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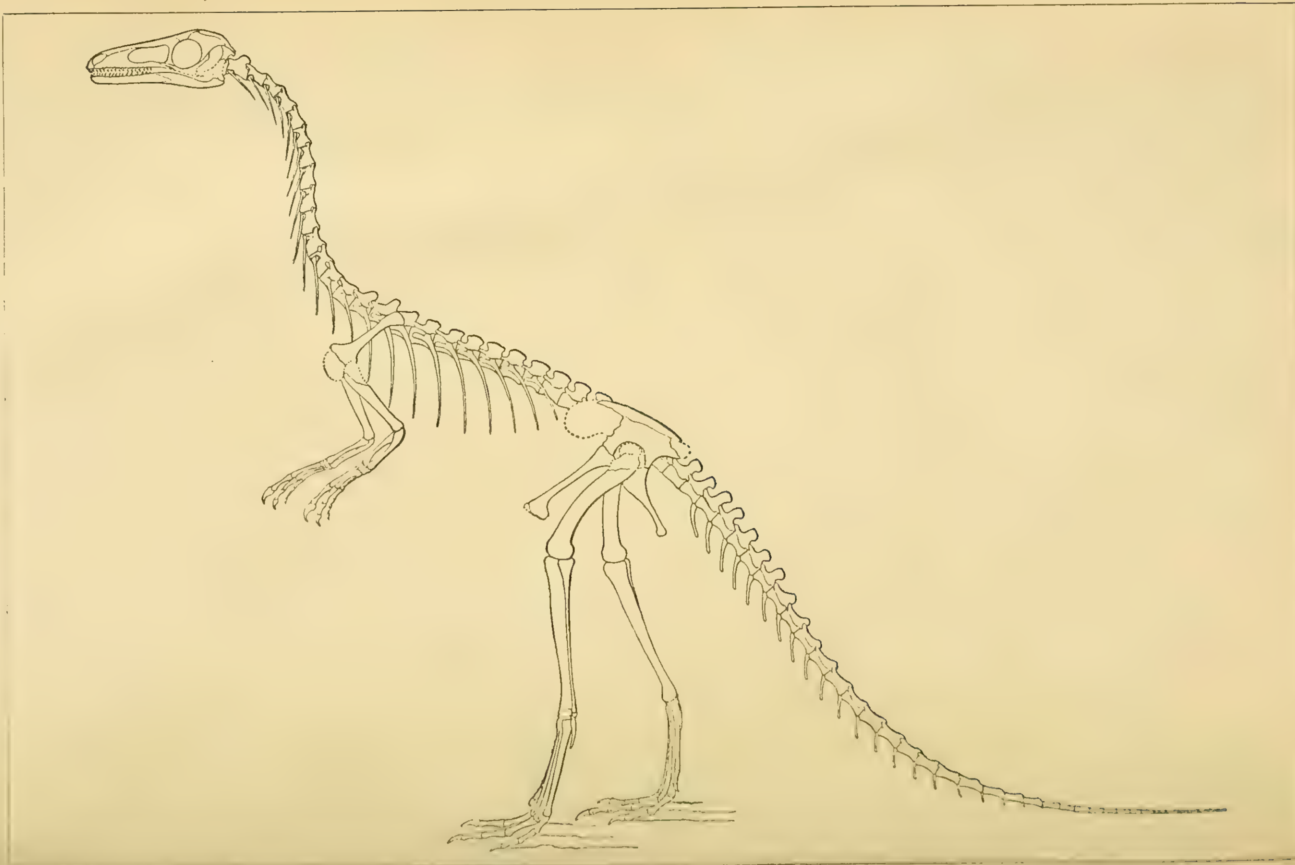
LIST OF PLATES.

LIST OF ILLUSTRATIONS IN THE TEXT.



THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. I.—JANUARY, 1896.

ORIGINAL ARTICLES.

I.—Restoration of some European Dinosaurs, with Suggestions as to their Place among the Reptilia.[1]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.

(PLATES I–IV.)

FOR several years I have been engaged in investigating the Dinosaurs of North America, where these extinct reptiles were very abundant during the whole of Mesozoic time. The results of my study have been published from time to time, and I have already had the honour of presenting some of these to the British Association. In carrying out this investigation so as to include the whole group of Dinosaurs, wherever found, and bringing all under one system of classification, it has been necessary for me to study the remains discovered in Europe, and I have made several visits to this country for that purpose.

In comparing the forms known from the two continents, certain important differences, as well as some marked resemblances between the two, have been observed, and placed on record. In concluding my investigations of the North American forms, I have fortunately been able to make restorations of the skeletons of quite a number of very complete type specimens, and this has proved a most instructive means of comparing those from different horizons, and of different groups, among the known Dinosauria of America.

