction from Dumfries to Berwick, and that the rocks lie, as a whole, in an ascending order as we proceed in a N.E. or S.W. direction at right angles to this line.

Taking advantage of this fact, we will briefly describe the strata as they occur in this way, first to the north, then to the south, of this axis :—

1. *The Hawick Rocks.*—The great anticlinal and the beds for a few miles on either side consist in this district of very arenaceous grey and purple sandstones and schists. The purple colour is most conspicuous in the west between Dumfries and the dreary uplands of Eskdale-muir, but dies almost entirely to the east, where we find the prevailing tint is a dull brownish grey. These strata are best seen on the hills to the north of the town of Hawick, where their upturned edges, which are singularly bare of soil or clay, have been cut and carved by the old ice-sheet into narrow streamless valleys, sometimes closed at one end by an abrupt cliff of rock overhanging a lonely tarn.

Professor Harkness found the track of a Crustacean in these beds at Binks, a few miles to the south of the axis. We have ourselves detected *Protovirgularia* and *Annelides* within a mile of it; but our friend Professor Elliot of Goldielands, who has devoted himself to the careful investigation of these strata, has met with much greater success, and has procured specimens of worm-tracks, *Arenicolites, Protichnites trichoides,* rain prints, ripple markings, and those peculiar forms called plants by some of the American geologists, in great variety and abundance.

These ancient rocks bear a strong resemblance both in their lithological characters and in their fossil contents to the Cambrians of the Longmynd, but they are very probably of later age.

2. *The Selkirk Beds.*—As we proceed farther from the axial line, the arenaceous character of the rocks is gradually lost, and we pass insensibly upward into a great thickness of fine grained grits, flags, and shales of a very light grey or greenish colour. The whole of the beds are much crumpled and jointed. The thicker strata are usually veined with calc-spar, some of the veins being more than a foot in thickness. Almost every joint is coated with the same substance, and this gives the whole set of strata a very peculiar appearance. These rocks cover a large tract of country to the west of the Hawick rocks, which, however, gradually decrease as we proceed to the south-west, where we have found that the Selkirk and Hawick beds slowly die away to a point between the Upper Silurian and Moffat beds of Kirkcudbright.

We have only procured a couple of species of *Protovirgularia,* a Crustacean, and a few Annelides from these rocks; but the beds look very promising in places, and we expect a much richer harvest in the future.

3. *The Moffat series.*—Immediately to the north of the Selkirk beds, we reach another set of strata of a little more inviting appearance. It consists of thick and thin beds of greywackes and shales of a dark grey or greenish colour, often weathering, especially where a little altered, of a brownish or yellowish colour. The great feature of the series, however, is the bed of anthracitic shale at its summit. This band is of incalculable assistance to us in working out the order of this portion of the system, as it seems to be continuous from sea to

sea, and appears to retain very much the same characteristics throughout the whole length and breadth of the northern slope. It is beautifully developed in the neighbourhood of Moffat. In one place, stretching in an unbroken and slightly undulating line of ten or twelve miles, afterwards let down by little faults that cut it entirely out at irregular intervals; in a second, folded in such a way that the outcrop maps a number of sub-parallel inosculating lines; in a third, shown as a long fusiform patch peeping from a denuded anticline, or left snug in the hollow of a synclinal fold. The mineral character of this bed, the deep black shale loaded with graptolites, and the yellow or white mud-stones, all disfigured by stains of oxide of iron, so clearly mark the bed, that it is picked out at once from the surrounding strata. These shales and mud-stones, where they are unaltered, are easily destroyed by the elements, and their position is frequently marked by a deep red gash, conspicuous against the dark heather high up on the mountain side, and visible at a great distance. It is the metropolis of the Graptolites in Scotland, and is crammed with a great variety of peculiar species—the majority of them, in fact, being unknown in beds of later age.

In the St. Mary's Lake districts, the Douglas Burn, the Upper Tweed, and in the Holms Water, we ascertained that these beds come up again and again, and almost the whole of the country in that direction must consist of beds of Moffat age; but the ground they occupy in the district we are describing is comparatively small. We find them in two distinct areas—one to the north, the other to the south, of our Gala group. To the south, they succeed at once to the Selkirk beds, and contain a couple of lines of the anthracite band—one running from the rapids of the river at Ettrick Bridgend for about four miles, till it is lost under the gravel of the Ettrick, near Selkirk; the second, emerging from below the Gala beds at Ettrickbank, is continued in a broken line through Lindean, the romantic dingle of the Rhymer's Glen, and Melrose, till it plunges beneath the Old Red Conglomerate near Leaderfoot. It thins out very rapidly, however, in this distance, being only about a few feet thick at its termination. We have detected in these bands a great number of the Moffat fossils, including:—

Siphonotreta micula, M'Coy.	*Cladograpsus capillaris*, Carr.
Acrotreta Nicholsoni, Davidson.	*Heliocograpsus gracilis*, Hall.
Dicranograpsus ramosus, *D. sextans*, Hall.	*Diplograpsus pristis*, His.
Dicellograpsus Forchammeri, Gein.	,, *Whitfieldii*, Hall.
,, *Moffatensis*, Carr.	,, *vesiculosus*, Nich.
Cladograpsus linearis, Carr.	*Climacograpsus teretiusculus*, His.

and a few other peculiar Moffat species, but the beds are usually so crushed and altered that they can only be procured in very small fragments.

The whole Moffat series then sinks below the Gala beds, afterwards to be described, and comes to the surface again along the northern edge of the Silurian.

We have found here three distinct lines of the anthracitic band running approximately parallel and pretty close to each other.

One goes very near to the great fault from the north slope of the Moorfoots to the Gala near Heriot Station; the second, from the centre of Blackhope Burn, down the lower course of the Heriot water; while a third cuts through the high ground at the sources of the Leithen and South Esk. These beds are much altered and crushed, but we have obtained a great number of Moffat Graptolites from each and all of them, more especially from Browbeat Rig, where the fossils are most numerous and in the best preservation.

From the northern line we obtained:—

Diplograpsus pristis, His. *Diplograpsus vesiculosus*, and a *Dicranograpsus*. *Climacograpsus teretiusculus*, His.

From the middle band:—

Diplograpsus pristis, His. *Diplograpsus tamariscus*.
" *vesiculosus*, Nich. *Cladograpsus linearis*, Carr., etc.

While the third line has yielded in addition:—

Dicanograptus ramosus, Hall. *Dicellograpsus Morrisii*.
Dicellograpsus " sp. " *Moffatensis*, Carr.

and a few others.

The Gala Group.—Lying in the irregular trough formed by these two appearances of the Moffat rocks, we find an entirely distinct series of strata of a very varied lithological character, and known to us as the Gala group. We made out enough of the fossils of these beds in 1869, to see that they formed a fauna clearly separate and distinct from that of Moffat, and our discovery was published in a paper read before the Geological Society of Edinburgh, in March, 1870.[1] At that time, our investigations had been confined to the beds in the neighbourhood of Galashiels, but we have since examined a great deal of the country, both to the west and north, still finding the same fossils. In that paper, we split up the beds as known to us into four portions, which were, however, almost entirely geographical, and were only useful as an index of the localities of the different fossil forms. Although we have expended a great amount of labour on the group since that time, we think that it would be rash were we to attempt to give any sub-divisions at present, though, with such well-marked differences in the strata, we are of opinion that it will soon be possible to split up the formation.

The usual type of rock is a grey thick-bedded grit, separated by a seam or bed of shivery shale, but there are large areas of purple sandstones and mud-stones, and thick beds of grey shale, together with masses of pebbly grit and conglomerate.

One of the lines of pebbly grit runs for a mile or two close to the north of the town of Galashiels, while a second appears to underlie the Grieston Slates from the head of the Douglas Burn almost to the town of Stow, a distance of fourteen miles. It consists in its typical form of a coarse grey grit, containing large nests or heaps of pebbles, rounded and angular, that often weather out, and leave a honeycombed rock of a peculiar appearance. It is seen, however, in some places entirely without these pebble-beds, and bears only a large solitary stone here and there.

[1] See Geol. Mag., 1870, Vol. VII., p. 204, Pl. VIII., and p. 279.

There is also another conglomerate made up of millions of little white quartz pebbles, very like that of the Winkstone Quarry, and which is traceable in four distinct lines to the north of the pebbly grit. This conglomerate contains both rounded and angular pieces of the Moffat shale, often full of its characteristic graptolites. Some of these fragments are much altered, and full of little quartz veins, and exactly resemble the little pebbles of the altered Moffat shale now found in the burns; proving that in some localities, at least, the anthracite beds must have been hardened into rock, upheaved, and greatly altered before this conglomerate was deposited. The first line appears to cap the Grieston slates throughout, the second runs across the hill tops between Fountainhall and the Luggate water, for a distance of six or seven miles. The third appears a little to the north of this, and at the cottage of Ladyside, and the fourth runs parallel with the anthracite down the south bank of the Heriot. There are also thin bands of carbonaceous shale that run on for many miles, more especially towards the bottom of the group.

The fossils of the Gala group include:—

Diplograpsus palmeus, Barr.
" *bullatus*, Salter.
Graptolithus priodon, Bronn.
" *colonus*, Barr.
" *Sedgwickii*, M'Coy.
" *sagittarius*, His.
" *lobiferus*, M'Coy.
" *Salteri*, Geinitz.
" *Griestonensis*, Nicol.
" *Nilssoni*, Barr.
" *turriculatus*, Barr.
Graptolithus socialis (n. sp.).
" *gemmatus*, Barr.
Rastrites Linnæi, Barr.
Retiolites Geinitzianus, Barr.
" *obesus* (n. sp.).
Dictyonema (sp.).
Ceratiocaris (2 species).
Aptychopsis (2 species).
Peltocaris aptychoides.
Annelidæ, such as *Crossopodia.*
Nereites, and many others.

The fauna is, as a whole, remarkably different from that of the Moffat series. About 9-10ths of the Graptolites of the anthracitic band have disappeared, the branching forms all extinct, and their place is usurped by the mono-grapsus, which is specifically unimportant in the Moffat beds. This change is very sudden, as nearly the whole of the peculiar Gala forms may be collected within a few yards of the anthracitic band itself, both in the neighbourhood of Galashiels, and apparently also on the Douglas water. The great alteration in the fauna cannot be due to a change in the condition of the sea-bottom, for the beds from which the lowest Gala species are obtained are black carbonaceous shales, of a foot or two in thickness, with an out-crop that seems to be continuous for nine or ten miles at a stretch.

The great majority of the Gala species run from the base to the summit of the group, proving the unity of the whole, but rendering it utterly impossible to subdivide the strata by means of the fossils.

For these and many other reasons, which time will not allow us to discuss here, we consider that the Gala group is a distinct and single division of the Silurian rocks, commencing immediately above the anthracite bed of the Moffat series.

One fact should here in honesty be stated concerning the Gala beds. The rocks of the group to the north of the Grieston slates have, as a whole, a different appearance from those lying to the south of that line; but this needs much fuller investigation. At one time, we were of opinion that the Gala beds rested unconformably upon the Moffat rocks, but we have been compelled to give up this theory for the southern area at least; but there are many facts in the north that appear to us utterly inexplicable, unless we admit a slight unconformability or an overlap.

Returning once more to the great anticlinal from which we started, and proceeding thence up the strata as before, but this time in a southerly direction, we find the Selkirk beds coming in their proper place upon the Hawick Rocks, and containing *Protovirgularia, Phyllopoda,* and *Annedides*; but instead of the Moffat beds following them, we have a thick series of rock of quite a different aspect, which are called by us the Riccarton beds, and are of Upper Silurian age. We made the discovery in the spring of last year, and a paper by one of us upon the subject was read before the Geological Section of the British Association at Liverpool.

These rocks are found in five separate areas—

1. In the well-known tract of country to the south of the town of Kirkcudbright.

2. To the south of the granite area of Criffel and Dumfries.

3. In a long stretch of country extending from a point near Lockerby to the Old Red Sandstone near Stobbs Castle.

4. In a large inlier surrounded by Old Red Sandstone and Carboniferous, and reaching from the village of Oxnam, near Jedburgh, to Ernton Fell on the Liddel.

5. In a small patch at the head of the Kale Water, high up among the porphyries and limestone of the Cheviot Hills.

The northern boundary of these rocks seems to form an almost exact straight line parallel with the average strike of the Lower Silurian. It is very probably a fault, though we are unable to prove this.

The strata in these districts are lithologically identical with those of Kirkcudbright. They consist of grit and shale not unlike those of the Lower Silurian, but there are hundreds of little bands of carbonaceous schist full of Graptolites, always, however, in a very bad state of preservation. The whole set of beds are very calcareous, more especially the dark shales.

The fossils are—*Rhynchonella nucula, Orthoceras tenuicinctum, O. ibex, O. tracheale, Graptolithus priodon, G. colonus,* and *Flemingii,* together with many forms of *Phyllopoda,* etc., such as *Ceratiocaris* and *Aptychopsis,* and possibly *Pterygotus.* We have also found specimens of *Cyrtograpsus, Ptilograpsus,* and *Inocaulis,* genera new to Scotland.

Thus, in the country examined by us, there appears to be five distinct and separate groups of Silurian strata, the first two differing in lithological characters alone, none of the fossil forms found in them being of any value in estimating their age.

The superior groups, however, contain a great number of fossils, and their place in the Silurian system can be approximately ascertained. The number of species known to us has not been made up without a very large amount of labour and research. When it is remembered that the officers of the Geological Survey, with all their experience, mapped the whole of Haddington and the North of Berwickshire without detecting more than two Graptolites in the whole of the Gala beds of that district, and added but a single species in Peeblesshire to our Grieston Fauna—when it is known that the most careful examination of the large tracts is often entirely fruitless, and that the majority of the fossil beds only yielded up their remains after having been examined without result again and again—the interest and value of the fossils yet obtained is seen to be very great.

We have made out about forty species from the Moffat series, a little less from the Gala group, and only about a dozen as yet from the Riccarton beds.

An examination of these fossils shows us the enormous predominance of the Graptolites. These peculiar creatures have never yet received the attention they deserve, and those of Britain have been treated so carelessly that the real horizon of some of the species cannot be even guessed at.

Enough, however, is known of their localities in the North of England, in Bohemia, and in North America, to enable us to speak pretty confidently as to the range of many of the forms in the Silurian system, and to fix approximately at least the age of the Gala and Moffat formations.

It would greatly lengthen this paper were we to lay all the evidence before you in order, but it is sufficient for our present purpose merely to state the conclusions at which we have arrived.

A careful comparison of the Moffat Graptolites with those of other countries has convinced us that these beds should be classed with the Utica Slate and Hudson River Group of North America and the Graptolite-bearing schist of Wexford and Waterford; in other words, that they are of Bala age, or bridge over the gap between the Bala and Llandeilo.

The fossils of the Gala Group lead us to place it high in the Lower Silurian, and to believe that it is very probable that some of the higher beds are of Upper Silurian age. Its fauna approximates most closely to that of the Coniston mud-stones of Cumberland and Westmoreland, and which are placed by the Geological Survey of England at the base of the Upper Silurian; it has also a very close relationship to that of Barrande's Colonies and the band E. e. 1, the last of which is also classed with the Upper Division.

Such, then, is a summary, as short as we can make it, of the work already done by us in these old sedimentary deposits; very little, it is true, in comparison with what yet remains to be done in the future, but enough to encourage us to persevere.

We have purposely abstained from comparing the structure of this district with that further to the west, leaving the task to those who are more familiar with that country. We believe that our subdivisions (which are those into which our strata naturally fall), for this district at least, will, in effect, ultimately be adopted. We hold that our Upper Groups can be separated from each other, even lithologically, but more certainly and effectually by their fossils, which our paper shows only need a little extra perseverance to be detected almost everywhere. It may be urged that if we draw the lines of separation at the horizons mentioned, these boundaries will have as strange an appearance on the map as a diagram of the contortions to which their irregularaties are due. But for the purpose of science, the strata must be separated, if not in the present, then in the future, and wherever the divisional lines may be drawn, the same difficulties will occur.

One thing is plain from the large list of fossils we have discovered—all that is necessary is careful untiring work amongst these strange old strata, and these will in time fall into their proper groups, and form as grand and interesting a series as the typical Silurians themselves.

NOTICES OF MEMOIRS.

I.—On the Fossil Mammals of Australia.—Part V. Genus *Nototherium*, Owen.[1]

By Prof. R. Owen, F.R.S.

THE genus of large extinct Marsupial herbivores which forms the subject of the present paper was founded on specimens transmitted (in 1842) to the author by the Surveyor-General of Australia, Sir Thomas Mitchell, C.B. They consisted of mutilated fossil mandibles and teeth. Subsequent specimens confirmed the distinction of *Nototherium* from *Diprotodon*, and more especially exemplified a singular and extreme modification of the cranium of the former genus. A detailed description is given of this part from specimens of portions of the skull in the British Museum, and from a cast and photographs of the entire cranium in the Australian Museum at Sydney, New South Wales. The descriptions of the mandible, and of the dentition in both upper and lower jaws, are taken from actual specimens in the British Museum, in the Museum of Natural History at Worcester, and in the Museum at Adelaide, S. Australia, all of which have been confided to the author for this purpose. The results of comparisons of these fossils of *Nototherium* with the answerable parts in *Diprotodon, Macropus, Phascolarctos,* and *Phascolomys* are detailed.

Characters of three species, *Nototherium Mitchelli, N. inerme,* and *N. Victoriæ,* are defined chiefly from modifications of the mandible and mandibular molars. A table of the localities where fossils of *Nototherium* have been found, with the dates of discovery and names of the finders or donors, is appended. The paper is illustrated by subjects for nine quarto plates.

[1] Abstracted from the Proceedings of the Royal Society, No. 129, 1871.

II.—On the presence of a Reptile of the Mosasaurian type in the Upper Jurassic Formations of Boulogne-sur-Mer.[1]

By M. H. E. Sauvage.

The most ancient Mosasaurian known is the *Geosaurus Sœmmerringii*, of Monheim and Solenhofen. This last-named locality belongs to the Lower Kimmeridgian; nor have any been heretofore noticed higher up in the Jurassic series. Re-appearing in the Greensand of New Jersey (where we find *Geosaurus Mitchelli*, and *Mosasaurus Maximiliani*), this type is extended to the Lower Chalk by the *Mosasaurus Hofmanni* and *M. gracilis*. There is then a break in the life of the Mosasaurian type, but only an apparent break, for the types are always continuous throughout the whole period; they never disappear entirely, and then re-appear higher up: such breaks are only the result of the imperfect state of our knowledge.

Prof. Owen has published, under the name of *Leiodon*, a reptile of the Mosasaurian type, characterized by its teeth, of which the inside is as convex as the out, and whose crown, of an elliptical form, is bordered on each side by a sharp edge.

The only known species, *Leiodon anceps*, occurs in the Chalk of Norfolk and of Meudon. It is to this genus *Leiodon* that the teeth, and a fragment of jaw found in the Middle Portland Marls of Portel, near Boulogne, and in the clays which form the Upper Kimmeridgian, belong; this genus is also found a little lower, namely, in the zone of *Ammonites longispinus* of the Middle Kimmeridgian. The genus *Leiodon* appears then almost as early as the genus *Geosaurus*, and has lived during the Upper Jurassic epoch, along with the *Steneosauri*, the *Pliosaurus*, *Megalosaurus*, and Pterodactyle; we have, in fact, found these genera again in our Kimmeridge and Portland strata.

The species which we propose to name *Leiodon primævum* is characterized by smooth strong teeth, more or less large and curved, according to the place which they occupy, with faces regularly convex, separated on each side by a strong sharp cutting edge running from the base to the crown, which is pointed. The largest teeth are 65 millimètres high, the diameters near the base being 25×18. As M. P. Gervais has remarked, it is wrong that "they described the teeth of the *Mosasauri* as really acrodont, like those of many of the true Saurians." In our *Leiodon* the teeth are inserted in large and deep sockets, which occupy nearly the whole depth of the jaw; the root therefore is closely united to the body of the bone by the bed of cement which surrounds it; the pulp-cavity is filled with a mould of calcareo-siliceous matter, arising from petrifaction; this cavity, which regularly and imperceptibly contracts, runs from the base of the root to near the crown of the tooth; extending to a little above the half of the latter. The Pterygoid bones were very probably furnished with smaller teeth, one of the faces of which is visibly flatter.

[1] Read at the meeting of the Académie des Sciences, July 10th, 1871.

REVIEWS.

On the Geology of the Eastern portion of European Turkey,[1] by Prof. Dr. Ferd. von Hochstetter of Vienna.

Communicated by Charles Ludolf Griesbach, Corr. Member of the K.K. geologischen Reichsanstalt, and of the K.K. geographischen Gesellschaft, Vienna.

THIS most interesting and valuable publication is the result of an investigation which Prof. von Hochstetter undertook on behalf of the Ottoman Railroad Company. We cannot accompany the author in all his excursions and travels over so wide a territory, where almost every spot visited was virgin ground for the Geologist, but must be content to give only a brief description of the stratigraphical system of the country, as the author found it to be.

I. Eastern Thracia, from a geological point of view, may best be divided into five distinct areas:—1. The Byzantine Peninsula (the Eastern portion). 2. The basin of the Erkene (the centre). 3. Tekir-Dagh (the Southern portion). 4. Strandscha Mountains with the Tundscha massive (North-eastern part). 5. Sub-Balkanian Eruptive formations (Northern part).

1. *The Byzantine or Thracian Peninsula.*—The Devonian Formation of the Bosphorus, comprising Clayslate, Siliceous slates, Sandstone (like Greywacke), and dark bluish limestone of a knotty appearance; the strata are elevated at a high angle. In the Southern portion of the district the rocks strike south-west by north, and dip south. This formation forms the Eastern portion of the Byzantine Peninsula, striking over towards Asia Minor. Many dykes of Diorite traverse its strata.

Of Fossils 402 species were obtained from this formation, namely: Crustacea, 25; Mollusca, 295; Crinoidea, 25; others, 57. Amongst these may be specially mentioned the following:—

Homalonotus Gervillei.	*Orthis orbicularis.*
Rhynchonella Guerangéri.	*Chonetes sarcinulata.*
Spirifer macropterus.	,, *Boblayei.*
,, *subspeciosus.*	*Pleurodictyum problematicum.*
,, *Davoustii.*	

Viewed palæontologically, the strata resemble the Lower Devonian beds of Western Europe, but at the same time some few Upper Silurian forms occur with them, such, for instance, as *Trochoceras Barrandii*, *Orthis Gervillei*, and *Tentaculites ornatus*.

A quarry near the Ajasma Chapel, Constantinople, exposes a bed of greyish-blue calcareous clayslate, showing cleavage intersected by Diorite dykes. This bed yielded:

Spirifer loculatus.	*Orthis pernoides.*
,, *quadratus.*	*Cryphæus papilis.*
Strophomena tortuosa.	,, *Fritschii.*
,, *undulata.*	

The Tertiary Formation of Thracia will be treated of in a separate publication, shortly to be expected. The whole of the Western

[1] Die geologischen Verhältnisse des östlichen Theiles der Europäischen Türkei von Professor Dr. Ferd. von Hochstetter. With numerous sections and a geological map. Jahrbuch der K.K. geol. Reichsanstalt, 1870, xx. Bd.

portion of the Peninsula consists of Tertiary limestone. The North is composed of Eocene Nummulitic limestone, Coral limestone, and Argillaceous limestone; deposits of a Cretaceous appearance, with *Cancer punctulatus*, Desm.; *Nautilus* (*Aturia*) *lingulatus*, Buch.; *Nautilus undulatus*, Sow.; *Pholadomya Puschi*, Gdfss.; *Isocardia*, *Spondylus*, *Cardium*, etc., etc. The coast-line of the Sea of Marmora is composed of Miocene limestone, with *Mactra podolica* and *Ervilia podolica*, belonging to the Sarmatian facies.

The lower portion of the Neogene formation of the Vienna Basin (Leitha limestone and Baden clay) is wanting, as also the lower group of the Sarmatian facies, thus resembling the Desert limestone of the Caspian region.

The Sarmatian group is overlaid by freshwater limestone of the same lithological and palæontological character as the extensive freshwater deposits, which Capt. Spratt, R.N., described in the Levant, full of *Melanopsis*, *Neritina*, *Paludina*, etc., etc. Hochstetter calls this deposit the *Levantinian facies* of the Sarmatian group. The highest stratum is formed by argillaceous marls, sand, and pebbles. Igneous rocks of a doleritic, audesitic, and trachytic character, are found associated with this formation.

2. *The Basin of the Erkene.*—The Erkene (Ergines or Agrianes of the ancients) is the principal tributary of the lower Maritza on its left side; this river drains the extensive territory between the Strandscha Mountains and the Tekir-Dagh, forming a vast high plateau of 150 to 200 metres above the level of the sea, with small brooks and rivulets, dry during the summer, and altogether of a desert-like character. The banks of the insignificant rivulets of this part of the country expose a Loess deposit, which is of great thickness, resembling the Belvedere beds of the Vienna Basin. This Loess is considered the most recent deposit of this Tertiary basin. Von Hochstetter calls these the *Thracian beds.*

Of the lower beds, only greyish white clay, light argillaceous marls, and thin calcareous strata are noticed, under which beds of Lignite will most probably be found. The outer rim of this basin is formed of Eocene limestone (Nummulite, Coral, and Nullipore limestone), which rests (at Sarai, Wisa, and Kirk-klissi) on Gneiss.

Besides these limestones, unconformable to the former, are observed (at Tena, Adrianople, etc., etc.) limestones and calcareous marl deposits of considerable thickness, full of casts and shells of *Congeria*, *Corbula nucleus*, Lam.; *Cardium claudiense*, ? Eich.; *Mytilus acutirostris*, Gdfss. (= *Congeria Basteroti*, Desh.); *Congeria Brardi.*

These deposits Von Hochstetter considers as the *Pontic* beds of the Tertiary age. Strata of the Sarmatic group have not yet been observed in the basin of the Erkene; the *Congeria* deposits seem to take the place of the latter as well as of the Levantine group.

Trachytes were observed near Enos, Ipsala, etc., etc., partly belonging to the Eocene epoch, partly of Miocene age, analogous to the Trachytes and Tuffs of Hungary and Transylvania.

Isolated masses of Basalt were found near Tschorlu.

3. *The Tekir-Dagh or the holy Mountains of Demosthenes* form a

range of hills of from 600 to 800 mètres in height, running in a south-west direction towards the Bay of Saros. They consist of old crystalline rocks, principally rocks of the Phyllite zone, enveloped and overlaid by Eocene Nummulitic limestone and Sandstone. Mica schists or talcose slate, Clayslate and Quartzite (Vignesnel), occur near Axamil. The Peninsula of Gallipoli, and the coast beyond the Straits of the Dardanelles, consist of an extensive formation of Tertiary freshwater deposits (Capt. Spratt).

4. *The Strandscha Mountains and Tundscha* consist principally of Gneiss (micaceous gneiss and hornblende-gneiss, with much crystalline limestone imbedded), Granite and Syenite.

5. *The Eruptive rocks of the Sub-Balkanian Territory between Burgas and Jamboli,* the country between Jamboli, Karnabat, Aidos, Burgas on the Black Sea, and the Cape Kury Burun at the Gulf of Inada, has witnessed since the beginning of the Cretaceous, and even so late as during the Miocene epoch, a continuous series of Eruptions of basic igneous rocks, partly submarine, partly supramarine. We find here hills of brownish red, porphyrite like audesite, and augite, containing audesite and dolerite, which show by their peculiar shape that they are extinct volcanos. They are accompanied by colossal masses of augite, containing tuffs and conglomerates. These conglomerates and tuffs alternate with strata of the lower Cretaceous series with *Inoceramus*, etc., showing thus clearly the time when the eruptions took place.

These eastern igneous rocks find their analogy in some eruptive rocks near Sofia, in the so-called Lülün mountains between Sofia and Trn. There, too, the tuff alternates with strata of the Cretaceous formation. Basic rocks also prevail. Just between these two eruptive regions is situated the great dislocation of the Balkany, so that the explanation of this dislocation being caused by the eruption of the audesites and dolerites at once suggests itself to the geologist.

II. The Balkany and Surrounding District.—Under this heading Von Hochstetter not only comprises the Haemus of the ancients, but the whole of Bulgaria, as far as the line of Rustschuk-Warna, with the exception of the Dobrudscha. The western limits of this mountain-system would be the valley of the Timok, along the Servian-Bulgarian boundary. The basis of the steep southern slopes of the Balkany form its southern limits. The Balkany is, therefore, not, as hitherto considered, a chain or a continuation of the Illyrian Alps, but forms an elevated plain, which slopes gently down towards the Danube, but with an abrupt descent towards the south. This latter sharp descent was no doubt originated by a tremendous dislocation; causing the portion of the plain, which once extended as far south as the Despoto-Dagh, to sink below the level of the present Balkany. The dislocation may, as already suggested, be explained by the enormous eruptions of audesite and trachyte, which took place during the Cretaceous epoch, and lasted through the Miocene period. This dislocation may readily be traced along a line, which runs between Cape Emineh on the Black Sea, and Pirot or Sharkiöi (north-west of Sofia) for a distance of about 240 miles.

From the Black Sea to Sliwno Cretaceous rocks, intersected by porphyries, form the southern steep slopes of the Balkany. To the west of Sliwno we find Granite and Gneiss, whilst between Tschipka and Slatica mica schists and clayslate form the Balkany. Lastly, the northern rim of the basin of Sofia consists of Triassic sandstone and limestone.

The Isker (with its springs in the Rilo-Dagh) intersects the whole Balkany from south to north, dividing this mountain system in a western and eastern portion. The western portion is a perfect *terra incognita* to geologists, as well as to geographers. In the following notice only the eastern portion is referred to. The highest points of the Balkany, the Kodscha or Weliki-Balkany belong to this eastern half, with elevations above 2800 mètres.

Miocene deposits.—Sarmatian group (*Cerithium* beds), These deposits are limited to the valleys of the Wid and Osma (south of Nikopoli) and to the neighbourhood of Warna, near the coast of the Black Sea. They occur also in the Dobrudscha.

Mediterranean group (Leitha limestone and Baden clay).—Underlying the Sarmatian group we find, near Plewna, almost horizontally stratified beds of a white limestone, rich in corals and other fossils (*Pectunculus,* etc., etc.), resembling in every respect the Leitha limestone of the Vienna basin. In the valley of the Wid bluish grey clay is observed under this limestone, which contains many fossils in excellent condition, scarcely to be distinguished from those of the Baden clay in the Vienna basin. The following list gives the most important, namely :—

Conus Dujardini.
,, *Noë.*
Rostellaria pes-pelicani.
Ancillaria glandiformis.
Pleurotoma asperulata.
Turritella Vindobonensis.
Cypræa pyrum.
Cassis texta.
Arca diluvii.
Venus multilamella.
Dentalium elephantanum.
Flabellum cuneatum.
Turbinolia duodecem-costata.

And a great many Foraminifera.

The Mediterranean-Indian sea must have communicated with the Bulgarian basin through a passage which most probably was situated northwards of the passage of the Danube through the Banat mountains, as there the late Dr. N. Schloenbach found Neogen deposits at a height of 600 mètres above the level of the sea, at the watershed of the Almasch and Tscherna.

Cretaceous formation.—*Upper Cretaceous strata.*—South of Plewna Von Hochstetter observed a system of limestones with hornstones, partly dolomitic and porous. He observed in it remains of *Exogyra, Belemnites, Ananchytes, Rhynchonella,* etc., etc., and near Schumla *Ostrea vesicularis, Inoceramus labiatus, Pecten quinque-costatus, Exogyra columba,* corals, etc., etc.

Near Jenikiöi, white Pläner marls were observed with *Belemnites subfusimis,* Rasp., *Ammonites,* etc. These Upper Cretaceous strata possess a North-European character, whilst the

Middle Cretaceous deposits (with *Orbitulites*), of a Karpathian sandstone like appearance, with thin beds of coal (Gault), partly at least closely resemble the North-Karpathian sandstone zone.

Southern slopes of the Balkany near Aidos, Karnabat, and Sliwno. Here sandstones and calcareous marls with Cretaceous *Fucoides* alternate with volcanic tuffs. Near Trn, in a similar sandstone and marl, was found *Ammonites Milletianus*, D'Orb.

Lower Cretaceous deposits: (*a*) *Caprotina* limestone (*Urgonien*). In the country south of Nikopoli is found a light grey dense limestone of alpine character, yielding *Caprotina, Gasteropods,* and *Radiolites.* (*b*) Neocomian shales, marl, and limestone. Underlying the Caprotina limestones near Jablanica are found dark calcareous shales and limestones, which dip at an angle of from 15 to 20 degrees towards the north. These beds yield—

Belemnites subfusiformis, Rasp.	*Ammonites cryptoceras*, D'Orb.
Ammonites Matheroni, D'Orb.	,, *Grasianus*, D'Orb.
,, *Jeannoti*, D'Orb.	*Crioceras Duvalii*, Lĕv.

Near Sliwno a series of shales and calcareous marls of great thickness, with a red quartz-porphyry of peculiar character, but without fossil remains, is also considered as of Neocomian age.

Dyas or Lower Trias.—Red Conglomerates and Sandstones at the southern slopes of the Balkany near Sofia. The whole of the southern slopes of the Balkan chain of mountains, so far as it forms the northern rim of the basin of Sofia, consist of an uninterrupted sandstone zone, which forms a conspicuously-marked country at the base of the high limestone mountains behind. The height of this sandstone zone is about 1,000 mètres. Coarse Red Conglomerates, containing pebbles of Gneiss, Phyllite, Clayslate, Quartz, and siliceous slate, etc., etc., alternate with thick layers of an argillaceous sandstone and marls of an intense red colour. The strata of this zone form a saddle, and are overlain by a greenish-grey marly shale of great thickness falling north. Above these strata rest the enormous masses of limestone deposits of the Balkany.

Von Hochstetter identifies the marl-shale with the Neocomian shales of Jablanica, and thinks it very probable that the red conglomerates represent either Dyas (Permian) or Triassic rocks. With the sole exception of a small patch of a Triassic deposit, between the rivers Isker and Slatica, which Boué mentions, true Triassic or Jurassic rocks of *Alpine* character seem entirely wanting in the Balkany; the formations of this mountain system seem to represent the system of strata which were deposited northwards of the old crystalline massive of central Europe. We meet with Triassic and Jurassic rocks only on the southern slopes of the Balkany, which are to be looked upon as offshoots of the Alpine system.

Palæozoic Rocks of doubtful age.—If we draw a section in a southern direction through Etropol we meet with a different series of formations altogether. There mica schists, talcose, and clayslates are greatly developed; in fact, they form (according to Boué) the watershed between the rivers Wid and Osma. According to the same author, dark limestone deposits of a considerable thickness, with greywacke-like sandstones, occur at the northern slopes of the above-mentioned crystalline formation.

Hochstetter met with similar strata at the southern slopes of the Balkany, near Kisanlik, where a peculiar set of brown, micaceous, and bituminous shales rests on a gneissic granite, rich in hornstone. These shales contain a bed of anthractic coal of one foot in thickness, resembling the anthracite of the Werchzirm-Alps in Styria. Brown shales and sandstone follow further up in the narrow valley, which seem to fall south (the former dipped 10 to 15 degrees north), also light grey dolomitic limestone. White micaceous coal-bearing sandstone, with bituminous shales, alternates with the limestone. The strata strike east to west, and are raised up, dipping slightly south. The whole has the aspect of a Palæozoic group of rocks, and seems to rest on a crystalline formation. The beds of coal are too insignificant and too much disturbed and contorted to be of any importance in this remote region of Turkey.[1]

The Crystalline zone of the Balkan, which is the most southern one, forms a belt between Slatica, Tekke, Karlowa, Tschipka, and Kisanlik. It is only a small part of the great crystalline central massive, which once formed the greatest portion of Turkey, but which became through dislocations so diminished as it now appears. These disturbances must have occurred during the Cretaceous epoch, although they did not cease until the Miocene age. Between Karlowa and Tschipka rocks of the Phyllite zone form this belt of crystalline rocks. The strata are much contorted, and dip generally 80° south, and contain many quartz-reefs. Chloritic shales, calcareous clay-slate, and Hornblende-Phyllite alternate with pure Phyllite. Near Kisanlik granite and granitic gneiss are found.

Near Slatica a small quantity of gold is obtained by washing, and in the Trojan-Balkan some silver lead ore (Galena) and copper ores are found, which are said to have been formerly worked by the Romans.

III. Roumelian Mountains, with the Upper Maritza and Upper Tundscha Basin.—The western continuation of the Tundscha mountains, between the Balkan and the Rhodope, must have been broken down most probably during the Tertiary epoch, and formed large basins, flats, and low ranges of hills. One of these basins is the basin of the upper Maritza or of Phillippopel, a beautiful and productive level, inhabited for ages by an industrious people. The height over the level of the sea is about 200 mètres. Most probably the bottom of this basin is formed by deposits of Post-tertiary, diluvial age, although in one (the eastern) corner of the basin, Eocene Nummulitic limestone indicates that during the Eocene epoch the sea reached as far

[1] It is most probable that it is this locality, near Michleskiöi, which the English Geologist, Mr. Arthur C. W. Lennox, F.G.S., mentions in a report in French (Rapport sur la Géologie d'une Partie de la Roumélie inspectée par ordre du Gouvernement Imperial Ottoman en 1866, Londres, 1867). The geological portion of this report is a real curiosity; for instance, the author talks of this coal, near Michleskiöi, as "Lignites du Balkan, Nord de Mufluskoi." Still less credible seems what Mr. Lennox says of the Lias of the Tschipka-Balkan, p. 36 : "C'est le Dr. K. Peters, qui le premier détermina l'âge véritable du singulier dépôt de calcaire secondaire qui se présente au nord et au sud du sommet du Col de Tschipka. Les formes caractéristiques suivantes ont été observées dans cette localité (!!) *Natica macrostoma*, Römer, *Nerinoea Visurgis* ?, Römer, *Pterocera*, *Chama*, etc." Dr. Peters was never in the Balkany, and the said fossils come from the Upper Jurassic formation of the Dobrudscha. (See Verhandl. K. K. geol. Reichsanst., 3. November, 1863.)

as Chaskiöi. Near Philippopel a few syenite cliffs remain of the old Syenite continent still at the surface, forming thus the ground on which the town is built. A similarly-formed basin is that of the Upper Tundscha, at the base of the Balkan, which lies about 200 mètres higher than the former. No remains of Tertiary deposits were found there; in fact, the basin looks like the bottom of a recently dried-up lake, which it no doubt is. Two large tributaries of the Maritza, the Raska and the Topolnica, divide the Roumelian mountains in three divisions:—1. The Karadscha Dagh; 2. Sredna Gora; and, 3, the Ichtiman mountains.

1. *Karadscha Dagh,* a long mountain chain of a general height of 700 to 800 mètres, with some summits of 1000 mètres, between Sliwno and Kalofer. In a section from Eski Saara to Kisanlik (Upper Tundscha basin) we meet thinly stratified limestone and marls, striking east to west, and dipping 80 degrees south, resting on thinly stratified grey limestone with flints, dipping south-east, and resting on reddish, green, and light marls and limestone, with dykes of audesite. This series of strata Von Hochstetter considers most likely to be Neocomian, by comparison with other similar looking strata in Turkey. It rests unconformably on reddish, very hard quartzite and quartz sandstone, with a bluish limestone, containing crinoids of Triassic (St. Cassian) type. Granite and gneiss form the base of this formation.

2. *The Sredna Gora* forms the highest portion of the Roumelian mountains, but is almost unfortunately a *terra incognita,* as Hochstetter only touched it at the most southern extremity, from an examination of which he suggested that the principal mass of this system consists of Crystalline rocks. This part of the country is remarkable for several warm and other springs, used since Roman times as watering-places.

3. *The Ichtiman Mountains* are hardly known. All maps of this part of Turkey are incorrect, giving the river Wed an entirely wrong course. In the Ichtiman mountains lies the watershed between the numerous tributaries of the Maritza and the Isker rivers, forming also the watershed between the Ægean and the Black Sea. Two small basins (of Ichtiman, height 610 mètres, and of Banja, 590 mètres), belong to the Maritza river system, and the basin of Samakov (960 mètres) belongs to the Isker river. All of the three basins are surrounded by crystalline rocks, and filled with fluviatile conglomerates, sands, etc. Tertiary strata are nowhere met with. Along the road from Phillippopel to Banja and Samakov, Hochstetter describes alluvial deposits as far as near to Bazardshik, where the road passes into crystalline rocks, which are partly in basins like Banja (which possesses a warm spring) covered by alluvial deposits. Much Crystalline limestone, Hornblende-gneiss, and Mica-gneiss. Near Sipotsch, syenite occurs with pegmatite. Near Bazardshik, red trachyte was observed.

The road from Samakov to Sofia leads over a high saddle of the Brdo mountains (1,300 mètres). The section exposed there exhibits syenite, gneiss, red quartzites, and white sandstone, the strata of which are raised up vertically (most probably either Lower Trias or Dyas), Limestone and Dolomite (Upper Trias), Red Calcareous marl with augite-porphyry containing *Plicatula radiola*, Lam. (Gault).