The success of this plan rendered it very desirable to extend it, if possible, to the best-known forms of European Dinosaurs. This I have been enabled to do in a few instances, and the main object of the present paper is to lay these latest results before you.

In approaching the subject of European Dinosaurs, and especially those of England, where the study of the group first began, I am well aware that I am on delicate ground, since many and various opinions have been expressed in regard to the nature of the remains here discovered, and particularly as to the form and appearance during life of the animals they represent. I may, perhaps, be permitted, in this connection, to say, what has often occurred to me, that the Dinosaurs seem to have been rather unfortunate, and

[1] Abstract of paper read before Section C, British Association for the Advancement of Science, Ipswich, September 14th, 1895.

to have suffered much from both their enemies and their friends. Many of them were destroyed and dismembered long ago by their natural enemies, but, more recently, their friends have done them further injustice in putting together their scattered remains, and restoring them to supposed lifelike forms.

You are all doubtless familiar with the story told by your witty countryman, George Lewis, in his life of Goethe, of an international attempt to reconstruct the camel. To complete this task, the Englishman, it is said, travelled to distant lands, studied the animal in its native wilds, and then prepared his report; the Frenchman went to the museum in Paris, examined stuffed specimens and skeletons, and wrote his account; while the German remained in his study at home, meditated on the subject, and finally evolved his idea of the camel from his inner consciousness. Similar methods, but not on the same international lines, have been followed in the case of the Dinosaurs, and if some of those that have been restored could speak, whatever they might say about the prehistoric enemies that destroyed them, they would surely ask to be saved from their latter-day friends.

Seriously, I think justice has not been done to this remarkable group of reptiles in rehabilitating them for the benefit of the rising generation in science, and some of the attempts, I fear, have been so firmly implanted in text-book literature, that, like the oft-repeated myth of the "coral insect," the errors will pass down to the next century before being eradicated. The German method has sometimes been used by Anglo-Saxons, and with a success quite equal to that in the case of the camel. To take one instance familiar to you all, let me mention *Megalosaurus*, the first Dinosaur described, and also *Iguanodon*, an herbivorous colleague, on which it doubtless preyed. The first restoration of these two reptiles made them, as they were supposed to be in life, quadrupedal, or four-footed animals, of forbidding aspect, and as such they have since haunted the visions of several generations, young and old, by night and by day. I have just made a pilgrimage to Sydenham to see with my own eyes these famous restorations, and, so far as I can judge, there is nothing like unto them in the heavens, or on the earth, or in the waters under the earth. We now know from good evidence that both *Megalosaurus* and *Iguanodon* were bipedal, and to represent them as creeping, except in their extreme youth, would be almost as incongruous as to do this by the genus *Homo*.

Lest it be supposed that I consider the Dinosaurs alone to have suffered from the attempts of their friends to restore them to life, I might recall to your remembrance the well-known figure in the text-books of *Dinotherium*, reclining peacefully, with its feet and limbs concealed, for the simple reason that no one knew anything about them; or that other picture of the *Labyrinthodon* without a tail, deliberately making footprints upon the sands of time, while no such form has yet been discovered. I might refer to still more frightful examples of the dangers encountered by over-zealous historians of ancient life, but those given will suffice.

Restorations of European Dinosaurs.

The restorations of Dinosaurs I have now to submit to you are four in number, and represent some of the best-known European forms, types of the genera *Compsognathus*, *Scelidosaurus*, *Hypsilophodon*, and *Iguanodon*. These outline restorations have been prepared by me mainly for comparison with the corresponding American forms, but in part to insure, so far as the present opportunity will allow, a more comprehensive review of the whole group. The specimens restored are all of great interest in themselves, and of special importance when compared with their nearest American allies.

Compsognathus. (Plate I.)

The first restoration, that of *Compsognathus longipes*, Wagner, 1861, shown one-fourth natural size in Plate I, is believed to represent fairly well the general form and natural position, when alive, of this diminutive carnivorous Dinosaur, that lived during the Jurassic period. The basis for this restoration comprises—(1) a careful study of the type specimen itself, made by me in Munich, in 1881; (2) an accurate cast of this specimen, sent to me by Prof. von Zittel; and (3) a careful drawing of the original made by Krapf, in 1887. The original description and figure of Wagner (Bavarian Academy of Sciences, 1861), and those of later authors, have also been used for some of the details. No restoration of the skeleton of this unique Dinosaur has hitherto been attempted.[1]

Compsognathus has been studied by so many anatomists of repute since its discovery, that any attempt to restore the skeleton to a natural position will be scrutinized from various points of view. My interest in this unique specimen led me long ago to examine it with care, and I have since made a minute study of it, as related elsewhere, not merely to ascertain all I could about its anatomy, but also to learn, if possible, what its relations were to another diminutive form, *Hallopus*, from a lower horizon in America, which has been asserted to be a near ally. Both are carnivorous Dinosaurs, probably, but certainly on quite different lines of descent.

The only previous attempt to restore this remarkable Dinosaur was by Huxley, when in America, in 1876. He made a rapid sketch from the Wagner figure, and I had this enlarged for his New York lecture. This sketch, reproduced on the diagram on p. 4 (Fig. 1), represents the animal sitting down, a position which such Dinosaurs occasionally assumed, as shown by the footprints in the Connecticut Valley, which Huxley examined in place at several localities with great interest.

The great majority of Dinosaurian footprints preserved were certainly made during ordinary locomotion, although some series show evidence of more rapid movement. All those referred to

[1] The remains of the embryo within the skeleton of *Compsognathus*, first detected by me in 1881, while examining the type specimen, is not represented in the present restoration. This unique fossil affords the only known evidence that Dinosaurs were viviparous.

carnivorous Dinosaurs are bipedal, and this is true of the footprints of many herbivorous forms.

In the present restoration of *Compsognathus* (Plate I) I have tried to represent the animal as walking, in a characteristic and lifelike position.

FIG 1.—Sketch of *Compsognathus longipes*, Wagner. One-seventh natural size. (After Huxley.)

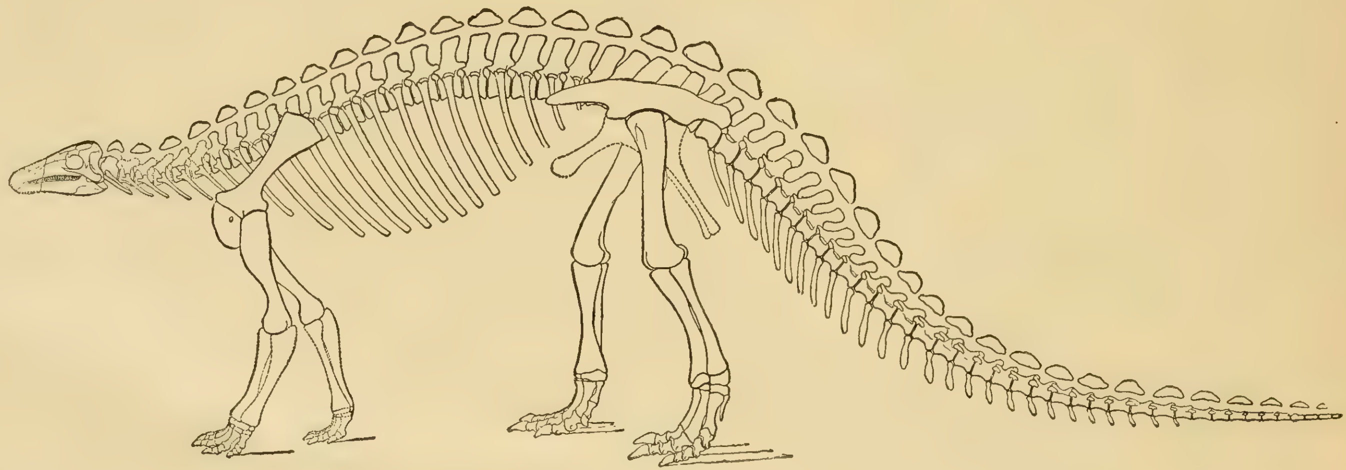
Scelidosaurus. Page 5 (Plate II).

The second of these restorations is that of *Scelidosaurus Harrisonii*, of Owen, shown one-eighteenth natural size on p. 5 (Plate II). This reptile was an herbivorous Dinosaur of moderate size, related to *Stegosaurus*, and was its predecessor from a lower geological horizon in England. This restoration is essentially based upon the original description and figures of Owen (Palæontographical Society, 1861). These have been supplemented by my own notes and sketches, made during examinations of the type specimen, now in the British Museum.

Scelidosaurus is a near relative, as it were, of one of our American forms, *Stegosaurus*, now represented by so many specimens that we know the skull, skeleton, and dermal armour with much certainty. The English form known as *Omosaurus* is still more nearly allied to *Stegosaurus*, perhaps identical.

A restoration of the skeleton of *Scelidosaurus*, by Dr. Henry Woodward, will be found in the British Museum Guide to Geology and Palæontology, 1890, p. 19. The missing parts are restored from *Iguanodon*, and the animal is represented as bipedal, as in that genus.