IV. The Despoto-Dagh or the Rhodope is, besides the Balkan and the Roumelian mountains, the third and highest ground of Eastern Turkey, an excellent example of a *massif*. The highest point is the Perim-Dagh (2,400 mètres) and the Rilo Dagh (3,000 mètres). It is an old crystalline continent, which remained so through all geological epochs until the Tertiary time, when the Eocene ocean covered some of the lower Eastern portions. During this latter epoch great Trachytic eruptions took place, and lasted till the Miocene time. Hochstetter distinguishes two Gneiss formations in the Despoto-Dagh, which he compares to the Gneiss formations of Bohemia and Southern Germany; Crystalline limestone, Granite, etc. The centre of this enormous crystalline *massif* strikes E.S.E. to W.N.W. No ores of any kind are at present known there, unless small quantities of gold, which are washed out of the alluvium near Balukkiöi.

The Eocene formation in Rhodope is found only in the Eastern part: near Feredshik (S.), Demotika (E.), Chaskiöi (N.) Wherever it occurs, it is in close proximity to the Trachytes of the Rhodope.

Near Balukkiöi, the lowest strata are Reddish-green Argillaceous Marls, which gradually pass into and alternate with Micaceous Sandstone. Above, coarse Sandstone and conglomerate, Clayish Sandy Limestone, with *Vignesnelia lenticularis*, Desh., *Paludina*, *Unio*, etc. which is overlain by fine-grained Sandstone and Clay-marls. The highest stratum is formed by Nummulite and Coral Limestone. The strata are raised up, and do not lie comformably on their base, which is (according to Vignesnel) formed of Sandstone, Shaly Greywacke, and Argillaceous Limestone (*terrain de Transition*).

Von Hochstetter divides the Eocene formation of the south-east and east Rhodope into two divisions. Lower division: at the base thick layers of conglomerate above clay and sands, often of lacustrine origin (*Vignesnelia*, *Paludina*, etc.). Upper division, of purely marine origin, consisting generally of limestone strata.

Beds of Lignite, until now unworked, belong to the first division, and are comparable to the Lignite-bearing Cosina beds of Istria, and also to the Eocene formation of Gran and Ofen in Hungary.

The enormous Trachyte and Trachyte-tuff dykes are part of the long Southern Trachyte chain which reaches from Servia and Bosnia right through Macedonia, Thracia, and from thence through Asia Minor. The Trachytes of Hungary and Transylvania belong to a Northern Trachyte chain, which do not differ much in lithological character, although the first are older (Eocene), whilst the Hungarian Trachytes are of Miocene age.

Miocene Deposits of the Rhodope.—Conglomerates, soft sandstone and sands, argillaceous and marly limestones, most probably belonging to the Miocene epoch.

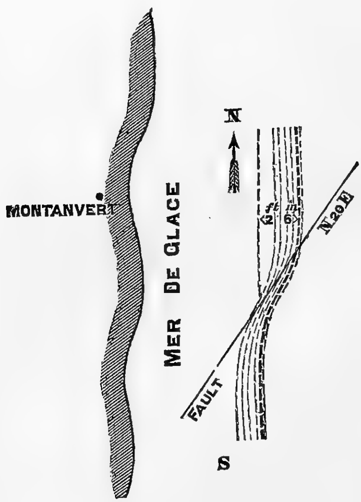
No traces of old glaciers were observed anywhere.

CORRESPONDENCE.

THE MOTION OF GLACIERS.

Sir,—As the motion of glaciers at the present time is by no means a decided point, perhaps the following extracts from my note-book may not be inopportune, more especially as such was observed by me for the first time, and wants corroborative evidence:—"On the 20th July, 1870, when crossing the Mer de Glace, where its breadth is reduced above Montanvert, a distinct fault was observed running N. 20 E., while the general motion of the glacier was N. This fault was observed to extend throughout the glacier, and to be a lateral fault, evidently due to contraction. The exact measurement of the throw was 2 feet 6 inches, and was measured from the veinous structure, which, along the fault, exactly corresponded with the twists peculiar to faults in shaly beds, viz., that the veinous structure was drawn in the direction of the throw. The fault line was plainly visible, but sealed as it were by pressure, and having no unevenness on the surface."

Plan of a Fault observed in the Mer de Glace, July 20, 1870.



The only conclusions I could come to were, that such fault was a very recent one, produced probably by the very uneven rate of motion, through the action of the Sun, which for that month was most intense. If not a recent fault, the veinous structure would have assumed its normal position.

Richard G. Symes.

Ballina, Co. Mayo, Ireland, *August* 14, 1871.

TERRACES OF NORWAY.

Sir,—I much regret that Col. Greenwood hit upon the wrong Aardal. That which I referred to is at the east end of the Sogne Fjord. Steamers make the trip, and, once a fortnight, also call at Fjærland, within an hour's stroll of a glacier remanié, the Suphelle Bræ, which descends to certainly not more than 150 feet above the sea level. A valley to the north contains capital terrace examples, and is closed by the great glacier of Boium's Bræ. From Bergen to the Sogne Fjord, to Fjærland, and to Aardal, the Mörk Foss, back to Gudvangen, across to the Hardanger Fjord, up the Sör Fjord to Odde, thence across the Folge Fond by an easy glacier pass to Bondhus, and westward to Stavanger, would be a fortnight's deliberate trip, and afford sublime scenery, with geology enough for a glutton, besides numerous lateral excursions, should the traveller have time. He must study the times of the steamers well in laying his plans.

I am sorry Col. Greenwood did not accept my invitation to intending explorers to ask me any questions. Marshall Hall.

Yacht Norna, *Sept.* 19, 1871.

RIVER TERRACES.

Sir,—In the two letters on this subject which you have done me the honour to publish in your numbers for April and September, I have contended that *inland* river terraces are very simple effects of rain on rivers; that they are the remains of alluviums formed on land by the overflow of rivers; and in the report of Mr. Chief Justice Begbie's account of the "Benches of British Columbia" in the Proceedings of the Royal Geographical Society for July, the Chief Justice remarks (page 138) that the rise of the Fraser river in flood at Lilloet is 40 feet; at Fort Alexandria 25 feet. Here, then, must be two alluviums forming on land at the present day below the old terraces. Gorges, by checking the rain-floods of the river, cause these enormous rises. When, however, the beds of these gorges are deepened by erosion, the river, unable to overflow the alluvial banks which it has built up, will, in floods, tear them down and will drive them to the hill-side as two parallel terraces.

The prevalent opinion, however, in the discussion of the paper was that the terraces have been formed at the water level of lakes by materials washed down by the river, and not on land alluviums. A "bursting of the barrier" is then supposed, and "a sudden drainage" of the lake to the level of the succeeding terraces. And so a succession of "bursting of barriers" and a succession of "sudden drainages," one of each of these for each pair of terraces. Each barrier which it is required to "*burst*" being perhaps a gorge of the hardest possible rock, and extending for any number of miles. But to form two parallel terraces the river must have filled the lake entirely with the materials carried down. In this case there could be no "sudden drainage" of a lake which had no water in it. Or are we to suppose that in former times all rivers on entering the lakes bifurcated and deposited their materials as terraces at the level of the water on the two opposite side-shores of the lakes, leaving the central water pellucid? And that this central pellucid water only was subjected to the "sudden drainage"? If so, in former times, the laws of rivers and lakes differed much from those of the present day. The cause supposed is an actual impossibility.

Brookwood Park, Alresford, GEORGE GREENWOOD, Colonel.
9th September, 1871.

LOCAL MUSEUMS AND SCIENTIFIC SOCIETIES.

Sir,—Why does not the British Association exert its influence in stimulating local Scientific Societies to form in their Museums collections representing the Geology, Mineralogy, and Natural History of their own respective neighbourhoods? Such a system, combined with a central Museum in London, would tend more than anything to the advancement of science. At present, provincial Museums are little better than curiosity shops, with no recognized plan of arrangement whatever. Numerous valuable private collections exist throughout the country, representing the geology, etc., of various localities, which are too often dispersed and lost. Perhaps private Collectors would show more public spirit, if greater zeal and better judgment were shown by local Societies.—F.G.S. (Brighton).

A SILICIFIED CORAL FROM THE COAST OF SUSSEX, ETC.

Sir,—Rolled fragments of a Silicified Coral, resembling the Tisbury *Isastræa,* are occasionally found on the coast of Sussex and the Isle of Wight. Major Barnes, of Southampton, who has for many years collected the south-coast agates, has found four specimens, one on the beach at Ryde, two at Sandown, and one at Hastings. I also obtained a fine specimen on the beach at Hove, near Brighton. The only locality from which they could have been drifted, if belonging to the Oolite, is Portland. Does the Tisbury Coral occur there? or, can they be derived from the Upper Greensand, like the silicified wood found at Hove?

SPENCER GEO. PERCEVAL.

MISCELLANEOUS.

Occurrence of Diamond in Xanthophyllite.—Writing from St. Petersburgh to the Editor of the *Jahrbuch für Mineralogie,* 1871, part 3, Jeremejew announces the discovery of microscopic crystals of diamond in the xanthophyllite of the Schischimskiaw mountains in the Urals. Magnified 30 diameters they are distinctly visible, and with a power of 200, their crystalline form can be determined with great precision. It is a hexakistetrahedron combined with a slightly developed tetrahedron, the faces of the first form being rounded, those of the latter completely flat. The greater part of the crystals are colourless and completely transparent, and some few are slightly brown. They lie in parallel position in the matrix, their trigonal intermediate axes being vertical to the foliation of the xanthophyllite. The green plates of the latter near the rounded aggregations of the talcose slate and serpentine, contain an unusually large number of crystals, and they are also found in these rocks themselves.

Erratum.—Geol. Mag. for September. In Mr. Searles V. Wood, jun's. paper "on the Sequence of the Glacial Beds," p. 410, line 2 from bottom of page, for *Dentalium dentale* read *Dentalium entale.*

Dentalium dentale (Mid-Glacial shell) occurs exclusively to the South of Britain. *Dentalium entale* (Lancashire fossil) is a British species.

OBITUARY.

Dr. Georg Justin Carl Urban Schloenbach.—Born on the 10th of March, 1841, at Liebenhall, near Salzgitter, in Hanover, he studied principally natural history, chemistry, botany, geology, and palæontology, at the Universities of Göttingen, Tübingen, and Munich, under the celebrated Professors Bödecker, Quenstedt, and Oppel. The influence and tuition of the two latter men of science induced Schloenbach to decide upon his future career, and constant intercourse with such warm friends of geological science developed the interest which the young student afterwards took in Jurassic fossils. In 1862 he went to Berlin, where he completed his studies under Professors Beyrich and Gustav Rose. The year after he gained his degree as Doctor of Philosophy, at the University of Halle, by his work on the Ironstone of the Middle Lias of North-western Germany. After travelling and seeing the most interesting localities of Germany and France, he produced his second paper (see list). He devoted himself much to the study of the Cretaceous formation, in the mean time publishing a series of papers on Jurassic fossils. In 1867 he went to the Tyrol, and while staying in Vienna to see the large collection of fossils, etc., of the k. k. Geol. Reichsanstalt, he was offered an appointment in this Institute, which he accepted, declining at the same time the office of Director of a new Mining School in Peru. Until he became Professor of Geology of the Polytechnic Institute of Prague in 1870, he remained in Vienna, much liked and respected, an active and energetic member of the k. k. Geol. Reichsanstalt. It was whilst engaged, for this Institute, travelling in Servia, that his constitution broke down, under the tremendous fatigue which geologists in these parts have sometimes to undergo. Camping out in what is by no means a tropical latitude brought on rheumatism, and shortly afterwards congestion of the lungs ended his life, after a painful but short illness. He published the following papers:—

"Ueber den Eisenstein des mittlern Lias im Nordwestlichen Deutschland mit Berücksichtigung der ältern und jüngern Liasschichten."—Inaugural Dissertation; afterwards reprinted in Vol. 15 of the Deutsch. Geol. Ges.

Die Schichtenfolge des untern und mittlern Lias in Norddeutschland. Neues Jahrb. Leonh. und Gein. 1863.

Ueber die Parallelen zwischen dem oberen Pläner Norddeutschlands und den gleichaltrigen Bildungen im Seinebecken. Neues Jahrb. von Leonh. und Geinitz, 1866.

Ueber einige neue und weniger bekannte jurassiche Ammoniten Cassel, 1865. Paläontographica, Vol. 13.

Ueber die Brachiopoden aus dem untern Gault (Aptien) von Ahaus in Westphalen. Zeitschr. deutsch geol. G. 1866.

Kritische Studien über Kreidebrachiopeden. Cassel, 1866. Pal., Vol. 13.

Ueber die Brachiopoden der norddeutschen Cenomanbildungen. In Benecke's geogr.-paläont. Beiträge Vol. 1. 1867.

Beitrag zur altersbestimmung des Grünsandes von Rothenfelde unweit Osnabrück. Neues Jahrb. von Leonh. und Geinitz, 1869.

Ueber die norddeutschen Galeritenschichten und ihre Brachiopodenfauna. Sitz. Ber. k. k. Acad. Wiss. Wien. 1868.

Published in the Jahrbuch of the k. k. Geol. Reichsanstalt in Vienna:—

Ueber einen Belemniten aus der alpinen Kreide von Grünbach bei Weiner Neustadt; *Aspidocaris liasica*, eine neue Crustacean aus dem mittlern Lias; both in Vol. 17.

Die Brachiopoden der böhmischen Kreide. Vol. 18.

Ueber *Belemnites rugifer*, nov. spec., aus dem eocenen Tuff von Ronca. Vol. 18.

Bemerkungen ueber Sharpe's und Sowerby's *Belemnites lanceolatus* und ueber Sowerby's *Belemnites granulatus*. Vol. 18.

Polyptychodon, Owen vom Dniesternfer bei Onuth in der Bukowina. Vol. 18.

Ammonites Austeni, Sharpe von Parnica bei Unter Kubin. Vol. 18.

Ueber *Sepia vindobonensis* aus dem neogenen Tegel von Baden bei Wien. Vol. 19.

Bemerkungen über einige Cephalopoden der Gosaubildungen. Vol. 19.

Published in the "Verhandlungen" of the k. k. geol. R.A.:—

Ueber die Gliederung der rhätischen Schichten bei Kössen. 1867.

Geologische Untersuchungen in den Südtyroler und Venetianer Alpen. 1867.

Ueber die Lithonische Fauna in Spanien verglichen mit der Südtyrols. 1867.

James de Carle Sowerby, F.L.S., F.Z.S., etc., etc., born June 5th, 1787, eldest son of Mr. James Sowerby, the well-known naturalist and artist, was descended from an old Border family. As a boy he delighted in the pursuit of Natural History, but his special study was experimental and analytical chemistry. He was the friend and companion of Faraday, and with him studied under Sir Humphry Davy, delighting in the honour of assisting the great master in his experiments. His knowledge of Chemistry led him to propose the classification of minerals according to their chemical composition, and for this purpose he analyzed the specimens published in his father's works entitled, "British Mineralogy," and "Exotic Mineralogy." Before he was twenty years of age he named and arranged the collections of the Marchioness of Bath, Miss Codrington, and other amateurs. Working with his father, James de Carle Sowerby's name does not appear to any of his plates until after his father's death, which occurred in 1822. After that event he continued the celebrated works, "English Botany," and "Mineral Conchology," of both which he published several volumes. It was by Mr. Jas. de Carle Sowerby's wish, that the type-collections illustrating this latter important work, were in 1861, acquired for the British Museum, and are now preserved for reference in the Geological Department of that Institution. From 1823 to about 1850, he contributed papers principally relating to Fossil Conchology to the Philosophical Transactions, and to the Proceedings and Transactions of the Geological, Linnæan, and Zoological Societies; he also described, named, and arranged fossil shells for Dr. Buckland, Prof. Sedgwick, Sir Roderick Murchison, Dr. Fitton, Mr. Dixon, Colonel Sykes and others, who in their several published works and papers gratefully acknowledged his assistance. James de Carle Sowerby, in conjunction with his brother George B. Sowerby and other naturalists, conducted the "Zoological Journal," from 1825 to 1835. In 1840, the Council of the Geological Society awarded him the "Wollaston Fund," in order to facilitate the continuation of his researches in Mineral Conchology.

Dr. Buckland, at that time President, spoke in the highest terms of the great services rendered to geological science by Mr. James de Carle Sowerby, especially in illustrating so many works with drawings and engravings of fossil shells and plants, "expressing their characters with a degree of accuracy and truth, which no pencil or burin but those of a scientific artist could possibly accomplish."

In 1846 he was appointed Curator of the Geological Society's Museum—a post which his engagements with the Royal Botanic Society did not permit him to retain for any great length of time.

In 1838 he joined his cousin, Mr. Philip Barnes, F.L.S., (the original proposer of the project) in founding the Royal Botanic Society, and his name appears, together with Mr. Barnes and others, in the Royal Charter of Incorporation granted in 1839.

Mr. James de Carle Sowerby was appointed Secretary to the Society from its commencement, and resided for thirty years at the Royal Botanic Gardens, Regent's Park. He is succeeded in his post of Secretary by his son Mr. William Sowerby.

No doubt the most valuable assistance given by Mr. Sowerby to the naturalist has been by means of the vast number of *portraits* of plants, animals, minerals, fossils, etc., most of which he engraved from the specimens themselves. Scientific names, descriptions, and systems of arrangement vary with the progress of the science which gave them birth, and are often superseded and rendered valueless; but such *vivid portraits* of natural objects as those so ably delineated by Mr. James de Carle Sowerby will always remain lasting memorials of his scientific accuracy and fidelity. He died August 26th, 1871, in his 85th year.

Geological and other Papers, by James de Carle Sowerby.

"Mineral Conchology," continued from plate 393, in vol. iv., to the end.

1824. *Helix nemoralis* (carnivorous?); and Description of a remarkable fossil found in Coal shale (spine of *Gyracanthus*). Zoological Journal.

1827. Descriptive Notes on Fossil Shells found in the Strata below the Chalk (Dr. Fitton's paper in Geological Trans.).

1829. List, etc., of Fossil Shells (Sedgwick and Murchison's paper on the Structure of the Eastern Alps, etc.). Geol. Trans.

1835. Fossil Shells (Dr. Buckland, "Bridgewater Treatise").

1837. On the genus *Crioceratites* and on *Scaphites gigas*. Geol. Trans.

" Descriptions, etc., of Fossil Shells (Sedgwick and Murchison's paper on the Physical Structure of Devonshire). Geol. Trans.

" Ditto (Captain Grant's paper on Geology of Cutch, India). Geol. Trans.

" Ditto (Colonel Sykes' paper on Geology of Cutch). Geol. Trans.

" Ditto (Mr. Prestwich, Colebrookdale). Geol. Trans.

" Ditto (Mr. Wetherell, Hampstead). Geol. Trans.

" Ditto (Mr. Malcolmson (Geology of Parts of India). Geol. Trans.

" On a New Genus of Fossil Shells (*Tropæum*). Geological Proceedings.

1839. Descriptions, etc., of Fossil Shells in Murchison's "SilurianSystem."

1842. List of Silurian Fossils from Rhenish Provinces. Geol. Trans.

1850. Description of Mollusca in Dixon's Geology of Sussex.

James Yates, F.R.S., F.G.S., &c.—With regret we record the loss of this amiable and learned man of science. James Yates was born at Liverpool in 1789. He studied at Edinburgh and Glasgow, taking his M.A. in 1812. The early years of his active life were devoted to the ministry in connexion with the Unitarian Church, first at Glasgow, then at Birmingham, and finally at London. Having retired from the ministry, he devoted himself to scientific and literary pursuits. He was elected a member of the Geological Society in 1819, of the Linnæan in 1822, and of the Royal in 1839. He was one of the founders of the British Association, and took an active part in its early management. In later years he specially devoted his attention to the question of a uniform international system of decimal coins, weights, and measures. This subject, together with the arranging and annotating the Canton Papers for the Royal Society, engaged his thoughts up to the time of his death. His first paper was published in the original series of the Geological Transactions in 1821. It was devoted to a description of an argillaceous limestone from Staffordshire. This was followed by others treating of petrological, stratigraphical, and palæontological questions. He early devoted attention to the remarkable Oolitic Cycads of Yorkshire; and submitted to the Yorkshire Philosophical Society a restoration of their numerous though fragmentary remains, which was the first attempt at a scientific estimate of their relations to known structures. He was specially fitted to deal with these fossils, from his extensive acquaintance with the living Cycads. In his Palm House, at Highgate, he had collected the largest series of living Cycads that have ever belonged to a private individual, or that have been brought together, perhaps, in any public institution. Considering the important part which the Cycads have played in the Secondary Floras of Britain, few sights in the neighbourhood of London were more instructive to the geologist than Mr. Yates's Cycadeæ, which were always open to every inquirer. Indeed, Mr. Yates seemed to realize that his collections were performing their highest functions and amply repaying all his trouble and labour when they were made the means of supplying information to scientific men. He made extensive notes on his specimens, and when chance gave him a dead plant or a fruit, he carefully dissected it. Some of these valuable observations have been published in the *Linnæan Journal* and the *Gardener's Chronicle.* His botanical manuscripts, and his collection of dried foliage and fruits of Cycadeæ he presented some years ago to the Botanical Department of the British Museum. Miquel dedicated a species of *Zamia* to him, and Mr. Carruthers gave his name to a genus of fossil Cycads, the type of which was published in the Fourth Volume of this Magazine, Plate IX., under the name *Cycadoidea Yatesii*, being now *Yatesia Morrisii.* James Yates died at Lauderdale House, Highgate, on the 7th of May, 1871, at the age of 82. He has left a handsome bequest to the Geological Society, which will long preserve his memory among the members of that Society. A large circle will not soon forget the extensive learning, the thorough integrity, and the unvaried urbanity which characterized their departed friend.

W. C.

THE

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OBITUARY.

SIR RODERICK IMPEY MURCHISON, Bart., K.C.B., LL.D., D.C.L., M.A., F.R.S., F.G.S.,

Director-General of the Geological Survey of Great Britain and Ireland; late President of the Royal Geographical Society of London; Trustee of the British and Hunterian Museums, and of the British Association for the Advancement of Science; Member of the Imperial Academy of Sciences, the Geographical and Mineralogical Societies of St. Petersburg; Corresponding Member of the Imperial Academy of Vienna, of the Royal Academy of Hungary, of the Institute of France; Honorary Member of the Royal Academies of Berlin, Copenhagen, Stockholm, Brussels, Munich, Holland, Turin, Rome; and of the Scientific Societies of Switzerland, Moscow, Breslau, Frankfort, Boston, New York, Philadelphia, etc., etc., etc.

Born February, 19, 1792; Died October 22, 1871.

(With a Portrait.)

THE death of Sir Roderick Murchison, although at the ripe age of 80 years, is a loss which Geologists and Geographers are alike called upon to mourn. In relation to both these sciences, he has for many years justly occupied the most prominent positions. But, apart from his high social and scientific standing, he was a man full of genial and kindly feeling, who could be readily approached; and those who knew him most intimately acknowledge that he was never known to fail his friends in the hour of need, but was ready to aid them with his advice, his influence, and his purse, as many a young scientific man amongst us can testify.

Born at Tarradale, in Ross-shire, he received his early education as a boy at the Grammar School at Durham.

But the associations of his Highland home—his ancient Scottish pedigree, numbering in the long roll many a staunch supporter of the Stuarts, who had freely laid down their lives for their Sovereign—combined with the stirring events which marked the period of his own youth, no doubt powerfully influenced young Murchison in selecting a profession, until in imagination he too, like Roderick Vich Alpine, heard the mountains say—

> "To you as to your sires of yore,
> Belong the target and claymore!"

Having made up his mind to follow the military profession, he was sent by his father, Mr. Kenneth Murchison, to the Royal Military College, Great Marlow, after which, having pursued his studies for a few months at the University of Edinburgh, he obtained a commission in the army in 1807, and joining his regiment the following year, served in the 36th Foot with the army in Spain and Portugal under Lord Wellington, afterwards on the Staff of his uncle, General Sir Alexander Mackenzie, and lastly as Captain in the 6th Dragoons. He took an active part in several of the most important battles in the war, and earned the reputation of being a brave and able officer. He carried the colours of his regiment at the Battle of Vimiera, and afterwards accompanied the army in its advance to Madrid and its junction with the force under Sir John Moore, and shared in the dangers and retreat at Corunna. At the end of the war in 1815, he married Charlotte, only daughter of the late General Francis Hugonin. It was Sir Roderick's own conviction that to his wife's influence was mainly to be attributed the choice he made in following scientific pursuits with her, and giving up, as he did, the ordinary amusements of a retired cavalry officer.[1] She was his friend, companion, and fellow-labourer, in geology aiding him in his observations, and making for him those remarkable geological sketches of landscape that illustrate his works. He is also said to have early become acquainted with Sir Humphry Davy, who suggested to him that he should attend the lectures of the Royal Institution. This advice he followed, and he also studied with Mr. Richard Phillips, F.R.S.

In 1825 he was elected a Fellow of the Geological Society of London, and in the same year he read his first paper on "The Geological Formation of the North-west extremity of Sussex, and the adjoining parts of Hants and Surrey," before that Society.[2]

In 1826 he recorded the results of his investigations in the Oolitic series of Sutherland, Ross, and the Hebrides, and in the same year he was elected to the Fellowship of the Royal Society; the following year he again visited the Highlands in company with Professor Sedgwick and succeeded in showing that the primary Sandstone of McCulloch was really the true Old Red Sandstone or Devonian.

In 1828 he resolved to extend his researches abroad, and to study the extinct volcanos of Auvergne and the geology of the Tyrol. He was accompanied on this occasion by Mr. (now Sir Charles) Lyell.

Following Dr. Buckland's advice, Murchison next devoted himself to a careful examination of the geology of Hereford, Shropshire, and the Welsh Borders, the ancient country of the *Silures*, and it was upon this investigation that his great Silurian system was afterwards founded.

These researches he afterwards followed up by others in Pembrokeshire, to the west of Milford Haven; and his conclusions as to the stratigraphical relation between the Devonian and the under-

[1] See notice of Lady Murchison, Geol. Mag., 1869, Vol. VI., p. 227, by Prof. Geikie, F.R.S., President Edinburgh Geological Society.

[2] This paper is of great historical interest, being accompanied by a letter from the illustrious Baron Cuvier, in which he gives a detailed description of the Reptilian remains forwarded to him by Mr. Murchison for examination. The specimens which are figured and described in this paper are now preserved in the British Museum.

lying Silurian systems was made public at the meeting of the British Association for the Advancement of Science in 1831, but his great work did not appear until 1839.

Further geographical investigations in Devon and Cornwall followed, in which Professor Sedgwick took part, and in 1835 and 1839, two journeys were performed by Sedgwick and Murchison to the Rhenish Provinces; on the latter occasion M. de Verneuil also accompanied them. The result of these researches, and comparison of the English Devonians with those of Rhenish Prussia, was published in 1839, and a final classification adopted.

In 1840, accompanied by De Verneuil, Murchison visited Russia, at that period but very little known geologically.

They examined the banks of the rivers Volkoff and Siass, and the shores of Lake Onega, thence to Archangel and the borders of the White Sea, and followed the river Dwina in the government of Vologda. They traversed the Volga and returned by Moscow to St. Petersburg, examining the Valdai Hills, Lake Ilmen, and the banks of the rivers which they passed. They then returned to England, but having been invited by the late Emperor Nicholas to superintend a Geological Survey of Russia, the two geologists returned to St. Petersburg in the spring of 1841, and being joined by Count Keyserling and Lieutenant Kokscharow, they proceeded to explore the Ural Mountains, the Southern Provinces of the Empire and the Coal Districts between the Dneiper and the Don. In 1842 Murchison travelled alone through several parts of Germany, Poland, and the Carpathian Mountains, the better to understand the relations of the great formations to each other over wide areas. In 1844 he explored the Palæozoic rocks of Sweden and Norway. In 1845–6 he completed his great joint work on "The Geology of Russia and the Ural Mountains," in two quarto volumes of 700 and 600 pages, copiously illustrated with maps, sections, and plates of fossils. Not long after the publication of this work, Mr. Murchison was knighted by Her Majesty, the Emperor having previously conferred several Russian orders on him, including that of St. Stanislaus. In 1849 he received the Copley medal from the Royal Society, in recognition of his having established the Silurian system in geology.

His researches (extending over six visits) in the Alps, Apennines, and Carpathian mountains, established the fact of a graduated transition from Secondary to Tertiary rocks, and clearly separates the great Nummulitic formation from the Cretaceous formations with which it was confounded.

Ranking next in importance to his definition of the Silurian System was his differentiation of the Permians. Having satisfied himself that the Lower New Red Sandstone, and the Magnesian Limestone and Marl Slates constituted one natural group only, which, from their organic contents, must be entirely separated from the overlying formations, he proposed, in 1841, that the group should receive the name of the "Permian" system, from Perm, a Russian Government, where these strata are more extensively developed than elsewhere, occupying an area twice the size of France, and containing an abundant and varied suite of fossils. The name Permian is now generally adopted.

In 1854 Sir Roderick published the first edition of his best-known work, "Siluria," which had, in 1867, reached its fourth edition, and contains 566 pages 8vo. of closely printed matter, 41 plates and explanations.

In 1855 he produced a memoir in conjunction with Prof. Morris on the German Palæozoic rocks, and shows that there is no break between the Permian system and the Triassic series.

By the death of Sir H. T. de la Beche, Sir Roderick, in 1855, succeeded to the post of Director General of the Geological Survey and the Museum of Practical Geology in Jermyn Street, which have owed their efficiency for the past fifteen years very largely to his energy and constant attention.

Sir Roderick Murchison will long be remembered both in the world of science and of commerce in connexion with the discovery of gold in Australia. Long years before the actual discovery of gold in Australia was made known, he inferred the presence of auriferous deposits in the Australian mountain-ranges from the analogy which existed between their rock-formations and those of the Ural mountains, with the physical characters of which he had made himself familiar. He endeavoured most earnestly at the time to awaken the attention of the Home Government to the great importance of the subject to our colonies in the Southern hemisphere, but with little success.

During his scientific career he has been identified most intimately with the Geological Society. He acted as Secretary for five years, was elected President in 1831-2, and again in 1842-3.

He aided Sir David Brewster, in 1830, to establish the British Association, of which for several years he acted as General Secretary. He was President at the Meeting for 1846, at Southampton.

In 1844 he was elected President of the Royal Geographical Society, and again in 1845, in 1852, and in 1856; indeed, he has held the Presidential chair of that Society almost down to the present time; having been succeeded only a few months ago by Sir Henry Rawlinson.

His energetic efforts in advocating the search after Sir John Franklin; his success in raising a monument to Lieutenant Bellot, of the French Navy; his advocacy of the explorers of Central Africa, Burton, Speke, Grant, Baker, and especially his friend Livingstone, are among the proofs of his earnest self-devotion to the cause of Geographical research.

Amongst the many workers in the fields of science how few there are whose actual published labours extend over half a century; yet almost the last Blue Book which has appeared, namely, "the Report of the Commissioners appointed to inquire into the several matters relating to Coal in the United Kingdom," (Vol. I. General Report and Twenty-two Sub-reports, folio, 1871), bears Sir Roderick's name second on the Commission.

The Council of the Geological Society awarded him the Wollaston

Gold Medal, in 1864, in recognition of his contributions to geology as an inductive science. The Universities of Oxford, Cambridge, and Dublin have also bestowed on him their Honorary Degree.

He held for many years the post of a Trustee to the British Museum, with great advantage to the Natural History Departments in that Institution, which he specially promoted.

Sir Roderick was created, in 1863, a Knight Commandant of the Order of the Bath (civil division), and in the following year he received the prize named after Baron Cuvier from the French Institute. In 1859 the Royal Society of Scotland presented him with their first Brisbane gold medal, for his scientific classification of the Highland rocks, and for the establishment of the remarkable fact that the Gneiss of the north-west coasts is the oldest rock in the British Islands. He was created a baronet in January, 1866.

One of his latest acts consisted in offering the munificent sum of £6,000 to found a Chair of Geology and Mineralogy in the University of Edinburgh, on condition that the Government would supplement the proceeds by an annual grant of £200. This was duly acceded to, and the chair so endowed, is now held by Professor Geikie, F.R.S., etc.

The death of Lady Murchison in 1869 was most keenly felt by Sir Roderick, indeed it may be said to have given him a shock from which he never wholly recovered. He was first attacked by paralysis in December, 1870, but gradually rallied until two months since, when he had a second stroke, but the symptoms had lately abated. A slight attack of bronchitis, caused by a cold caught in riding out on the 19th ulto., ended his valuable and well-spent life on Sunday evening, Oct. 22, at 8.30 p.m.

His scientific career, now brought to a close, represents the period of the dawn and development of Geology as a science in this country. He commenced work at the moment when William Smith issued the first Geologically-coloured map of England, and he has lived on to see half the world surveyed geologically, and has himself mapped a vast extent of territory in Europe for his Silurian kingdom.

In conclusion (to quote the words of the *Daily News*), "the honours he won are a great testimony to the scientific enlightenment of the age. We have crowned Science Queen, and all her servants form her court, and wear the titles she bestows. And, truly, a scientific man earns his honours more nobly, and wears them more honourably, than those who win them in political intrigue or on the field of battle. Sir Roderick Murchison, dying at eighty, covered with titles of literary and scientific honour, and satisfied with social position and renown, is a prophet of the coming time. He may not be looked back on as a great scientific genius; but he is one of the pioneers of that new order of renown which is won by fruitful service rather than by destructive deeds."

(We are indebted to the *Times* of October 23rd, for a part of the foregoing sketch.—Edit. Geol. Mag.)

The following is a list of the Books, Papers, and Memoirs, written by Sir Roderick Murchison:—

1. Geological Sketch of the North-western Extremity of Sussex, and the adjoining parts of Hants and Surrey.—Trans. Geol. Soc. ser. 2, ii. p. 97; Phil. Mag. lxvii. p. 70; *Féruss.* Bull. 1826, viii. p. 24; 1827, x. p. 211.

2. Supplementary Remarks on the Strata of the Oolitic Series, and the rocks associated with them in the Counties of Sutherland and Ross, and in the Hebrides.—Trans. Geol. Soc. ser. 2, ii. p. 353; Proc. Geol. Soc. i. p. 33; Phil. Mag. ser. 2, ii. p. 454; *Féruss.* Bull. 1829, xvi. pp. 50, 183; xvii. p. 25.

3. On the Coal-field of Brora in Sutherlandshire, and some other stratified deposits of the North of Scotland.—Trans. Geol. Soc. ser. 2, ii. p. 293; Proc. Geol. Soc. i. p. 13; Phil. Mag. ser. 2, i. p. 229; *Féruss.* Bull. 1828, xv. p. 25; 1829, xvi. p. 47.; Ann. Phil. 1827, pp. 229, 445; Edin. Phil. Journ. 1827, p. 188.

4. On the Tertiary and Secondary Rocks forming the Southern Flank of the Tyrolese Alps, near Bassano.—Proc. Geol. Soc. i. p. 137; Phil. Mag. ser. 2, v. p. 401; vi. p. 55.

5. On the Bituminous Schist and Fossil Fish of Seefeld in the Tyrol.—Proc. Geol. Soc. i. p. 139; Phil. Mag. ser. 2, vi. p. 57; Ann. Sc. Nat. xviii. p. 132.

6. On a Fossil Fox found at Œningen near Constance, with an account of the deposit in which it was imbedded.—Trans. Geol. Soc. ser. 2, iii. p. 277; Proc. Geol. Soc. i. p. 167; Phil. Mag. ser. 2, vii. p. 207.

7. Supplementary Observations on the Structure of the Austrian and Bavarian Alps.—Proc. Geol. Soc. i. p. 250; Phil. Mag. ser. 2, ix. p. 213; Bull. Soc. Géol. Fr. i. p. 144; *Leonard* und *Bronn* N. Jahrb. 1833, p. 440.

8. On the Secondary Formations of Germany, as compared with those of England; Proc. Geol. Soc. i. p. 325; Phil. Mag. ser. 2, x. p. 45.

9. Address to the Geological Society, 1832.—Proc. Geol. Soc. i. p. 362; Phil. Mag. ser. 2, xi. p. 363.

10. Observations on Clay, Gravel, Marl, and Sand in Lancashire, containing existing species of Sea Shells.—Report Brit. Assoc. i. p. 82.

11. On the Structure of the Cotteswold Hills and country round Cheltenham; and on the occurrence of Stems of Fossil Plants in vertical positions in the Sandstone of the Inferior Oolite of the Cleveland Hills.—Proc. Geol. Soc. i. p. 388; Phil. Mag. ser. 3, i. p. 221.

12. Address to the Geological Society, 1833.—Proc. Geol. Soc. i. p. 440; Phil. Mag. ser. 3, ii. p. 467; iii. p. 42.

13. On the Secondary Deposits which occupy the western parts of Shropshire and Herefordshire, and are prolonged from north-east to south-west, through Radnor, Brecknock, and Caermarthenshires, with descriptions of the accompanying rocks of intrusive or igneous characters.—Proc. Geol. Soc. i. pp. 470, 474; Phil. Mag. ser. 3, iii. p. 224.

14. On Freshwater Limestone between the Seams of Coal in the neighbourhood of Shrewsbury.—Phil. Mag. ser. 3, iv. p. 158.

15. On the Old Red Sandstone in the Counties of Hereford, Brecknock, and Caermarthen, with Collateral Observations on the Dislocations which affect the north-west margin of the South Welsh Coal-basin.—Proc. Geol. Soc. ii. p. 11; Phil. Mag. ser. 3, iv. p. 228; *L.* u. *Br.* N. Jahrb. 1836, p. 404.

16. On the Structure and Classification of the Transition Rocks of Shropshire, Herefordshire, and part of Wales, and on the Lines of Disturbance which have affected that series of Deposits, including the Valley of Elevation of Woolhope.—Proc. Geol. Soc. ii. p. 13; Phil. Mag. ser. 3, iv. p. 370; *L.* u. *Br.* N. Jahrb. 1836, p. 70.

17. On the Gravel and Alluvial Deposits of those parts of the Counties of Hereford, Salop, and Worcester, which consist of Old Red Sandstone; with an Account of the Ruffstone, or Travertin of Spouthouse, and of the Southstone Rock near Tenbury.—Proc. Geol. Soc. ii. p. 77; Phil. Mag. ser. 3, v. p. 217.

18. On certain Trap Rocks in the Counties of Salop, Montgomery, Radnor, Brecon, Caermarthen, Hereford, and Worcester; and the effects produced by them upon the stratified deposits.—Proc. Geol. Soc. ii. p. 85; Phil. Mag. ser. 3, v. pp. 225, 292.

19. On an outlying Basin of Lias on the borders of Salop and Cheshire, with a

short Account of the Lower Lias between Gloucester and Worcester.—Proc. Geol. Soc. ii. p. 114; Phil. Mag. ser. 3, vi. p. 314.

20. On the New Red Sandstone Series of the Counties of Salop, Stafford, Worcester, and Gloucester.—Proc. Geol. Soc. ii. p. 116; Phil. Mag. ser. 3, vi. p. 315; *L.* u. *Br.* N. Jahrb. 1836, p. 406.

21. On certain Coal-tracts in Salop, Worcestershire, and North Gloucestershire.—Proc. Geol. Soc. ii. p. 119.

22. On certain Lines of Elevation and Dislocation of the New Red Sandstone of North Salop and Staffordshire, with an Account of Trap Dykes in that Formation, at Acton Reynolds near Shrewsbury.—Proc. Geol. Soc. ii. p. 194; Phil. Mag. ser. 3, vii. p. 415.

23. On the Silurian System of Rocks.—Phil. Mag. ser. 3, vii. p. 46.

24. On the recent Discovery of Fossil Fishes (*Palæoniscus catopterus*, Agassiz) in the New Red Sandstone of Tyrone, Ireland.—Proc. Geol. Soc. ii. p. 206; Phil. Mag. ser. 3, viii. p. 72; *L.* u. *Br.* N. Jahrb. 1836, p. 735.

25. On the Geological Structure of Pembrokeshire, more particularly on the Extension of the Silurian System of Rocks into the coast cliffs of that country.—Proc. Geol. Soc. II. p. 226; Phil. Mag. ser. 3, viii. p. 561.

26. On the Gravel and Alluvia of S. Wales, and Siluria as distinguished from a northern Drift covering Lancashire, Cheshire, N. Salop, and parts of Worcester and Gloucester.—Proc. Geol. Soc. ii. p. 230; Phil. Mag. ser. 3, viii. p. 566.

27. On the Silurian and other Rocks of the Dudley and Wolverhampton Coal-field, followed by a Sketch proving the Lickey Quartz Rock to be of the same age as the Caradoc Sandstone.—Proc. Geol. Soc. ii. p. 407; Phil. Mag. ser. 3, ix. p. 489; *L.* u. *Br.* N. Jahrb. 1838, p. 597.