In the present outline restoration of *Scelidosaurus*, I have endeavoured merely to place on record my idea of the form and position of the skeleton, when the animal was alive, based on the remains I have myself examined. In case of doubt, as, for example, in regard to the front of the skull, which is wanting in the type



Restoration of *Scelidosaurus Harrisonii*, Owen. One-eighteenth natural size. Lower Lias. Charmouth, Dorset.

specimen, I have used a dotted outline, based on the nearest allied form. Of the dermal armour, only the row of plates best known is indicated. The position chosen in this Figure (Pl. II) is one that would be assumed by the animal in walking on all four feet, and this I believe to have been its natural mode of progression.

Hypsilophodon. (Plate III.)

The third of these restorations, that of *Hypsilophodon Foxii*, Huxley, 1870, given in outline, one-eighth natural size, in Plate III, has been made with much care, partly from the type specimen and in part from other material mostly now in the British Museum. The figures and description by the late Dr. Hulke [1] were of special value, although my own conclusions as to the natural position of the animal when alive do not coincide with those of my honoured friend, who did so much to make this genus of Dinosaurs, and others, known to Science. The restoration by Dr. Hulke is shown in the subjoined diagram (Fig. 2).

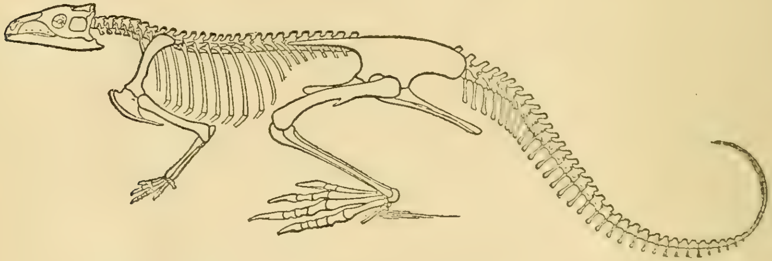


FIG. 2.—Restoration of *Hypsilophodon Foxii*, Huxley. One-tenth natural size. (After Hulke.)

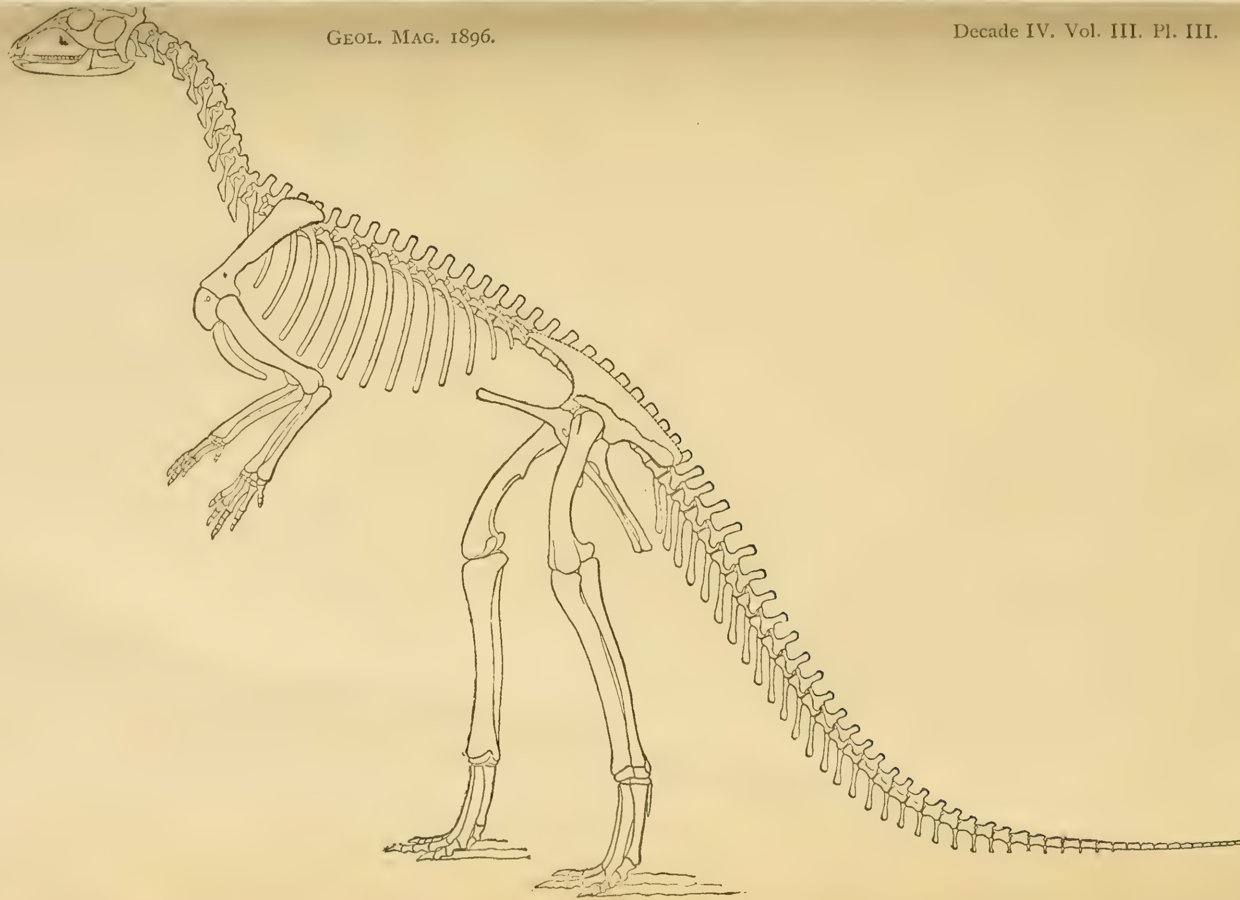
In the case of *Hypsilophodon*, a number of specimens are available instead of only one. This makes the problem of restoration in itself a simpler matter than in *Scelidosaurus*. Moreover, we have in America a closely allied form, *Laosaurus*, of which several species are known. A study of the genus *Laosaurus*, and the restoration of *Hypsilophodon* given on Plate III, will clear up several points long in doubt.

Huxley and Hulke both shed much light on this interesting genus, *Hypsilophodon*; indeed, on many of the Dinosauria. The mystery of the Dinosaurian pelvis, which baffled Cuvier, Mantell, and Owen, was mainly solved by them—the ilium and ischium by Huxley, and the pubis by Hulke. The more perfect American specimens have demonstrated the correctness of nearly all their conclusions.

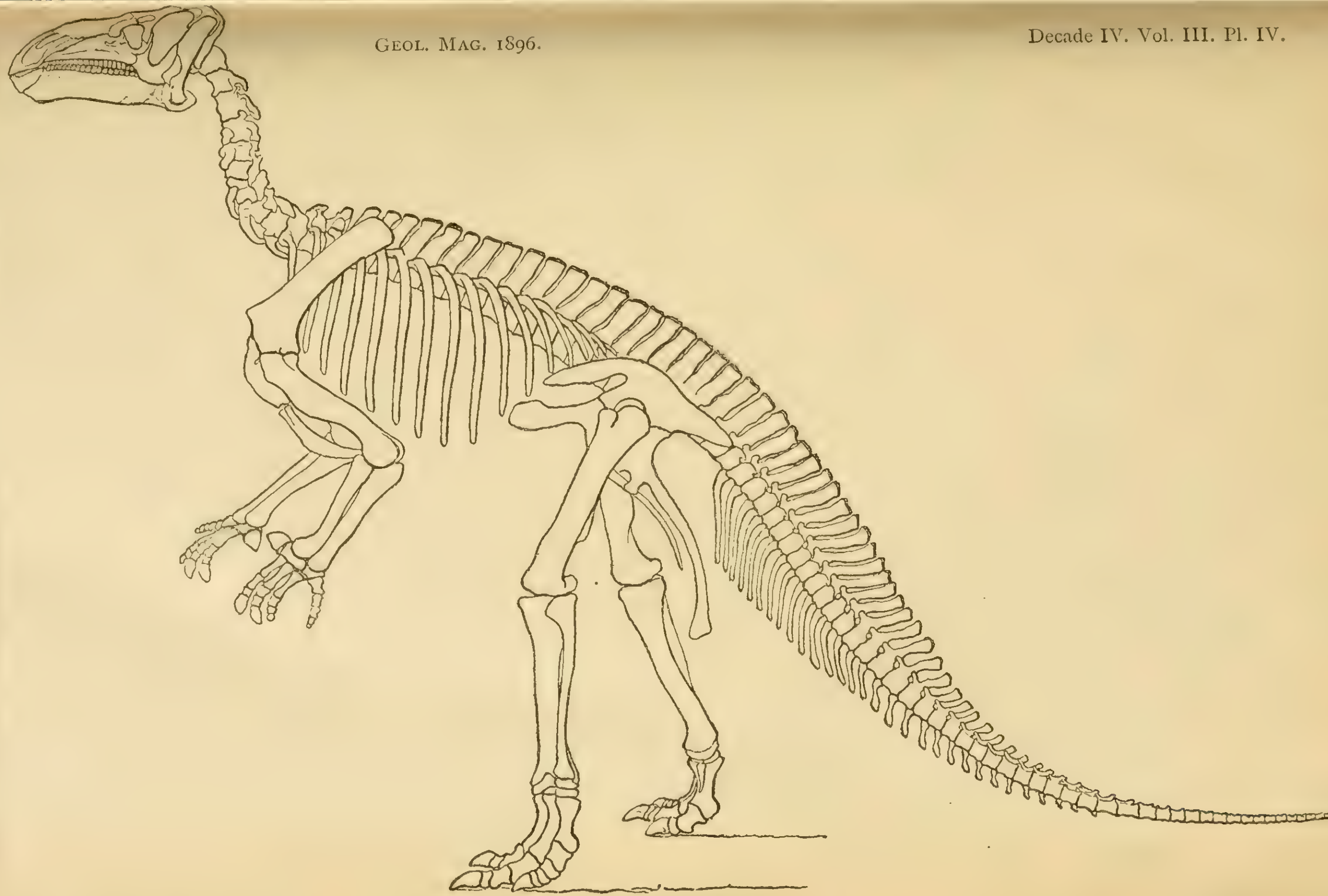
Iguanodon. (Plate IV.)