28. On the Supposed Existence of the Lias Formation in Africa.—Proc. Geol. Soc. ii. p. 415; Phil. Mag. ser. 3, ix. p. 496; *L.* u. *Br.* N. Jahrb. 1838, p. 197.

29. On a specimen from the Oar's Rock, nine miles south of Little Hampton, Sussex.—Proc. Geol. Soc. ii. p. 686; Phil. Mag. ser. 3, xiii. p. 387.

30. On Fishes of the Ludlow Rocks.—Rep. Brit. Assoc. vi. Sect. p. 91.

31. Address to the British Association for the Advancement of Science (Newcastle).—Rep. Brit. Assoc. p. xxxi.

32. The Silurian System founded on Geological Researches in the counties of Salop, Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester, and Stafford. 4to. Lond. 1839.

33. On the Carboniferous and Devonian system of Westphalia.—Rep. Brit. Assoc. 1839, Sect. p. 72.

34. On the Classification of the older Stratified Rocks of Devon and Cornwall.—Phil. Mag. xiv. pp. 241, 317, 354; Ed. New. Phil. Journ. xliii. p. 33.

35. Sur les Roches Dévoniennes du Boulonnais.—Bull. Soc. Géol. Fr. xi. p. 229; *L.* u. *Br.* N. Jahrb. 1841, p. 772.

36. Fishes of the Old Red Sandstone.—Rep. Brit. Assoc. 1840, Sect. p. 99.

37. On a section with a List of Fossils from the State of New York, by *James Hall, Esq.*—Proc. Geol. Soc. iii. p. 416; Phil. Mag. ser. 3, xix. p. 530.

38. Address to the Geol. Soc., 1842.—Proc. Geol. Soc. iii. p. 637; Phil. Mag. ser. 3, xx. p. 541; Edinb. New. Phil. Journ. xxxiii. p. 124.

39. On the Salt Steppe south of Orenburg, and on a remarkable Freezing Cavern. Proc. Geol. Soc. iii. p. 695; Phil. Mag. ser. 3, xxi. p. 357; Edinb. New. Phil. Journ. xxxiv. p. 10.

40. On Tchornoi Zem, or Black Earth of Central Russia.—Proc. Geol. Soc. iii. p. 712; Phil. Mag. ser. 3, xxii. p. 71; Journ. Agric. Soc. Engl. iii.

41. On some of the results of his Second Geological Survey of Russia.—Proc. Geol. Soc. iii. p. 717; Edinb. New. Phil. Journ. xxxii. p. 99; Phil. Mag. ser. 3, xix. p. 417; Ann. and Mag. Nat. Hist. ser. 1, viii. p. 289.

42. Inaugural Address at the first General Meeting of the Dudley and Midland Geol. Soc. Jan. 1842, Lond.

43. On the distinction between the Striated Surface of Rocks and Parallel Undulations dependent on Original Structure.—Rep. Brit. Assoc. 1842, Sect. p. 53.

44. Address to the Geological Society, 1843.—Proc. Geol. Soc. iv. p. 65; Phil. Mag. ser. 3, xxii. p. 511; Edinb. New. Phil. Journ. xxxv. p. 115.

45. On the occurrence of Freshwater Beds in the Oolitic Deposits of Brora, Sutherlandshire; and on the British Equivalents of the Neocomian System of Foreign

Geologists.—Proc. Geol. Soc. iv. p. 174; Phil. Mag. ser. 3, xxiv. p. 72; *L.* u. *Br.* N. Jahrb. 1844, p. 623.

46. The "Permian System" as applied to Germany, with collateral observations on similar Deposits in other countries; showing that Rothe-todte-liegende, Kupferschiefer, Zechstein, and the lower Limestone constitute the Upper Member of the Palæozoic Rocks.—Rep. Brit. Assoc. 1843, Sect. p. 52.

47. On the important Additions recently made to the Fossil contents of the Tertiary and Alluvial Basin of the Middle Rhine.—Rep. Brit. Assoc. 1843, Sect. p. 55.

48. Anniversary Addresses to the Royal Geographical Society of London.—Journ. Roy. Geogr. Soc. xiv.; xv., 1844.

49. Observations on the Ural Mountains to accompany a new Map of the Southern portion of that Chain.—Journ. Roy. Geogr. Soc. xiii. p. 269.

50. On the Palæozoic Deposits of Scandinavia and the Baltic Provinces of Russia, and their relations to Azoic or more ancient Crystalline Rocks; with an Account of some great features of Dislocation and Metamorphism along their northern frontiers.—Proc. Geol. Soc. iv. p. 601; Journ. Geol. Soc. i. p. 467; Rep. Brit. Assoc. 1844, Sect. p. 53; Verhand. Kais. Min. Gesellsch. Petersb. 1844.

51. Fragments of a Geologist.—Quart. Rev. lxxiii. p. 324.

52. On the Palæozoic Deposits of the Basin of Christiania.—Förhand. Skand. Naturf. Möte, Christiania, 1845.

53. On the Superficial Detritus of Sweden, and on the Probable Causes which have affected the Surface of the Rocks in the Central and Southern portions of that Kingdom.—Journ. Geol. Soc. ii. p. 350.

54. Outline of the Geology of the Neighbourhood of Cheltenham. 8vo. Cheltenham, 1834.—Ed. 2., augmented by *J. Buckman* and *H. E. Strickland.* 8vo. London, 1845.

55. On the Silurian Rocks of Cornwall, with Opinions on the Gold of Australia.—Trans. R. Geol. Soc., Cornwall; Ann. and Mag. Nat. Hist. xix. p. 326.

56. On the Silurian and associated Rocks in Dalecarlia, and on the succession from Lower to Upper Silurian in Smoland, Oeland, and Gothland, and in Scania.—Journ. Geol. Soc. iii. p. 1.

57. Address to the British Association for the Advancement of Science (Southampton).—Rep. Brit. Assoc., 1846.

58.—Additional Remarks on the Deposit of Œningen, in Switzerland.—Journ. Geol. Soc. iii. p. 54.

59. On the Meaning originally attached to the term "Cambrian System," and on the evidences since obtained of its being geologically synonymous with the previously established term "Lower Silurian."—Journ. Geol. Soc. iii. p. 165; Edin. N. Phil. Journ. xliii. p. 147.

60. Introduction to a Second Memoir of *Capt. Vicary* on the Geology of parts of Sinde.—Journ. Geol. Soc. iii. p. 331.

61. On the Distribution of Gold Ore in the Crust and on the Surface of the Earth.—Rep. Brit. Assoc. 1849, Sect. p. 60.

62. On "the Silurian Rocks of Bohemia," with Remarks on the Devonian Rocks of Moravia.—Edinb. New. Phil. Journ. xliv. p. 66.

63. On the Geological Structure of the Alps, Apennines, and Carpathians, more especially to prove a transition from Secondary to Tertiary Rocks, and the development of Eocene Deposits in Southern Europe.—Journ. Geol. Soc. v. p. 157.

64. On the Distribution of the Superficial Detritus of the Alps, as compared with that of Northern Europe.—Journ. Geol. Soc., vi. p. 65; Edinb. New. Phil. Journ., xlviii. p. 256.

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3 (*a*). Murchison (R.I.) and Sabine (E.) Anniversary Address to the British Association for the Advancement of Science (Glasgow).—Rep. Brit. Assoc. 1840.

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10 (*a*). Murchison (R. I.), and Morris (Professor John). On the Palæozoic and associated Rocks of the Thüringerwald and the Harz. Quart. Journ. Geol. Soc. Lond. 1855, vol. xi. p. 409.

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12 (*b*). On the Coincidence between Stratification and Foliation in the Crystalline Rocks of the Scotch Highlands.—Op. cit. 1861, vol. xvii., p. 232.

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Mr. Charles Babbage, F.R.S.—This eminent mathematician and philosopher was born 26th December, 1792, and died at his residence, Dorset St., Marylebone, on the 20th inst., in his eightieth year. He was the inventor and partial constructor of the famous calculating engine or machine, which the world has associated with his name, and which is now preserved in the Museum of King's College, London. As a writer in the *Dictionary of Universal Biography* remarks:

"The possibility of constructing a piece of mechanism capable of performing certain operations on numbers is by no means new; it was thought of by Pascal and geometers, and more recently it has been reduced to practice by M. Thomas, of Colmar, in France, and by the Messrs. Schütz, of Sweden; but never before or since has any scheme so gigantic as that of Mr. Babbage been anywhere imagined."

His achievements, says the *Times*, were two-fold; he constructed what he called a Difference Engine, and he planned and demonstrated the practicability of an Analytical Engine also.

It would be entirely beyond our province to refer here in any detail to Mr. Babbage's labours and sacrifices; his history is that of almost all original inventors; his machine, the labour of his life, over which he expended his time, his brains, and his fortune, was never completed, and will remain unfinished, until perchance some adapter of other men's ideas shall be able to effect its completion by some more economic method than was known to him.

Geologists are indebted to Mr. Babbage for a most valuable and philosophical paper on the rate of Geological changes, and the movements of elevation and subsidence of land as illustrated by the Temple of Serapis, at Puzzuoli, in the Bay of Baiæ, near Naples (see Quart. Journ. Geol. Soc., 1847, vol. iii.). This celebrated monument of antiquity affords in itself unequivocal evidence that the relative level of land and sea has changed twice at Puzzuoli since the Christian era; and each movement of elevation and subsidence has exceeded 20 feet. Mr. Babbage examined the temple and inland cliff (covered with *Balani* and full of the perforations of Lithodomous Mollusca) in company with Sir Edmund Head, in June, 1828; and a full account will be found of his researches both in his original paper and also in Sir Charles Lyell's "Principles" (vol. ii. pp. 164-179, 10th edition, 1868). It may seem strange at the present day that the idea of the permanence of the ocean's level should have been denied by many otherwise able writers, but the phenomena of the Bay of Baiæ have given rise to interminable controversies, all arising (says Sir Charles Lyell) from an extreme reluctance to admit that the land, rather than the sea, is subject alternately to rise and fall (Principles, *op. cit.* p. 179).

A list of eighty papers and works by Mr. Babbage is recorded; the most valuable no doubt of all are his "Tables of Logarithms," from 1 to 108,000, a work which, although now forty years old, is still held in high esteem by all upon whom the laborious calculations of astronomy and mathematical science devolve. Mr. Babbage was one of the oldest members of the Royal Society, and more than fifty years ago was one of the founders of the Astronomical Society; he and Sir John Herschel were the last survivors of that body.

ORIGINAL ARTICLES.

I.—Relics of the Carboniferous and other Old Land-Surfaces.

By Henry Woodward, F.G.S., F.Z.S.[1]

ALTHOUGH unwilling to admit that in the history of our Earth special and peculiar conditions have prevailed at any period since the first advent of organic beings, yet we cannot doubt, that during particular eras, circumstances favoured the development of special groups of organisms which, in consequence, flourished in greater perfection and numbers than the rest.

Thus, in the earlier Palæozoic rocks Trilobites abounded; in the Secondary rocks, Ammonites; in the Tertiary, Nummulites; whilst the Carboniferous period was marked by its great development of Land Vegetation. Other land-floras we know, however, existed, both pre- and post-Carboniferous, but, apparently, they did not attain to the same richness of vegetation or longevity as that of the Coal-period proper.

In speaking of any period of the past, especially of one marked by terrestrial conditions, we should carefully guard ourselves against the too common practice of generalizing upon insufficient data.

We have so very few records left to us of the old Land-surfaces, whence all the sediments came which form our stratified rocks, that in studying the latter we are too apt to ignore the source from whence they were derived, and to think of our earth in the past as of a great marine aquarium, full of strange creatures of the sea.

Yet, a moment's reflection tells us that as the forces of heat and attraction have been for ever acting on our earth since it came into being, there must have been land from very remote geologic times; and, further, if conditions in the sea were favourable to the development of abundance of animal life, those on the land were in all probability equally so.

Admitting, however, as we inevitably must, the imperfection of the geological record (especially as regards the preservation of land-surfaces), let us endeavour to ascertain whether there is evidence to show a continuity of terrestrial conditions, and how far we can follow the same as it recedes back from land to land, further and further into the past, until its shadowy shores disappear beneath the pre-Silurian seas, and we reach the last waif washed from its Cambrian coasts.

If we seek for the remains of land-surfaces belonging to the Quaternary period, we shall find them everywhere most abundant and wide-spread, including, as we do under this division, all the latest changes to which our globe has been subjected, and of which primitive man was a passive witness.

[1] Read before the Geologists' Association, May 5th, 1871.

It includes changes of level and modifications of coast-lines of enormous extent. In Australia the land has probably undergone great depression, for we find old land-surfaces at a depth of more than 100 feet beneath the present surface (*vide* R. Brough-Smyth's "Gold Fields of Victoria") covered with remains of a vegetation exactly like that now existing, and inhabited by many of the same species of animals, as well as by gigantic Marsupials now quite extinct.

In Northern Africa we have evidences of a great upheaval in Quaternary times, which laid dry the Sahara, and produced a wonderful climatal change in Southern Europe (*vide* Prof. Desor's paper, Geol. Mag., Vol. I., p. 27, translated by Prof. Ramsay).

In Britain we have abundant evidences of depression and upheaval in late geological times, as witnessed by our Glacial deposits requiring a change of level of 1,500 or 2,000 feet (*vide* "Lyell," Shells on Moel Tryfaen, "Principles," vol. i., p. 195, tenth edition; and "Elements," p. 158, sixth edition).

The coast of Norway, with its raised beaches of recent shells, also attests a change of level of more than 200 feet ("Lyell's Principles," tenth edition, vol. ii., p. 191).

The west coast of Greenland, on the contrary, has been subsiding during the past century for a distance surveyed of more than 600 miles from north to south.

The submerged forests around our own coasts are silent witnesses to the same ceaseless round of change; whilst the evidences derived from their ancient fauna show an equally marked variation in climate and distribution.

Passing from Quaternary to Tertiary times, we have in the deposits of our own island, in France, Germany, Switzerland, Italy, and Greece, abundant evidence both of land-plants and animals diverging, however, more and more from those which occupy the same regions at the present day.

In this long series of Tertiary and Quaternary deposits, evidences of terrestrial conditions seem present in almost every stratum, and we never lose sight of land, but when the base of the Tertiaries is reached the land-surfaces are divided by greater marine accumulations. Still, freshwater deposits, with land-plants and animals, mark the incoming of the Chalk series in America, and the Maestricht Chalk is found to afford remains of Dinosaurian and Amphibian Reptiles, although these former have yet to be described.[1]

Leaves of exogenous plants have long been known from the "Quader Sandstein" and the "Planer-kalk," of Germany, beds equivalent in age to the White Chalk and Gault of England.

More recently, in the neighbourhood of Aix-la-Chapelle, beds have been discovered several hundreds of feet in thickness rich in silicified woods and impressions of leaves, representing more than two hundred species, of which Tree-ferns, Conifers, and Dicotyledonous Angiosperms form the chief part. In the Kentish Chalk itself—a truly marine deposit—evidences exist (in the remains of

[1] The specimens referred to are in the collections lately acquired by the British Museum from the Van Breda Museum at Haarlem.

the gigantic Pterodactyles and the turtle) of the proximity of land. In the Chalk Marl of Folkestone a Dinosaurian allied to *Iguanodon*,[1] has also been discovered; and in the Cambridge Greensand the rare remains of birds, besides abundance of Pterodactyles, Cheloniæ, and other reptilia, evidence littoral conditions.

At the base of the Neocomian series—and included in it by Mr. J. W. Judd[2]—we come to the great Wealden formation, remarkable for its gigantic Dinosauria, on which so much new light has lately been thrown by Prof. Huxley, Mr. J. W. Hulke, and others.[3] Here we also meet with entire beds of minute *Cyprides*, whilst the celebrated band of stone in this formation known as Petworth marble, composed entirely of the shells of *Paludinæ*, together with *Unio*, *Cyclas*, *Cyrena*, etc., mark its freshwater origin. The *Lepidotus Mantelli*, a fine Ganoid fish, from the Wealden, with large rhomboidal scales, was probably (like the great Gar-pike of the American rivers) a freshwater fish. Cheloniæ (represented by *Trionyx* and *Emys*) and a Pterodactyle are also found; whilst Coniferæ Cycadean plants and Arborescent Ferns, with others of lowlier growth, complete the Wealden landscape.

In the uppermost member of the Oolitic group, we again find, at Purbeck, in Dorsetshire, evidence of a land-surface of the highest interest marked by remains of above ten genera and twenty-five species of MAMMALIA![4] together with some six or seven genera of freshwater Mollusca—*Cyprides*, Turtles, and Fish, and about forty species of Insects; whilst a large number of small land-Reptilia remain undescribed.

In the Lower Purbeck we also meet with a most interesting geologic relic in the Portland Dirt-bed, with its old vegetable soil and its silicified trunks of Cycadeæ and stools of Coniferæ still preserved *in situ*. We have here also evidences of repeated changes of level, causing alternations of fresh and marine conditions, as shown by the successive beds and their fossil contents.

Passing on to the Kimmeridgian series, we have bituminous shales and impure coal-seams, forming in all a mass of strata several hundred feet in thickness, marked also by the remains of one of the largest Saurians known, the gigantic *Cetiosaurus*, from near Oxford, and by numerous Teleosaurians and other Crocodilian and Gavial-like reptiles. The Solenhofen-stone again reveals an Oolitic long-tailed bird, the *Archæopteryx*, numberless *Pterodactyles*, both of the long and short-tailed type; together with lacertilian reptiles and countless insects, telling of an Oolitic land rich in Coniferæ and other trees and plants, and swarming with animal existences.

Passing over a series of marine beds, we come again, in the Stonesfield slate, upon abundance of Insect-life; upon remains of the great *Megalosaurus* and *Pterodactyles;* three genera of Mammalia, and a

[1] *Acanthopholis horridus*, Huxley. GEOL. MAG., 1867. Vol. IV., p. 65. Pl. V.

[2] See Quart. Journ. Geol. Soc., vol. xxvi., 1870, p. 326.

[3] *Iguanodon*, *Hylæosaurus*, *Hypsilophodon*, *Streptospondylus*, *Megalosaurus*, etc.

[4] See Prof. Owen's Monograph on "the Fossil Mammals of the Mesozoic Formations." Pal. Soc. vol. xxiv. 1871.

land-vegetation rich in Ferns, Cycads, and Conifers. Lower still, in the Oolitic series, we come to the Plant-beds of Yorkshire, and the Coal-beds of Brora, in Sutherlandshire (also of Oolitic age), rich in Equisetaceæ, Ferns, Cycadeæ, and Coniferæ; and, again, in the Lower Lias of Lyme Regis and elsewhere we have Araucarian trunks and foliage, and another Iguanodon-like Dinosaur (*Scelidosaurus Harrisoni*, Owen), and the remarkable long-tailed Pterodactyle, the *Dimorphodon macronyx;* with Insects' wings and other remains to further attest the continuity of land-conditions.

Descending still, we come to the Rhætic Bone-bed, with its *Microlestes* (*Hypsiprymnopsis*, B. Dawkins) *Rhæticus*, *M. Moorei*, and *M. antiquus*, species of Marsupials, founded upon the evidence of minute detached teeth, discovered in a Bone-bed in Somersetshire and at Diegerloch, Stuttgart; another form, named *Dromatherium Sylvestre* by Emmons, occurs in the Chatham Coal-fields. We have also in Triassic rocks Plant-remains, and in Richmond, Virginia, Coal of pure and fine quality, in some places thirty to forty feet in thickness, yielding Coniferæ, Cycadeæ, Calamites, Equisetites, and Ferns. Thin shaly beds divide the Coal, composed almost entirely of the shells of *Estheria*.

In the Trias of Stuttgart, Reptilia are also met with in considerable numbers.

Perhaps one of the most interesting features of this formation is the occurrence of the most extensive beds (not only in this country but in Germany and America) of unfossiliferous sandstone, the surfaces of which are ripple-marked, sun-cracked, and impressed with innumerable foot-prints—many of these tridactyle impressions appear to be arranged in bipedal series, like bird-tracks, and others to be those of five-toed, four-footed, flat-footed Labyrinthodont reptilia. The vast accumulations of salt in certain of these beds probably indicate salt waters in the act of being evaporated down to dryness by isolation from the parent ocean in inland seas and lakes.[1]

Here the Secondary rocks end, and we pass on to the Permian or Magnesian Limestone. Again we find land amidst the ocean; for in the Permian of Saxony and Russia as many as sixty species of fossil plants have been obtained, including many Tree-ferns, a great Calamite, a Conifer, and a Lepidodendron.

Still receding further on the Palæozoic seas, we reach the low-lying shores of the Carboniferous epoch, and once again we find in the "Coal-measures" abundant evidence of land-conditions.

Looked at as a whole, the Carboniferous series embraces not only the Coal-measures proper, but also the Millstone Grit and the Mountain-limestone. Sufficient care seems never to have been taken to dis-associate (*palæontologically*) this last great formation from the preceding two.

The "Mountain" or "Carboniferous Limestone," is a truly marine formation, devoid of coal-seams (unless we except the Scottish series), and rich in the remains of Corals, Crinoids, Brachiopoda, Conchifera, Gasteropoda, Cephalopoda, and Pteropoda.

[1] See Prof. Ramsay, F.R.S., "On the Red Rocks of England," etc., Quart. Journ. Geol. Soc., 1871, vol. xxvii., p. 189, and p. 241.

In England it attains a thickness of 1500 feet, whilst in Ireland its mass is even greater still.

Above the Carboniferous Limestone comes a coarse quartzose sandstone, containing but few fossils, and known as the "Millstone Grit" (from the economic use to which its material is applied). This deposit is above 600 feet in thickness, but is not purely of marine origin.

Again, above the Millstone Grit come the "Coal-measures" proper. Some idea of their vast geological importance may be formed when we find that in the South Wales Coal-field the strata attain an aggregate thickness of 12,000 feet!

The Coal itself forms only a small proportion of this mass, the main part being made up of intercalated beds of mixed freshwater, and marine origin, and comprising layers of shale, sandstone, grit, clay, and ironstone.

Wherever the Coal-measures have been examined, beneath each seam of Coal is found a layer called the "under-clay" or "fire-clay," which forms the floor upon which the Coal itself rests.

Every one of the 100 seams of Coal in the South Wales Coal-field has its under-clay. These Clays, full of roots of plants (called *Stigmaria*), are, in fact, the soils in which the trees and plants grew, which formed by their growth and decay the several layers of Coal.

In many instances the trunks of these old fossil trees have been found standing erect, still attached by their roots to the soil; their decayed and hollow trunks (filled up from above with sediment within) and often penetrating through several of the superimposed layers by which the Coal-seam is covered.

Indeed, these aged trees have proved of the highest geological importance, for within their hollow walls have been found a Myriapod, two land-snails (*Pupa vetusta* and *Zonites priscus*), and several species of small Reptilia, which, either intentionally or by accident, had found their way in, but, being unable to escape, they were enveloped in stone, to remain hidden until the energy of Dr. Dawson, of Montreal, should bring them to light.

Coal is, as already stated, the product of the destruction of the continued growth of plants *in situ*. The more perfect the chemical conversion of the tissues of plants into Coal, the less are we able to detect the presence of the organisms which have contributed to its formation. Nevertheless, the "mother-coal," which occurs between the layers of completely-formed Coal, is composed of the broken-up tissues of the plants converted into Anthracite, but still retaining their external forms.

Prof. Morris originally pointed out that the "better-bed-coal" owed its peculiar chemical composition, which gave it its great value for smelting purposes, to the fact that it was composed entirely of a mass of spore-cases, which Mr. Carruthers has shown to belong to a Lepidodendroid genus called *Flemingites* (See Geol. Mag., 1865, Vol. II., Pl. XII., p. 433), and (as he informs me) to *Sigillaria*, and other allied forms. Prof. Huxley subsequently made the interesting observation, from specimens prepared with singular care and skill by

Mr. Newton, that these spore-cases were buried in the shed spores themselves, and both together make up the substance of this most remarkable deposit of Coal. But in readily accepting this interesting discovery, let us guard ourselves against the tendency of all modern scientific generalizers who take up ideas as soon as issued from the mental mint, "and run into extremes;" for, admitting that a giant Lycopod Forest in the Coal-period would, *in the course of years*, probably shed several times its actual tree-and-branch-bulk of seed-spores, yet it most probably shed its leaves as well as its spores and its wood-growth, and that of the forests of giant *Calamites* and ferns around would amount to an enormous mass in the course of ages of accumulated growth and decay, such as the Coal-forests reveal to us. The tiny acicular leaves of a pine-forest of to-day often form a mass several feet in thickness beneath and around the parent trees, which needs but the proper accessory circumstances to convert it into Quaternary Coal.

Of the three hundred plants which occur in the Coal-period we know but little, whilst a great part of the vegetation has probably left no sign. For experiments made long ago by Dr. Lindley go far to prove that most vegetable tissues break up with great readiness and become completely disorganized when saturated under water. Thus he found that after two years submersion beneath freshwater, 121 out of 177 species of plants had entirely disappeared; and of the fifty-six remaining, the most perfect were *Coniferæ*, Palms, Ferns, and *Lycopodiaceæ*. There are probably no palms in the Coal-measures, but remains of the other three classes are most abundantly preserved, which lends strong confirmation to Dr. Lindley's experiment.

Formerly, it was supposed necessary, in order to account for the rich deposits of carbonized vegetable remains in the Coal, to assume a tropical temperature with a damp humid atmosphere, composed in great part of carbonic acid gas.

Indeed, surprising as it may seem, so lately as May, 1869, this doctrine was advocated by an eminent chemist, Dr. T. Sterry Hunt, F.R.S., in a lecture delivered before the Royal Institution (see Report, Geol. Mag., Vol. IV. pp. 357–369). He there stated—"With regard to the composition of this earlier atmosphere—unfitted as it was for the higher forms of life, still from the comparatively large amount of carbonic acid present, it would seem to have been peculiarly fitted for the development of luxuriant vegetation; and it was long since pointed out by Brongniart that we might suppose a marvellous luxuriance of vegetation in earlier periods of the earth which gave rise to enormous beds of coal and other fossil fuel; for we should judge that this abundance of carbonic acid favoured a wonderful development of vegetation, and at the same time the elimination of the carbon in the shape of coal would help powerfully to purify the air at that time."[1] He further suggests that this dense canopy of carbonic acid gas "would permit the solar heat to pass

[1] Later experiments have, however, proved that plants, like animals, are at once *poisoned* by an excess of carbonic acid.

through our atmosphere, but would prevent its escape by radiation after it had once heated the surface of the earth, and would thus immensely augment the temperature of the lower strata of the atmosphere, producing an effect precisely as if we had covered the whole earth with an immense dome of glass—had transformed it into a great orchard-house—and had thus established from the equator to the poles, a moist, warm, equable climate, which would permit even within the limits of the polar circle a luxuriant vegetation." [1]

However ready we might be to accept Prof. Sterry Hunt's dictum —if applied to *pre-Carboniferous vegetation*, about which we know so little—we cannot, with our present knowledge of the Coal-period, and the requirements both of its animal and vegetable life, accept his views, or admit them to be tenable, having regard to the known fauna and flora of that epoch.

Furthermore, the fact that precisely similar deposits are found to occur in arctic as well as temperate and subtropical regions, does not seem to us to prove "a moist, warm, equable climate established from the equator to the poles," but rather proves that at particular periods *parts* of the earth were *then, as now,* favoured with special advantages, as regards climate, over other parts in the same degree of latitude; because, *then, as now,* the isothermal lines were (owing to local circumstances of coast-lines, winds, and currents) deflected from a straight course.

Thus, as I have elsewhere pointed out (see Geol. Mag., 1868, Vol. V. pp. 297–303), at the present day, in the month of July, huge icebergs may be seen off the east coast of N. America, *in the same latitude* as London, with an atmospheric temperature of only 48°! Whilst the harbour of St. John's, Newfoundland, 2° further south than Liverpool, has been blocked up with ice as late as the month of June!

Surely if the small portion of the Gulf-stream which we enjoy can effect such a deflection in the isothermal line as these two facts indicate, what might it not be able to achieve under a different arrangement of land, by which its whole volume might be made to pass in a northerly direction. For we know that Greenland bears testimony to *two* fossil floras—one in the Tertiary and one in the Carboniferous period—and it seems highly improbable that an "envelope of carbonic acid gas" was—*if it ever existed*—present at so late a period as the Miocene Tertiary. If, then, this later flora flourished in this exceptionally high arctic latitude, favoured by the varying eccentricity of the earth's orbit, aided by the warm currents from the equator, why should not the recurrence of such conditions, at an earlier period, have sufficed to favour the production of the older coal-beds?

Not for a moment questioning the proposition that in the earlier ages of our globe, its condition was very different both *terrestrially* and *atmospherically too* (if chemists please) than at the present

[1] Chemical investigation shows that at the present day there is probably as much or more carbonic acid in the atmosphere in a free state as is in the whole mass already fixed as carbon by plants and animals on the surface, and by all the coal-seams put together.

day; nor, that cataclysmic action has effected many important changes in the configuration of land-surfaces in past geological time; yet by far the greatest part of the work performed in Nature's laboratory must be attributed to those humble yet untiring agents—upheaval and denudation, sunshine and shower, snow and ice, heat and cold, ebb and flow, which have never rested night nor day through all the ages of time since the waters were gathered together into one place and the dry land appeared.

But to return to our subject, had the Coal been accumulated under exceptional conditions of light, heat, and atmosphere, it would be absolutely necessary to exclude animal life from the scene of its formation.

Such, however, was not the case, for in the progress of geological discovery we have become acquainted with no fewer than 30 species of land-dwelling, or amphibian reptiles, 150 fishes, more than 12 species of insects, two myriapods, two scorpions, a *Eurypterus*, six species of King-crabs, a host of Entomostraca, one or more Macrouran Decapod, two land-snails, besides *Unionidæ* and a host of other Mollusca.

There are evidences of sunshine in the flowering organs,[1] called *Antholithes*, and in the ripened fruits and seeds; of shower in the impressions of raindrops on the mud; of tides in the ripple-marked sandstones, covered also with the impress of the feet of the reptilia, which must have swarmed along the Carboniferous shores and rivers.

Nor were these wooded shores destitute of melody, for albeit, no bird (so far as we yet know) built its nest there, the familiar chirp of the cricket was already to be heard, whilst the hum of the many winged insects enlivened the solitudes of these strange old forests.

We have referred to the numerous beds of Coal occurring in the South Wales Coal-field, but in the cliffs of the South Joggins in Nova Scotia the total thickness of Coal strata is not less than 14,570 feet. In a space of 1400 feet Dr. Dawson noted no fewer than sixty-eight root-bearing soils; and erect trunks have been observed at seventeen different levels. (See Dr. Dawson's "Acadian Geology.")

The Coal-strata here, it should be observed, are exposed in a long sea-cliff, and are tilted up at an angle of 24°; but the trees stand at right angles to the "dirt-bed" or soil in which they grew.

Various are the hypotheses which have been offered in explanation of the accumulation of the successive beds of the Coal in horizontal superposition. The most plausible hitherto propounded are:—(1st). Coal was accumulated in the wide alluvial plains and deltas of great rivers, such as the Amazons, the Mississippi, the Ganges, or the Yang-tse-Kiang river. In the Mississippi, four or more buried forests have been observed superimposed one upon another, with their underclays or root-beds and the erect Cypress-trees buried in drift and mud.

(2nd). The Mangrove swamps along tropical insular coasts. In the former case the layers of vegetation are covered by freshwater

[1] Indeed no *green* leaf can be formed without sunlight, for the Chlorophyll is not developed in plants living in the dark or shade.

mud, with the organisms living in, and common to, a great river. In the latter case the vegetable growth is covered up by marine silt, sea-shells, etc.

One difficulty, however, not met by these illustrations, and requiring to be explained in order to clear up the origin of coal, is its *exceeding purity* and *freedom from* admixture of foreign matter; each coal-seam being, so to say, *completed* and then *sealed up*, so that its hydro-carbons should all be retained in the best possible condition for fuel. This could not have taken place in a mere Cypress-swamp or Mangrove-swamp, such as one sees in tropical America at the present day.

If, however, you picture a vast alluvial plain covered with a Cryptogamic forest of giant Lepidodendra and Sigillaria growing on a stiff tenacious clay-soil, capable of retaining the rain-fall, then you have the conditions suited for the rapid accumulation of peat, and that is the purest form we know of any great accumulation of vegetable matter *unmixed* with foreign material, which is the peculiar feature of the Coal-measures.

If any stronger argument than we have used against claiming for the Coal-period special and abnormal conditions were needed, it is to be found in the fact that we have Coal of Tertiary and Secondary ages as well as Primary or Palæozoic.

The Tertiary Brown Coal of Germany and Russia, the Bovey-Tracey Lignites, the Miocene Coal of the Mackenzie River, North America; the Kimmeridge Coal; the Brora Coal (Oolitic in age); and, indeed, judging by the plant-remains, there is good reason for believing the Coal of China to be of Secondary age; the accumulated growth of plants, such as Cycads, Taxineæ, Araucarians, Equisetaceæ and Ferns, corresponding in character with those found in the Oolitic plant-beds near Scarborough, Yorkshire.

Again, there is reason to believe that some coal may be of Devonian age, for Dr. Dawson has already made known a land-flora and fauna of Devonian times, agreeing somewhat with the plants which form the true coal.

Lastly, Lycopodiaceous seeds occur in the Upper Silurian, and lower still, we get Graphites, which may owe their origin (as the oil-bearing strata of pre-Carboniferous age no doubt did) to the destructive distillation of old Silurian Coal-beds, the products of old land-surfaces, distilled in Nature's own retort.[1]

II.—Remarks on the Prospects of Coal to the South of the Mendips.

By H. W. Bristow, F.R.S., F.G.S., and H. B. Woodward, F.G.S., of the Geological Survey of England.

THE question as to the probable existence of a Coal-field on the south side of the Mendips having lately been prominently brought before the public in the Report of the Royal Coal Com-

[1] Read also before the British Association, Edinburgh, Section C, August, 1871.

mission (vol. i.), it may not be uninteresting to offer a few remarks on the present aspect of the question.

But few new facts have been brought to light during the re-survey of the geology of the district.

Traces of Old Red Sandstone and Lower Limestone Shales were detected in a wooded hollow extending in a north-westerly direction from the entrance to the picturesque Mountain Limestone ravine to which the name of Ebber Rocks is given. These beds are brought in by a fault which throws the Old Red Sandstone against the Mountain Limestone on the western side. (See section.)

Higher up there is marshy ground, where a spring is given out; and on still higher ground above this, at the head of the ravine, we come suddenly upon Millstone Grit,[1] large boulders of which lie strewn about the surface. Crossing over the lane between Easton and Priddy, there is a dilapidated old building, where the Mountain Limestone is seen dipping at an angle of 35° S.W. A few yards to the south, hard close-grained quartzites, with small reddish-brown ferruginous specks, occur, overlying conformably the Mountain Limestone. Their extension in a westerly direction is concealed by the Dolomitic Conglomerate. These are, undoubtedly, the bottom beds of the Millstone Grit, and in places thin beds of hard grit and shale may be seen. A little east of the lane, near the bends, there is a shallow hole, apparently a trial-shaft, from which black Carbonaceous shales have been obtained, and which, no doubt, are beds belonging to the Millstone Grit. The working was evidently abandoned after a very short trial, when, probably, the Mountain Limestone was reached. To the east, at the head of the ravine, the Millstone Grit is cut off by a north and south fault, which brings in the before-mentioned Old Red Sandstone and shales; and a short distance down the ravine, we were astonished, when paying a visit to the spot in October, to find a shaft was being sunk, with steam winding machinery, in search of coal in the Lower Limestone Shales, which had evidently been passed through, inasmuch as the rock then brought to the surface was Old Red Sandstone. The fragments of Carbonaceous shale in the old trial-shaft had probably misled the prosecutors of the second undertaking to suppose that the Coal-measures were present, and that lower down, in a southerly direction, they would be likely to succeed in finding coal. (See Woodcut, p. 502.)

A more unpromising place for finding coal could scarcely have been selected anywhere in the neighbourhood, for the spot where the shaft was being sunk is closely surrounded on all sides by rocks of greater age than the Coal-measures; in fact, the little valley in which the works were being carried on may, in general terms, be described as two narrow strips of Lower Limestone Shale and Old Red Sandstone a few chains wide, and surrounded by higher ground composed of Mountain Limestone. The sinking of this shaft under such manifestly hopeless conditions shows a want of knowledge of the elements of geology and coal-mining that could scarcely be sup-

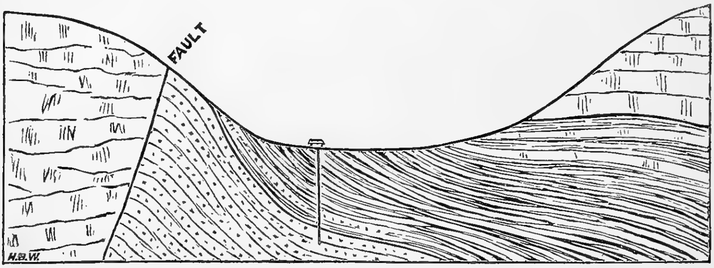
[1] Noticed by H. B. W., Geol. Mag., Vol. VIII., 1871, p. 152.

posed to exist at the present day on the part of persons likely to embark in a search for coal within five miles of a Cathedral City.[1]

In addition to these new traces of Millstone Grit, Lower Limestone Shale, and Old Red Sandstone, another small mass of Millstone Grit, not previously noticed, has been detected east of Wells, near Dinder,[2] while between Cheddar and Draycot a trace of Old Red Sandstone has been mapped by Mr. J. H. Blake, F.G.S.

These new additions to the geology of the district have little bearing on the question of the occurrence of coal on the south side of the Mendips; the appearance of the Old Red Sandstone near Draycot seems to be due rather to local disturbance than to anything affecting the general anticlinal structure of this range of hills, upon which many years ago Professor Ramsay based his opinion as to the presence of coal in the district to the south of it.[3]

Section across ravine, West of Ebber Rocks.



The abortive search for coal mentioned by Mr. Prestwich,[4] as having been made at Witham Hole, about four miles south of Frome, in 1867 and 1868, is of an altogether different kind from the attempt at winning coal near Wells, for the borings were commenced in Secondary strata, far above the place occupied by the Coal-measures in the geological scale. This last boring was carried to a total depth of 600 feet without coming upon any sign of Coal-measures. There seems to be some confusion in the details of this as given by Mr. Prestwich. The strata comprised under the head of Cornbrash (?) in the printed section seem to be referable rather to the underlying Forest Marble, while the lower 36 feet assigned to the Oxford Clay might be placed with the Cornbrash. As regards the uppermost beds of the section, the footnote to the effect that "it is a question with some whether it is not Lias," is apparently an oversight; for the published maps of the Geological Survey prove beyond the possibility of a doubt that Oxford Clay, and not Lias, is the rock at the surface.

[1] When surveying Black Down (Mendip), Mr. J. H. Blake came across an old Shaft, with machinery and building, now abandoned, which had been sunk in the Lower Limestone Shales to a considerable depth in search of coal.—H. B. W.

[2] By H. B. W.

[3] Mem. Geol. Survey, vol. i.

[4] Report of Coal Commission, p. 163.

Another boring in search of coal has been made about three miles north of Langport, near High Ham; but this also was given up after it had been carried down to the depth of 90 feet. Begun in the Rhætic beds, it was only carried a little way into the Keuper Marls, in which beds of Alabaster, 20 feet thick, are said to have been met with; and it was probably the presence of the black paper-shales of the Rhætic series which led to this trial for coal.

An attempt to find coal was made in the Lower Lias at Badgworth, near Wedmore, but of this we have no details.

The most vigorous attempt, however, was that made at Compton Dundon, in 1815.[1] The lower beds of the Rhætic series were passed through, and the shaft was then sunk for nearly 600 feet in the Keuper beds.

These borings are of no value as regards any information they might be expected to afford as to the possible occurrence of coal under the Secondary rocks at the places where they were made. Probably they originated from some misapprehension of the depth of these rocks, or of their identity; but in any case they should have been continued to much greater depths to have thrown any light on the question, as the Coal-measures could certainly not be expected to occur at a less depth than one thousand feet below the surface.[2]

It would seem to be highly probable that a coal-basin may set in south of the Mendip Hills, beneath the flat alluvial lands of Sedgemoor, and the course of the River Brue; but how far it may extend in this direction, or to the east, it is very difficult to imagine, as there is no evidence to show. The prevailing dip of the Mountain Limestone along the southern flank of the Mendips is in a southerly direction; we have noted the Millstone Grit to appear in two places. The probability, therefore, seems to be that in the rolling over of the Mendip range, the Palæozoic strata on its south side have been thrown into a great synclinal trough, and thus have been the means of preserving the Coal-measures from the enormous amount of denudation which, as Professor Ramsay has shown, the same rocks have been subjected to that formed the anticlinal ridges.[3]

At some future time, when the increased price makes it worth while, or the adjacent Coal-fields approach exhaustion, this district will not fail to attract the attention of enterprising persons interested in coal-mining. To prove the question trials might be made near Meare, Wedmore, Polsham and Pilton, which are all places favourably situated for the purpose, and where the Coal-measures might reasonably be expected at a depth of 1000 feet, estimating 100 feet for the Lower Lias and Rhætic beds where present near these localities, and 800 feet for the Keuper beds.