The fourth restoration here given, that of *Iguanodon Bernissartensis*. Boulenger, 1881, one-fortieth natural size, has been made in outline for comparison with American forms. It is based mainly on photographs

[1] Philosophical Transactions, 1882.



Restoration of *Hypsilophodon Foxii*, Huxley. One-eighth natural size. Wealden. Cowleaze Chine, Isle of Wight.



Restoration of *Iguanodon Bernissartensis*, Boulenger. One-fortieth natural size. Wealden, Belgium.

of the well-known Belgian specimens, the originals of which I have studied with considerable care during several visits to Brussels. The descriptions and figures of Dollo[1] have been used in the preparation of this restoration. A few changes only have been introduced in the accompanying Plate, based mainly upon a study of the original specimens.

Besides the four genera here represented, no other European Dinosaurs at present known are sufficiently well preserved to admit of accurate restorations of the skeleton. This is true, moreover, of the Dinosaurian remains from other parts of the world outside of North America.

To present a comprehensive view of the Dinosaurs, so far as now known, I have prepared a plate, here shown, which gives restorations of the twelve best-known types, as I have thus far been able to reconstruct them. Of these twelve forms, eight are from America: *Anchisaurus*, a small carnivorous type from the Trias; *Brontosaurus*, *Camptosaurus*, *Laosaurus*, and *Stegosaurus*, all herbivorous, and the carnivorous *Ceratosaurus*, from the Jurassic; with *Claosaurus* and *Triceratops*, herbivores from the Cretaceous. These American forms, with the four from Europe already noticed, complete the series represented on this chart.[2] They form an instructive group of the remarkable reptiles known as Dinosauria.

The geological positions of *Compsognathus* and of *Scelidosaurus* are fully determined, but that of *Hypsilophodon* and *Iguanodon* is not so clear. The latter are found in the so-called Wealden, but just what the Wealden is I have not been able to determine from the authorities I have consulted. The Cretaceous age of these deposits appears to be taken for granted here, but the evidence as it now stands seems to me to point rather to the Upper Jurassic as their true position. If I should find the vertebrate fossils now known from your Wealden in the Rocky Mountains, where I have collected many corresponding forms, I should certainly call them Jurassic, and have good reason for so doing. Moreover, after visiting typical Wealden localities here and on the Continent, I can still see no reason for doing otherwise so far as the vertebrate fossils are concerned, and in such fresh-water deposits their evidence should be conclusive. I have already called attention to this question of the age of the Wealden, and do so again, as I believe it worthy of a careful reconsideration by English geologists.

EXPLANATION OF PLATES I–IV.

PLATE I.—Outline restoration of the skeleton of *Compsognathus longipes*, Wagner. One-fourth natural size. Jurassic, Bavaria.

PLATE II.—Outline restoration of the skeleton of *Scelidosaurus Harrisonii*, Owen. One-eighteenth natural size. Jurassic, England.

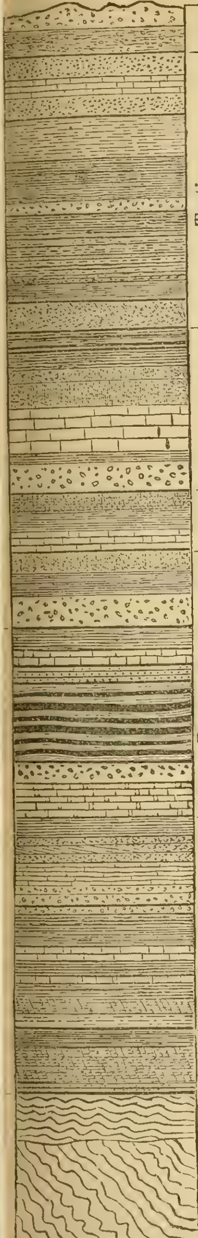
PLATE III.—Outline restoration of the skeleton of *Hypsilophodon Foxii*, Huxley. One-eighth natural size. Wealden, England.

PLATE IV.—Outline restoration of the skeleton of *Iguanodon Bernissartensis*, Boulenger. One-fortieth natural size. Wealden, Belgium.