[1] Recorded by Mr. C. Moore, Quart. Journ. Geol. Soc., vol. xxiii., 1867, p. 457.

[2] In Mr. Prestwich's opinion, coal would not be found at a depth less than from 1500 to 2000 feet. Report of Coal Commission, p. 163.

[3] Mem. Geol. Survey, vol. i. Mr. Prestwich thinks "it is possible that the great thickness of the Secondary strata south of the Mendips may arise from a greater denudation of the Palæozoic rocks on the south than on the north of the Mendips, in which case a larger portion of the Coal-measures may have been there removed." Report of Coal Commission, p. 163.

It should, however, be borne in mind, that the Coal-measures of Somersetshire possess three divisions, an upper and lower productive series, separated by a middle one, the Pennant Grit, which is from 2,000 to 3,000 feet in thickness, and contains but two or three seams of coal.

The opinion has been expressed by Mr. Prestwich and Mr. Etheridge[1] that possibly to the south of the Mendips the Coal-measures might assume the Devonian type of Culm-measures. This goes to the heart of the Devonian question, for if we regard the Culm-measures as representing the true Coal-measures, Professor Jukes's classification must be accepted. For it is acknowledged that the boundary line between the Culm-measures and Upper Devonian of North Devon is so gradual that it is hard to separate the two; and therefore the latter must represent the underlying Carboniferous formations. Be this as it may, we cannot consider this great and difficult question as by any means finally settled at present, and we must look forward to the careful working out of the area by the Geological Survey as the only way in which it will be definitely solved. We do not, however, see any reason to suppose a great change in the Carboniferous strata immediately south of the Mendips, for at Cannington Park we have the Mountain Limestone presenting its ordinary features, as they are so well displayed in the corresponding beds at Clifton, on the Mendip Hills, and in South Wales.

The Report of the Royal Coal Commission is one of the most remarkable works of this or any other age or country. When the two remaining volumes are published, the whole will be an enduring monument to the honour of its authors, who seem to have spared neither time nor labour in the preparation of a mass of information relating to the Coal in the United Kingdom, such as has never been brought together before, and which will every day become of increasing value to all persons interested in this most important branch of our industrial resources. The country at large is under a great debt of obligation to the Commissioners, who, in the midst of public or private business, have given their best energies, without fee or reward, to a subject which most persons would consider sufficiently onerous in itself, apart from other duties.

This is especially noteworthy with regard to the contributions of Messrs. Ramsay, Prestwich, and Hunt, whose labours can scarcely be appreciated at their fullest extent except by those persons who have been engaged in inquiries of a similar nature.

The results arrived at by the Commissioners show that the public fears as to the immediately approaching exhaustion of the available coal were altogether groundless, and they establish the fact that the country possesses a supply of coal sufficient for the wants of the nation for a long period, equal to about three hundred years. In the face of that conclusion the Commissioners, as a body, have scarcely felt themselves justified in recommending that experimental borings should be made for the purpose of testing the existence of coal in areas where its occurrence has only been hypothetically inferred.

[1] Report of Coal Commission, vol. i., pp. 147, 163.

Otherwise such borings might have been made in the country to the south of the Mendips, as well as in other localities in the south of England, where the presence of Coal-measures has been inferred beneath the Secondary rocks.[1]

III.—Note on a Futile Search for Coal near Northampton.

By Samuel Sharp, F.S.A., F.G.S.

HAVING had my attention drawn to a communication from H. W. Bristow, Esq., F.R.S., District Surveyor of the Geological Survey of England and Wales, which appeared in the *Wells Journal* of 12th October, and which relates how he came upon a shaft (with steam-engine, etc., in full operation) that was being sunk for Coal about three-quarters of a mile North of Easton, in Somersetshire, and which shaft penetrated the Old Red Sandstone to a depth of 112 yards, starting at a point from 3,000 to 4,000 feet below the horizon of the lowest strata of the true Coal-measures, I think it not undesirable to make known the fact of an as unwise and hopeless search for Coal in Northamptonshire, at a point probably more removed vertically, but in the opposite direction, from any strata in which Coal wonld be likely to be found.

About thirty-five years ago, a company was formed, based upon the advice also of "a practical man," at Northampton, and a shaft was sunk at Kingsthorpe, a village lying immediately North of that county town. The spot selected was nearly the highest in the neighbourhood, and remarkable for the presence of quarries in a bed of Limestone of the Great Oolite formation, of a thickness of about twenty-five feet; which limestone overlies an estuarine Clay (also Great Oolite) of fifteen feet. These are succeeded by the three divisions of the Northampton Sand (Inferior Oolite), having an aggregate depth of say eighty feet, which repose upon the Upper Lias. So that these upper beds have a depth of about 120 feet.

No accurate detailed section of the shaft was taken at the time; but at a depth of 210 feet from the surface, a water-yielding "Limestone rock," in the Middle Lias (Marlstone), was pierced, which produced 36,000 gallons of water per hour. At the depth of 880 feet (as is stated in pencil-notes on a diagram in my possession, which notes are said to have been made by Dr. Wm. Smith, F.R.S., F.G.S., etc.), the New Red Sandstone was reached, and a flow of brackish water of a like volume to the former occurred. The New Red Sandstone is stated to have consisted of "sixty feet of Sandstone, twelve feet of Red Marl, and fifteen feet of Conglomerate." At this point (a depth of 967 feet having been attained, and about £30,000 expended) the enterprise was abandoned.

[1] Mr. Prestwich remarks that a few trials for coal would not be very costly, and that they could hardly fail in important results, as in case of failing at once to hit the Coal-measures, we might possibly find the Lower Greensands, and obtain its pure and abundant waters, a consideration of high importance to the metropolis. Report of Coal Commission, p. 165.—This is not the place for going fully into the question of the occurrence of Coal in the south-eastern counties, but I agree with Sir Roderick Murchison that it is highly improbable that a remunerative Coal-field will ever be discovered in that area.—H. B. W.

The question, however, has lately been again agitated, and a proposal has been made to form a new company to recommence operations from the bottom of the old shaft. In view of this circumstance, it may not be without interest or utility to consider what thickness of beds possibly intervene between the bottom of the shaft and the horizon of workable Coal. The Coal-field of Warwickshire is the nearest Coal-field to this locality, and as no important change from the thining-out or denudation of intermediate beds, or from a great fault, is known to occur in the space lying between this locality and that, it will not be unreasonable to apply the data furnished by sections in Warwickshire to an approximate calculation of the probable thickness of the same beds in this district. Mr. Hull, in *The Coal-fields of Great Britain*, quoting from Mr. Howell's Memoir "On the Geology of the Warwickshire Coal-field, etc.," gives the following thicknesses:—Trias, 780 feet; Lower Permian, 2,000 feet; Sandstones, Shales, etc., of the Coal-measures before workable Coal is reached, 1,500 feet. So that, if these beds extend into the adjoining county of Northampton without material alteration, we shall have underlying the bottom of the Kingsthorpe shaft, and above the horizon of the Warwickshire Coal, beds of the aggregate thickness of 4,200 feet; which, added to the depth of the old shaft, would give a total depth of some 5,000 feet, or about twice the depth of the deepest Coal-mine in this country.

Moreover, according to the views of Mr. Hull, as stated by him in a paper read in the Geological Section of the British Association at Liverpool last year, Northamptonshire is quite without the area of the original Coal-field of this country, as it existed before denudation took place; and in such case no Coal could possibly be found at any depth.

The faith of the projectors of the proposed new company, however, is not based upon any geological considerations, but upon the opinions of *practical men*; indeed, one prominent mover in the matter, a man of means, having large connexion with the iron-producing trade in the country, declares his utter lack of faith in geologists, and bases his belief that Coal will be found in Northamptonshire upon his conviction "that where God has sent iron-ore, he has also sent Coal to smelt it!"

Dallington Hall, *Oct.* 20, 1871.

IV.—On the Foraminifera of the Chalk of Gravesend and Meudon, figured by Prof. Dr. Chr. G. Ehrenberg.

By Prof. T. Rupert Jones, F.G.S., and W. K. Parker, F.R.S.

The Second Edition of Prof. Morris's "Catalogue of British Fossils" appeared in 1854, and in the same year was published Dr. Chr. G. Ehrenberg's "Mikrogeologie," containing the figures of numerous Foraminifera found by that eminent German microscopist, in specimens of Chalk from Gravesend, Kent. A preliminary notice, indeed, of these had been given in the Transactions of the Berlin Academy of Sciences for 1838 (1839), pp. 92, 133—135, 146, pl. iv., fig. IV.; and some of the species were quoted in the "Catalogue;" but a more matured consideration was subsequently given them; and, together with many others from other sources, recent and fossil, they were most carefully figured and enumerated in the above-mentioned magnificent work on Microzoa. In its fine folio plates, so richly illustrating the Foraminiferal faunæ of many localities, and of many geological horizons, the artistic work is of high order in the zoologist's eyes; it is faithfully correct as to form, aspect, ornamentation, colour, and all details, modified, however, by the specimens being mostly seen as transparent objects, with the thickness of the walls rather too much pronounced at the edges; the objects, too, are somewhat in perspective. It being difficult to combine transparency and perspective in a drawing, especially with the attending minutiæ of pores, tubercles, ridges, internal septa, septal apertures, and other characteristics of Foraminifera, the result is that the task of recognizing the real zoological place of the figured forms is difficult, or impossible, except to those who have long studied similar hosts of microzoa, similarly mounted in Canada-balsam. Having had such advantages, we feel called on to add to the list of British fossils, with our own nomenclature, the Cretaceous Foraminifera of Gravesend, figured by Ehrenberg.

Though we differ very considerably in our estimation of generic and specific distinctions and arrangement from this veteran naturalist, as shown by the different appellations we decide to annex to his figured specimens, yet we must remark that the divisions and collocations of the figures on his plates in the "Mikrogeologie" are generally quite *natural,* according to some characters, which Dr. Ehrenberg has recognized, but not clearly elaborated, and which agree to a very great extent with our own basis of generic arrangement.

In plate xxviii. of the Mikrogeologie are figured numerous Foraminifera from the soft Chalk of Gravesend, England. They are magnified 300 times in linear dimensions. These are referred to in the "Monatsberichte" of the Berlin Academy for 1838, pages 193, 194, where some of them are stated to have been found in the Chalk of Brighton also, and in the "Abhandlungen" for 1838, as stated above. An able abstract of this and another memoir in the "Abhandlungen" was made by the late T. Weaver, F.R.S., F.G.S., in 1841, and published in the "Phil Mag.," Nos. 118 and 119, and in "Annals and Mag. Nat. Hist.," vol. vii., pp. 296, 374, etc.; and in Taylor's "Scientific Memoirs," vol. iii. is a full translation, with plates, of Ehrenberg's memoir "on the numerous animals of the Chalk Formation which are still found living." Berlin Acad. Transact. for 1840.

The results of our careful examination of Ehrenberg's figures are as follows:—

Fig. 1. *Miliola lævis* is probably a single joint or a detached chamber of a *Nodosaria.* Ehrenberg's *Miliola* is the same as *Lagena* of other authors. 2. *Nodosaria Anglica* is *N. ovicula,* D'Orb., with a rather excentric aperture. 3. *N. monile* is a variety

of *N. ovicula*, D'Orb., with rather short chambers. 4. *Vaginulina nodulosa* is a variety of Roemer's *V. lævigata*, with a peculiar (concretionary?) shell-structure. 5. *V. cretæ* (*brachyarthra*) seems to be (if really flat, as is probable) *V. longa*, Cornuel sp. 6. *Textilaria striata*, Ehr. 1838. More fully illustrated in pl. xxxii., I., figs. 4*a*, 4*b*, 7, and II., 6, 18, from the Missouri and Mississippi Chalk. 7. A broad individual of *T. striata*. 8. *Text. ampliata* (*T. aspera*, 1838) is a young *T. gibbosa*, D'Orb., with roughish shell. 9 and 10. *Text. globulosa* (1838). 11. *T. leptotheca*, and 12. *T. globulosa ampliata*, are individuals of *T. gibbosa*. 13. *Loxostomum curvatum* is an arcuate *T. agglutinans*, the later chambers of which have the aperture higher and higher up; thus passing, in its *quasi*-generic character, from *Textilaria* proper into *Grammostomum*. Indeed, it may be the young of Ehrenberg's *Lox. Anglicum* (fig. 19 of the same plate), which is a rather narrow and neat *Gram. pennatula*, Batsch sp. 14. *Grammostomum scabrum* seems to be only a small coarse-shelled *Text. agglutinans*, D'Orb. 15, 16. *Gr. polytrema* is *Virgulina Schreibersii*, D'Orb. 17. *Gr. aculeatum* is a variety of *Verneuilina triquetra*, Münster sp., with aculeate edges: it is seen from one of its three flat sides. 18. *Textilaria aculeata* is a small rough *T. agglutinans*, with flattish chambers. 19. See above. 20. *Proroporus cretæ* is *Polymorphina Thouini*, D'Orb. See the "Monograph on Polymorphina[1] by Brady, Parker, and Jones, Linn. Soc. Trans., 1870, vol. xxvii., p. 232. 21. *Bigenerina cretæ*, and 22. *B. acanthopora*, are also *P. Thouini* (*loc. cit.*). 23. *B. apiculata* is *P. compressa*, "Mon. Polym." p. 227. 24. *Loxostomum vorax* is also *Polym. compressa*, and should be added to the synonyms in the "Monograph Polym.," p. 227. 27. *Lox. tumens*, and 26. *Lox. aculeatum*, however, are slightly differing individuals of *Heterostomella aculeata*, Ehr. sp. This may be described as a prickly loose-grown *Textilaria*, which, having ceased to grow in the typical manner (with a double row of alternating chambers), has continued with a single row (as a *Bigenerina*), and these have not only got terminal, instead of lateral, apertures, but have become lipped, as in *Sagrina rugosa*, D'Orb. (1840). D'Orbigny, however, had applied the name "*Sagrina*" to a Uvigerine Foraminifer (*S. pulchella*) in 1839. In 1866 Reuss published the name *Heterostomella* as distinctive of the "Textilarian" *Sagraina* (Sitzungsb. Akad. Wien, vol. lii.). Ehrenberg's "*Loxostomum*," though older (1854), is so misapplied by him (to *Polymorphina*, *Grammostomum*, and a transitional form between the latter and *Textilaria* proper), that naturalists may well hesitate to use it. *H. aculeata* is figured also in pl. xxvii., figs. 21, 22. 27. *Polymorphina turio* is a narrow and typical specimen of *Virgulina Schreibersii*, D'Orb., which is subgenerically related to *Bulimina*. 28 and 29. *Pleurites? calciparus*, 30. *Sphæroidina cretacea*, and 32. *Grammobotrys Anglica*, are broad and flattish individuals of *Virgulina Hemprichii*, Ehr. sp This species is well figured (under many different names) in the "Mikrogeologie." It is very variable in form, but constant in

[1] Some of Ehrenberg's figures quoted in this Monograph as *Polymorphina*, we find, on fuller consideration, to be *Virgulinæ*, etc.

the cloudy, or seemingly muddy, opacity of its shell,—a structure beautifully engraved in pl. xxix., fig. 38, and elsewhere. This species is very common in the Indian seas, with its misty, dull shell, of variable growth, sometimes regularly Virguline, with alternate chambers, sometimes passing into *Bulimina* proper, sometimes short and nearly round, like *Cassidulina,* and in other subvarietal shapes. It is the only *Virgulina* that takes on a sandy condition, becoming subarenaceous, and thereby very delicately rugose. Ehrenberg appears to have first noticed it in the Tertiary Limestone from Thebes, Egypt. In pl. xxiv., illustrating the Foraminifera from that rich rock, he gives the name *Strophoconus Hemprichii* to a fine complanate specimen (fig. 32); some smaller individuals, figs. 29, 30, 31, he puts under the same genus, and another as "*Textilaria?* or *Grammobotrys.*" His "*Strophoconi*" are all either *Virgulinæ* or *Buliminæ*; therefore the name is not required. Other instances of *V. Hemprichii* (fossil) occur at pl. xix., fig. 86 (?), Ægina; xxi. fig. 88, Oran; xxiii., fig. 19, Mokattam; xxv., fig. 15 (?), Antilibanon; xxvi., figs. 19—24, 26, 27, Cattolica; xxix., figs. 32—36, Moen Chalk; xxx., figs. 18, 19, 21, Rügen Chalk; xxxii., II., figs. 18, 20, Mississippi Chalk; xxxiii., XIII., fig. 27 (?), San Francisco. Of these some are remarkable; for instance, the *Vaginulina? paradoxa* and *V. obscura* (xxvi., 26, 27) are nearly cylindrical and subarcuate, such as occur in the Jurassic Clays, in the Gault, and in the Chalk; they are old "Secondary" *Virgulinæ.* A variety, xxx., fig. 18, termed "*Polymorphina nucleus,*" shows a passage into *Cassidulina.* An outspread, rhomboidal, and suboblong Textilariform variety is seen in xxxii., II., figs. 18 and 20, termed "*Grammostomum tessera,*" and "*Pleurites? Americanus.*"

Pl. xxviii., fig. 31, *Heterostomum cyclostomum,* and 33, *Grammostomum platytheca* are young, broad, coarse-shelled *Textulariæ gibbosæ.* 32. See above. 34—42*a*., variously named "*Rotaliæ*" (including *R. globulosa,* 1838, figs. 40, 41), are so many individuals of *Globigerina cretacea,* D'Orb., an outspread, flattish variety of *Gl. bulloides,* D'Orb., smooth in the youngest (41, 42), coarser and prickly in older specimens.

43. *Planulina omphalolepta* (*Pl. turgida,* 1838) is a small and somewhat complanate *Cristellaria rotulata,* Lamarck sp., or feebly keeled *Cr. cultrata,* Montf. sp. 44. *Pl. annulosa* is a still smaller specimen. 45*a*, *b*. *Pl. odontophæna* is *Crist. cultrata,* Montf. sp. Fig. 45*a* has tear-like and ridgy exogenous growths of shell-matter near the umbilicus, but no umbo. 46. *Pl. hexas* (*Rosalina globularis?* 1838) is *Cr. cultrata* with a small keel. 47. *Rotalia prætexta* is a produced suboval individual of *Crist. cultrata.* 48. *Planulina adspersa* is probably a small *Cr. cultrata* or *rotulata.* In fact, figs. 43—48 show various stages and conditions of growth of the common *Cristellaria* of the Chalk, in its umbilicate condition, and with more or less of a keel or crest. 49. *Pl. umbilicata,* also 54, *Cristellaria megalomphala,* and 55, *Cr. Anglica,* are limbate specimens of *Cr. cultrata,* that is, having the shell thickened over the septal lines. 50. *Rotalia lenticulina,* 51. *R. Londinensis,* and 52. *R. lepida,* are

small individuals of *Planorbulina ammonoides.* 53. *R. picta?* This is *Pulvinulina Micheliniana,* D'Orb. sp., seen from its flat (upper) spiral face. The same species is represented in pl. xxvii., fig. 52, by a rather larger specimen ("*Planulina picta*") from the Chalk of Meudon, viewed through the vertical thickness of the shell from its high umbilical (lower) face. This belongs to a large family of Rotaline Foraminifera, which group themselves around *Pulvinulina repanda,* Fichtel and Moll, sp. It belongs more especially to the subgroup of which *P. Menardii* is the type. This attains its best growth at about 100 fathoms in the existing seas, but lives well at abyssal depths, even at more than two miles depth; whilst, on the contrary, in shallow water it degenerates into *bizarre* varieties. D'Orbigny's *Rotalia crassa,* figured on the same plate (Mém. Soc. Géol. Fr., iv. pl. 3, f. 7, 8), is also a variety of *Pulvinulina Menardii.* These are found in existing seas under the conditions mentioned above, and are abundant in the Gault, Chalk-marl, and Chalk.

The other objects from the Chalk shown in this interesting plate are some siliceous and calcareous Sponge Spicula, some Morpholites, including Coccoliths, possibly a variety of Cyatholith without its centrum, and two Diatoms, *Fragilaria rhabdosoma,* 1838, and *Fr. pinnata,* 1844 (*Fr. striolata,* 1838).

According to our views, as explained above, and in our papers on the Nomenclature of the Foraminifera in the Ann. Nat. Hist., and in other memoirs, we regard Dr. Ehrenberg's figures of the Foraminifera from the Chalk of Gravesend as referable to—

Nodosaria ovicula, D'Orb.	*Grammostomum pennatula,* Batsch sp.
Vaginulina lævigata Roemer.	*Virgulina Schreibersii,* D'Orb.
——— *longa,* Cornuel sp.	——— *Hemprichii,* Ehr. sp.
Textilaria striata, Ehr.	*Polymorphina Thouini,* D'Orb.
——— *gibbosa,* D'Orb.	*Globigerina cretacea,* D'Orb.
——— *agglutinans,* D'Orb.	*Cristellaria cultrata,* Montfort sp.
Heterostomella aculeata, Ehr. sp.	*Planorbulina ammonoides,* Reuss sp.
Verneuilina triquetra, Münster sp.	*Pulvinulina Micheliniana,* D'Orb. sp.

Those of Ehrenberg's species that are mentioned in Morris's "Cat. Brit. Foss.," second edition, are :—

1. *Planulina* (*? Cristellaria*) *turgida* = *Cristellaria cultrata,* small (*Pl. omphalolepta,* 1854). 2. *Rosalina globularis* = *Cr. cultrata,* feeble (*Pl. hexas,* 1854). 3. *Rotalia globulosa* = *Globigerina cretacea.* 4. *Rotalia ornata* = *?* Not figured in 1838, nor in 1854. 5. *Rotalia perforata* = *Globigerina cretacea.* 6. *Textilaria aciculata* = ? Not figured in 1854: the figure given in 1838 is like that of a small *Virgulina.* 7. *Textilaria aspera* = *T. gibbosa* (*T. ampliata,* 1854). 8. *T. globulosa* = *T. gibbosa,* small. 9. *T. perforata* (= *T. gibbosa*) should not have been inserted, as Ehrenberg does not refer to it as occurring in the English Chalk.

It will add to the interest of these notes on Cretaceous Foraminifera, if we allude to Pl. xxvii. of the "Mikrogeologie," illustrating the species and varieties that Dr. Ehrenberg discovered in the Chalk of Meudon, France. These are similarly treated, and are also referred to in the same papers in the Journal and Transactions of the

Berlin Academy, as the English specimens. Studied in the same manner as the latter, these French forms appear to us to belong to the following species and notable varieties:—

Lagena globosa, Montagu.
Nodosaria ovicula, D'Orb.
Bolivina punctata, D'Orb.
Virgulina squamosa, D'Orb.
——— *Schreibersii*, D'Orb.
Textilaria striata, Ehr.
——— *gibbosa*, D'Orb.
——— *aculeata*, Ehr.
——— *sagittula*, Defrance.
——— *agglutinans*, D'Orb.
Heterostomella aculeata, Ehr. sp.
Verneuilina pygmæa, Egger.
Polymorphina Thouini, D'Orb.
Sphæroidina bulloides, D'Orb. sp.
Cristellaria cultrata, Montf. sp.
Globigerina cretacea, D'Orb.
Planorbulina ammonoides, Rss. sp.
Planorbulina farcta, F. & M. sp.; small varieties.
Pulvinulina truncatulinoides, D'Orb. sp.
——— *Micheliniana*, D'Orb. sp. (See above, page 510.)

These may be with advantage compared with the Foraminifera from the Chalk near Paris, described and figured by Alcide D'Orbigny, in 1840, "Mém. Soc. Géol. France," vol. iv., part 1, pl. 1–4. We must, however, premise that, to bring all to the same terms of comparison, some of the generic terms used for these Foraminifera in 1840 have now to be altered, thus:—

Rotalina Voltziana = *Planorbulina*.
——— *Micheliniana* = *Pulvinulina*.
——— *umbilicata* = *Rotalia*.
——— *crassa*, ——— *Cordieriana* } = *Pulvinulina*.
Rosalina Lorneiana, ——— *Clementiana* } = *Planorbulina*.
Uvigerina tricarinata = *Tritaxia* (near *Verneuilina*).
Pyrulina acuminata = *Polymorphina*.
Sagrina rugosa = *Heterostomella*.

A full list of D'Orbigny's species from the Chalk is given in Mr. Weaver's Appendix to his Abstract of Ehrenberg's Memoirs, Ann. Nat. Hist., vii., p. 395, etc.; together with notes on their localities and distribution in France, England, and elsewhere.

Lastly, we must not lose sight of the fact that the specimens figured in the "Mikrogeologie" are for the most part very minute, such as lie among the finer débris of washed Chalk; whilst those treated of by D'Orbigny were larger individuals picked out by means of hand-lenses from the coarser dust of the disintegrated material. The great difference of size, however, among individual Foraminifera carries but little weight in the determination of species; for the conditions, not only of growth, but of feeding-ground, depth of water, and climate affect them so greatly, that a form which may be gigantic in one *habitat*, will be arrested or dwarfed in another, retaining all the essential characteristics of shape and structure which are required for its specific identification.

NOTICES OF MEMOIRS.

On the Geology of the Kingsclere Valley.

A Lecture addressed to Newbury District Field Club, during an Excursion, on September 19, 1871.

PROFESSOR RUPERT JONES, who took his stand on the northern edge of Ladel Hill, from which an extensive view of the country was obtained, proceeded to deliver a lecture "On the

Geology of the Kingsclere Valley," with various illustrative maps and diagrams placed around him on the sward. He prefaced his observations with an apology for having to deal with such a large subject in so limited a time, and for the difficulty of treating in a popular way such complicated geological facts as were concerned in the origin and history of the beautiful valley lying at the feet of his audience. He would take for granted that all present were acquainted to some extent with geology; that they knew that chalk is not always what it seems; that it is made up of innumerable microscopic shells, and is subject to change; that the valleys were due to causes of which even geologists had not in all cases a very clear idea; that the hills were not masses of earth or stone placed, as it were artificially, upon a given horizontal surface, but were intimately connected with the internal structure of the earth, and that their constituent strata could be traced out as massive stony sheets or layers, stretching away, not only through Berks and Hants, but through England and Europe, and other parts of the world. The hills and valleys spread out before them were not created as such. There was a time when this valley did not exist, but its place was occupied by a great solid arching of the Chalk and other strata, continued on all sides as a vast plateau, gradually rising from the sea. The broken upper courses of this great arch, or elliptical dome, two miles by six in its chief diameters, were washed away, together with the softer materials, by sea and rain; and the broad undulating hollows and sloping sides were left that now form the Kingsclere "valley of elevation," so well described by Buckland many years ago. It is of a long triangular shape, pinched in at the sides; and it constitutes what geologists term an "inlier" of some of the strata below the Chalk. The containing hills, or scarped edges of the broken Chalk, stand high up above the floor of the valley, because of their relative hardness. Their white calcareous substance, though soft as a rock, is homogeneous and tough, especially in their lower tiers or courses, where the greyish Chalk-marl (or Malm-rock) is tougher still, and projects around the valley as low, smooth, rounded hills and level benches, too tough for the natural growth of trees, but yielding rich crops to the plough and harrow. Of this formation, Beacon Hill (just visited by the Field Club) is a part, where the more forcible curvature of the strata, in the chief focus of elevation, raised this Lower Chalk higher than elsewhere. The central portion of the valley is made up of a different substance, which is called the "Greensand," or "Upper Greensand." It is a calcareous or chalky substance, with a considerable quantity of sand in its constitution. Some of this sand is green, being fragments and minute concretions of a mineral called glauconite. In Wiltshire the green sand predominates, hence these strata got the name of "Greensand." Here and there this rock is hardened into a "rag-stone" by the infiltration of silex; just as some of the Chalk is frequently changed into lumps of flint. The Greensand, being more friable than the Chalk or the Chalk-marl, and of unequal texture, has rotted away at the surface into a rich loam, bearing trees and copses, which still abound in the valley round about Burghclere and Sydmonton; and it well repays the farmer's toil.

Recurring to the evidences of the arching or dome-structure of strata over the area of the Kingsclere Valley, Professor Jones insisted on the importance of the evidences seen in chalk-pits and other excavations, where the sections show that the strata incline, or "dip" away north or south, or in other directions, as the case may be; and he referred to the value of stratification in elucidating the history of the earth's crust. The uprising and the washing away of twelve, twenty, or hundreds of square miles of upraised strata, even a thousand or more feet in thickness, has been of relatively common occurrence, when we look over the world geologically; for many such hollow areas, or "inliers," have been swept clean of the broken upper layers of an "anticlinal" fold of crumpled strata. Another such "valley of elevation" lies six miles to the north-west, along the Hampshire Hills, where Ham and Shalborne are built on similar "Greensand;" and still further west, the Vale of Pusey, of still larger dimensions, indicates the continuance of the line of elevation towards the Bristol area. On the south-west also a similar and parallel line of uplift has exposed the beds beneath the Chalk in the picturesque Vale of Wardour; and on the south-east, in the extensive and interesting Valley of the Wealden, including the Wealds of Kent, Surrey, and Sussex. The destruction of so much rocky material as that not only which, in the form of continuous strata, connected the side-hills of the valleys, but which also had once existed to a great height above the present surface of the plateaux, is a subject of serious geological thought. That the land was below the level of the sea, as a sea-bed, must be remembered; and, though once in a way the sea may have been accumulated to an extra height in this or that part of the world, yet, as a rule, the rising of the sea-beds from beneath the sea is owing to crumplings of the earth's crust, from contractions, as the layers in a great roll of cloth or linen, when crushed and folded by side pressure, rise up above the general level; and if such ridges of the crumpled cloth were pared down, as the curved strata have been by the waves and currents of the sea, the lower layers would be exposed, and, if soft, would be still more deeply worn away. Further, this destruction, or rather removal, of the upper beds, and the exposure of the lower by "denudation," would be continued, if not enhanced, by the action of snow, frost, ice, rain, and torrents, when the land rose higher and higher. Such work we see is going on around us, even on a common rainy day; and much more active are these agents of nature in the tropical and the arctic regions respectively. And there was a time not long ago geologically, though at least ten thousand years since, when an arctic climate was succeeded in these regions by a time of snow and rains, called the "Pluvial Period" by Mr. Alfred Tylor, to which the old broad valleys and gravel-beds of our rivers and many other features of this country bear witness.

Regarding the continuity of the Chalk with the other great strata, —it forms the country south of Ladel Hill to right and left, with a diminished thickness, compared with its original condition, and with the loss of all the once overlying Tertiary beds, as far as the confines of the New Forest, where it dips below the Tertiary clays and sands there preserved; but it comes out again in the Isle of Wight, and passes on beyond the water-worn hollow (called the Channel) in its surface, to form a great portion of Northern France and other parts of Europe. On the northern edge of the Kingsclere valley the Chalk immediately dips at a high angle, leaving little more than its escarped edge to form the surface there, and continues in a wide thick sheet beneath the clays and sands that form the country drained by the Enborne, until it emerges at Newbury and elsewhere along the Kennet. Here it is masked by peat and gravel along the valley bottom, but to the north and west it is soon found to constitute the soil, except where "outliers," or remnants of the Tertiary strata, chiefly Woolwich beds and London Clay, form hills and spurs near the confluence of the Kennet and Lamborne. At Shaw brickfield, one mile north-east of Newbury, is seen the best exposed section of the Chalk, overlain by the Woolwich beds (with fossil oysters, leaves, etc.), and these surmounted by the lower portion of the London Clay. Here, however, these Tertiaries have suffered more loss by denudation than in the country south of Newbury, where broad patches of a still higher formation, the "Bagshot Sands," constitute the heaths and commons on the borders of Berks and Hants. These are based on the London Clay, which is exposed along the deep-cut valleys of the Enborne and its tributaries. This rests on the Woolwich beds, noted for their plastic clay, which crops out at their edge as a narrow riband along the northern foot of the Chalk hills of Hampshire, and as a broader and more irregular area on the Chalk of the Kennet valley.

The lecturer then alluded to the conditions of land and water existing when the Chalk was formed as a deep-sea deposit, mainly composed of innumerable microscopic shells, similar to such as still live in deep seas at great depths, and form white calcareous ooze, The different depths of this old sea, stretching east and west where now Europe and Asia exist, were filled with different materials, and hence the differences in Chalk beds and their equivalents in different countries. The succeeding changes that produced the fresh-water Woolwich beds, and the subsequent marine London Clay and Bagshot Sands, were alluded to; and these sands, seen on the Wash Common and elsewhere (as above mentioned), were noted as having been formed in shallow water, and continuous with and equivalent to other sea-deposits of deep-water origin. Thus these barren and here non-fossiliferous sands are of the same age, and were formed in the same sea, as the great Nummulitic limestone, which has not only supplied material for the Pyramids of Egypt, but forms natural buttresses to the Alps and Himalayas.

The consideration of the gravel-beds, coating many parts of the country, was not attempted for want of time; but the great features due to the crumpling of strata in course of the earth's contractions, and the effect of water as a denuding agent in making and modifying geographical contours, were specially treated of in the Professor's *résumé* of the facts and notions offered to his audience.

Dr. Stevens, of St. Mary Bourne, thought that a vote of thanks was due to Professor Rupert Jones for his very full and interesting lecture. He wished further to say that when coursing in the Burghclere Valley, he had observed that there was very little flint drift, which was singular, considering the large amount of denudation the Chalk hills had undergone. This had also been noticed by Mr. Bristow, in the Memoir on Sheet 12 of the *Geological Survey Map.* Dr. Hills, of Basingstoke, intimated that there is a small exposure of the Gault near Burghclere.—[From the *Newbury Weekly News* of September 26, with corrections by T. R. J.]

REVIEWS.

I.—Transactions of the Royal Geological Society of Cornwall. Parts I. and II., Vol. VIII. Containing Observations on Metalliferous Deposits and Subterranean Temperatures. By William Jory Henwood, F.R.S., F.G.S., President of the Royal Polytechnic Institution of Cornwall. London, 1871. 8vo. Trübner & Co.

THE conditions under which mineral matter has filled fissures in the earth's crust, and thus formed veins or lodes, has long been the subject of observation and study among scientific men, and others who have been desirous of rendering the search for metallic ores more of a science, and less of a speculation, than has hitherto been the case. Careful and accurate observations, therefore, upon all the modes of occurrence of mineral or metalliferous matter, and of the apparent causes affecting their distribution in veins, is of the highest importance to a generalization of facts, and the consequent deduction of sound rules whereby the miner may in future be guided. Of such a character are the many contributions to this study which have appeared in the past volumes of the Transactions of the Royal Geological Society of Cornwall, a high place being accorded to those prepared by Mr. William Jory Henwood, who indeed appears to have devoted the whole of his time for many years past to this one subject, and, avoiding all theories and speculations, has been content to record what he has himself seen and noted. His works will form a foundation upon which the theorist can erect his edifice. Science, in all its branches, owes much to those who devote themselves to the hard practical work of accumulating and recording the minutest details of phenomena coming immediately under their own observation, and who concentrate the whole power of their intellect upon such work.

The present volume, like one of its predecessors, is occupied exclusively with a continuation of Mr. Henwood's observations on metalliferous deposits and subterranean temperatures, with the exception that in this volume he has extended his sphere of work and carried us to important mining districts in the North-west of India, North and South America, West Indies, the Continent of Europe, etc. In Cornwall and Devon, however, the conditions of the mineral deposits are so varied, that we have in that small corner of our island an epitome, as it were, of all the most important phenomena of mineral veins, so that, with a few exceptions, those exhibited in metalliferous deposits in other parts of the world are but repetitions and illustrations on a grander scale of those already observed in this country.

The first chapter in the volume before us treats of the deposits of the provinces of Kumaon and Guhrwal in North-western India, the rocks being first described, with their geological structure and relative position; then follows an account of the mode of distribution of the enclosed metallic ores, succeeded by descriptions of the methods of working the mines and dressing the ores. The same order is observed in the succeeding chapters.

In the second chapter we have an account of the deposits of the rich mining district of Chañarcillo, in Chili, whence for many years past very large quantities of silver have been procured. Notwithstanding that the yield of silver has been so enormous, and is still very considerable, it appears that great waste is the rule there, and that the very large masses of inferior ores usually accompanying and surrounding the rich *bunches*, are seldom brought to grass to be dressed, but are thrown aside in the deserted portions of the mine. And this, too, although the place is but fifty miles inland, and has good roads, and for part of the way railway communication to the coast. In these days of improved and economical methods for dressing poor ores this is somewhat surprising; but it may be partly accounted for by the want of water, as we read in one place that "a large mining population, attracted by the discovery, quickly stripped the surface of its wood; so that neither tree, shrub, field, garden, nor even an occasional wild flower, now relieves the brown and dreary monotony, the uniform and frightful barrenness, of this rich but horrible desert. Although the bed of every valley and glen is overlaid by a thick bed of shingle, pebbles, and gravel, deeply scored with ruts and other indications that the country was formerly well watered, there is neither a single spring in the district, nor is one streamlet now visible from the bleak summit of Chañarcillo, except —perhaps twice or thrice in the year—when an occasional shower may for a few hours supply each ravine with a scantily trickling rill; these are, however, quickly absorbed by the thirsty soil.

"No water has ever been drawn to the surface of any mine in the district; a little moisture, however,—derived, perhaps, from ascending vapour,—exudes from some of the rocks and veins, but it is immediately absorbed by other portions of the neighbouring strata."

Of the richness of some portions of the Limestone beds which appear to be the silver-bearing rocks here, and particularly of one bed known in several mines under different names, the author says: "Throughout this bed, especially where calcareous spar and earthy iron-ore abound, for some distance on either side of the *Candelaria*, *Colorado*, and *Descubridora* lodes, the rock is sprinkled, its laminæ are interlaid, and its joints are invested or filled with granules, filagrees, leaves, plates, and veins of native silver, mixed with the sulphuret, the chloride, and—less frequently—the chloro-bromide of silver.

In many such parts of the *Manto* this impregnation has been so general and so rich that the workmen have left only a few slender pillars of it to support the roof; and these are mostly pierced and scored in pursuit of rich veins and fibres. On every side of the caverns thus opened, galleries, extended on lines of ore nearly coincident with the joints, form, as they interlace, an almost inextricable labyrinth."

The gold-mines in the province of Minas Geraes in Brazil form the subject of the next chapter, and are most exhaustively treated. Here the *Jacotinga,* a micaceous iron-ore, and the *Itabirite,* a micaceous iron-schist, form the principal matrix of the metal, and being almost peculiar to this locality, are distributed, in greater or less quantity, over most of the gold districts.

The remaining chapters treat of: Notices of Copper Mines near Copiapo, in Chili; Notices of Gold Mines in Virginia; On the Native Copper of Lake Superior; the Metalliferous Rocks of Gloucester, in New Brunswick; On the Copper-bearing Sandstone of Huidobro, in Spain; On the Mines of Chalanches d'Allemont, France; Notice of the Sark's Hope Mine, Sark; On the Copper Mines in Ireland; On the Detrital Gold in Wicklow; a Notice of the Clogan Gold Mine in North Wales; On the Chrome-ore of Breadalbane; On the Molybdenite of Tomnadashan, in Perthshire; On the Caradon District of East Cornwall; and on the Lead Mines of Menheniot, Lanreath, and Saint Pinnock, in Cornwall.

The second part contains the Notes on Subterranean Temperatures, by the same author, and numerous plates illustrating the papers above named; also voluminous tables, containing a mass of valuable information relating to the mines described. These are accompanied by a most copious Index, occupying 131 pages, which, with the very numerous notes and references, greatly enhance the value and usefulness of the work.

It is impossible to give in these pages an adequate notion of the minuteness of detail and acuteness of observation which characterize every page of the book; they must be studied, and thoroughly too, to be properly appreciated by all interested in so very important a subject as the progress and economy of mining.—T. D.

II.—Report of the Commissioners Appointed to Inquire into the Several Matters Relating to Coal in the United Kingdom. Vol. I. General Report and Twenty-two Sub-reports. Folio. 1871.

It was in June, 1866, that the now celebrated Coal Commission was appointed. It had for objects—firstly, to investigate the probable quantity of coal contained in the Coal-fields of the United Kingdom, and to report on the quantity of such coal which may be reasonably expected to be available for use; secondly, to ascertain whether it is probable that coal exists at workable depths under the Permian, New Red Sandstone, and superincumbent strata; thirdly, to inquire as to the quantity of coal at present consumed in the various branches of manufacture, for steam navigation, and for domestic purposes, as well as the quantity exported, and how far, and to what extent, such consumption and export may be expected to increase; and, lastly, to trace out whether there is reason to believe that coal is wasted by bad working, or by carelessness or neglect of proper appliances for its economical consumption.

The Commission consisted of the Duke of Argyll; Sir R. I. Murchison, Bart.; H. H. Vivian, Esq., M.P.; Sir W. G. Armstrong; Professor A. C. Ramsay; J. T. Woodhouse, Esq.; R. Hunt, Esq.; J. Prestwich, Esq.; J. Dickinson, Esq.; J. Geddes, Esq.; J. Hartley, Esq.; T. E. Forster, Esq.; G. T. Clark, Esq.; Dr. J. Percy; G. Elliot, Esq.; and J. F. Campbell, Esq. (Secretary).

At the first meeting it was found expedient to divide the inquiry, and to appoint committees to investigate separate subjects; thus, five committees were chosen, and the results of their investigations are given in the general report with which the present volume commences, and they are also (with the exception of that by Committee E) printed in full in the same. To Committee A, it was given to inquire into the possible depth of working coal. Increase of temperature was the only cause they had to consider, as limiting the depths at which it may be practicable to work coal, and they are of opinion that a depth of at least four thousand feet might be reached. Committee B report on the waste in combustion; and they conclude that as great efforts have been made in our manufactures to economize coal, it may be assumed that the progress of economy in using coal is not likely to operate in future with greater effect in keeping down the increase of consumption than it has hitherto done. As regards the consumption of coal for domestic purposes, its future increase may be expected to coincide with the increase of the population. The waste in working coal was investigated by Committee C, who report that coal is wasted by bad working and carelessness to a very considerable degree in proportion to the amount which is actually used, in some cases the loss being forty per cent. Committee D report on coal under the Permian and newer strata. The determination of the extent of these tracts of coal was assigned—in England, to Professor Ramsay and Mr. Prestwich; in Scotland, to Professor Geikie; and in Ireland to the late Professor Jukes, and afterwards to Professor Hull. They give estimates of the quantities of the coal under the newer formations, and which may be looked for at a depth of less than 4000 feet. They also investigated the probability of the existence of coal in the South of England. Upon a general review of the whole subject, Mr. Prestwich adopts with slight variations the views of Mr. Godwin-Austen, and is led to the conclusion that there is the highest probability of a large area of productive Coal-measures existing under the Secondary rocks of the South of England. He shows from statistics furnished by Mr. Bristow that the thickness of these overlying rocks is not likely to exceed 1000 to 1200 feet, and he considers that there is reason to infer that the underground Coal-basins may have a length of 150 miles, with a breadth of two to eight miles,—limits within which are confined the rich and valuable Coal-measures of Belgium.

Mr. Prestwich shows that there are grounds for believing in the existence of coal on the south side of the Mendips, and under adjacent parts of the Bristol Channel, but at a depth of not less than 1500 to 2000 feet; and he mentions also a small new Coal-basin in the Severn valley, near New Passage.

In regard to the future exportation of Coal, Committee E report that although a large increase has taken place since the year 1855, yet this increase has merely averaged one per cent. each year, and there is reason to doubt whether much further increase will take place in this direction.

The large increase which in recent years has taken place in the consumption of coal has an intimate connexion with the introduction and extension of railways; moreover the town-population, which represents the chief coal-consuming population, is increasing in a far more rapid ratio than the population of the kingdom generally; and the extension of machinery and improvements for economizing labour cause the consumption of coal to be constantly increasing.

Adopting four thousand feet as the limit of practicable depth in working, excluding all beds of coal less than one foot in thickness, and deducting an amount for the waste and loss incident to working the coal, it is estimated that in known Coal-fields in the British Isles there is an available quantity of coal equal to 90,207 millions of tons, while the coal which probably exists at workable depths under the Permian, New Red Sandstone, and other superincumbent strata in the United Kingdom, is estimated at 56,273 millions of tons, making an aggregate quantity of 146,480 millions of tons which may be reasonably expected to be available for use. From careful calculations respecting the duration of this coal, taking into account the increased consumption, it is estimated that this quantity of coal would represent a consumption of 276 years.

There is, however, a large amount of coal excluded from these estimates, namely, that lying beneath Permian and newer strata, at depths exceeding 4,000 feet. The amount at depths from 4,000 to 10,000 feet is estimated at 41,144 millions of tons, to which may be added 7,320 millions of tons at greater depths than 4,000 feet within the area of the known Coal-fields, making a total of 48,465 millions of tons. It is entirely a matter of conjecture whether any or what portion of this coal can ever be worked; but the absolute exhaustion of coal is a stage which will probably never be reached.

In order to investigate the probable quantity of coal contained in the known Coal-fields of the United Kingdom, the area was divided into thirteen districts, which were assigned to different members, or to gentlemen specially acquainted with the areas. Thus, Mr. Vivian reported on the South Wales Mineral Basin westward of "Glyncorrwg Fault," and Mr. G. T. Clark on the eastern division of the South Wales Coal-field. Their reports are accompanied by elaborate tables showing the calculations of the areas and quantities of coal in the field.

Mr. Dickinson reported on the quantity of coal remaining unwrought in the Coal-fields of Lancashire, Cheshire, North Wales, and the Forest of Dean; and Mr. T. E. Forster investigated the Northumberland and Cumberland Coal-fields. Durham and North Staffordshire were reported on by Mr. G. Elliott; South Staffordshire, East Worcestershire and Shropshire, by Mr. D. Jones; Yorkshire, Derbyshire, Nottinghamshire, Leicestershire, and Warwickshire, by Mr. J. T. Woodhouse.

The most elaborate report, however, and that most interesting to geologists, is, as might be expected, the report on the quantities of coal wrought and unwrought in the Coal-fields of Somersetshire and part of Gloucestershire, by Mr. Prestwich, President of the Geological Society of London. He points out the extent of the Coal-field, giving lists of the seams, and also notices the minerals associated with them, the faults and disturbances by which the beds are affected, and the conditions under which the coal is now worked.

It having been arranged that the outcrop of each Coal-seam should, so far as possible, be mapped, this was done by Mr. Anstie, upon copies of Mr. Sanders's excellent map of the Bristol Coal-field, and the details which he has collected will form a valuable record of the workings and capabilities of these Coal-fields. In Appendices Mr. Prestwich has given sections of the Coal-measures as proved in the collieries of Gloucestershire and Somerset, also lists of the Coal-seams, with remarks on each, stating for what purpose used, its character and quality.

The Scotch Coal-fields are somewhat briefly treated by Mr. J. Geddes, and those of Ireland by Professor Hull.

The vast amount of practical information contained in this the first volume of the Report shows at once the great value of the results which have been brought about by the Coal Commission. We learn that we have an accessible supply of coal that will last about 276 years, but after that the coal that will remain could never be worked except under conditions of scarcity and high price. As we approach this exhaustion, the country will by slow degrees lose the advantageous position it now enjoys in regard to its coal supply; for although other countries would undoubtedly be in a position to supply our deficiencies, it may well be doubted whether the manufacturing supremacy of this kingdom can be maintained after the importation of coal has become a necessity.

This being the opinion of the Commission, we are led to wonder that they have not more strongly pointed out to the Government the great importance of settling the question as to whether or not there is coal in the Southern and South-eastern portion of England.[1] With one exception, the members are of opinion that workable coal may reasonably be looked for at certain points in this area. The view is certainly purely theoretical; it is opposed by Sir R. I. Murchison, and

[1] Mr. Prestwich remarks, that "a few trials for coal would not be very costly, and could hardly fail in important results, as in case of failing at once to hit the Coal-measures we might possibly find the Lower Greensands, and thus solve one or other of the great questions,—of discovering the productive Coal-strata of the Somerset and Belgian band, or of obtaining the pure and abundant waters of the Lower Greensands, both considerations of high importance for this great metropolis." (p. 165.)

also by Professor Hull and Mr. Bristow, in answer to questions put to them. They consider that no remunerative coal can be found. But there are certain scientific grounds which lead to the notion that coal may be present; and as its importance cannot be overrated, a few trial borings, which would definitely settle the question, would be far more valuable to the country than a mass of theoretical evidence, which is not likely to lead to any practical result; for but little can be expected from private enterprise, when the Government, after spending something like £30,000 in collecting the evidence, part of which is now published, should hesitate to spend a few additional thousand pounds in settling these important questions.—H.B.W.

REPORTS AND PROCEEDINGS.

BRITISH ASSOCIATION, EDINBURGH, August, 1871.

Report of the Committee, consisting of Henry Woodward, F.G.S., F.Z.S., Dr. Duncan, F.R.S., and R. Etheridge, F.R.S., on the Structure and Classification of the Fossil Crustacea.

Drawn up by Henry Woodward, F.G.S., F.Z.S.

Since I had last the honour to present a Report on the Structure and Classification of the Fossil Crustacea, I have published figures and descriptions of the following species, namely :—

Decapoda-Brachyura.

1. *Rhachiosoma bispinosa*, H. Woodw. Lower Eocene, Portsmouth.
2. ——— *echinata*, H. Woodw. Lower Eocene, Portsmouth.
3. *Palæocorystes glabra*, H. Woodw. Lower Eocene, Portsmouth.

All figured and described in Quart. Journ. Geol. Soc. vol. xxvii. p. 90, pl. 4.

Decapoda-Macrura.

4. *Scyllaridia Belli*, H. Woodw. London Clay, Sheppey. Geol. Mag., 1870. Vol. VII., Pl. 22, Fig. 1, p. 493.

Amphipoda.

5. *Necrogammarus Salweyi*, H. Woodw. Lower Ludlow, Leintwardine. Figured and described Trans. Woolhope Club, 1870, p. 271, pl. 11.

Isopoda.

6. *Palæga Carteri*, H. Woodw. Lower Chalk, Dover, etc. Geol. Mag., 1870, Vol. VII., p. 493, Pl. XXII., Fig. 1.
7. *Præarcturus gigas*, H. Woodw. Old Red Sandstone, Rowlestone, Herefordshire. Woolhope Club Trans., 1870, p. 266.

Merostomata.

8. *Eurypterus Brodiei*, H. Woodw. Quart. Journ. Geol. Soc., 1871, August. Woolhope Club Trans., 1870, p. 276.

Phyllopoda.

*9. *Dithyrocaris tenuistriatus*, M'Coy. Carboniferous Limestone, Settle, Yorkshire.
10. *Dithyrocaris Belli*, H. Woodw. Devonian, Gaspé, Canada.
11. *Ceratiocaris Ludensis*, H. Woodw. Lower Ludlow, Leintwardine.
12. *Ceratiocaris Oretonensis*, H. Woodw. Carboniferous Limestone, Oreton, Worcestershire.
13. *Ceratiocaris truncatus*, H. Woodw. Carboniferous Limestone, Oreton, Worcestershire.

Figured and described in the Geol. Mag., 1871, Vol. VIII., p. 104, Pl. III.

14. *Cyclus bilobatus*, H. Woodw. Carboniferous Limestone, Settle, Yorkshire.

15. *Cyclus torosus*, H. Woodw. Carboniferous Limestone, Little Island, Cork.
16. ——— *Wrightii*, H. Woodw. Carboniferous Limestone, Little Island, Cork.
17. ——— *Harknessi*, H. Woodw. Carboniferous Limestone, Little Island, Cork.
*18. ——— *radialis*, Phillips. Carboniferous Limestone, Settle, Yorkshire, Visé, Belgium.
*19. *Cyclus Rankini*, H. Woodw. Carboniferous Limestone, Carluke, Lanarkshire.
[*20. ——— "*Brongniartianus*," De Koninck. Carboniferous Limestone, Yorkshire, Belgium.]
21. *Cyclus Jonesianus*, H. Woodw. Carboniferous Limestone, Little Island, Cork. (These latter figured and described in the Geol. Mag., 1870, Vol. VII., Pl. XXIII., Figs. 1–9.)

[Those marked with an asterisk have been already figured, but have been redrawn and redescribed in order to add to or to correct previous descriptions. Thus, for example, "*Cyclus Brongniartianus*" proves upon careful examination to be only the hypostome of a Trilobite belonging to the genus *Phillipsia*. *Dithyrocaris tenuistriatus* is identical with *Avicula paradoxides* of De Koninck, etc.]

Since noticing the occurrence of an Isopod (*Palæga Carteri*), from the Kentish, Cambridge, and Bedford Chalk, Dr. Ferd. Roemer, of Breslau, has forwarded me the cast of a specimen of the same Crustacean from the Chalk of Upper Silesia. This, together with the example from the Miocene of Turin, gives a very wide geographical as well as chronological range to this genus.

A still more remarkable extension of the Isopoda in time is caused by the discovery of the form which I have named *Præarcturus* in the Devonian of Herefordshire, apparently the remains of a gigantic Isopod resembling the modern *Arcturus Baffinsii*.

I have also described from the Lower Ludlow a form which I have referred with some doubt to the Amphipoda, under the generic name of *Necrogammarus*.

Representatives both of the Isopoda and Amphipoda will doubtless be found in numbers in our Palæozoic rocks, seeing that Macrouran Decapods are found as far back as the Coal-measures,[1] and Brachyurous forms in the Oolites.[2]

Indeed the suggestion made by Mr. Billings as to the Trilobita being furnished with legs (see Quart. Journ. Geol. Soc., vol. xxvi., pl. 21, fig. 1), if established upon further evidence, so as to be applied to the whole class, would carry the Isopodous type back in time to our earliest Cambrian rocks.

I propose to carry out an investigation of this group for the purpose of confirming Mr. Billings's and my own observations, by the examination of a longer series of specimens than have hitherto been dealt with. In the mean time the authenticity of the conclusions arrived at by Mr. Billings having been called in question by Drs. Dana, Verrill, and Smith (see the American Journ. of Science for May last, p. 320; Annals and Mag. Nat. Hist. for May, p. 366), I have carefully considered their objections, and have replied to the same in the Geological Magazine for July last, p. 289, Pl. VIII.; and I may be permitted here to briefly state the arguments *pro* and *con*, seeing they are of the greatest importance in settling the systematic position of the Trilobita among the Crustacea.

Until the discovery of the remains of ambulatory appendages by Mr. Billings in an *Asaphus* from the Trenton Limestone (in 1870), the only appendage heretofore detected associated with any Trilobite was the hypostome or lip-plate.

From its close agreement with the lip-plate in the recent *Apus*, nearly all naturalists who have paid attention to the Trilobita in the past thirty years have concluded that they possessed only soft membranaceous gill-feet, similar to those of *Branchipus*, *Apus*, and other Phyllopods.

The type-number of segments in Crustacea is 20 or 21. In all the higher forms, as in the Decapoda, Stomapoda, Isopoda, etc., several of these segments are coalesced either in the head, thorax, or abdomen, so that we never meet with a Crustacean having 21 distinctly-marked segments until we arrive at the Branchiopoda and Phyllopoda, many of which have their full number of separate segments.

In the Trilobita, a very variable number of body-rings is met with, from 6 even to 26 (in *Harpes ungula*, Sternb.), so that on that account alone the Trilobita must be considered as a much lower type than the Isopoda, in which the body-segments are usually seven in number. There seems, however, no good reason against the conclusion

[1] *Anthrapalæmon Grossartii*, Salter, Coal-measures, Glasgow.
[2] *Palæinachus longipes*, H. Woodw., Forest Marble, Wilts.

that the Trilobita were an earlier and more generalized type of Crustacea from which the later and more specialized Isopoda have arisen.

The large compound sessile eyes, and the hard, shelly, many-segmented body, with its compound caudal and head-shield, differ from any known Phyllopod, but offer many points of analogy with the modern Isopods, and one would be led to presuppose the Trilobites possessed of organs of locomotion of a stronger texture than mere branchial frills.

The objection raised by Drs. Dana and Verrill to the special case of appendages in the *Asaphus* assumed by Mr. Billings to possess ambulatory legs is, that the said appendages were merely the semicalcified arches in the integument of the sternum to which the true appendages were attached.

A comparison, which these gentlemen have themselves suggested, between the abdomen of a Macrouran Decapod and the Trilobite in question, is the best refutation of their own argument.

The sternal arches in question are firmly united to each tergal piece at the margin, not along the median ventral line. If, then, the supposed legs of the Trilobite correspond to these semicalcified arches in the Macrouran Decapod, they might be expected to lie irregularly along the median line, but to unite with the tergal pieces at the lateral border of each somite. In the fossil we find just the contrary is the case; for the organs in question occupy a definite position on either side of a median line along the ventral surface, but diverge widely from their corresponding tergal pieces at each lateral border, being directed forward and outward in a very similar position to that in which we should expect legs (*not sternal arches*) to lie beneath the body-rings of a fossil crustacean. The presence, however, of semicalcified sternal arches presupposes the possession of stronger organs than mere foliaceous gill-feet; whilst the broad shield-shaped caudal plate suggests most strongly the position of the branchiæ. In the case of the Trenton *Asaphus* I shall be satisfied if it appears, from the arguments I have put forward, that they are *most probably* legs—feeling assured that more evidence ought to be demanded, before deciding on the systematic position of so large a group as the Trilobita from only two specimens.[1]

With regard to the embryology and development of the modern King-Crab (*Limulus polyphœmus*), we must await the conclusions of Dr. Anton Dohrn before deciding as to the affinities presented by its larval stages to certain of the Trilobita, such relations being only in *general external form.* Dr. Packard (Reports of the American Association for the Advancement of Science, August, 1870) remarks, "The whole embryo bears a very near resemblance to certain genera of Trilobites, as *Trinucleus, Asaphus,* and others;" and he adds, "previous to hatching it strikingly resembles *Trinucleus* and other Trilobites, suggesting that the two groups should, on embryonic and structural grounds, be included in the same order, especially now that Mr. E. Billings has demonstrated that *Asaphus* possessed eight pairs of five-jointed legs of uniform size."

Such statements are apt to mislead, unless we carefully compare the characters of each group. And first let me express a caution against the too hasty construction of a classification based upon *larval* characters.

Larval characters are useful guide-posts in defining great groups, and also in indicating affinities between great groups; but the more we become acquainted with larval forms the greater will be our tendency (if we attempt to base our classification on their study) to merge groups together which we had before held to be distinct.

To take a familiar instance: if we compare the larval stages of the Common Shore-Crab (*Carcinus mœnas*) with *Pterygotus*, we should be obliged (according to the arguments of Dr. Packard) to place them near to or in the same group.

The eyes in both are sessile, the functions of locomotion, prehension, and mastication are all performed by one set of appendages, which are attached to the mouth; the abdominal segments in both are natatory, but destitute of any appendages.

Such characters, however, are common to the larvæ of many Crustaceans widely separated when adult, the fact being that in the larval stage we find in this group, what has been so often observed by naturalists in other groups of the animal kingdom, namely, a shadowing forth in the larval stages of the road along which its ancestors travelled ere they arrived from the remote past at the living present.

If we place the characters of *Limulus* and *Pterygotus*, side by side, and also those

[1] One in Canada, and one in the British Museum, both of the same species.

of Trilobita and Isopoda, we shall find they may be, in the present state of our knowledge, so retained in classification.

I.

Pterygotus (Fossil, extinct).

1. Eyes sessile, compound.
2. Ocelli distinctly seen.
3. All the limbs serving as mouth-organs.
4. *Anterior* thoracic segments bearing branchiæ or reproductive organs.
5. Other segments destitute of any appendages.
6. Thoracic segments *unanchylosed.*
7. Abdominal segments *free and well developed.*
8. Metastoma, *large.*

Limulus (Fossil, and living).

1. Eyes sessile, compound.
2. Ocelli distinctly seen.
3. All the limbs serving as mouth-organs.
4. *All* the thoracic segments bearing the branchiæ or reproductive organs.
5. Other segments destitute of any appendages.
6. Thoracic segments *anchylosed.*
7. Abdominal segments *anchylosed and rudimentary.*
8. Metastoma, *rudimentary.*

II.

Trilobita (Fossil, extinct).

1. Eyes sessile, compound.
2. No ocelli visible.
3. (Appendages partly oral, partly ambulatory, arranged in pairs).
4. Thoracic segments *variable in number, from* 6 *even to* 26, free and movable (animal sometimes rolling in a ball).
5. Abdominal somites coalesced forming broad caudal shield (bearing the branchiæ beneath).
6. Lip-plate, *well developed.*

Isopoda (Fossil, and living).

1. Eyes sessile, compound.
2. No ocelli visible.
3. Appendages partly oral, partly ambulatory, arranged in pairs.
4. Thoracic segments *usually seven*, free and movable (animal sometimes rolling in a ball).
5. Abdominal somites coalesced, forming broad caudal shield, bearing the branchiæ beneath.
6. Lip-plate, *small.*

Should our further researches confirm Mr. Billings's discovery fully, we may propose for the second pair of these groups a common designation (as in the case of the Merostomata); meantime, the above may serve as representing the present state of our knowledge.

CORRESPONDENCE.

PORTLAND WOOD, ON THE COAST OF SUSSEX.—REPLY TO MR. PERCEVAL.

Sir,—I know the Portland beds in the Dorsetshire district pretty well, and, as far as I am aware, the Tisbury *Isastræa* does not occur there at the present day. But, considering that there are fragmentary patches of Portland beds fringing the coast for a considerable distance in Dorsetshire, it is highly probable that, in not very distant times, there was a considerable area occupied by them there; as, indeed, there probably now is beneath the Channel. The Portland beds vary in character rather rapidly at places not far from one another, so that the non-occurrence of a particular fossil in those now visible, need not lead us to conclude that it may not have occurred not very far off in former times.

I would, however, recommend Mr. Perceval to obtain an accurate determination of his fossil, so as to be sure of its specific identity.

That erratics from the Portland beds have found their way into Sussex, I believe to be a fact; for I saw in 1866 a block of indubitable Portland fossil wood at Selsey, in the garden of Mrs. Pullinger. I was informed that it had been found on the beach at that part of the shore called "The Park." It had been described to me as a petrified piece of wood from the submarine forest, which occurs along the coast; and my curiosity was raised, knowing that such wood was never petrified. I think the story was true, and certainly not improbable, because there can be little doubt that the numerous glacial erratics of that coast have travelled up the Channel from the direction of the Channel Islands. And it is quite likely that a block of silicified wood from Portland, almost as indestructible as any igneous rock among them, may have come in the same manner and from the same direction. The block was eighteen inches long and ten inches in diameter.

HARLTON, CAMBRIDGE. O. FISHER.

LOCAL MUSEUMS.

SIR,—I am glad to see in your October number a letter from F. G. S. advocating the formation of local museums. Nothing could prove a greater assistance to the student in any branch of Natural History than to find in each town a series of specimens arranged so as to show the various products of the neighbourhood; but the chief difficulty which stands in the way of provincial museums is the uncertainty of their tenure. There is usually no dearth of specimens flowing in from all quarters when once a museum is set on foot, but money must also be forthcoming for cases; rent has probably to be paid for a room to contain them, and somebody must necessarily be employed to look after the room, keep the cases dusted, and unlock the door for visitors. Under these conditions, it will, unfortunately, too often be found that local ardour becomes cooled, the sixpence or shilling from the stray visitor will very speedily be insufficient to pay for the dusting, the room is closed, and the neglected contents are either dispersed or thrown aside as useless lumber.

In a little work entitled "Hints on Local Museums, by the Treasurer of the Wimbledon Museum Committee,"[1] as well as in a paper published in *Chambers's Journal*[2] on provincial museums, F. G. S. will find some most valuable suggestions for their establishment and arrangement; but, at the same time, it is as well to bear in mind that in default of local collections, a great deal of good can be done by means of local catalogues. Let each member of a Naturalists' Club undertake whatever branch of Natural History he is best acquainted with, and compile a list of the species occurring in his own neighbourhood,—one might catalogue the fossils, giving the names of characteristic species found in each quarry; another might devote himself to the minerals, and others would take in hand the Botanical and Zoological departments. Thus, by a well-organized division of labour, an immense amount of valuable information would be accumulated, and the result would be a record of the distribution of species throughout the country, more lasting perhaps, though less attractive, than that afforded by many a local museum.

PILTON, BARNSTAPLE, *October* 10, 1871. TOWNSHEND M. HALL.

[1] R. Hardwicke, London. Price 1*s*. [2] April 7, 1866.

Prof. Owen during a recent visit to Brighton, called on the Mayor, Mr. Alderman Webb, and left a letter for his worship, on the desirability of taking steps for forming a collection or series of the Wealden Fossils of Sussex, corresponding, as far as time and means might permit, with the illustrations of the Chalk-beds which the Local Museum owes to the liberality of Mr. Willett. Not having been fortunate to meet with the Mayor, the Professor called on Mr. Cordy Burrowes, to whose active public spirit Brighton is much indebted. The worthy Alderman, who will probably hold the office of Mayor during the meeting of the British Association, entered warmly into the views of his visitor, and pledged himself to promote their realization to the extent of his influence.

RIVER TERRACES, ETC.

Sir,—I certainly did not understand that Colonel Greenwood was speaking *solely* of terraces in closed valleys. This, it appears to me, was by no means clearly brought out in his first letter. With regard to these I can only say that, owing to the general correspondence between all these terraces that I have seen and those in the open valleys, it seems more natural to refer both to the same cause, viz., the action of water in motion upon detritus that has been mainly deposited in water comparatively at rest, and this, if your summary be correct, seems to be Professor Kjerulf's opinion. Doubtless a delta may be elevated by floods, but as a rule the amount thus gained would be small compared with the mass deposited under the permanent water level. I should regard the inland terraces to be remains of deltas, either deposited in fjords during a period of depression, or in lakes which have been first more or less filled up, then re-excavated. In order to explain this, I do not think it necessary to *burst* any barriers, or call in other agencies to remove them than "rain and rivers" acting upon rocks liable to erosion. In thus venturing to differ from Colonel Greenwood, I would not be thought forgetful of the great services he has rendered to geologists by his careful observation of meteoric agents and their work in nature.

T. G. Bonney.

St. John's College, Cambridge.

ERRATA IN THE PAPER, "ON THE SYSTEMATIC POSITION OF *SIVATHERIUM GIGANTEUM*."

Sir,—In my communication on this subject in the October number of this Journal, I have observed two errors, which I feel it my duty to correct, in justice to the individuals concerned. At page 440, reference is made to Dr. Canfield's "concise paper on the manner of shedding and the nature of the Prongbuck's horns." This author has given some account of these, but to Mr. A. D. Bartlett, Superintendent of the Zoological Society's Gardens, the honour of the first accurate history is due (*vide* P.Z.S. 1865, p. 720).[1] I might

[1] This substitution of Dr. Canfield's name for that of Mr. Bartlett arose from Dr. Murie having accidentally quoted the wrong year of the Proceedings—namely, 1866, in which Dr. Canfield's (*not* Mr. Bartlett's) paper is published.—Edit. Geol. Mag.

further have alluded to some remarks on the same subject made by Dr. Marsh in a letter to Dr. Pickering, 1841 (see U. S. Expedition, Ungulata, p. 63), also Weiland (Zool. Garten. 1863, p. 255), and Martin (Die Hornbildung bei der Mozama Antilope, *ibid*, 1864, p. 254), but my former colleague Mr. Bartlett's observations are by far the most conclusive and accurate. Dr. Gray (Ann. and Mag. Nat. Hist. 1866, p. 326) has given a fair summary of the distinction of structure, etc. of the several kinds of ruminant's horns, which I may call attention to without saying more on the subject.

At p. 447, instead of "Waterhouse *and* Hawkins," read "*and Waterhouse-Hawkins*;" the same gentleman who produced the wonderful restorations at the Crystal Palace; the "and" has been *accidentally* transposed. James Murie.

Bethnal House, Cambridge Road, E.

GLACIAL DRIFT AT FINCHLEY.

Mr. H. Walker (of No. 100, Fleet-street, E.C.), addressing the *Daily News*, October 23rd, writes :—"Not a few Londoners have made a pilgrimage to Muswell Hill during the last fifteen years to see for themselves some tangible relics of the great climatic episode known as the Glacial period which the place is said to exhibit, but to their disappointment they have found the gravel-pits filled up. They may now indemnify themselves by a trip to Finchley Station on the Highgate and Edgware Railway, where the Boulder-clay is now being revealed in a section nearly 30 feet deep. The clay seems to have a maximum thickness of 9 feet, and is rich in fossils drifted hither from the Liassic, Oolitic, and Chalk formations of the north. The railway works are those of the branch line to Barnet. Ammonites are found in great variety and abundance." We will only add to this the additional piece of information, that there exists in the possession of N. T. Wetherell, Esq., F.G.S., of Highgate, the most interesting and extensive series of Boulder-clay fossils from the Drift of Muswell Hill, that have probably ever been assembled by any collector from any one locality, save perhaps that made by the late John Brown, Esq., F.G.S., in the vicinity of Stanway, Essex.

MISCELLANEOUS.

Professor Morris, F.G.S., of University College, London.—By a grace of the Senate of the University of Cambridge, the venerable Professor Sedgwick (who for upwards of fifty years has occupied the Chair of Geology) has named Professor John Morris, F.G.S., as the Deputy Woodwardian Professor to deliver the usual course of lectures on Geology for the present session, and his choice has received the approval of the Vice-Chancellor and Syndics of the University. Professor Morris will continue to lecture *as usual* at University College, London. He delivered his first lecture at Cambridge on October 23rd.

Dr. H. Alleyne Nicholson, M.B., F.G.S., formerly of Edinburgh, and author of numerous geological papers and text-books, has been recently appointed to the Professorship of Natural History and Botany in the University of Toronto, Canada.

Evidence of True Coal-Measures in Disco Island, North Greenland.—Dr. Robert Brown, of Edinburgh, has kindly sent us an extract from a letter he has received from his friend Mr. District-Surgeon C. G. F. Pfaff, dated Jakobshavn, North Greenland, 8th August, 1871. It announces the discovery of a *Sigillaria* in a river on the eastern coast of Disco, close to the inhabited place Ugarasusuk (or Ucarasuksumitok), he also found several boulders of hard Sandstone which contained fossil ferns, which may be older than Tertiary. As Mr. Pfaff had no books he speaks cautiously. The *Sigillaria,* it seems, was *not in situ* any more than the Ferns, but if it be a true *Sigillaria,* it is a most interesting discovery. True Coal-plants have been already determined from Melville Island in latitude 75° (Captain Parry's expedition). See Lyell's "Principles," vol. i., p. 225, tenth edition.

To London Geologists, Field-Naturalists, and Microscopists.—Members of Microscopical Clubs (the Quekett, Old Change, South London, Forest Hill, and Croydon), the Geologists' Association, the North-London Naturalists', Working Men's College, Working Men's Clubs, and the unprofessional botanists, microscopists, and geologists of London generally. Prizes for competition in Botany, Microscopy, and Geology. By the kindness of several distinguished friends of the Saturday half holiday in London, the sum of thirty guineas is proposed to be offered for competition to London field-naturalists and microscopists, for the encouragement of Saturday afternoon field excursions for botanical, geological, and microscopical purposes. Her Grace the Duchess of Sutherland, the Countess of Ducie, and the Most Noble the Marquis of Westminster, believing that the proposal would tend to popularize pleasant and instructive recreation on the Saturday afternoon, and commend the Saturday half holiday in departments of business where this weekly boon is greatly needed, have kindly entrusted the Committee of the Early-Closing Association with a fund for this purpose.

The following are the prizes and the subjects proposed for competition:—

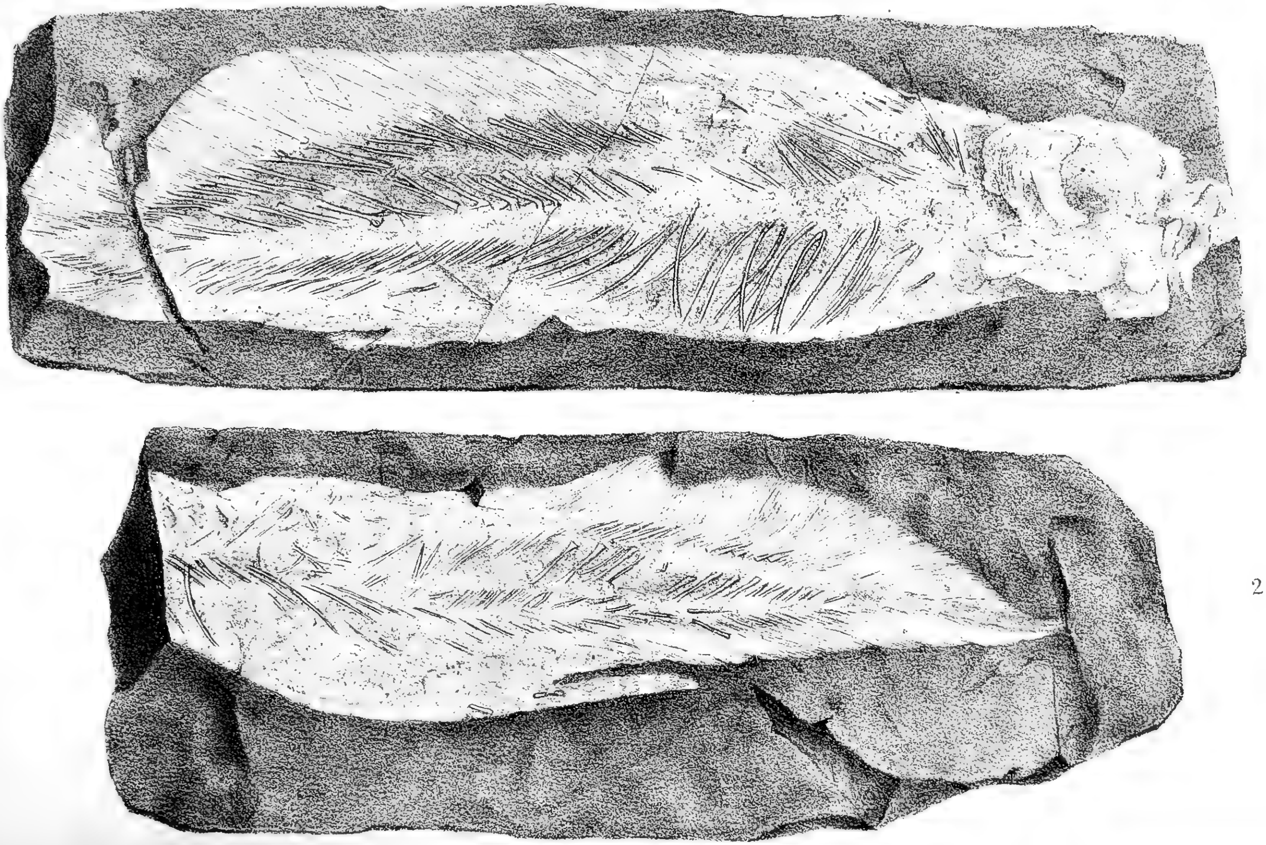
I. The Duchess of Sutherland's prize of ten guineas, for botanists: £5 5*s.* for the best collection of mosses, including the Hepaticæ, obtained within 20 miles of London; £3 3*s.* for the second best collection; £2 2*s.* for the third best collection. Adjudicator, Dr. Braithwaite, F.L.S.

II. The Countess of Ducie's Prize of Ten Guineas, for Microscopists. £5 5*s.* for the best List of the Ponds and other aquatic resorts, within fifteen miles of London, and the Microzoa found in them, in the twelve months between ———— 1871, and ———— 1872, giving the locality of Pond, the date of the visit, and the state of the weather at the time. £3 3*s.* for the second best ditto; £2 2*s.* for the third ditto. Total, £10 10*s.*

III. The Marquis of Westminster's Prize of Ten Guineas, for Geologists. £5 5*s.* for the best List of open Geological Sections and Exposures of the Strata of the London district, giving the Fossil Species found at each Section (in the order of their abundance), and the characteristic species of each formation exposed. Note.—As the object is to obtain information for the purpose of field excursions, the sections given must be such as are now open, and likely to continue open for several years, *e.g.*, Chalk-pits, Gravel-pits, Sand-pits, Clay-pits, Railway sections, and similar excavations. The Natural Exposures given should also be accessible for at least the next few years. £5 5*s.* for the best Notes on and Instances of the Connexion of the Landscape Scenery of the London district with its Geology. Adjudicator, Professor Morris, F.G.S.

The papers on Geology and Microscopy (Subjects II. and III.) must not in any instance exceed in length two columns of the *Times* newspaper Parliamentary Debates. Professional Collectors and Dealers are excluded from the competition. The Prizes are intended exclusively for those with whom Natural History pursuits are solely the recreation of their leisure after-business hours.

Early-Closing Association, HENRY WALKER, *Secretary.*
100, Fleet Street, E.C., *October,* 1871.



R. H. Traquair del[t]. ad nat. G. H. Ford. Mintern Bros imp.

Phaneropleuron elegans, nat. size. L. Carboniferous Limestone, Burdiehouse.

THE
GEOLOGICAL MAGAZINE.

No. XC.—DECEMBER, 1871.

ORIGINAL ARTICLES.

I.—Notes on the Genus *Phaneropleuron* (Huxley), with a Description of a New Species from the Carboniferous Formation.

By Ramsay H. Traquair, M.D.,
Professor of Zoology in the Royal College of Science, Dublin.

(PLATE XIV.)

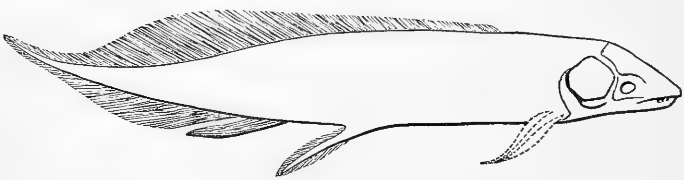
THE genus *Phaneropleuron* was instituted by Professor Huxley, in 1859,[1] for the reception of that singular fish *P. Andersoni*, from the Upper Devonian Yellow Sandstone of Dura Den, in Fifeshire, which species was also subsequently described by him in the tenth Decade of the Geological Survey, published in 1861. In the present communication I have to add a second species, from the Lower Carboniferous strata (Burdiehouse Limestone) of Edinburghshire, by which our knowledge of the genus is thus certainly carried a stage further upwards in the geological series.

Before, however, proceeding to the special description of the Carboniferous form, I have a few notes to contribute regarding the general characters of *Phaneropleuron*, as shown in the first described species, the results of a careful examination of the specimens in the St. Andrew's Museum, obtained subsequently to the publication of Professor Huxley's descriptions. I have also enjoyed the opportunity of comparing these results with the appearances exhibited in the suite of specimens in the British Museum, and in the Museum of Practical Geology in Jermyn Street.

As Professor Huxley has pointed out, in his excellent and concise descriptions above referred to, *Phaneropleuron Andersoni* is remarkable for its thin circular overlapping scales, for its persistent notochord, but well ossified neural and hæmal arches, spines, and median fin-supports, and for the great length and prominence of the ribs, which shine so conspicuously through the thin external covering of scales. The ventral, and most probably also the pectoral fins, are acutely lobate, with a central scaly axis fringed with rays on both sides, as in the recent *Ceratodus Forsteri*, the extinct *Holoptychius*, etc., and there is a distinct narrow anal fin in front of the lower lobe

[1] In Anderson's "Dura Den, a Monograph of the Yellow Sandstone." Edinburgh, 1859.

of the caudal. The dorsal fin commences low in front, but becomes deep and broad, as the form of the body narrows towards the tail. As regards the form of the tail, and the relations and configuration of the dorsal fin behind, Professor Huxley's views, at the time he wrote his descriptions, were, that the dorsal terminated posteriorly in an almost vertically truncated extremity, beyond which the notochord was continued for some distance. The upper lobe of the caudal seemed to be obsolete, while, on the other hand, he could trace the lower lobe, commencing immediately behind the anal, to near the extreme end of the body.[1] Subsequently obtained material, however, shows that the appearances which justified so eminent a palæontologist in adopting the above-mentioned views were due to defective preservation of the specimens at his disposal, and that the dorsal fin was, as in the recent *Lepidosiren* and *Ceratodus*, continued, as a *dorso-caudal*, to the very extremity of the body, which condition I have endeavoured to express in the subjoined woodcut, representing a restored outline of the fish. I may mention that Prof.



Restored outline of *Phaneropleuron Andersoni.*

Huxley has expressed to me his entire concurrence in this view. The tail of *Phaneropleuron* is, then, beautifully diphycercal, a slight tendency to the heterocercal form being, however, shown by a very constant, though slight, upward curvature of the caudal extremity of the body.