[1] Bulletin Royal Museum of Belgium, 1882–1888.

[2] A copy of this Chart will appear in the next Number of this MAGAZINE.—EDIT. GEOL. MAG.

TABLE OF BRITISH STRATA WITH THEIR NORTH AMERICAN EQUIVALENTS, AND A LIST OF THE VERTEBRATE FOSSILS WHICH ARE FOUND IN THEM IN THE UNITED STATES.



Recent. Quaternary.			Tapir, Peccary, Bison. *Bos, Equus, Tapirus, Dicotyles, Megatherium, Mylodon.*
Tertiary	Pliocene.	Equus Beds.	*Equus, Tapirus, Elephas.*
		Pliohippus Beds.	*Pliohippus, Tapiravus, Mastodon, Procamelus, Aceratherium, Bos, Morotherium, Platygonus.*
	Miocene.	Miohippus Beds.	*Miohippus, Diceratherium, Thinohyus, Protoceras.*
		Oreodon Beds.	*Oreodon, Eporeodon, Hyænodon, Moropus, Ictops, Hyracodon, Agriochœrus, Colodon, Leptochœrus.*
		Brontotherium Beds	*Brontotherium, Brontops, Allops, Titanops, Titanotherium, Mesohippus, Ancodus, Entelodon.*
	Eocene.	Diplacodon Beds.	*Diplacodon, Epihippus, Amynodon, Eomeryx.*
		Dinoceras Beds.	*Dinoceras, Tinoceras, Uintatherium, Palæosyops, Orohippus, Hyrachyus, Colonoceras, Homacodon.*
		Heliobatis Beds.	*Heliobatis, Amia, Lepidosteus, Asineops, Clupea.*
		Coryphodon Beds.	*Coryphodon, Eohippus, Eohyus, Hyracops, Parahyus* Lemurs, Ungulates, Tillodonts, Rodents, Serpents.
Cretaceous.		Laramie Series, or Ceratops Beds.	*Ceratops, Triceratops, Claosaurus, Ornithomimus.* Mammals, *Cimolomys, Dipriodon, Selenacodon, Nanomyops, Stagodon.* Birds, *Cimolopteryx.*
		Fox Hills Group.	
		Colorado Series, or Pteranodon Beds.	Birds with Teeth, *Hesperornis, Ichthyornis, Apatornis.* Mosasaurs, *Edestosaurus, Lestosaurus, Tylosaurus.* Pterodactyls, *Pteranodon.* Plesiosaurs, Turtles.
		Dakota Group.	
Jurassic.		Atlantosaurus Beds Baptanodon Beds. Hallopus Beds.	Dinosaurs, *Brontosaurus, Morosaurus, Diplodocus, Stegosaurus, Camptosaurus, Ceratosaurus.* Mammals, *Dryolestes, Stylacodon, Tinodon, Ctenacodon.*
Triassic.		Otozoum, or Conn. River, Beds.	First Mammals, *Dromatherium.* First Dinosaurs, *Anchisaurus, Ammosaurus, Bathygnathus, Clepsysaurus.* Many footprints. Crocodiles, *Belodon.* Fishes, *Catopterus, Ischypterus, Ptycholepis.*
Permian.		Nothodon Beds.	Reptiles, *Nothodon, Eryops, Sphenacodon.*
Carboniferous		Coal Measures, or Eosaurus Beds.	First Reptiles (?) *Eosaurus.* Amphibians, *Baphetes, Dendrerpeton, Hylonomus, Pelion.* Footprints, *Anthracopus, Allopus, Baropus, Dromopus, Hylopus, Limnopus, Nasopus.*
		Subcarboniferous, or Sauropus Beds.	First known Amphibians (Labyrinthodonts). Footprints, *Sauropus, Thenaropus.*
Devonian.		Dinichthys Beds. Lower Devonian.	*Dinichthys, Acanthodes, Bothriolepis, Chirolepis, Cladodus, Dipterus, Titanichthys.*
Silurian.		Upper Silurian. Lower Silurian.	First known Fishes.
Cambrian.		Primordial.	No Vertebrates known.
Archæan.		Huronian.	
		Laurentian.	

[To illustrate Prof. Marsh's paper on European Dinosaurs.]

II.—The European Species of *Etoblattina*, with Description of a New Form.

By Samuel H. Scudder.

FOR the convenience of students a first essay is here made to tabulate the European species of *Etoblattina*, the genus of Cockroaches most numerously represented in Carboniferous times, both in Europe and America. All the species described up to the present time are introduced, together with a new British species, a description of which is added. It will be seen that Deichmüller's var. *Stelzneri* (regarded by him as a form of *E. flabellata*) and Geinitz's var. *dyadica* (regarded by him as another form of the same) are considered distinct species; and that *E. Rollei*, Deichm., is not included, this last being more probably a *Gerablattina*. *E. Peachii*, Woodw., is also omitted, as the tegmina are undeveloped and therefore present no features which could admit it into the table. On the other hand, *Blattina intermedia*, Gold., formerly described by me as a *Gerablattina*, has had new light thrown upon it by Kliver, showing it to be an *Etoblattina*, and it is accordingly introduced here.