I am also in a position to give a few additional details regarding the structure of the head, though unfortunately our knowledge on this point still remains very imperfect. In general configuration the head must have resembled much that of *Ceratodus Forsteri*, being considerably flattened above, while the high occipital region slopes off downwards and forwards to the bluntly-pointed muzzle. Internally, the cranium seems to have been very extensively cartilaginous, as I have seen no trace of any ossifications of its base or side-walls, but above it was protected by a buckler formed of a great many osseous plates firmly articulated together by suture, though none of the specimens I have seen are sufficiently perfect to enable one to map out completely their number and arrangement. However, in two of the specimens in the St. Andrew's Museum, three plates, one median and two lateral, may be very distinctly made out, forming the posterior or nuchal margin of the cranial shield, and corresponding to the three similar plates in *Glyptolæmus*. In front of the median plate are two elongated *parietals*, while on each side of it, and articulating also with the posterior external

[1] Mem. Geol. Survey, Decade X., p. 49. Also in Anderson's "Dura Den," p. 67.

angle of the corresponding parietal, is another pretty large bony piece (*squamosal* ?). Between the latter and the external margin of the buckler is a row of smaller plates, of which three are evident enough; but in no specimen I have seen, can the arrangement of the plates in front of those described be definitely made out, nor can I settle the question as to the position of the nasal openings. I have seen no hyomandibular; but in two specimens, one in St. Andrews, the other in the British Museum, a stout *palato-pterygoid* may be seen to extend from near the articular extremity of the lower jaw forwards towards the snout: posteriorly, the surface of this bony lamina slopes upwards and inwards, but in front it becomes nearly horizontal, and there it is seen to be armed on its oral surface with numerous conical teeth. The form of the *maxillary* and *premaxillary* bones is not determinable, but the upper margin of the mouth was evidently bordered by dentigerous bones, the teeth being as described by Professor Huxley, in one row, short, conical, and pointed. The lower jaw is stout, composed evidently of several pieces, and close to the symphysis the ramus makes a pretty sharp bend horizontally inwards to meet its fellow. It is armed also with pointed teeth, an especially large one being seen at the symphyseal angle referred to. The *operculum* is very large, rounded posteriorly and inferiorly, but with nearly straight superior and anterior margins; below it overlaps an antero-posteriorly elongated, somewhat ovate *suboperculum*, not before noticed. There is no trace of any *preoperculum*. The orbit seems to have been situated rather far back; a curved bony plate is seen on the cheek, separating it from the operculum, and bounding it below and behind. Regarding the under surface of the head, I have nothing to add to Professor Huxley's description, not having seen any better specimen than that in the British Museum, to which he refers, and which certainly shows that the space between the rami of the lower jaw was occupied by bony plates, whatever their number might have been. Of the bones of the shoulder-girdle I have only seen two, viz., a well-marked *clavicle*, and at least one *supra-clavicular* proceeding from it towards the occipital region of the skull.

Phaneropleuron Andersoni (Huxley), towards the knowledge of whose structure I have contributed the above unfortunately only too imperfect notes, was hitherto the only species of the genus described, and the genus was known only from the Devonian beds of Dura Den. Some time ago, however, while looking through the Carboniferous fishes in the collection of the late Mr. Hugh Miller, my attention was directed by Mr. C. W. Peach, who was with me on that occasion, to certain un-named specimens, which he had already recognized as belonging to the genus in question, and which now gave undoubted evidence of its continuation upwards into, at least, the lower portion of the Carboniferous series. No locality was affixed to those fossils, but the stone in which they are imbedded is so identical in mineral character with the well-known Lower Carboniferous Limestone of Burdiehouse, near Edinburgh, that there can be no doubt but that they were derived from that locality. Moreover, I think that sufficient justification for recording them as Burdiehouse fossils may be found in the fact, that two additional specimens of the same fish have been also found by that most indefatigable and successful collector, Mr. Peach, in the quarries of the very place in question.[1]

Enumeration of Specimens.—For purposes of reference in the following description, the specimens before me may be numbered and characterized as follows:—

No. 1. Specimen (Fig. 1, Pl. XIV). measuring $5\frac{3}{8}$ inches in length, and showing the head, body, and caudal region, except the extreme termination of the tail. In the Miller Collection, Edinburgh Museum of Science and Art.

No. 2. Specimen (Fig. 2, Pl. XIV.) $4\frac{3}{8}$ inches in length, without head, but showing the greater part of the abdominal region, with the tail up to its very termination. Miller Collection.

No. 3. Portion of a fish, evidently originally a larger specimen than either of the two preceding. It shows a large portion both of the abdominal and caudal regions, but without either the head or the point of the tail. Length, $4\frac{1}{2}$ inches. Miller Collection.

No. 4. A nearly entire specimen, $5\frac{1}{8}$ inches long, somewhat distorted, showing a portion of the head and also the extreme termination of the tail, as in No. 2. In the collection of Mr. Peach.

No. 5. Portion of the caudal region, but without its extreme termination. Length, $3\frac{7}{16}$ inches. In Mr. Peach's collection.

Scales.—The body was evidently covered, as in the case of *P. Andersoni,* with thin and feebly ossified scales, which do not in any case conceal the bones of the prominent internal skeleton. Their exact size and configuration can hardly be accurately distinguished, owing to the state of preservation of the fossils, in which the scales are squeezed together into almost an homogeneous-looking film. As far as I can make out, they seem to have been of moderate size, cycloidal or somewhat rhombo-cycloidal in shape, imbricating in arrangement, and marked with concentric lines, but more especially with fine thread-like longitudinal or slightly radiating striæ.

Head.—In specimen No. 1 the head measures $1\frac{1}{4}$ inch in length, and is contained $5\frac{3}{4}$ times in the length of the whole specimen as preserved, but the end of the tail being lost, the original proportion would probably be, at least, as 1 to $6\frac{1}{2}$. In front a portion of bone is seen bearing a smooth, conical, sharp, tooth-like projection, $\frac{1}{20}$ of an inch long. In No. 3 the impression of a large broad operculum is distinctly visible, but in neither of the specimens can the contour of any other of the bones of the head be distinguished, though in places it may be seen that their free surfaces were ornamented with fine ridges.

Body.—In general form the body must have considerably resembled that of *Protopterus,* being moderately broad in the abdominal

[1] The following description of the new Carboniferous species formed part of a paper, entitled, "Additions to the Fossil Vertebrate Fauna of Burdiehouse, near Edinburgh," read before Section C of the British Association, at Edinburgh, August, 1871.

region, and becoming gradually attenuated to a fine point in the caudal, but in specimens free from distortion a very distinct upward curvature of the axis of the body is seen near the tail. There being no traces of vertebral bodies visible, the notochord must have been persistent, and the empty space which it occupied is well seen, especially in the caudal region. The neural arches and spines are well ossified; the latter are slender in form, and are long in front, getting gradually shorter as we proceed backwards. The form of the neural spines is most distinctly seen in the caudal region, where each, springing from a slightly expanded neural arch, passes very obliquely upwards and backwards, and becoming thin in the middle, ends in a laterally-flattened, expanded termination, to which one of the next set of elements, the dorsal fin-supports, may in many instances be clearly seen to have been articulated: indeed, I believe that this must always have been the case, though in the present fossils these elements are often displaced from each other, as in Fig. 2, Pl. XIV. These succeeding elements, the dorsal "inter-spinous bones," or fin-supports, well shown both in Figs. 1 and 2 of the plate, are likewise slender in form, expanded at both ends, and pass, like the neural spines which support them, obliquely upwards and backwards. They are frequently slightly curved, with a forwardly directed concavity. They are rather short and delicate in front, attaining their greatest length and stoutness opposite the beginning of the caudal region, whence backwards they again become smaller, till towards the end of the tail they can no longer be distinguished from the neural spines. The ribs are, as in *Ph. Andersoni*, very long and prominent, and are well seen in Fig. 1. The hæmal spines follow on the ribs as we pass from the abdominal to the caudal region, and with the appended supporting bones of the anal and inferior lobe of the caudal fins, agree essentially with the corresponding elements on the neural side of the notochord. The ribs, neural and hæmal spines, and median fin-supports seem to have been hollow, the central cavities, originally occupied by cartilage, being now filled with carbonate of lime.

Fins.—A comparison of the five specimens under examination shows that the dorsal fin was, as in *Ph. Andersoni* and in the recent *Lepidosiren*, perfectly continuous with the upper lobe of the caudal. In specimen No. 1 (Fig. 1, Pl. XIV.) the dorsal is seen distinctly to commence only three-quarters of an inch behind the head. This dorso-caudal fin is low at its commencement, but gets broader posteriorly, attaining its greatest breadth opposite the beginning of the caudal region, after which it becomes rapidly attenuated as it proceeds to the tip of the tail. On the hæmal aspect of the body there is some evidence in nearly all the specimens, but especially in No. 4, of a small, narrow, separate anal fin in front of the lower lobe of the caudal. This lower lobe of the caudal is not so broad as the upper lobe, and, proportionally, is considerably less deep than the corresponding part in *Ph. Andersoni;* like the upper lobe, it becomes finely attenuated posteriorly. The tail thus formed is beautifully diphycercal, as seen in Fig. 2; there being, however, as above remarked, a slight upward curvature of the axis of the body at its caudal extremity. This curvature is not seen in Fig. 2, as the specimen has undergone a slight distortion, but it may be observed in Fig. 1, and is still better seen in specimen No. 5, not figured.

The rays of the median fins are very fine, frequently bifurcating near their tips, and spring in bundles, which may be best studied in the dorso-caudal. They have, in fact, the same structure as in *Ph. Andersoni.* Each bundle results from the division, into numerous raylets, of the distally-directed apex of a small triangular basal piece, which, proximally, may frequently be seen to be articulated to the subjacent extremity of an interspinous bone or fin-support. A few of these triangular bases of the dorso-caudal fin-rays may be seen both in Figs. 1 and 2, though they are considerably more distinct in specimens Nos. 3 and 5, not figured.

In specimen No. 1 (Fig. 1), a bone of the shoulder girdle, probably the clavicle of the right side, is seen, but no undoubted trace of either pectoral or ventral fins can be detected in any of the fossils.

Conclusion.—In the Carboniferous specimens before us, we have a fish very closely resembling the *Phaneropleuron Andersoni* of Huxley, but differing from it in its smaller size, in its somewhat more slender form posteriorly, in the smaller depth of the lower lobe of the caudal fin, and apparently also in the greater extension forwards of the dorsal fin. As it is evidently at least specifically distinct, I propose to bestow on it the title of *Phaneropleuron elegans.*

The genus *Phaneropleuron* is thus common to the Upper Devonian and Lower Carboniferous formations. It is one of the most interesting of the Palæozoic Ganoids, as showing the intimate relations subsisting between the ancient Crossopterygians with acutely lobate pectorals and ventrals, and the remarkable recent types, *Lepidosiren, Protopterus,* and *Ceratodus.* One cannot fail to be struck, as Prof. Huxley has already indicated,[1] with the many points of resemblance which this genus bears to *Lepidosiren,* in the general form of the fish, in its thin circular scales, and in many points in the structure of its internal skeleton. But from the true *Dipnoi,* with which Dr. Günther now unites the Devonian *Dipterus,* and the Carboniferous *Ctenodus,*[2] it differs, as is well known, materially in its dentition; and the position of the nasal openings, so peculiar a character in the recent *Dipnoi,* and in the fossil *Dipterus,* as Günther has pointed out, remains yet to be definitely settled. *Phaneropleuron* must therefore remain, as Prof. Huxley has placed it, the type of a distinct subfamily of Crossopterygidæ, viz., *Phaneropleurini,* and not very far removed from *Holoptychius,* and other acutely lobate-membered cycliferous Ganoids of Palæozoic times.

My best thanks are due to Mr. Archer, the able and liberal-minded Director of the Edinburgh Museum of Science and Art, for permission to figure and describe the Carboniferous specimens in the Miller Collection; to my genial friend Mr. Peach, for the loan of the two specimens in his private cabinet, and for having originally

[1] Dec. Geol. Surv. X. p. 26.
[2] Proc. Royal Soc. March 16, 1871, p. 379.

directed my attention to the subject; and also to the Literary and Philosophical Society of St. Andrews, for the free permission which they accorded to me to examine and make notes of the beautiful specimens from Dura Den, in the Geological collection of their Museum.

EXPLANATION OF PLATE XIV.

FIG. 1. *Phaneropleuron elegans*, natural size, from the Lower Carboniferous Limestone of Burdiehouse.

FIG. 2. Another specimen, natural size, without the head, but showing the extreme tip of the tail. The dorso-caudal fin is injured in front, and the direction of the caudal axis slightly distorted, so as to spoil the beautiful, though gentle, upward curvature which in the other specimens it is seen to have towards its termination.

II.—On a Cirque in the Syenite Hills of Skye.

By T. G. Bonney, M.A., F.G.S.

(Read before the Cambridge Philosophical Society, October 30, 1871.)

IN a communication to the Geological Society,[1] "On the formation of Cirques, and their bearing upon theories attributing the excavation of Alpine valleys mainly to the action of Glaciers," I confined myself to the examination of Cirques in sedimentary strata, and these to a large extent calcareous. I observed this restriction because the most typical examples, so far as I could ascertain, lay in non-crystalline districts, and because my own experience had not presented to me any very striking instances in other districts. The present brief paper is an attempt to show that, under favourable circumstances, the principles there laid down may also be applied to regions wherein crystalline rock exists.

A Cirque may be defined as a variety of what in Scotland is called "a corrie," viz., a more or less semicircular recess in the heart of a mountain region, and at or near the head of a valley, inclosed by a high wall of approximately vertical cliffs.

In the above-named paper I attempted to show that these Cirques could not be explained by: (α) what earlier geologists termed a crater of elevation; (β) or by any kind of marine action, such as has excavated some of the coves which may be seen among coast cliffs; (γ) or by the action of a glacier ploughing up the ground; and that the only explanation, consistent with the phenomena which they presented, was to attribute them to the erosive action of several small streams of water, derived from sources higher up, which, aided by atmospheric denudation,—rain, heat, frost,—cut their way gradually backward into the mountain side.

At that time I put aside the question of how far a favourable configuration of the surface was needed before these agents could act, and by what physical causes it had been produced; all I attempted to establish was, that Cirques in their present condition are the result of the joint action of running water and meteoric agents; and the same limitation must be supposed to hold in the present paper.

[1] Quart. Journ. Geol. Soc., vol. xxvii. p. 312.

Before proceeding to discuss the formation of this Cirque in Skye, a few words about the geology of the island may not be out of place. Five very distinct regions are at once evident, even to the passing traveller. To the south is a long rolling line of uplands—quartzites, gneiss, and schists—resembling in their general contour the great mainland mass of altered Cambrian and Silurian rocks, of which they are only a prolongation. To this succeeds a wide open valley or plain, the Strath, occupied by sedimentary rocks of Mesozoic age, Lias, and Inferior Oolite, which, though occasionally shattered, pierced, and overflowed by igneous rocks, rarely rises to any great height above the sea.

Another mountain district now succeeds, itself comprising two very distinct regions. To the west, rising some 3000 feet, are the Cuchullin hills—wild aiguilles, whose crags of sombre hypersthene rock offer the grandest scenery in Scotland; to the east, and lower by full 1000 feet, is an irregular mass of hills of a peculiar rounded contour, the Syenite region. To the north of this comes the unevenly outlined trap district, forming the larger half of the island, where huge sheets of basalt break through and overlie rocks of Oolitic age, and rise occasionally in great plateaux to a height of full 1500 feet above the sea.

The syenite of which I speak has burst through the Jurassic rocks of the Strath, occasionally greatly displacing and altering them. In colour it is reddish-grey, giving the hills in the distance a tint varying from a rusty hue to one that in some lights is almost white. It appears to consist chiefly of orthoclase-feldspar, and hornblende, but weathers so easily that it is very difficult to obtain a specimen unaffected by decomposition; notwithstanding this, as is the case with other hornblendic rocks, it is very tough and difficult to break.[1]

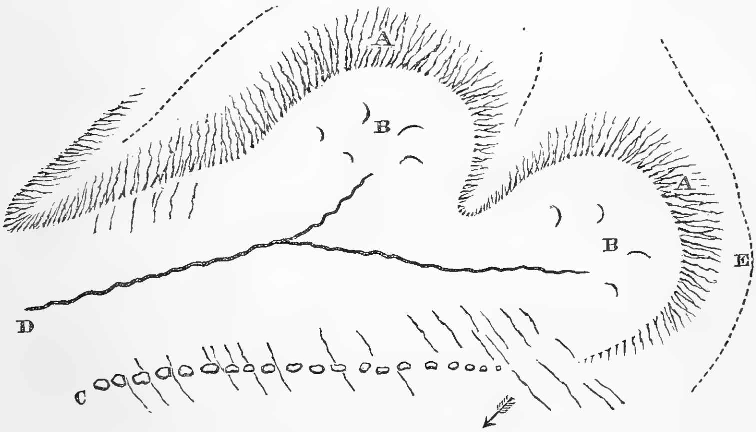
The date of this syenite mass is as yet uncertain. Without doubt it is posterior to all the Jurassic rocks of the island, and Professor Geikie[2] is of opinion that it, like the igneous rocks of the northern plateaux, is of Miocene age. Neither is it easy to say how far its present peculiar outline is the result of denudation. Without doubt its summits have been lowered by the almost incessant showers that have for thousands of years been driven against them by the Atlantic breezes; and the valleys among them have, to a great extent, been excavated by the same agencies, but still their peculiar forms, reminding us of the Puy de Dome, Sarcouï, and other domite hills in Auvergne, suggest that their present may, to a considerable extent, resemble their original configuration, and that these great bosses may have been excreted in a pasty state from numerous subjacent vents.

To proceed, however, with the special subject of this paper. On landing at Broadford, a little village at the north-east angle of the Strath, I was at once struck with two conspicuous corries, one on the side of Ben na Caillich, a fine dome-shaped mass of this syenite;

[1] MacCulloch (Western Isles, vol. i., p. 267) notices this tendency to decompose.
[2] Quart. Journ. Geol. Soc., vol. xxvii., 282.

the other in a mountain slightly behind it, the English name of which would be the Red Hill. Even at that distance I could see that they had once been occupied by glaciers, and I determined on the first opportunity to give them a closer examination. This intention was not exactly carried out, for in the course of a devious walk on Ben na Caillich, instituted with a view of such a visit, I came upon the double cirque which forms the subject of this paper.

Fig. 1.—Rough Sketch Diagram of Cirques.



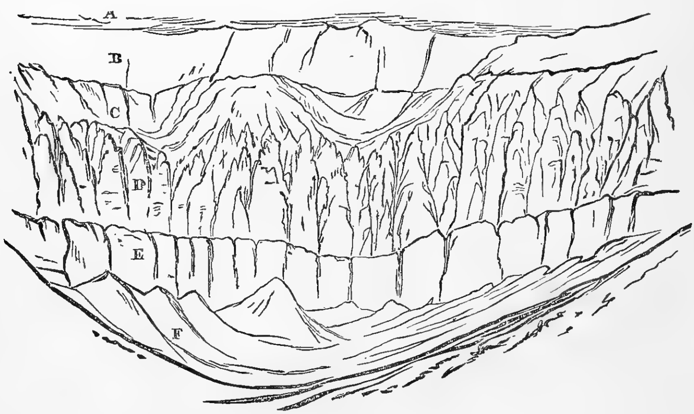
A. Cliffs and very steep screes. B. Ice-worn slopes of rock. C. Moraine. D. Burn. E. Saddle. The arrow indicates the direction of the Summit of Ben-na-Caillich.

It lies close to the head of a glen running behind Ben na Caillich, which thus is only joined on to the general syenite *massif* by a narrow saddle much lower than its summit. Heaps of moraine matter strewn about the lower part of the glen showed that it had once been occupied by a glacier; and presently we came upon a well-marked lateral moraine on the flank of Ben na Caillich, which could be traced to within two or three hundred yards of the head of the glen. Facing Ben na Caillich, and thus on the right bank of the glen, though very close to its head, were two small but very clearly marked Cirques. Each is inclosed by steep cliffs; the floor, as we may call it (though in this case it is on a considerable slope), is ice-worn in several places, and in the middle of each a tiny rill, all but dry, trickles down to form, when united, the little burn which drains the glen. Though on a small scale, they were true Cirques; and in many respects might have been models of those which I described on the Surenen Pass (Fig. 2).

Now here any notion of a crater of upheaval was absurd; one could not in this sequestered nook explain them by any wash of ocean-waves; to suppose that a glacier could have made them was to endue it with a property of vertical excavation, that I think the most ardent glacialist would hardly claim for it, and the comparatively small elevation of the mountain crest behind them showed that they could not be explained by any hypothesis of a long slope of snow pressing downwards upon the ground beneath it. The only lofty slope was that of Ben na Caillich, and that not only showed no corrie, but was in the wrong position.

But on looking closely at the cliffs, it was evident that, dry as they were then, this was not always the case; again and again they are seamed with tiny vertical furrows, streaks, and stains, which show that often—probably after each heavy shower (and Skye is proverbial for its rainy and stormy climate)—they drip with numerous rills. These act both chemically and mechanically: attacking the alkaline and calcareous silicates in the rock, and abrading it by the grit which they sweep along. Heat and frost also act upon the saturated rock; and so the cliff is sapped slowly back by the agency of these almost invisible but resistless forces.

FIG. 2.—Rough Sketch of Cirque in Rothstock, Surenen Pass.



A. Clouds concealing peaks. B. Limestone cliffs.
C. Shaly slope, with small combes and snow-beds.
D. Shaly cliffs furrowed by streamlets.
E. Limestone cliffs, occasionally slightly grooved by streamlets.
F. Floor of Cirque, with talus-heaps at side.

But there is other evidence: the ice-worn slopes below are strewn with débris, and their junction with the cliff is almost everywhere masked by screes. Beneath each one of these furrows which I have mentioned is its own tiny talus of fresh-fallen débris, showing whence it has come and by what path.

If it be urged that what I may call mere rain-drip, not yet collected into anything more than slender rills, which are dry again after an hour or two's sunshine, is inadequate, when aided by other meteoric agencies, to sap and remove solid rock, and hew back the slopes into a cliff, I would call attention to the mountains throughout all this syenite region. For several hundred feet from their bases their flanks are thickly clothed with sallow, heather, and coarse herbage, and even spotted with not a few patches of sodden peat; but the upper half is bare and bald, a stony desert; for the rain brings down fresh streams of screes from above faster than even the mountain grass can grow in a Hebridean summer.

Indeed, so rapid is this destructive agency, that in not a few corries and cirques, here as elsewhere, the transporting power can hardly keep pace with the excavatory. The water-saw and the ice-wedge can quarry the rock faster than the stream can carry away the spoil; and so, to some extent, they are counteracting themselves, and the excavation is being filled up faster than it is being enlarged.

Further, these Cirques, though not made by glaciers, have been occupied by them. The ice-worn slopes at the very foot of the cliffs show that comparatively little change has taken place since the time when the last snow melted away from the head of the glen;

Fig. 3.—Cirque in Process of Formation. Pass near Engelberg.

A. Limestone cliffs. B. Shaly bank, with some trees, etc., out of which the streams break. D. Cirque. The arrows mark Cascades.

they, therefore, were prior to the glacier, and far more the cause of it than it of them. They must have been Cirques when the approach of a polar climate first enabled the winter snow to remain in these sheltered nooks all through the summer. Some modification there would doubtless be then. The cliffs would still be cut back by water in summer, by frost in winter; the talus borne away, or crushed by the glacier; the rocks below somewhat worn and rounded; but still the completeness of the Cirque as a whole forbids us—unless we assign it entirely to glacial action—to suppose that it was more than slightly altered by this. It therefore, like those which I examined in the Alps, shows that in crystalline, as in sedimentary, districts the action of glaciers was little more than superficial. Since these Cirques also assign a far higher antiquity to the principal physical features of a mountain region than the upholders of the Glacier erosion theory appear to admit, and since "rain and rivers" have been restricted to no particular geological epoch, they, working "without haste, but without rest," may well have hewn out in the long lapse of ages the present shapely contours of hill and valley from the blocks left ready to their hands by other natural forces.

III.—On Two Undescribed Coniferous Fruits from the Secondary Rocks of Britain.[1]

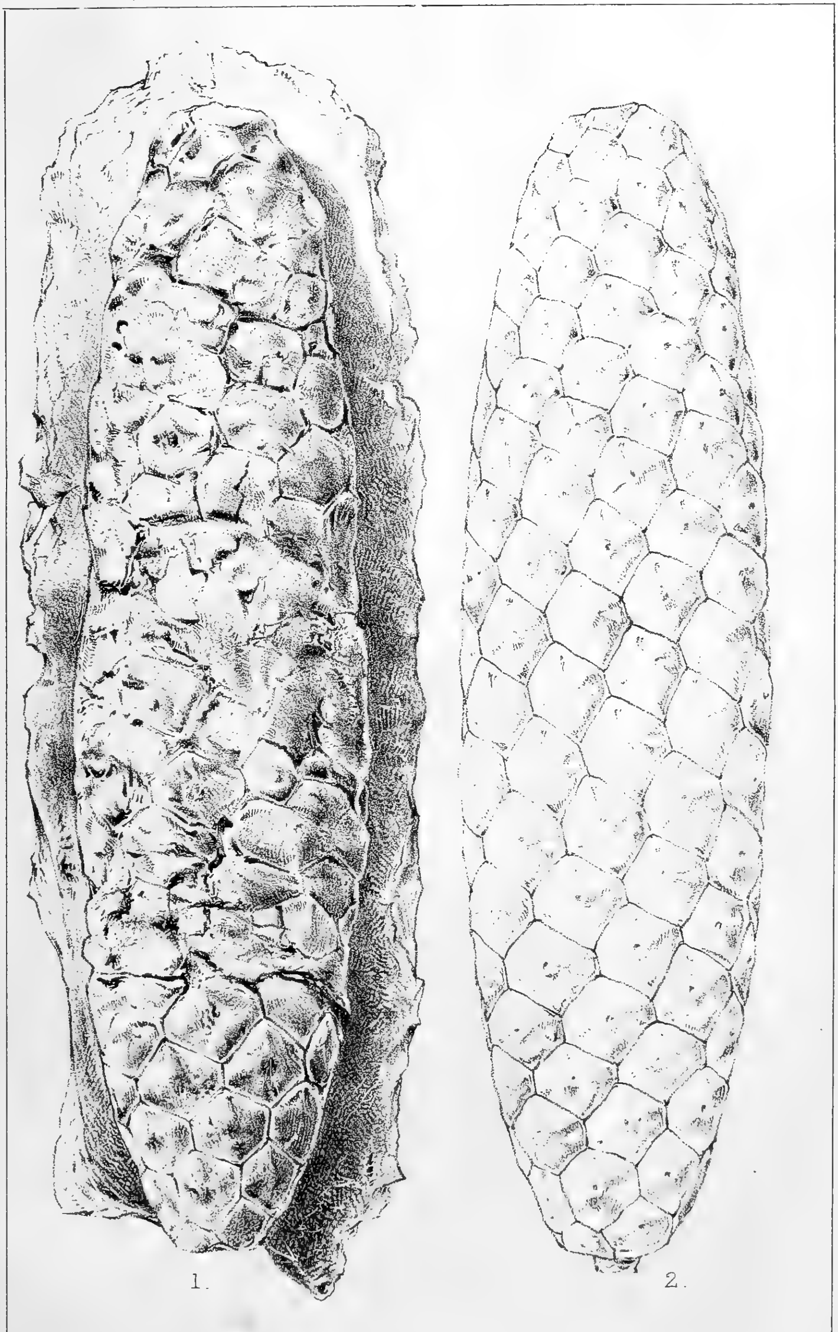
By William Carruthers, F.R.S., F.G.S.

(PLATE XV.)

It is a singular coincidence that in a former communication to this Magazine (Vol. VI., p. 1) I described, among other Coniferous fruits, two from the Gault at Folkestone, the one the cone of a pine, and the other of a Wellingtonia, and that in this communication I propose to describe two hitherto unknown fruits from the same deposit and found at the same locality, belonging also the one to a Wellingtonia and the other to a pine. Although the small pine-cone already described (*Pinites gracilis*) differs in form and in the arrangement of the scales from any known cone, recent or fossil, it is more nearly related to that group of the section *Pinea*, the members of which are now associated with the Wellingtonias in the west of North America, than with any other member of the great genus *Pinus*. I, however, hesitated to refer to this interesting fact, because the occurrence of the two cones in the Gault might have been due to their being accidentally brought into the same silt by rivers having widely separated drainage areas. And it is easier to keep back generalizations based on imperfect data, than to suppress them after publication, when in the progress of investigation they are shown to be false. But I have now to describe a second pine-cone more closely related to the Californian species of *Pinea*, and with it a new species of Wellingtonia. These surely point with tolerable certainty to the existence of a Coniferous vegetation on the high lands of the Upper Cretaceous period having a *facies* similar to that now existing in the mountains on the west of North America, between the thirtieth and fortieth parallels of latitude. No fossil referable to *Sequoia* has hitherto been found in strata older than the Gault, and here on the first appearance of the genus we find it associated with pines of the same group that now flourish by its side in the New World.

Pinites hexagonus, sp. nov. (Plate XV.) Cone elongate-oblong, decreasing equally from the middle towards the similarly-formed and truncate base and apex. Apophyses of the scales hexagonal throughout, thickened, scarcely elevated towards the central umbo,

[1] This paper is supplementary to one published in Vol. VI. of the Geological Magazine, at page 1.



W.G. Smith F.L.S. fec. W.West & C° imp.

Pine Cone from the Gault.

carina transverse obtuse. Cone 6 inches long, by an inch and a half broad at the middle. Apophyses of the scales in the middle of the cone, $\frac{5}{12}$ inch broad and $\frac{7}{12}$ inch deep.

Locality.—From the Gault of Eastware Bay, Folkestone. I am indebted to J. S. Gardner, Esq., F.G.S., for my knowledge of this species.

The genus *Pinus* is, with a single exception, confined to the northern hemisphere, extending from the Arctic regions, where it grows on the plains, to the flanks of high mountains within the tropics. It is remarkable that in the American continent the Isthmus of Panama suddenly stops their distribution southwards. The groves which occur on the mountains of Mexico and Guatemala are not continued on the similar mountains in the neighbouring regions of South America. The pines are a gregarious group of plants, vast tracts of country being frequently covered with trees of the same species.

Cones which may be referred with certainty to pines have not been hitherto found in strata older than the Upper Oolites. I exclude the fossil to which Lindley and Hutton gave the name of *Pinites anthracinus* (Foss. Fl., pl. 164), which is most probably the fragment of a Lepidodendroid branch.

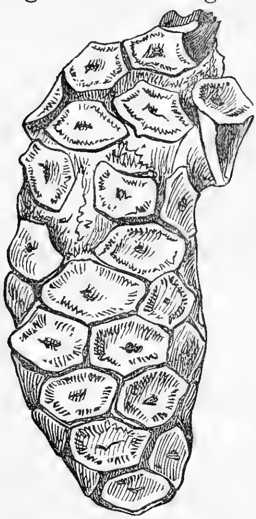
The earliest certain indication of a pine-cone is in the Kimmeridge Clay, from which I have described a small and imperfect specimen, with scales which are attenuate towards the margins, and which consequently belongs to the section *Sapinus* of the larger genus. I described this cone under the name *Pinites depressus* (Geol. Mag., VI. p. 2), overlooking the previous establishment of a species with the same specific name by my lamented friend, M. Coemans. I take this opportunity to substitute the name *P. dejectus* for this, which must be set aside. In the Cretaceous beds the pines become more numerous. They belong chiefly to the thin-scaled section *Sapinus*. The only exceptions with which I am acquainted, besides the two from the Gault to which I have already referred, are *P. Fittoni*, Carr., Geol. Mag., VI., p. 543, from the Purbeck; *P. Andræi*, Coem., Mem. Acad. Belg., xxxvi., p. 12; *P. aquensis*, Sap., in Schimper Tr. Pal., ii., p.27; *P. Coquandi*, Sap., l.c.; *P. humilis*, Sap., l.c., p. 28; and *P. Quenstedi*, Heer, Flor. Moletein, p. 13, all from Cretaceous rocks. In the Tertiary strata the species of the section *Pinea*, to which these belong, that is to say, cones with thickened apophyses or apices to the scales, greatly increase.

Sequoiites ovalis, sp. nov. Cone oval, composed of many scales, arranged spirally on the axis. Scales cuneate from the base, with a transversely-oblong hexagonal apex, which is rugose and depressed in the middle. Cone $2\frac{1}{4}$ inches long, and a little over one inch in width. Apex of the scales in the middle of the cone, $\frac{7}{12}$ of an inch broad and $\frac{4}{12}$ of an inch deep.

Locality.—From the Gault near Folkestone.

This is the largest fossil cone which has been referred to the genus *Sequoia*, being nearly as large as the largest cones of *Sequoia gigantea*.

The genus *Sequoia* is represented by two species in the existing vegetation of the globe. The one is the famous Wellingtonia or Mammoth Tree, supposed to be confined to a very limited region, but now known to occur in large groves through an extent of at least 120 miles along the western flank of the Sierra Nevada, North America, at a height of about 5000 feet above the level of the sea. The other is *S. sempervirens*, the red-wood of the timber trade, and has a much greater range, extending further to the north. The *Sequoia* groves contain immense numbers of trees of all ages, from the seedling to the king of the forest, so that there is no reason to fear their extirpation.



Cone of *Sequoiites ovalis*, sp. nov.

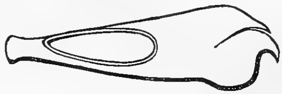
The Cretaceous rocks contain the earliest known representatives of the genus. If we refer, in accordance with the opinions of Heer and Schimper, the fossils known as *Geinitzia cretacea*, Endl., and *Widdringtonites fastigiatus*, Endl., to *Sequoiites*, we have six Mesozoic species of the genus, of which three are from the Gault, and three from the Upper Greensand or Chalk.[1]

Araucarites sphærocarpus, Carr., Geol. Mag., III., p. 349. I take this opportunity of recording a point in the structure of this cone which is additional to my description. In mounting the specimen on a tablet for exhibition, some of the scales freely separated from the others, and disclosed a structure and arrangement of parts which agrees with that in *Araucaria Bidwillii*, Hooker. The single

[1] Trautschold, in a recent memoir (Nouv. Mem. Soc. Nat. de Moscow, vol. xiii., 1871, p. 225), has separated, but without sufficient reason, the fossil from Kline, near Moscow, which Eichwald described as *Geinitzia cretacea*, Endl. (Lethæa Rossica, vol. ii., p. 48), and has placed it in the genus *Araucarites*, under the name *A. hamatus*, His uniting *Araucarites crassifolius*, Corda, in Eichwald, l.c. p. 50, pl. iv., fig. 10, is, as far as Eichwald's figure and description are concerned, obviously an error. Trautschold's figure (pl. xxi., fig. 3) shows in one of the branches a cone, which belongs to *Sequoia*, judging from the form and direction of the scales; a similar fruit is represented in pl. xxi., fig. 7. This is described as a new species under the name *Pinus elliptica* (p. 227), with the following diagnostic characters: "Strobilis ellipticis, squamis apice valde incrassatis, dorso rhomboidali carina transversali dimidiato, in medio carinæ tuberculo prominente." The size of the cone, the form of the scales, and the absence of imbrication in the scales, are characters which would place the cone in *Sequoia*, while the transverse carina and the prominent tubercle fall in with this interpretation of its position. A similar cone is given in the upper part of fig. 6, pl. xxi. If the restoration of the scale as given by Eichwald (l.c. pl. v., fig. 8, *f*, *g*, *h*) is accurate, it would throw doubt as to whether this fossil can be placed in the recent genus *Sequoia*, but it would certainly be nearly related to it, and far removed from *Pinus*, or *Araucaria*, with which Trautschold has associated it. In his text Trautschold considers this cone as nearly allied to *Pinus primæva*, Lindl. and Hutt.: but I have shown that this is a true Cycadean fruit (Geol. Mag., 1867, Vol. IV., p. 105). The facies of the flora from Kline suggest to me that they are of Cretaceous age.

seed is small and occupies the centre of the scale, near its base, leaving a large portion of the scale free beyond it. The accompanying outline drawing exhibits the position of the seed, and its proportion to the other parts.

Notwithstanding the criticism of the learned Professor Heer and the practice of some writers on fossil Botany, I still think it desirable to employ the termination *-ites* for the generic name of fossil forms which are on reasonable grounds referred to living generic types.



Detached Scale of *Araucarites sphærocarpus*, Carr.

Not only does this enable the student at once to distinguish the recent from the fossil forms, but it also gives an indication of the caution which should be exercised in dealing with the objects named when correlating them with species which are well known and fully diagnosed as living plants are. From the necessities of the case, the materials at the command of the botanist in dealing with extinct plants are not only scanty, but often of little value for systematic purposes. In the vast majority of cases only the vegetative organs are known, and the systematic value of these is comparatively small. The great variation in stems and leaves of different species of the same natural genus, and indeed of the individuals of many well-defined species, as well as the recurrence of identical leaf- and stem-forms in widely-separated members of the vegetable kingdom, make the botanist dealing with recent plants hesitate to establish species on foliage only. But inasmuch as many important deposits contain nothing but leaves, and as large and important families of plants are known, in a fossil condition, only by their foliage, it is necessary that these vegetative structures should give all the information that can be obtained from them. In working with recent plants the burden is not laid on the student to search out characters that may exist in foliage, as the worker hopes that ere long the flower or the fruit may be obtained, and with it the means of determining with certainty and facility the position of the plant. It is very different with geological investigations. The laying open the organic contents of a particular group of beds is a herculean labour, before which the exploration of the most dangerous and inaccessible region on the surface of the globe is but child's play, and the materials which generally some happy accident brings to light are but the fragments which originally escaped the natural decay. The remarkable labours of Prof. Heer, with the most unpromising materials, establish that even these may to the intelligent and educated investigator supply in part information as to the systematic position of the plants to which they belong. His determinations of even fragments of leaves have not unfrequently been confirmed by the subsequent discovery of flowers or fruit associated with them, as in the case of the arctic *Magnolia Inglefieldii*. Yet the materials are so imperfect that a large proportion of fossil species must remain doubtful. Obviously the value of these must be estimated by a different standard from that which we apply to a species founded on a recent plant, and it is, as it seems to me, a real gain to employ a terminology which will exhibit at once whether the species is existing or extinct, and so, to some extent, the nature of the evidence upon which it has been established.

Thus, in the section *Pinea* of the genus *Pinus*, to which the species described in this paper belongs, Parlatore enumerates fifty-four species, seventeen of which are natives of the old world and thirty-four of the new world, the larger number being found in the mountain ranges which run between the Rocky Mountains and the western shore of North America, and all are confined to the Northern Hemisphere. Schimper describes sixty-nine fossil species belonging to the same section of the genus, and these he allocates between the subsections of *Pinea*, viz., *Pinaster* and *Tæda*. The thickened apophyses of the scale of the cone with its central umbo is sufficient to distinguish this section from the *Cembra* group, which has a terminal umbo to the cone-scale, or the *Sapinus* group, which has the apex of the scale not thickened. But the cones supply no character in dividing the section *Pinea*. The subsections are based upon the number of leaves included within the sheath. As these are variable in the same plant, I doubt whether the distinction is of much value among recent plants. But how can the subsectional characters be detected in the sixty-nine fossils, fourteen only of which have the foliage associated with the cones? It is certain that the cones do not supply any appreciable distinction, so that one cannot allocate a series of cones without foliage. To be more exact than the specimen permits is a real error, and is likely to introduce more serious injury into geological reasoning than the more vague, though more truthful, estimate of the affinities of the plant.

The disposal by Schimper of the British pines justifies these observations. The only cone which he has placed in the *Pinea* section is *Pinites Plutonis*, Baily; but an examination of Baily's drawing will show that his imperfect cone belongs—as far as the characters are exhibited—to the section *Cembra*; for the scales want the central umbo, and have a "semi-circular ridge" (Baily), almost terminating the apophyses. The separate scale figured by Baily, and which he thinks most probably belongs to this species, is of course excluded in my estimate of the position of the cone, as the characters given in the drawing are at variance with those shown in the scales of the cone itself. The remaining cones supposed to have thickened apophyses found in the United Kingdom are placed together as "Species incertæ sedis." But the figures and descriptions I have given of them show that *P. macrocephalus*, Carr., *P. ovatus*, Carr., *P. Fittoni*, Carr., and *P. gracilis*, Carr., belong to the *Pinea* section; while *P. dejectus* (*depressus*), Carr., is as truly a member of the *Sapinus* section as *P. Mantellii*, Carr., which is placed there; and *P. Sussexiensis*, Carr., should probably be referred to the section *Cembra*. Without foliage, however, and even, in many cases, without perfect cones, it is not, as it seems to me, desirable to refer unhesitatingly these cones to the sections into which the species of the genus now living on the globe have been grouped.

EXPLANATION OF PLATE XV.

Pinites hexagonus, sp. nov., natural size, and outline restoration from the specimen in the cabinet of J. S. Gardner, Esq., F.G.S.; Gault, Folkestone.

IV.—On Changes of Climate during the Glacial Epoch.

By James Geikie, F.R.S.E.,
District Surveyor of the Geological Survey of Scotland.

First Paper.

If one were asked to put into a few words the general results which have been arrived at from a study of the Glacial deposits, he would probably say that these deposits gave evidence of a severe Arctic condition of things having obtained in this country,—that the gradual approach of this Arctic climate caused the disappearance from our area of the fauna and flora which had previously characterized it,—that during the continuance of the cold in Britain several species of mammalia appear to have died out in the more southern regions of Europe, whither they had migrated,—and that it was not until after our climate had become greatly ameliorated that these islands were visited by what are termed the "Post-glacial mammalia," several species of which, however, had been denizens of Britain and northern Europe in Pre-glacial times. In short, our island, throughout the Glacial period proper, is commonly supposed to have remained a barren waste of snow and ice. But the evidence which has been accumulating during recent years will compel us, I believe, to modify materially these general inferences. So far from the Glacial epoch having been one long continuous age of ice, it would appear to have been broken up by many intervening periods of less Arctic, and even temperate conditions, during which the snow and ice disappeared from our low grounds, and the glaciers shrunk back into our mountain valleys. I speak, of course, of that portion of the Glacial epoch which was antecedent to the general submergence, and is represented by the Till or Boulder-clay of Scotland. In this short paper I propose to give an outline of the facts upon which these conclusions are based. But before doing so it may be well to point out the order of succession of the Scottish drift deposits, which is now no longer a matter of dispute. Beginning with the lower beds, we have the following sequence;—

1. Boulder-clay or Till,[1] with subjacent and intercalated beds of

[1] Under this head I include those unstratified, more or less tenacious deposits of clay, which are so abundantly charged with well-polished and striated stones. They are all clearly of older date than the Kame and brick-clay series. I thought at one time that the less tenacious Till-beds might possibly be of later date than the tougher and harder stony clays: but subsequent investigation has shown that such is not the case. The character of the Till depends in large measure upon the nature of the rocks to the demolition of which it owes its origin; and also in some degree to the pressure of the ice under which it was formed. There is a coarse moraine-like accumulation of earthy clay full of rough unpolished angular blocks and debris, but with only a few scratched stones, which has sometimes been called Boulder-clay. But this deposit is clearly posterior in date to the true Till, and belongs to the upper drift series. Again, some of our later glacial brick-clays contain scattered stones, many of which are striated. These clays, if met with in the more southerly districts of England, would probably be called Boulder-clays: in Scotland they are all of marine origin.

gravel, sand, clay, silt, and mud; containing in places Arctic shells, and sometimes mammalian remains.

2. Beds of gravel, sand, brick-clay, silt, and mud, with Arctic and Boreal shells abundant in maritime districts. Heaps of unstratified or crudely stratified earth and clay, with abundant angular unpolished blocks and débris. The sand and gravel-beds frequently assume the form of Kames or Eskers. Erratic blocks.

3. Moraines, and raised beaches.

So much has already been written about the origin of the Scottish Till or Boulder-clay, that it is perhaps almost superfluous to return to this subject. There are still some geologists, however, who hesitate to accept what appears to be the more generally received opinion, namely, that the Till has been formed and accumulated below a *mer de glace*. Quite recently Mr. Milne Home has sought to resuscitate the iceberg hypothesis, and has collected a large amount of evidence in support of this once favourite theory. He seems to me, however, not to have sufficiently distinguished between the various kinds of drift. It is admitted that during the deposition of the second group, mentioned above, icebergs played a prominent part, but the large erratic blocks, which are scattered up and down the country, together with the whole of the Kame series, belong to a later date than the accumulation of the Boulder-clay or Till. There is no fact about which one can be more positive than this. But some of my geological friends who reject the iceberg theory yet find much difficulty in admitting the feasibility of the views held by Professor Agassiz and others. They cannot conceive how any accumulation of clay and stones could take place underneath a mass of moving ice. The ice-sheet, according to their notion, must always have scraped along the surface of the bare rock, and the débris derived from this scraping-process would, they think, be dragged along and pushed out from below the ice-sheet upon the bottom of the sea. So that if at any time during the period of greatest glaciation the ice could suddenly have been peeled off the surface of the land, nothing but bare rock would have been visible, from the highest points rubbed by the ice down to the margin of the sea. According to this theory, the Till could only have been deposited during a period of subsidence —the Boulder-clay at the higher levels of the country having been the last to be laid down. It cannot be denied that this hypothesis has a plausible appearance, and that it does away with many difficulties which the iceberg theory fails to remove. But it still leaves much unexplained, and is moreover opposed to so many well-known facts, that it cannot, I think, be maintained.

It would lead me too far away from the matter more immediately in hand were I to attempt to show in detail how this hypothesis comes short of what is wanted. One or two points, however, may be mentioned, which appear quite enough for this purpose. And, first, it may be remarked that if the Scottish Boulder-clay be neither iceberg droppings nor terminal moraine matter (at least in the same sense as the débris at the foot of an Alpine glacier is), but has actually been derived from the wear and tear of the rockhead underneath the ice, then it is hard to see what difficulty lies in the way of accepting Agassiz's theory. For since Boulder-clay was formed below the *mer de glace*, there must always have been a certain amount of it underlying the ice, which, upon the melting of that ice, would be exposed, the presence of the sea not being at all necessary to its accumulation. As a matter of fact, Boulder-clay occurs on the tops of hills which are quite isolated and separated by broad deep valleys from other high grounds. Thus, on the tops of the Ochils, which it will be remembered divide the broad basin of the Forth from that of the Tay, I have met with Boulder-clay at a height of 1500 feet above the sea. Upon the watershed of the Renfrewshire uplands, also, I have seen very respectable accumulations of typical Till, filling up the hollows of the hills, and even capping some of the broader-topped eminences themselves. The same deposit was observed by my colleague, Mr. Croll, on the very crest of the Pentland Hills at a height of 1617 feet.[1] My brother also mentions the occurrence of numerous striated stones—the wreck of the Boulder-clay—near the top of Tinto Hill, in Lanarkshire. Now all the hills referred to (and many other localities might be enumerated) are more or less isolated heights rising up from that broad tract of low ground which separates the Highlands of the north from the pastoral uplands of the south of Scotland.

According to the hypothesis I at present refer to, Boulder-clay, although produced upon the land, could only have been deposited in the sea. Consequently, wherever Boulder-clay is found, there we must infer the seaward margin of the ice-sheet to have been. But if we in imagination depress below the sea the isolated heights just mentioned, we may well ask whence the glaciers could have come which are supposed to have pushed the Till forwards and upwards upon those hills. A submergence sufficient to have carried down below the waves the Ochil Hills, the Pentland Hills, Tinto Hill, and the Renfrewshire uplands, must have drowned all Scotland between the northern Highlands and the southern uplands. It is, therefore, physically impossible that the Boulder-clay lying on the crests of the hilly districts of central Scotland could have been deposited there from the snouts of glaciers entering the sea. A glance at the map of Scotland will satisfy any one of this. Take, for example, that section of the Ochils which overlooks the valley of the Earn. These hills, as already remarked, separate the basin of the Tay from that of the Forth, nevertheless the Till on their crests and slopes reaches in places a considerable thickness, and contains many boulders of mica-schist and other Highland rocks, intermingled with numerous fragments of Old Red Sandstone, and the various igneous rocks of which the hills themselves are composed. There can be no manner of doubt, therefore, that the ice which deposited this stony clay came from the north—that it crossed the basin of the Tay, and thereafter surmounted the Ochils, and made its way into the valley of the Leven. If the Ochil Hills were depressed to the highest level attained by

[1] This was on the top of Allermuir Hill. The clay contained fragments of mica-schist and several other rocks, none of which belonged to the hill itself.

the Till, a broad sea would separate the few tops remaining above water from the Grampian mountains, whence no small proportion of the stones in the Till referred to have been derived. How, then, could this Boulder-clay be deposited from the seaward margin of the ice-sheet? In this instance the exploded iceberg theory has more to commend it as an explanation of the facts than the hypothesis under review. This latter hypothesis is no less irreconcilable with the appearances presented by the Boulder-clay of the southern uplands. Let those regions be submerged so as to bring all the Till-covered portions below the level of the sea, and we shall find only a few scattered hill-tops left as islets, not one of them large enough to nourish a glacier of sufficient extent to accumulate and deposit Boulder-clay at the high levels which it now occupies.

During a period of subsidence, as the area of the land became more and more contracted, both snow-fields and glaciers would likewise diminish in extent; glaciers would cease to ride over the minor elevations, and would be restricted to narrower valleys; some of the steeper hill-sides would be uncovered, and, breaking up under the influence of the frost, would shower down upon the surface of the glaciers heaps of broken rocks and débris. This rubbish, eventually reaching the ends of the glaciers, would be shot forward into the sea. Supposing, therefore, that the Till had been deposited on the sea-bottom during a period of subsidence, we ought to find this deposit, as we approach its upper limits, becoming coarser and earthier, and more and more charged with rough angular blocks and débris, scratched stones being in the minority. But nothing of the kind takes place. The Till at the very highest levels is identical in structure and composition with the same deposit in the bottoms of the valleys in central Scotland—the stones it contains are not less well polished and striated, and rough unsmoothed angular blocks and débris occur just as seldom.

The only theory which seems to satisfy all the requirements of our present knowledge is that so long ago advanced by Agassiz. Every part of Scotland, with the possible exception of a few peaks or tips of some of the loftier mountains, has certainly been buried underneath snow and ice. This *mer de glace* must have levelled up the valleys and occupied all the fiords, sounds, and shallow seas around our island. Below this deep sea of ice hill-slopes were ground and polished, valleys were deepened and smoothed, and the wreck and rubbish resulting from all this work gathered unequally below the ice, according as the direction and pressure of the superincumbent mass determined. On steep slopes, where the motion of the ice would be more rapid, the clay and stones would not readily collect, but as the ice crept across the low ground deep accumulations of such waste materials would begin to thicken below it. It is not, of course, supposed that Boulder-clay continued to increase to an indefinite thickness, nor that, having been once formed, it remained at rest below the ice. If such had been the case, it would be difficult to see how the ice could have had much denuding effect upon the subjacent rocks; for the moment that a layer of Till had been formed between the ice and the rock, the tear and wear of the latter would cease. But when we bear in mind the vast weight of the moving mass of ice, we need surely have no difficulty in conceiving how this ice-sheet must have acted upon the Boulder-clay much in the same way as a river acts upon the detritus in its bed. For just as a stream will sometimes pile up long banks of mud, sand, and gravel, and after a time sweep these away again, so the old ice-sheet must frequently have ploughed out the materials which gathered below it, and squeezed and pushed them from one position to another. There is plenty of evidence to show that the ice which moved over the central districts of Scotland was ever and anon deflected—now towards the south by the powerful current of ice that set in from the Highlands, now to the north by the strong current that swept outwards from the southern uplands. During such changes in the course of the ice-flow, the underlying Boulder-clay would come to be shifted about by the varying direction and pressure of the ice. Again, there are wide districts in the Lowlands where Boulder-clay either does not occur at all, or is represented by only a few little patches; nor is this always, or even often the result of subsequent aqueous denudation. The deposition of the Till has been much less continuous and wide-spread than is generally believed; but the evidence on this head can hardly be given here.

But even if it be admitted that Till not only was formed, but also accumulated underneath the ice, being dragged and squeezed forward from one part of the bed of the *mer de glace* to another, how, it may be asked, can we account for the presence below and in the Boulder-clay itself of gravel, sand, and clay? How have the beds below the Till escaped destruction, and in what manner did that Till come to contain accumulations of water-assorted materials? The beds to which I allude have long been known to geologists, but their occurrence has generally been looked upon as quite exceptional, and the deposits themselves of too trifling an extent to merit much attention. But a wider acquaintance with the superficial deposits has taught us that the stratified beds of the Boulder-clay are neither so exceptional nor so insignificant. They occur not only very frequently, but often attain a thickness of many feet, or even fathoms. Mere lines of sand and gravel might perhaps be ignored or explained away; but when we come to deal with deposits upwards of thirty or seventy feet and more in thickness, it is evident we can no longer consider them in the light of accidental accompaniments of the Boulder-clay in which they occur. Yet it needs only a very superficial examination to assure one that the intercalated beds are merely the wrecks of what they must at one time have been. Over and over again we find them twisted, bent, crumpled, and confused, often in the wildest manner. Layers of clay, sand, and gravel, which must have been deposited in a nearly horizontal plane, are puckered into folds, and sharply curved into vertical positions. I have seen whole beds of sand and clay which had all the appearance of having been pushed forward bodily for some distance, the bedding assuming the most fantastic appearance. But the intercalated beds have not been crumpled only; they are everywhere cut through by the overlying Boulder-clay, and large portions have been carried away. Indeed, when we compare the bulk of these beds with that of the Till, we must at once allow that they form but a small fraction of the glacial deposits. But the geological importance of a deposit is not usually measured by its bulk. In exposed positions, such as hill-tops and hill-slopes, the Boulder-clay never contains intercalated beds, nor do these often occur save as interrupted and fragmentary patches in places which appear to have been open to the full sweep of the ice-currents.

It is in the numerous small tributary valleys, whose trend is often at right angles to the path, followed by the ice, that the intercalated beds of the Boulder-clay attain their best development. Nor is it difficult to see why this should be so. The ice-sheet which, as we know, flowed along the principal valleys, must frequently have crossed the lateral and subsidiary valleys at an angle. In the main valleys the glacier mass would exert its full influence, but it would not be able to do so in the narrow lateral valleys and ravines. The ice and Boulder-clay would merely topple into the glens referred to, and gradually choke them up, and the main mass of the glacier would then pass on over the whole. There could be little or no glacial erosion in the beds of these valleys, consequently any superficial deposits they might contain would be preserved. And such in point of fact is the case. Many of the lateral streams which feed the principal rivers are found to flow in deep rocky channels, which have either been partially or entirely eroded since the close of the Glacial epoch. And, curiously enough, these newer river-cuts frequently intersect the pre-Glacial and inter-Glacial ravines which are seen to be entirely filled up with successions of Boulder-clay and sand, silt, and gravel. In the mining operations of our coal-fields, not a few obliterated water-courses have been traced out, often for long distances, in the underground workings, the coal-seams being mined up to the edge of the buried ravines. There is often nothing at the surface of the ground to indicate that a buried valley lies underneath. A wide pall of Boulder-clay usually stretches across the whole district, and were it not for stream cuttings and mining operations, we should certainly never have guessed the existence below of old deserted water-courses, over the sites of which whole hills of Boulder-clay are sometimes piled up.

It can easily be seen that these ravines have not been filled up all at once. The beds of sand and silt which they contain are frequently finely stratified, and layers of gravel and coarse shingle often alternate with the finer materials. Interstratified with these deposits come masses of Boulder-clay, the stones in which are well polished and scratched. By successive accumulations of all these beds, the old ravines and valleys were slowly and gradually levelled up and obliterated. There were thus distinct pauses in the formation and deposition of the Till.

The intercalated beds consist, as I have just said, of silt, clay, sand, and gravel—sometimes the coarser, and at other times the finer grained ingredients predominating. In certain localities they have yielded Arctic shells of species identical with those which occur so abundantly in the later Glacial deposits of our maritime regions. It is quite certain, therefore, that some inter-Glacial beds are of marine origin. Examples of such marine shell-bearing beds occur at Airdrie overlain by Boulder-clay; more recently similar deposits have been met with in the Till near Greenock; and other localities might be named. But some inter-Glacial beds are no less certainly of freshwater origin. A few years ago I described in this MAGAZINE[1] a very interesting section at Crofthead, which showed most clearly a set of lacustrine beds resting upon and covered by the Till. From these beds the skull of *Bos primigenius* and other mammalian remains were obtained. Thin layers of peat occurred here and there in the sandy silt. I need only remind the geologist that other mammalian remains, such as the Mammoth and the Reindeer, have been met with, either below or in the Till of other districts in Scotland.

It may be as well to remark, in passing, that we can seldom be certain that beds of sand and gravel underlying the Till are necessarily of pre-Glacial age. We can only say that they are older than the mass of Till by which they are covered. Pre-existing masses of Boulder-clay may have been removed before the beds referred to were laid down. Unless they occur in those deep buried ravines which have intersected the path of the ice-sheet, I should be very doubtful of their pre-Glacial age; and even in such sheltered nooks we cannot be at all sure that their deposition preceded that of the true Glacial beds. For in the intervals between the accumulation of successive masses of Till, the erosion in ravines and valleys by water action must have been excessive. Thus, bearing in mind the many successive descents of the glaciers from the high grounds to the sea, and the intervening periods of aqueous erosion, it is exceedingly unlikely that any pre-Glacial accumulations whatever have been preserved in Scotland. I would therefore include all the deposits that underlie or are intercalated with the Boulder-clay under the same head. But, as will be seen in the sequel, it is of no consequence, so far as the views which I support are concerned, whether the underlying deposits be considered of pre-Glacial or of inter-Glacial age.

The freshwater origin of many of the intercalated beds can be made out even in the absence of fossils. The materials of which these beds consist are arranged precisely as we should expect them to have been by streams and rivers—the "lie" of the gravel-stones, and the dip of the bedding, showing that the water which pushed the detritus along must have flowed in a direction down the valleys in which these deposits occur. Besides such distinctly fluviatile accumulations, we also find in the upper reaches of our valleys laminated brick-clays resting in little basin-shaped hollows of the Till, and clearly covered over by the same deposit, In these may sometimes be detected thin lines of peat, like those of the Crofthead section, and the general appearance of the deposits themselves betokens a lacustrine origin. In the lower reaches of our broad open

[1] Vol. V. p. 393.

valleys, the intercalated beds of the Till, although exceedingly fragmentary, yet appear frequently (not always) to have, if I may so express it, a marine aspect. I may just add, that intercalated beds occur at all levels in our valleys, up to the highest limits reached by the Till.

From the facts thus briefly indicated, we are entitled to conclude that that section of the Glacial epoch which is represented by the Scottish Boulder-clay was not one long unbroken age of ice. It was certainly interrupted by several intervening periods of less Arctic conditions, during the prevalence of which the ice-sheet must gradually have melted away from the low grounds, and given place to streams and lakes and rivers. At such periods a vegetation like that of cold temperate regions clothed the valleys with grasses and heaths, and the hill-sides with pine and birch. Reindeer wandered across the country, while herds of the great ox and the mammoth frequented the grassy vales. If one might draw conclusions from the aspect of the few fossil remains which have been disinterred from the Boulder-clay deposits, he might compare Scotland during the inter-Glacial periods to that tract of country which extends along the extreme southern limits of the "barren grounds" of North America—a region where a few firs and other hardy trees cover the drier slopes, and where carices and grasses grow luxuriantly enough in the sheltered valleys—those favourite breeding-places of the reindeer which roam over the dreary deserts to the north. Whether during any of our inter-Glacial periods the climate was ever mild enough to melt away all the ice and snow from our Highland valleys, the record does not say. What evidence we have points to the existence of local glaciers in our higher valleys—to moderate summers and severe winters—during such inter-Glacial periods as we have any certain records of. Nor must we forget the evidence supplied by the mollusca of some inter-Glacial beds. At the time these shells frequented our coasts, Scotland could hardly have had other than an Arctic climate.

And yet we might be committing a grave error were we to assume that Scotland, during inter-Glacial times, never enjoyed milder conditions than now obtain in the forest regions and barrens of North America. We must ever bear in mind that the inter-Glacial deposits are the veriest fragments. They have been preserved only in sheltered hollows from the ravages of the great ice-plough, and the interrupted and patchy portions that remain are mere wrecks of what must once have been, in the broader valleys, widespread and continuous deposits. Every renewed descent of the glaciers upon the low ground would tend to effect the removal of these accumulations, and it may well be that of many inter-Glacial periods not a single representative deposit now remains. Even during the inter-Glacial periods themselves, the streams and rivers would help to clear away and redistribute those beds of sand, gravel and silt which the glaciers had spared; just as in our own day the streams are gradually excavating and washing away the materials which fill up old pre-Glacial and inter-Glacial ravines and water-courses. Moreover, we must not forget that if really warm climates ever did supervene during inter-Glacial times, every such warm period must have been followed by temperate, cold-temperate, and Arctic conditions. And these last would consequently be the most fully represented of the series.

So far, then, as the Scottish Glacial drifts are concerned, there is no evidence whatever to show that the inter-Glacial periods may not have been warm enough at times to cause all the snow and ice to disappear from the country. Whether we shall ever obtain any decisive evidence on this head will probably depend upon the assiduity with which the inter-Glacial deposits are examined. The Till was for many years looked upon as an Azoic deposit, and only a very few hammerers continued, Micawber-like, to hope for "something turning up." I believe that mammalian remains have been oftener obtained from the beds in the Boulder-clay during shaft-sinking and other mining operations than geologists are aware of. While carrying on the Geological Survey of the Scottish Coal-fields, I have frequently heard of "bones" and "horns" having been met with by the workmen in sinking through the deep drifts. These relics, unfortunately, have almost invariably been lost or mislaid; but there can be little doubt, from the descriptions that were given to me by intelligent overseers, that the relics were true fossils, and still less doubt that these fossils were obtained, not in recent alluvial, but in Glacial deposits.[1]

V.—Notes on the Geology of Part of Co. Donegal, Ireland.

By A. H. Green, M.A., F.G.S.

In the early part of this year I paid a visit to the north-western part of Donegal. My stay was short and my time too much taken up with other matters to allow of detailed geological work; but there were two things that at once attracted the attention of the most casual observer, the bedded character of the granite, and the traces of former wide-spread glaciation. To these I gave such time as I could, and on my return threw my notes into a paper which was read before the Geological Society of London. On seeing my paper, Mr. R. H. Scott had the kindness to send me copies of two papers of his own and of a report by himself, Sir R. Griffith, and Professor Haughton, on the Donegal Granites, in which, among other matters, the bedded character of these rocks was pointed out.[2]

[1] Descriptions of inter-Glacial deposits will be found in "Glacial Drift of Scotland," by A. Geikie, Glasgow Geol. Soc., vol. i., part ii.; "On the Surface Geology of the District round Glasgow," by James Bennie, Glasgow Geol. Soc., vol. iii., part i.; "On Two River Channels buried under Drift," etc., by James Croll, Edinburgh Geol. Soc., vol. i., part iii.; "On the Discovery of a Sand Dyke," etc., by Robert Dick, Edinburgh Geol. Soc., vol. i. part. iii.; Explanation of Sheet 24, Geol. Survey of Scotland, etc., etc.

[2] On the Granitic Rocks of Donegal. By R. H. Scott, M.A. Dublin: Printed at the University Press. Part 1, 1862; Part 2, 1863.—On the Chemical and Mineralogical Constitution of the Granites of Donegal, and of the Rocks associated with them. By a Committee, consisting of Robert H. Scott, Sir R. Griffith, Bart., and the Rev. S. Haughton, M.D., F.R.S., appointed at the Manchester Meeting of the British Association, 1861.

Then I saw that I had found out nothing new—which was at first disappointing—but, also, that I had good names on my side, which was comforting; but it seemed to me that there might still be some use in publishing my paper, because the papers mentioned are mainly mineralogical, and the fact that the granite is bedded, though most strongly insisted on, comes out in them somewhat incidentally; because I flattered myself that it was just worth while putting on record that I had independently come to the same conclusion as previous observers; and, lastly, because I wished, even at the risk of tiresome iteration, to recall the attention of geologists to a district so eminently suited to throw light on the vexed question of the metamorphic origin of certain granites.

My head-quarters were at Dunlewey, in the north-west corner of the county. The general structure of the country and lie of the rocks is shown in the section, Fig. 1. While I believe the section to be correct as far as the order in which the rocks occur, I should not wish to commit myself positively to the statement that the quartz-rock of Errigal is the lowest, and the granite the highest, of the rocks shown on it. The dip is everywhere so steep, the folds so sharp and sudden, and the possibility of inversion so great, that the reverse may be the case. It was mainly on physical grounds that I considered the order of superposition to be that adopted: the abrupt westerly face of Errigal has so much the look of an escarpment, and its less steep easterly side so much of the character of a dip-slope, that, after considerable hesitation as to which was the highest and which the lowest rock in the district, I at last thought it most probable, mainly on the above ground, that the dip was on the whole towards the east, and the rocks, therefore, in that quarter the highest in the series.

Whether this or the reverse be the case, however, matters little to the main object I have in view; the arguments I shall bring forward in favour of the bedded character of the granite will hold equally good, whether that rock be the highest or lowest in the district; at the same time, if this granite can be shown to overlie conformably undoubtedly stratified rocks, it will be an additional fact in favour of its metamorphic origin. The strike of the district is remarkably constant, never departing more than a few degrees from magnetic east and west, the variation being about 24° or 25°. To the east of the quartz rock of Errigal[1] we have a belt of country mainly made up of mica-schist, with beds of grey crystalline limestone here and there, and a few occasional patches of white marble, seemingly of very limited extent; beds of quartzite also occur. Beyond this belt lies a large tract of rock, the mineral composition and physical features of which are those of granite, and as such it has been described and coloured in Geological Maps. I shall without prejudice speak of it as granite.

Along the eastern margin of the belt of mica-schist, we find distinctly interstratified beds of a rock, which in hand-specimens it

[1] So spelt on the Ordnance Map. I believe that Aracal represents more nearly this Celtic name, the meaning of which is "Beware."

would be impossible to tell from granite: some varieties are extremely coarsely grained, and would, I think, be certainly classed with that rock; indeed, the first instance that came before me I at first took for a granite vein, and it was only after much doubting that I felt sure it was truly interbedded with the mica-schist; some beds are finer in grain, and in them perhaps a rude foliation may be seen, though for my own part I doubt if I should ever have suspected the presence of this structure if I had not discovered that the rock was bedded, and thought it my duty to call it gneiss.

As we go eastward, these beds of granitic gneiss, as I decided in the hope of pleasing both sides to call them, become thicker and more numerous, and the interstratifications of mica-schist thinner and fewer, till at last the latter disappear altogether, and we seem to have reached a district of granite only, where, even supposing the latter to be a metamorphic rock, metamorphism has effaced all traces of bedding. Looking a little closer, however, we find we have been too hasty, and even in the heart of the granite region we are able to detect what seemed to me most unmistakably bedding.

I would wish, then, to lay particular stress on the following facts. The interstratification with mica-schist of beds of rock which can hardly, if at all, be distinguished from granite; the very gradual passage from alternations of granitic gneiss and mica-schist into granite alone; and the marked traces of bedding and other signs of stratification that appear in the last.

In support of these statements I will now put forward one or two detailed observations.

On my first day, with Sir R. Griffith's map in hand, I started from Dunlewey, in a north-easterly direction, along the road to Letterkenney, to fix the place of the boundary between the mica-schist and granite which was laid down on that map. After passing over country where mica-schist was well shown, an interval occurred over which there was no section; then about half a mile beyond Sand Lough, I came to a crag of what I at first sight called granite. I concluded, therefore, that I had crossed the boundary I was in search of. The rock was coarse, and in parts had weathered down into coarse sand after the manner of granite. I noticed, however, planes of division in it, which looked like bedding, but which might be joints. Their bearing, however, coincided with the general strike of the district; so I noted this fact, and waited to see what it was worth.

Leaving the road and striking eastward across the moor, it was soon clear that no such boundary as that I was in search of existed, and that no hard line could be drawn parting mica-schist from granite. Though the greater part of the ground was occupied by the latter rock, narrow bands of the former, with the usual strike of the country, were crossed, evidently interbedded with the latter. These bands became fewer and fewer as I went further east, and at last disappeared altogether, and I reached ground wholly granitic. But even here the rock was traversed by divisional planes, which might be joints, but which had a suspiciously bedded look about them, and the strike of these planes was everywhere parallel to that of the undoubtedly bedded rocks which I had left to the west. The rock, however, could scarcely, perhaps, be fairly called granite; rude foliation was discernible; it was rude, but perhaps enough to justify any one, who disliked the idea of bedded granite, in calling the rock gneiss.

With my suspicions excited by what I had seen, I started next up the Poisoned Glen, determined to go well into the heart of the granitic district, and see how far these glimmerings of bedding could be followed.

I crossed, as before, the mica-schist with its limestone, the same alternations of that rock with bedded granitic gneiss, and noted the same gradual decrease in number and thickness of the bands of mica-schist, and their final disappearance altogether. Scrambling up the steep southern end of the glen, I found myself in a region strikingly granitic both in its physical features and in the minute character of its rocks. In spite of the universal glaciation, which had smoothed and rounded off every hill-top and edge, atmospheric wear, acting on a very characteristically jointed structure, had begun to produce Tors, which any geological artist would pronounce eminently granitic in their outline; and in the rock itself I could detect nothing deserving the name of foliation. Here for a while I was undecided. This rock might have been once bedded, but its metamorphism has been carried so far as to destroy all traces of bedding; or, on the other hand, we may have here an intrusive igneous mass, which has produced the metamorphism of the rocks to the west.

I sat down to take breath and think. Casting my eyes over the country I saw the hills everywhere traversed by a set of divisional planes ranging parallel to one another, and to the general strike of the rocks I had crossed in coming up, and dipping at high angles towards the south-east. If I had not known what rock I was standing on, I should without hesitation, from an instinctive feeling which every field-geologist will understand, have called these planes of bedding. But they might be joints. This doubt was soon settled. I was sitting on a smoothed moutonnéed boss, the wetted surface of which laid bare the structure of the rock as clearly as if it were an artificially polished section. I then saw that this granite was made up of a number of layers of different thicknesses, and differing from one another in composition, grain, and other mineral peculiarities, and that these layers had the same high dip towards the south-east, and exactly the same strike across the country as the larger divisional planes I had noticed just before. The layers of the boss had so exactly the look of a group of alternations of coarseish and more finely grained sandstones with sandy shales, such as any section in ordinary Carboniferous rocks would furnish, that I could have no doubt that they were true laminæ of deposition; and hence the conclusion was obvious that the larger divisional planes were main planes of bedding. I spent the rest of the day on the granite hills, and found numberless other ice-cut sections of the highly inclined rocks, showing the same undoubted alternation of layers of coarse and fine rock so clearly marked that no one could have distinguished them from the laminæ of an unaltered stratified rock.

I am quite sure that this structure was not foliation; some of the layers may have been rudely foliated in themselves; but along the planes separating layer from layer there was no gathering of any one particular mineral, such as mica. The structure, indeed, was exactly that which is universally accepted in the case of a cleaved slate rock as proof of its originally bedded nature, an arrangement of the rock in parallel layers of various thicknesses and different mineral composition, grain, and colour.

One other point of resemblance between these bedded granites and unaltered stratified rocks deserves notice. I have compared them to sandstones. Now it is well known that in sandstones the most persistent layers are those which are finest in grain, and that the coarse beds are generally wedge-shaped, and thin away often very suddenly. This was just the case with these granite laminæ. I found many cases of a coarsely grained bed wedging out sharply, while the beds of finer grain were regular and persistent in their thickness; and I was constantly reminded among these granite hills of the behaviour, in this respect, of the Carboniferous sandstones of the North of England, from which I had just come. In both cases coarseness of grain went along with irregularity of bedding, and the contrary.

To give more instances of detailed observations would be mere repetition. The two cases I have selected were the most marked that came under my notice; but it was not on the strength of these two alone that I formed my conclusions. The same thing was seen wherever I entered the granitic area.

One very obvious objection deserves notice. The layers of granitic gneiss, which I have looked upon as interbedded with mica-schist, and other undoubtedly stratified rocks, may be sheets of intrusive igneous rock injected between the planes of bedding. The possibility of this occurred to me, and I kept my eyes open for any instance of the granitic gneiss cutting across the bedding, a thing which was sure to occur somewhere, if it were really an intrusive rock. I never saw anything of the kind; and it is hard to believe that, if these crystalline rocks have been injected from below, they should everywhere have confined their lines of exit to the spaces between two adjoining beds; and if the main granitic mass be itself intrusive, it would surely somewhere or other have thrust out dykes and veins into the beds which it invaded. Moreover, we could not in this way explain away the bedded structure of the main body of the granite. A little further to the west a large mass of intrusive trap does occur, and it is instructive to compare what is seen along its margin with the border ground between the mica-schist and granite. The boundary of the trap is a winding line running in and out among stratified rocks, whose strike is all but invariable; big wedges spring from the main mass; and innumerable dykes, many only a few feet wide, and probably occupying the openings between joints, cut across at large angles with the trend of the bedding. No contrast could be more striking; on the one hand we have a gradual passage from bedded metamorphic strata into granitic rocks, where the bedding becomes fainter and fainter, and can at last only be detected by the closest observation, and the line along which this passage takes place maintaining a steady course parallel to the trend of those rocks, which still retain their bedding; on the other hand, a sharp change from bedded to unstratified crystalline rocks, and the line along which this change takes place, winding over the country and cutting at all possible angles across the strike of the bedded rocks, and dykes running out in numbers from the crystalline mass.

I have incidentally mentioned the glaciation of the district. Except where weathering may have effaced them, there are everywhere superb traces of wide-spread ice-action.

The Granite Hills, the highest of which, Slieve Snaght, is 2240 feet above the sea, are everywhere moutonnéed up to and over their summits. The coarse nature of the rock, however, and its rapid weathering, has not allowed of the preservation of scratches to show the direction of the flow.

To the south-west of Dunlewey, however, is a tract of quartzite, and the scorings on this hard rock have been beautifully preserved. The direction of all that I saw was nearly magnetic east and west; they show a total disregard to the surface of the ground, running across ridges up and down hill, and sometimes barring a precipice with horizontal scratches, where its face happens to be parallel to their trend. The grooves are extremely regular, and where the ice-marked surface rock has broken up under the action of the weather a very singular effect is produced; for so true are the flutings on the rounded surfaces of each moutonnéed boss that, as one stands among the fragments which have split off, one could almost fancy oneself amidst the fallen columns of a ruined Grecian temple. Fig. 2 will give some notion of these fluted surfaces.

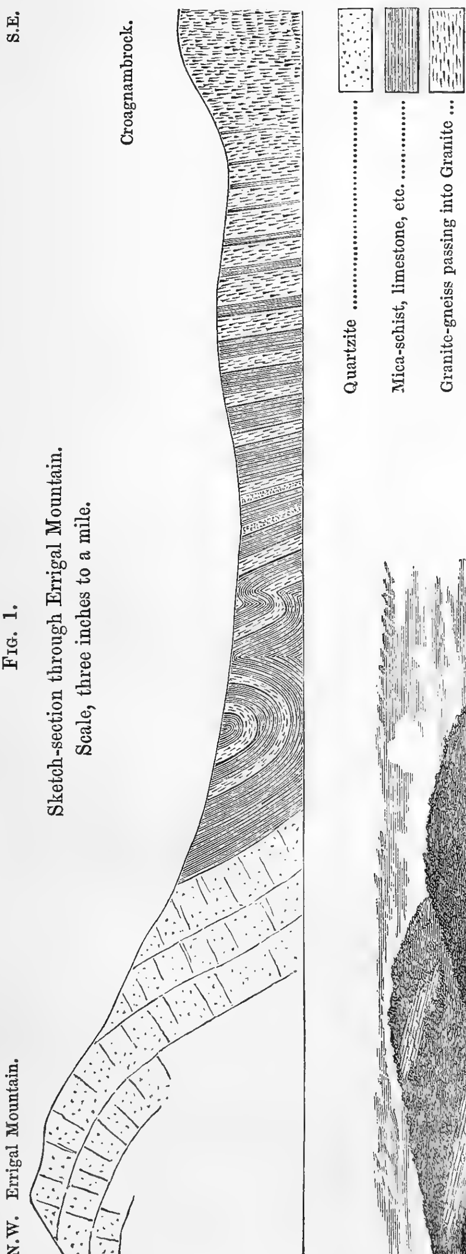
Whether the ice passed over Errigal, the highest point (2466 feet), it is impossible to say; for the rapid weathering of its well-jointed quartzite has long ago effaced any marks that may once have been there.[1] The low country of mica-schist is everywhere moutonnéed, but, like the granite, shows no scratches.

Lakes are abundant; many certainly, and probably all, lie in rock-basins; and those that are grown- or silted-up quite equal in number those that still remain. Fig. 3, which is on a true scale, shows a very common arrangement of these lakes. The faces A and B are often very nearly plane surfaces, when not covered by débris, so steep and smooth that it is all but impossible to stand on them; and seen from a distance they glitter in the sun, when wet, like polished glass; they plunge straight down in many cases into the lake. At the other end smoothed rock-surfaces rise at a low

[1] Mr. Campbell mentions a doubtful ice-marked patch at the summit. "Frost and Fire," vol. ii., p. 56.

Fig. 1.

Sketch-section through Errigal Mountain.
Scale, three inches to a mile.



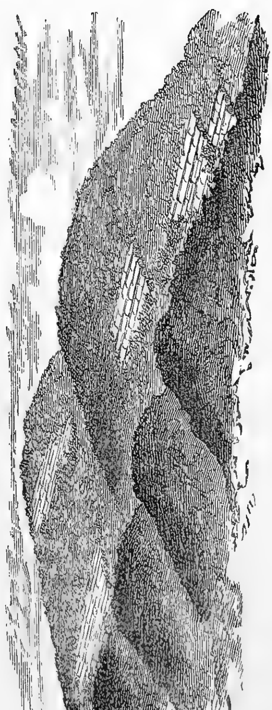


Fig. 2.—Ice-fluting on Quartzite.

Fig. 3.

angle from beneath the water, and slope up gently to the crest of the next abrupt descent. It seems as if the ice had cascaded down the steep faces, dug out a hole at the bottom of each, and flowed out of the hole up the gentle further slope. I do not think I ever quite realized Prof. Ramsay's theory till I saw these little lakes, where the whole process is before you as if in a model. Possibly the hollowing out of these lakes was the work of local ice-flows subsequent to the general glaciation; but this point I had not time to go into.

In the discussion which followed the reading of this paper, Mr. David Forbes took a chief part, and I am glad of this opportunity of replying to his objections.

He states, 1st, that Mr. Scott and Prof. Haughton declare the granites to be decidedly intrusive. We are not accustomed to rely much on authority in scientific matters; and, even if I had these eminent names against me, it would not be absolutely fatal to my views; but, as a fact, nothing can be more strong and decided than the expression of both Mr. Scott and the authors of the Report of their conviction of the bedded character of the mass of these granites. They do mention one or two cases where, to use their own words, the granite is "apparently intrusive," so that the state of the case is this: we have a great mass of granite, which almost everywhere seems decidedly interbedded with rocks whose sedimentary origin is not questioned; in one or two cases we find granite apparently cutting across the beds. What is to be our guide as to the origin of this granite? Are we to look to its general character on a large scale, or are we to rely on a few local exceptions? And these exceptions are capable of the simplest explanation in two ways. There may be two granites, one metamorphic, the other intrusive. Or it may be that, while for the most part metamorphism has not gone so far as to destroy the bedding, it has at some spots been extreme enough completely to fuse the rock; and the fused rock, expanding by heat and urged on by the pressure of gases confined below, has behaved intrusively. That a metamorphic rock may be at places intrusive has been explained so often that I am almost ashamed to have to repeat it.

2nd. Mr. Forbes states that I start from the idea that if rocks lie conformably on beds of undoubtedly sedimentary origin, it is a proof that they are themselves sedimentary or stratified. I have not, that I am aware of, stated this proposition either directly or indirectly; and I have heard of such things as contemporaneous or interbedded traps or lavas. But even supposing that the rocks in dispute were originally of this class, they were not poured out as granite, and must have undergone metamorphism to reduce them to their present condition; and this is all that I have ventured to assert. I have simply said that they are bedded, and contemporaneous with the mica-schist and quartzite of the district; and whether they are contemporaneous sedimentary rocks, or sheets of contemporaneous lava, matters little to the question we are discussing; for in either case we should require metamorphism to convert them into granitic gneiss.

3rd. Mr. Forbes states that a parallel structure, equally, if not better, developed than any occurring in the gneiss of Donegal, is common to many volcanic rocks. I know that my friend is in the habit of carrying about in his pocket bits of lava or recent slag with this banded or ribboned structure. So seldom is he without one such specimen that he runs the risk of being looked upon by the vulgar as a believer in talismans or charms; for on no other ground could they explain his apparent attachment to these pretty specimens. Really he uses them to crush rash theorizers like myself by bringing them forward as proofs that rocks may be of igneous origin and still bedded; but I cannot imagine that there is any danger of confounding bedded structure on a large scale with the lamination of such specimens as Mr. Forbes is in the habit of basing his arguments on. In hand-specimens it might be difficult to distinguish between the two; but in the field I do not think that any one accustomed to the look of rocks could mistake one for the other.

VI.—The Valley of the Yar, Isle of Wight.

By Alfred J. Browne, Esq.

It may seem superfluous to describe any part of such a well-known district as the Isle of Wight; but although its geology has been so well investigated, still the Post-Pliocene deposits of the island have perhaps received less attention than any others. The origin of its valleys, moreover, has not, so far as I am aware, been carefully studied; and as it may throw light on the date of formation of the Solent and Spithead, I venture to send a few notes made on a recent examination of the valley of the Yar, in the hope they may prove interesting, even if not original.

I will begin at its mouth. From Yarmouth to the village of Freshwater, a distance of two miles, the river is estuarine and the banks low and sloping. Freshwater is the present limit of the tidal influence, and here the valley is about 150 yards wide. Above this it consists of a series of marshes about 100 yards wide as far as Freshwater Gate, where the river takes its rise on the north side of the shingle beach; I say "takes its rise," in deference to its ancient title and name of river, which it still retains, though there is now no spring or stream, merely marshes and ditches, through which the water soaks down to the estuary at Freshwater; in fact, before the beach at Freshwater Gate was raised and strengthened, these marshes were often overflowed at high tides. So recent, however, does the river-bed look that when standing on one of its banks in this neighbourhood, it is difficult to divest oneself of the idea that the marshy grass in the bend of the valley is not rippling water.

Although the valley is now almost a dead level, the following considerations seem to lead to the conclusion that it once had a greater declination, not in the present direction, but on an incline from Yarmouth to Freshwater Gate.

1. At Freshwater Gate there are extensive gravel-beds, filling the gap in the Chalk Downs, which is the only one between the Needles and Shalcomb Down, a distance of seven miles; in these beds the teeth of *Elephas primigenius* have been found, and their formation requires the water-power of a large river to bring down so much material from the land.

2. A lateral series of marshes near Freshwater, through which a small stream runs after continuous rain, was evidently a tributary of the old river, and its debouchure points upwards and not down towards Yarmouth, as do the tributary streams lower down, which are possibly of more recent production.

3. In writings of the time of Charles I. the western extremity of the island is spoken of as Freshwater Isle—"He went westwards towards Worsley's Tower, *in Freshwater Isle,* a little beyond Yarmouth Harbour." (Herbert's Memoirs.)

The deduction from the foregoing facts seems to be that the river was of large size, and flowed down from the direction of Hampshire. Now, if reference be made to a map of that county, it will be seen that exactly opposite to the Yar is the mouth of the river Lymington, also that the Medina corresponds to Southampton water, and possibly Brading Harbour to Portsmouth Harbour; thus strongly suggesting the idea that these rivers in the Isle of Wight were once continuations of the Hampshire ones; and this is rendered more probable by a consideration of the depth to which the valleys of the rivers are cut through the Chalk Downs; these form the natural watershed of the island, and any river flowing northwards would seem incapable of cutting so deep a trough as at Newport and Freshwater Gate. I would, therefore, conclude that there has been a gradual elevation along the old anticlinal axis of the Cretaceous strata, causing the rivers to find an easier exit over the low country of the Fluvio-marine strata, which must once have existed where the Solent and Spithead now are. If these surmises be correct, the Solent must have been excavated very soon after the deposition of the Post-pliocene gravel at Freshwater Gate; and its considerable width, notwithstanding the lateness of the date, would not appear surprising to any one who knows the destructible nature of the coast. The latest alteration of level seems to have been one of depression, in accordance with a well-known similar and general movement all along the British Channel; for at Brading there is an old well now covered by high tide; and in the Yar valley there existed about forty years ago a large pool above Freshwater open to the influence of the tide, and the stream from which at low water is said to have turned a mill; this has since been abandoned, and the pool drained, though both still appear on the Ordnance Map; and I may here take the opportunity of noticing the antiquity of this production—it was published in 1810, and has only been furbished up for modern use by the insertion of the railways and a few other prominent objects, but much is omitted, and much should be erased from the map as obsolete.

NOTICES OF MEMOIRS.

I.—The Geology and Extinct Volcanos of Clermont, Auvergne.[1]

By Richard G. Symes, F.G.S.

MR. SYMES having visited this district in the summer of 1870, in company with Mr. Leonard, gives us an interesting paper, the results of their observations on the Plutonic, Aqueous, and Volcanic rocks. The country chiefly examined was that between four and five miles west of Clermont. The granite is described as generally consisting of two micas (margarodite and lepidomelane, the latter predominating in nearly every case over the former), one felspar (oligoclase) and glassy quartz. It was found to decompose the more readily as it approached Volcanic rocks. The Aqueous rocks, of Upper Eocene or Miocene age, are briefly described as consisting of grits, marls, and indusial limestone or travertin. The grits are for the most part composed of the débris of granite and basalt, bound together by a siliceous cement. Mr. Symes obtained a specimen containing a well-rounded pebble of basalt: a fact of some importance, as Scrope and Lyell remark that no traces of volcanic rocks occur in these beds. In regard to the volcanic phenomena, the inferences drawn are: that the condition to which the volcanos are referable is that in which eruptive paroxysms of intense energy alternate with lengthened periods of complete inertness; that the cinder cones, Domitic hills, and recent lavas are all due to one violent paroxysm spread over an area twenty miles long by two broad; that the presence of two such different rocks as basalt and trachyte, in close juxtaposition, can only be accounted for on the supposition that the rocks from which they are derived, namely, hornblende rock and some highly felspathic rock, such as granite, were in contact prior to their being reduced to the forms we now find them in; that the granite plateau was very much in the same condition prior to the deposition of the lacustrine strata, as it is now; that prior to the deposition of the lacustrine strata, this district was probably the seat of volcanic eruption.

II.—On Ehrenberg's Foraminifera from the Chalk of Meudon, France.

By Prof. T. Rupert Jones, F.G.S., and W. K. Parker, F.R.S.

IN No. 89 of the Geological Magazine, p. 511, we indicated the genera and species of Foraminifera found by Dr. Ehrenberg in the White Chalk of Meudon, near Paris, and figured in his "Mikrogeologie," 1854.

In our list twenty species were enumerated (with the nomenclature now in use) as the result of our study of the fifty-six forms

[1] A paper read before the Royal Geological Society of Ireland, April 12, 1871.

figured and separately named in the plate of Meudon Foraminifera. To render our work more useful to Rhizopodists and Bibliographists, we proceed to take the figures in succession, noting that, as we before stated, the grouping on the plate has a more natural association of allied forms than that shown by the numerical order.

Pl. xxvii., fig. 1, *Miliola ovum* = *Lagena globosa.* 2, *Nodosaria turgescens* is one and a half of the last chambers of a compact variety of the simple *N. ovicula.* 3, *Textilaria striata* (1838); 4, *T. sulcata;* and 5, *T. dilatata* ("*T. brevis?* 1838"), belong to Ehrenberg's *T. striata,* a subspecies or notable variety, worthy of a binomial term. 6, *Text. globulosa* (1838) is the small or young form of *T. gibbosa,* D'Orb., and for convenience is often referred to by the name given by Ehrenberg. 7*a–d*, *T. linearis* = *Bolivina punctata.* 8, *Text. aculeata* ("*T. aspera,* 1838, in part") is a thick-walled form of *Textilaria gibbosa,* produced and aculeate on the edges at the outer angle or base of each chamber, and is conveniently distinguished by the name here given. 9*a*, *b*, *Grammostomum pachyderma* ("*Text. aciculata,* 1838, = several thin species of *Grammostomum*"), and 10, *Gr. angulatum,* are specimens of a coarse-shelled *Bolivina punctata.* 11, *Gr. polystigma* = *Text. sagittula.* 12, *Gr. Thebaicum* seems to be an oblong *Textilaria agglutinans* with a growth like that of *T. sagittula;* but *Gr. Thebaicum,* pl. xxiv., figs. 20, 21, certainly appears to be *Bolivina dilatata.* 13, *Gr. platystigma* is *Bol. dilatata.* 14, *Polymorphina asparagus* is *Virgulina squamosa;* so also is 15, *Grammostomum lingua.* 16, *Gr. macilentum* is a very neatly Textilariform *V. squamosa.* 17, *Strophoconus efflorescens* is a rather twisted *V. squamosa.* 18, *Grammostomum* (*Polymorphina?*) *myoglossum* is a fragment of apparently a *V. squamosa* of regular growth. 19, *Loxostomum subrostratum,* and 20, *Lox. rostratum,* are varieties of *Text. agglutinans,* becoming Bigenerine (passing into *Bigenerina*) by the aperture getting more and more terminal in successive chambers (fig. 20 shows the more advanced stage of the transition). 21 and 22, *Lox. aculeatum* is a pouting *Textilaria,* tending towards *Sagrina rugosa,* D'Orb. (*Heterostomella,* Reuss). The aperture is entire (not ragged or prickly, as shown in figures of some *Polymorphinæ* in other plates), and lipped, as in *Uvigerina.* The edges of the shell are aculeate by the production of the base of each chamber. See above, p. 508. Fig. 23, *Strophoconus polymorphus* = *Virgulina Schreibersii.* 24, *Str. spicula* = *V. squamosa;* so also 25, *Grammostomum gracile.* 26 and 28, *Strophoconus polymorphus,* and 27, *Str.* (*Grammost.?*) *ovum?*, are *Virg. Schreibersii.* 29, *Proroprorus cretæ* = *Polymorphina Thouini.* 30, 31, *Grammobotrys? Parisiensis* = *Sphæroidina bulloides;* and probably also 32, *Pleurites cretæ.* 33, 34, *Sphæroidina Parisiensis* = (33, probably, and 34, certainly) *Sph. bulloides.* 35, *Guttulina aculeata,* and 36, *Gut. turrita,* are *Verneuilina pygmæa,* Egger; but 35 has the outer margins of its chambers more or less aculeate. 37, *Nonionina? ocellata* is *Cristellaria cultrata.* Figs. 38–45 and 47 are various individuals of the neat little variety of *Planorbulina farcta,* known as *Pl. ammonoides,* Reuss, sp., very common in the Chalk. (38*a*, *b*, 39, and 40, *Planulina micromphala*

= "*Pl. turgida*, 1838, in part." 41, *Pl. angusta*. 42*a*, *b*, *Pl. annulosa*. 43, *Pl. leptostigma*. 44, 45, *Pl. ampla*. 47, *Pl. ampliata*.) 46, *Pl. euomphala* is a slightly keeled *Cristellaria cultrata*. 48, *Pl. umbilicata* is *Pulvinulina truncatulinoides*, D'Orb., sp., seen from the upper (flat) surface. 49 and ? 50, *Pl. heteromphala*, seem to be small varieties of *Planorbulina farcta*, approaching *Pl.* (*Truncatulina*) *lobatula;* such are not rare in the Chalk. It is difficult to correlate the many small *Planorbulinæ* and *Truncatulinæ*, from the Chalk, figured by D'Orbigny, Reuss, and Ehrenberg. Fig. 49 is perhaps comparable with D'Orbigny's *Rotalina umbilicata* from the Chalk, which we are inclined to refer to *Rotalia* proper, though with some doubt. 51, *Rotalina umbilicata* is a side view of *Pulv. truncatulinoides*, D'Orb., sp. Not quite so angular in its profile as the recent specimen figured in "Hist. nat. des Iles Canaries, etc. Foraminifères," pl. 2, figs. 25–27. This species is figured also by Soldani, "Testaceographia," vol. i., p. 58, pl. 46, fig. *nn*. It is a variety of *Pulv. Menardii*, and closely related to *Pulv. Micheliniana* and *Pulv. crassa*, both found in the Chalk. See "Philos. Transact.," vol. clv., p. 393. 52, *Planulina picta* = *Pulv. Micheliniana*, D'Orb., sp. See above, p. 510. Figs. 53–58 are young, and 59 an adult, *Globigerina cretacea*, D'Orb., a rather discoidal form of *Gl. bulloides*, D'Orb. Young flattish *Globigerinæ* closely resemble young *Planorbulinæ*. (53, *Rotalia quaterna;* 54, *R. rosa*; 55, *R. pachyomphala;* 56, *R. globosa-ampliata*. 57, 58, *R. aspera;* 59, *Globigerina cretæ*, referred with doubt to *Gl. bulloides* in 1838.) Figs. 60–64 are young and arrested specimens of *Planorbulina farcta*. (60, *Rotalia globulosa-tenuior* = "*R. Glob.*, 1838"; 61, *R. senaria;* 62, *R. densa;* 63, *R. glomerata* = "*R. senaria?*"; 64, *R. cretæ*, rough-shelled.) Spongiliths and Coccoliths occur among the other figures on this plate.

REVIEWS.

I.—Letters and Extracts from the Addresses and occasional Writings of J. Beete Jukes, M.A., F.R.S., F.G.S., late Local Director of the Geological Survey of Ireland. Edited, with connecting memorial notes, by his Sister. London: Chapman and Hall. 1871. pp. 596. 8vo. With a Portrait.

As in military service, "the place of honour is the place of danger," so in Science, the men who by their earnest labours occupy its foremost ranks, acting as pioneers to smooth our path, are likewise risking their lives for us, and not unfrequently pay all too dearly for the transitory honours they enjoy.

For Professor Jukes—whose memory, so dear to geologists, this book is intended to keep alive,—may certainly be claimed the merit of having been always *at the front*. From the time he left Cambridge, when, inspired by Professor Sedgwick's zeal, he set forth on foot to walk through the length and the breadth of England geologizing; he began to teach others, and we find him lecturing first in one town and then in another, often to crowded audiences; for, whatever he did, whether lecturing, writing, or working in the field or on the sea, he was ever full of genuine earnestness, which inspired others with an ambition to do their best also.

The book before us sketches out, by the help of connective narrative, and by letters and extracts from his writings, the life of Professor Jukes from his birth in the old house at Summerhill, near Birmingham, on October 10th, 1811, through his schoolboy days at Wolverhampton and Birmingham, to his entry at St. John's College, Cambridge, in 1830. Of this part of his life little has to be recorded save that the first preceptor who appears to have made any deep or lasting impress on Jukes's mind was Professor Sedgwick, whose teachings certainly fashioned the course of his after-life. After leaving Cambridge, Jukes, as we have said, took the field and mastered the geology of a great part of England for himself, covering his expenses with his lectures and other scientific work. He also devoted some time to learning practical Field-surveying.

In 1839 commenced his real start in life, as Geological Surveyor of Newfoundland, a post which, though rough and somewhat perilous in its nature and full of hardship, had for Jukes a charm which is only fully understood by those who, to a love of wild sports, can add the consciousness of a sound and vigorous constitution, a dauntless courage, and a happy knack of making themselves at home anywhere and with anybody.

The work of surveying this inhospitable island was found to be exceedingly difficult. No map of the country existed, the interior being for the most part trackless, uninhabited, and obscured by woods and morasses, geological observations could only be carried on along the coast by means of boats. But here, though the cliffs are bold, they are frequently inaccessible, and often either too perpendicular, or too well guarded by surf, to render landing practicable. The inclemency of the climate too forbad the carrying on of such work save in the short but brilliant summer season. Mr. Jukes, however, completed his report, and returned to England at the end of 1840.

Far different and more congenial was the next work in which we find him engaged. Having been offered the post of Naturalist on board H.M. ship "Fly," under the command of Captain E. P. Blackwood, R.N., bound on an expedition to survey Torres Strait, New Guinea, etc., he left England on April 11th, 1842.

The results of this exploration are detailed in the "Narrative of the Surveying Voyage of H.M.S., Fly" (2 vols. 8vo. London, 1847). In the book before us they are told in the shape of letters to friends at home, and occupy some 142 pages, giving sketches of places, people, and incidents in Australia, New Guinea, Java, and the Eastern Archipelago, pleasant to read about, if not all agreeable to the narrator.

On the return of the expedition, in 1846, Mr. Jukes once more sought his first love, and entered the Geological Survey, working principally in Wales, and at the South Staffordshire Coal-field. Speaking afterwards about the difficulties of surveying and mapping the older Palæozoic rocks, he says, "I had once been working hard for about five weeks, trying to understand and delineate on the one-inch map a complicated bit of mountain ground a few miles south of Conway, in North Wales. It was made up of interstratified slates, sandstones, and felstones, with large and irregular masses of intrusive greenstone, the exposed parts of each being frequent, but not continuous. Many a weary day had I climbed the sides, and clambered along the crags of a hill, some five or six miles in length, by two or three in breadth, and the highest peak of which was not more than 1,800 feet above the sea, trying in vain to reduce to order the seemingly endless complexity of its structure, and having at length on the map as curiously complex a patchwork of incongruous colours and unnatural forms as Punch, had he turned geologist, could have devised; when one evening, as, after a hard day's work, I was descending a steep bit of ground, almost in despair at all my labour seeming to be thrown away, I hit upon the clue to a great fault or dislocation. I had only time then to verify the observation, but it gave me at once the solution of all the puzzle; and in two or three days I was enabled to map the whole district, with as near an approach to accuracy as the scale of the map admitted of. The country was chopped up by a series of large parallel faults, that were quite easy to be seen when once the clue to one of them and its bearings were obtained, but which there was nothing to render *à priori* probable, and which could not have been discovered without that thoroughly exhaustive process of examination which I was enabled to apply to the district. I have ever since regretted that, in my haste and joy at acquiring a right notion, I obliterated all my former work from the map which contained it; for I should have been glad to preserve it now as a curious instance of the contrast between laborious hypothesis and the simplicity of natural truth." (pp. 306–308).

Speaking of Coal-mining, Mr. Jukes says, "Very few people are aware of the enormous amount of loss which has been incurred, and is even yet of annual occurrence, in fruitless mining enterprises."

"Sedgwick, on a visit to Sir H. Halford, in the south part of Leicestershire, saw an engine, etc., at the top of a hill a few miles off, and was told it was a coal-pit. He naturally went to look, and on going up the hill found Lias shale with Lias fossils, etc. 'Why,' says he, 'this is Lias!' 'Lias!' says the proprietor, coming down on him; 'You're a liar, and you're all liars together!' etc. Naturally the man ruined himself."

The stories of two equally futile explorations are given in the Geological Magazine for November last (pages 500 and 505).

"In South Staffordshire (says Mr. Jukes), I knew two instances of ground bailiffs, intelligent men, well versed in 'coal-getting,' continuing to sink in Silurian shale, and heaps of the fossils of that formation lying on the pit bank; they were still going down for coal."

"The name of these stories is legion. The money wasted *in this century*, for want of the very rudiments of geological knowledge in those who wasted it, would have paid for the whole Survey and Museum since its establishment, and given it an endowment of £2000 per annum for ever." (p. 469).

The appointment of Dr. Oldham to the Directorship of the Indian Geological Survey, in November, 1850, rendered vacant the post of Director of the Irish branch of the Geological Survey, which was offered to Mr. Jukes, and undertaken by him early in 1851. From this date to his death, on 29th July, 1869, he worked, if possible, harder than before; but we are inclined to believe that his was a mind and body constituted for active mental and physical exercise. What really operated unfavourably upon him may be termed the official worry and the constant sense of responsibility in which his new duties involved him. Heretofore he had been a "private" in the ranks of the English Survey, working indeed both with head and hands; but now that he was suddenly raised to the rank of a Director (with the Professorship of Geology in the Royal College of Science in Dublin, added thereto in 1854), the light-heartedness which could laugh at difficulties gradually faded away. Like the late Prof. Edward Forbes, he chafed under official restraint, and doubtless was ready to exclaim with his beloved friend,

"Oh, the red-tape worm is gnawing my soul."

Work, however, went on with a will; for, although his staff of assistants was small, he completed the survey of about one-half the superficial area of Ireland, together with the editing and partial authorship of about forty-two explanatory Memoirs on the Geology of the country.[1]

Nor were his labours confined to his official work; for in the list of 77 Books, Reports, Articles, and papers, given at the end of this volume, 53 were published between 1850 and 1868; the last paper he wrote being that on "the Chalk of Antrim," which appeared in the Geological Magazine, Vol. V., 1868, p. 345. Nearly all his spare time, from 1864 to 1868, was devoted to an examination and comparison of the Devonian Rocks of the South of Ireland with those of Devon and Somerset and of Rhenish Prussia. Several papers relating to this much-vexed question were communicated by Prof. Jukes to the Royal Geological Society of Ireland; to the Geological Society of London; and the Geological Magazine, 1866, Vol. IV., p. 87. Had Mr. Jukes's life been spared, he would probably have more fully worked out his views; this much, however, must be said, in justice to Mr. Jukes, that the result of his researches and papers has led to an entire and careful re-examination of the country under dispute; and only on the evening of 22nd of November, in the course of debate on a paper, read before the Geological Society of London, Mr. Godwin-Austen expressed his conviction that we should live to see the term "Devonian" abolished from the series of formations! there being no true separation between the Devonian and Carboniferous series.

The most highly valued of all Professor Jukes's publications is doubtless his "Manual of Geology," the *third* edition of which has

[1] See Obituary Notice by Prof. Edward Hull, F.R.S., Geol. Mag., Vol. VI. 1869, p. 430.

this moment reached us, completed, since our lamented friend's death, by Prof. Geikie, F.R.S., Director of the Geological Survey of Scotland.

This memorial volume of letters, prepared by the loving hands of his sister, Mrs. A. H. Browne, is enriched by an admirably-engraved portrait of Professor J. Beete Jukes, true to life, but withal a little too sad, as if the care that oppressed his later years saddened his thoughts at the very moment when his photograph was taken. There are abundant evidences throughout the book, however, to prove that Mr. Jukes was by no means a dull companion or correspondent, and we only regret that space precludes our giving a fuller notice of him. We will conclude this sketch with an odd verse of a geological rhyme, intended, doubtless, for one of those annual dinners of the Survey which the genius of the late Professor Edward Forbes rendered notable events to every member of the staff:—

"Then roll, roll,
The rocks like a scroll.
Let them be "flat," or "upright," let them stand;
By "strike" and by "dip,"
Through "fault" and through slip,"
We'll map them and section them right through the land."

[Extracted from a letter to Dr. Ingleby, p. 377]. H. W.

II.—A Handbook to the Mineralogy of Cornwall and Devon, with Instructions for their Discrimination, and Copious Tables of Localities. By J. H. Collins, F.G.S., etc., etc. 8vo. pp. 182. Ten Plates. 1871. Truro: Heard and Sons. London: Longmans.

The most useful books on our shelves, or perhaps in any library, are the dictionaries. They form a goodly company; broad backed and sturdy, each capable of standing alone; catholic in their usefulness, but the very type and bulwark of the nationalities in their individual distinctness.

This little book may be classed with them, for the second part, which occupies the greater bulk of the work, is arranged alphabetically, after the style of Bristow's Glossary of Mineralogy, but includes, interpolated with the names of minerals, technical terms and apparatus, etc., required in the determination of their identity; and the first is also so arranged as to be equally convenient for reference.

Immediately on opening the book we perceived that Mr. Collins must be a thoroughly practical man from his style, for all his sentences are to the point, and in the fewest number of words,—a great advantage in this verbose age,—although his English is occasionally open to criticism, as will be seen by merely a glance at the title. We will follow his example, and without further delay describe the contents of the Handbook.

In the first chapter, after defining what is meant by the word "mineral," and laying down the rules for the systematic determination of a specimen, he gives a list of the apparatus and few chemicals that are necessary. The second chapter gives tables of blowpipe reactions from Plattner and Muspratt, and Scheerer and Blandford; then follow tables of minerals arranged in groups according to their physical properties, *e.g.*, "pulverulent," "capillary," "colour of streak," etc. The next chapter contains a list of the Cornish and Devonian minerals, with the derivation of their names, dates, and of their discovery, and names of those by whom they were first noticed. This list we think might very well have been incorporated in the Glossary forming the second part. Then follow lists showing the different methods of arrangement in vogue amongst collectors.

Chapter five is devoted to tables of minerals occurring in the different divisions of Cornwall and Devon, in which, as indeed, throughout the book, the names are printed in various types, to show their abundance or scarcity.

These tables seem generally very well prepared, though we notice too great a number of inaccuracies, which we shall hope to see corrected in future editions, as they seem principally such as are attributable to the work having been hurried through the press, of which many indications are noticeable throughout the book. The last chapter, occupying twenty lines only, is on a most important branch of the subject—"Paragenesis"—and adds a few short lists of minerals "congenial to one another," as the miners say. We thoroughly concur with the author in his wish that all students would carefully register and accumulate observations on this part of the subject, and make them publicly known through any convenient channel, as also the position in which minerals occur, whether in the walls or joints, etc., of the lodes. The figures of crystals fill ten plates at the end of the second part. As an instance of want of care in revising the authorities from which the glossary is compiled, we would mention that Stenna Gwynn is given as a locality for Wavellite, while under Tavistockite it is correctly stated that this is the mineral, as first noticed by Dana, that really occurs there, and *not* Wavellite, for which it was formerly mistaken. This book will be found to be indispensable to all who are connected with the mining interests of Cornwall and Devon, being the only work on the subject specially devoted to these two counties; it will also be found extremely useful to all students of mineralogy.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.—The first meeting of this Society for the present session was held on November 8, 1871. Joseph Prestwich, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. A letter from the Embassy at Copenhagen, transmitted by Earl Granville, mentioning that a Swedish scientific expedition, just returned from the coast of Greenland, had brought home a number of masses of meteoric iron, found there upon the surface of the ground. These masses varied greatly in size; the largest was said to weigh 25 tons.

Discussion.—Mr. David Forbes having recently returned from Stockholm, where he had the opportunity of examining these remarkable masses of native iron, stated that they had been first discovered last year by the Swedish Arctic expedition, which brought back several blocks of considerable size found on the coast of Greenland. The expedition of this year, however, has just succeeded in bringing back more than twenty additional specimens, amongst which two were of enormous size. The largest, weighing more than 49,000 Swedish pounds, or about 21 tons English, with a maximum sectional area of about 42 square feet, is now placed in the hall of the Royal Academy at Stockholm; whilst, as a compliment to Denmark, on whose territory they were found, the second largest, weighing 20,000 lbs., or about 9 tons, has been presented to the Museum of Copenhagen.

Several of these specimens have been submitted to chemical analysis, which proved them to contain nearly five per cent. of nickel, with from one to two per cent. of carbon, and to be quite identical, in chemical composition, with many aërolites of known meteoric origin. When polished and etched by acids, the surface of these masses of metallic iron shows the peculiar figures or markings usually considered characteristic of native iron of meteoric origin.

The masses themselves were discovered lying loose on the shore, but immediately resting upon basaltic rocks (probably of Miocene age), in which they appeared to have originally been imbedded; and not only have fragments of similar iron been met with in the basalt, but the basalt itself, upon being examined, is found to contain minute particles of metallic iron, identical in chemical composition with that of the large masses themselves, whilst some of the masses of native iron are observed to inclose fragments of basalt.

As the chemical composition and mineralogical character of these masses of native iron are quite different from those of any iron of terrestrial origin, and altogether identical with those of undoubted meteoric iron, Professor Nordenskiöld regards them as aërolites, and accounts for their occurrence in the basalt by supposing that they proceeded from a shower of meteorites which had fallen down and buried themselves in the molten basalt during an eruption in the Miocene period.

Notwithstanding that these masses of metallic iron were found lying on the shore between the ebb and flow of tide, it has been found, upon their removal to Stockholm, that they perish with extraordinary rapidity, breaking up and falling to a fine powder. Attempts to preserve them by covering them with a coating of varnish have as yet proved unsuccessful, and it is actually proposed to preserve them from destruction by keeping them in a tank of alcohol.

Mr. Maskelyne stated that the British Museum already possessed a specimen of this native iron, and accounted for its rapid destruction on exposure by the absorption of chlorine from terrestrial sources, which brought about the formation of ferrous chloride. This was particularly marked in the case of the great Melbourne meteorite in the British Museum; he had succeeded in protecting this, as well as the Greenland specimen, by coating them externally, after previously heating them gently, with a varnish made of shellac dissolved in nearly absolute alcohol.

He considered it probable that a meteoric mass falling with immense velocity might so shatter itself as to cause some of its fragments to inclose fragments of basalt, and even to impregnate the neighbouring mass of basalt with minute particles of the metallic iron; but he considered the question of meteoric origin could only be decided by examining the same mass of basalt at some greater distance from the stones themselves, so as to prove whether the presence of such metallic iron was actually characteristic of the entire mass of the rock.

Prof. Ramsay referred to the general nature of meteorites and to their mineral relationship to the planetary bodies, and remarked that, supposing the earth to have in part an elementary metallic core, eruptive igneous matter might occasionally bring native iron to the surface.

Mr. Daintree mentioned that he had been present at the exhumation of the Melbourne meteorite, and that at that time there was little or no trace of any exudation of ferrous chloride, the external crust on the meteorite being not above 1/32-inch in thickness.

2. "On the Geology of the Diamond-fields of South Africa." By Dr. John Shaw, of Colesberg. Communicated by Dr. Hooker, F.R.S., F.G.S.

The author described the general structure of the region in which diamonds had been found. He considered that the diamonds originally belonged to some metamorphic rock, probably a talcose slate, which occupied the heights during a late period of the "trappean upheaval," to which he ascribed the origin of the chief physical features of the country. This upheaval was followed by a period of lakes, the traces of which still exist in the so-called "pans" of the region; the Vaal river probably connected a chain of these lakes; and it is in the valley of the Vaal and the soil of the dried-up "pans" that the diamonds are found. The author referred also to the frequent disturbance and removal of the diamantiferous gravels by the floods which prevail in these districts after thunder-storms.

3. "On the Diamond-gravels of the Vaal River, South Africa." By G. W. Stow, Esq., of Queenstown, Cape Colony. Communicated by Prof. T. Rupert Jones, F.G.S.

The author described the general geographical features of the country in which diamonds have been found, from Mamusa on the south-west to the headwaters of the Vaal and Orange Rivers. He then indicated the mode of occurrence of the diamonds in the gravels, gravelly clays, and boulder-drifts of the Vaal Valley, near Pniel, including Hebron, Diamondia, Cawood's Hope, Gong Gong, Klip Drift, Du Toit's Pan, and other diggings. By means of sections, he showed the successive deepenings of the Vaal Valley and the gradual accumulation of gravel-banks and terraces, and illustrated the enormous catchment area of the river-system, with indications of the geological structure of the mountains at the headwaters. The specimens sent by Mr. Stow, as interpreted by Prof. T. R. Jones, showed that both igneous and metamorphic rocks had supplied the material of these gravels. The author concluded that a large proportion of these materials have travelled long distances, probably from the Draakensberg range; but whether the original matrix of the diamonds is to be found in the distant mountains or at intermediate spots in the valleys, the worn and crushed condition of some of the diamonds indicates long travel, probably with ice-action. Polished rock-surfaces and striated boulders, seen by Mr. Gilfillan, were quoted in corroboration of this view.

Discussion.—Mr. Henry Woodward mentioned that Mr. Griesbach, who was present, informed him that his fellow traveller, Mr. Hübner, had been over the country described in these papers, and had communicated a map and a paper thereon in July, 1870, to Petermann's Journal.

Mr. Griesbach stated that the rock described as metamorphic in the paper was by M. Hübner regarded as melaphyre, and that in some parts of the Vaal valley the beds of the Karoo formation might be seen *in situ*. He disputed the possibility of any of the gravels being of glacial origin. He was convinced that there were no metamorphic rocks on the western side of the Draakensberg; those regarded as such probably belonged to the Karoo formation.

Prof. Tennant commented on the large size of the diamonds from the Cape, of which he had within the last few months seen at least 10,000, many of them from 30 to 90 carats each. Some broken specimens must, when perfect, have been as large as the Koh-i-noor.

Mr. Tobin corroborated the information given by Mr. Stow, and stated that the source of the Vaal was in sandstone, and that it was not until it had traversed some distance that agates, peridot, and spinel were met with. The large diamonds, in his view, occurred principally in old high-level gravels, at a considerable elevation above the river, which had much deepened its valley since the time of their deposit. At Du Toit's Pan, however, none of the diamonds, nor indeed any of the other stones, showed any signs of wear; and he considered that at that spot was one of the centres at which diamonds had been found in their original matrix.

Mr. Daintree stated that in Australia there were agate-bearing beds of amygdaloid greenstone, similar to those in South Africa, and that he had called attention to their existence in the neighbourhood of the Burnett river, where since then a diamond of the value of £80 had been discovered.

Mr. Maskelyne commented on the dissimilarity of the minerals found in the diamond-bearing beds of Brazil from those of Du Toit's Pan or of South Africa generally. He thought that possibly the minerals described as peridot and spinel might be bronzite and garnet, which, however, came from igneous rocks; and the remarkable fact was that with them occurred unrolled natrolite and diamonds in an equally unrolled condition, which was suggestive of their having been due to a common origin.

Mr. Ward gave an account of an examination of some of the rock from Du Toit's Pan, with a view of discovering microscopic diamonds, none of which, however, had been found.

Prof. Rupert Jones had been equally unsuccessful in the search for minute diamonds, both in sand from Du Toit's and in the ocherous gravel from Klip Drift. He pointed out the water-worn condition of the agate from Du Toit's Pan, which showed aqueous action, though there were also several other minerals present in a perfectly fresh and unrolled condition. He thought a careful examination of the constituent parts of the gravel might ultimately throw light on their origin. That fluviatile action was sufficient to account for their presence had already been shown by Dr. Rubidge and others, who had treated of the grand plateaux and denudations of the district under notice.

II. Royal Geological Society of Ireland.—This Society met on the evening of Wednesday, November 8th, 1871. Edward Hull, Esq., F.R.S., Director of the Irish branch of the Geological Survey, in the Chair.

Dr. Frazer exhibited some diamonds from the South African fields.

Mr. G. H. Kinahan, M.R.I.A., of the Geological Survey, read a short paper on the Coal-measures of Ireland. This communication was a reply to a statement made before the Society in January last in a paper, "On the Ballycastle Coal-field," by Mr. E. Hull, in which it was asserted that there were true Coal-measures in Connaught, while none exist in the provinces of Munster or Leinster, as laid down in the Geological Maps published under the direction of the late Mr. J. B. Jukes. The author of this paper showed that the Coal-measures of Leinster, Munster, and Connaught were identical; therefore, if Mr. Hull's statement respecting Connaught was correct, his assertion as to Munster and Leinster must be wrong. He pointed out that the late Mr. Foot and himself wished to divide the Coal-measures into four series, but that the late Mr. Jukes objected, and stated, "If we were to seek to force this Coal-measure series into a strict analogy with those of other districts, we might look upon these lower black shales with marine fossils as the representative of the upper limestone shale of Derbyshire; and the set of sandstones and flagstones No. 2 as the representative of the Millstone Grit of that county. It would, however, be *impossible* in the South of Ireland to draw any recognizable boundary subdividing the Coal-measure series, and the attempt would, therefore, only tend to confusion." The author next pointed out that palæontologically the Coal-measures of Kilkenny, Queen's County, Limerick, Clare, Kerry, etc., were similar to those of Coalbrookdale, Staffordshire, and other places in England.

Mr. W. Hellier Baily, F.G.S., gave a list of the fossils common to both the English and Irish Coal-measures.

Mr. Hull, F.R.S., briefly replied, and referred chiefly to the lower members of the Coal-measures in England, with which he compared the Irish coal.

The Secretary, Prof. McAlister, exhibited the skull of the grizzly bear (*Ursus ferox*), found in digging the Ulster Canal. This led to a discussion on fossil bears, after which the Society adjourned.

CORRESPONDENCE.

RIVER TERRACES, ETC.

Sir,—I make no remarks on the obliging expressions at the end of the Rev. Mr. Bonney's letter (Geol. Mag., p. 526), but the beginning of his letter *is* of public and scientific interest. He says, "I certainly did not understand that Colonel Greenwood was speaking *solely* (Mr. Bonney's italics) of terraces in closed valleys. This, it appears to me, was by no means clearly brought out in his first letter. With regard to these, I can only say that, owing to the general correspondence between all these terraces that I have seen and those in the open valleys, it seems more natural to refer both to the same cause."

The difference between the two is this, that marine terraces (including those deposited in "fiords") cannot be formed without a *general* cause, that is, without a general subterranean upthrow of the *district*. Whereas inland terraces arise from a *local* cause, that is, flood and deposit caused by rain-water checked at a gorge, and when the gorge, by erosion, is widened and deepened, the alluvium being cut into two parallel terraces.

With regard to my first letter (Geol. Mag., April, 1871) "speaking *solely* of terraces in closed valleys," the first half of that letter is on marine terraces. The second half begins, "So far in reference to marine alluvial plains," and refers to the difference of the causes of marine and inland terraces. My letter exists in black and white. Has Mr. Bonney written his letter without referring to mine?

Brookwood Park, Alresford,
2 *November*, 1871.

George Greenwood, Colonel.

ROYAL COAL COMMISSION.

Sir,—In the review of the Royal Coal Commission Report (Geol. Mag., p. 520, November, 1871) the reviewer has fallen into an error in stating that I reported to the Commissioners on South Staffordshire, East Worcestershire, and Shropshire. By reference to vol. i., p. 27, of the Report it will be found that Mr. John Hartley, of Tong Castle, Shropshire, reported upon South Staffordshire and East Worcestershire. My report only refers to the county of Shropshire (*vide* p. 28), the charge of which I was intrusted with by Mr. Hartley, one of the Commissioners.

I regret that my evidence on the co-relation of the Shropshire and Staffordshire Coal-fields is not published in detail in vol. ii. Prof. Ramsay has given an importance to it by his remarks (p. 121, vol. i. Coal Commission Report) which it might not otherwise have enjoyed. I hope shortly to arrange for its appearance in print, so that the reader may judge for himself of the reasonableness of my arguments.

Albrighton, near Wolverhampton,
November 8, 1871.

Daniel Jones.

RELATIVE AGES OF IGNEOUS ROCKS.

Sir,—On my return from Italy a few days since, I had the pleasure of reading Mr. Allport's article, "On the Relative Ages of Igneous Rocks," in the Geol. Mag. for October, p. 448. I am obliged to him for directing my attention to an error into which I was led by quoting from my impression of the results of Mr. Forbes's researches on the microscopical structure of basalts, and if I have incorrectly represented them, I sincerely apologize.

I am glad, however, that I have correctly stated the result of Mr. Allport's own observations, with which I was well acquainted through the valuable papers he has contributed to this Magazine, and I take this opportunity of thanking him for the ready assistance he afforded myself when commencing the microscopical examination of rocks. As he has shown, olivine, which was once considered as characteristic of Tertiary or modern basalts, is present either in its primary form or by its pseudomorphs in melaphyres, dolerites, and basalts of various geological epochs; and with reference to Dr. Zirkel, whose name I ventured also to quote, I have it on very good authority that he has arrived at a similar conclusion.

My own observations on the microscopical structure of basalts and dolerites are not sufficiently extended to enable me to come to any certain conclusion as regards the presence of olivine, or the structural peculiarities of rocks of different ages. It is, in the first place, often quite impossible to determine to what geological period or epoch a trap-dyke may be referable. In the case of the Mourne Mountains we have an unusual means for the determination of the relative ages of two sets of basaltic or doleritic dykes, owing to their relations to the granite; and we cannot be far wrong in assuming that the dykes more recent than the granite are referable to the Tertiary epoch, and that those more ancient than the granite are of Upper Carboniferous, or possibly Permian, age. Now, on referring to my notes of the few specimens I have been able to examine microscopically from this district, I find that the crystalline grains of olivine, or its pseudomorphs, are (as far as I can determine) only present in the more recent dykes. The number of specimens is, however, quite insufficient for any general conclusions to be founded on them.

In conclusion, allow me to express a hope that Mr. Allport will not be content with publishing a few papers on the interesting branch of inquiry which he has been pursuing for some years back. Since the publication of Zirkel's work on the microscopical structure of basalt, with figures and descriptions of the crystalline forms of sliced specimens of minerals, students have been placed at a great advantage as regards the augitic group of rocks. We are now much in need of similar hand-books of reference for diorites, diabasic rocks, felstones, and lavas, with their varieties. As Mr. Allport has, I believe, submitted several hundred specimens to examination, I feel sure he has the materials at hand for a valuable work.

ROYAL COLLEGE OF SCIENCE,
STEPHEN'S GREEN, DUBLIN, *Nov.* 8, 1871. EDWARD HULL.

SILICIFIED CORAL ON THE COAST OF SUSSEX, ETC.

SIR,—The specimens of silicified wood occurring on the beach at Hove, near Brighton, are, no doubt, derived from the Upper Greensand, and will at once be recognized by those familiar with that occurring on the coast near Axmouth, in South Devon.

The semi-chalcedonic chert composing the specimens of silicified coral is more characteristic of the Upper Greensand than the Oolite; that found at Hove exhibits a boring lined with chalcedony, such as may be seen in the Greensand silicified wood. Their greater abundance at Sandown than elsewhere, in which neighbourhood the Greensand is exposed, would be corroborative of such an origin; though specifically they would be assigned to the Oolite. The specimens I have seen vary in quality, and would appear to be derived from distinct localities. I have seen numberless specimens of the Tisbury coral in collections at Salisbury and elsewhere, so am able to judge of the comparative appearance of the specimens.

November 13*th*, 1871. S. G. PERCEVAL.

MISCELLANEOUS.

COAL DISCOVERY.—An important discovery of coal has been made at Halesowen, a village on the East Worcestershire side of the Black Country, and within a few miles of Birmingham. Mr. J. S. Dawes has been sinking trial shafts and exploring in this neighbourhood for the last seven years and at length, after an expenditure of £20,000, his enterprise has been rewarded by the discovery of a seam of coal, 14 feet thick and of excellent quality. It is believed, from the position and general features of the measure, that its thickness will be found to increase as the work progresses. Enough has, however, already been proved to controvert the theories hitherto held as to the boundary of the coal-field in this direction, and the impending exhaustion of the Black Country fuel supply. The coal lies at a depth of about 420 yards, a headway of 1,005 yards having been driven from the bottom of one of the trial shafts. Mr. Dawes intends to continue his lateral excavations 1,000 yards further, through the property of Lord Lyttelton.—*The Times*, 24th November.

ERRATA.—Page 505, last line, *for* "H. B. W." *read* "H. W. B." Page 501, line 22 from top, *for* "bends" *read* "bend."

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