Table of the European Species of Etoblattina.

a^1. Tegmina broad, at most but little more than twice as long as broad; the mediastinal area usually broad at base, here generally occupying a third or more of the tegmina.
  b^1. Mediastinal area tapering gradually, and relatively long, more, often much more, than four times as long as greatest breadth.
    c^1. Relatively slender, the tegmina distinctly more than twice as long as broad.
      d^1. Apical margin divided between the scapular and externomedian areas. 1. *E. Labachensis.*
      d^2. Apical margin divided between the externomedian and internomedian areas . . . . 2. *E. intermedia.*
    c^2. Tegmina broad, not more than twice as long as broad, the immediate apex occupied by the externomedian branches.
      d^1. Tegmina less than twice as long as broad; mediastinal area reaching nearly to the middle of the distal half of the tegmina; externomedian vein first forking not before the middle of the tegmina. 3. *E. propria.*
      d^2. Tegmina twice as long as broad; mediastinal area hardly extending beyond the middle of the tegmina; externomedian vein first branching far before the middle of the tegmina. 4. *E. Deichmülleri.*
  b^2. Mediastinal area tapering rapidly and relatively short, less, often much less, than four times as long as basal breadth.
    c^1. Internomedian area long and numerously branched, falling but little short of the apex of the tegmina.
      d^1. Humeral angle prominent, the tegmina less than twice as long as broad. 5. *E. Steinbachensis.*
      d^2. Humeral angle roundly excised, the tegmina more than twice as long as broad . . . . 6. *E. primæva.*
    c^2. Internomedian area relatively short and with few branches, falling far short of the apex of the tegmina.
      d^1. Mediastinal vein with frequent branches; scapular branches few, mostly forked deeply or compound . . . . 7. *E. Deanensis.*
      d^2. Mediastinal vein with infrequent branches; scapular branches numerous, mostly simple or only apically forked . . . 8. *E. lanceolata.*

a^2. Tegmina relatively slender, rarely less than two and a half times as long as broad; the mediastinal area usually rather slender and ribbon-shaped, not or scarcely broader at base than in the middle, and rarely occupying more than a fourth of the basal width of the tegmina.

b^1. Tegmina distinctly less than three times as long as broad.

c^1. Internomedian area long, but far from attaining the apex of the tegmina, rarely prolonged by distinct sinuosity of the main vein.[1]

d^1. Mediastinal area extending well beyond the middle of the tegmina.

e^1. Externomedian vein first branching beyond the middle of the tegmina. 9. *E. carbonaria.*

e^2. Externomedian vein first branching far before the middle of the tegmina.

f^1. Tegmina of large or medium size, well rounded at apex; externomedian area expanded, and on the margin as important as the scapular.

g^1. First scapular branch arising far before the succeeding, near the middle of the basal half of the tegmina; internomedian vein scarcely sinuate . . . . 10. *E. russoma.*

g^2. First scapular branch arising but little before the middle of the tegmina and at ordinary distance before the succeeding; internomedian vein strongly sinuate . . . . . . 11. *E. dyadica.*

f^2. Tegmina of small size, subacuminate at apex; externomedian area compressed and on margin of much less importance than the scapular . . . . 12. *E. parvula.*

d^2. Mediastinal area scarcely, if at all, surpassing the middle of the tegmina.[2]

e^1. Scapular and externomedian veins first branching at nearly the same point.[3]

f^1. Primary offshoots of the externomedian vein numerous.

g^1. Course of the externo-internomedian interspace gently oblique, arcuate . . . . 13. *E. Manebachensis.*

g^2. Course of the externo-internomedian interspace strongly oblique, sinuous . . . . 14. *E. ornatissima.*

f^2. Primary offshoots of the externomedian vein only two or three in number . . . . 15. *E. anthracophila.*

e^2. First branching of the externomedian vein far beyond that of the scapular . . . . 16. *E. mantidioides.*

c^2. Internomedian area very long, nearly reaching the apex, or reaching the apical margin, often prolonged by distinct sinuosity of the main vein.

d^1. Mediastinal area extending well beyond the middle of the tegmina.

e^1. Scapular vein first branching far beyond the middle of the tegmina. 17. *E. Johnsoni.*

e^2. Scapular vein first branching before, often far before, the middle of the tegmina.

f^1. All the internomedian branches simple or simply forked.

g^1. Scapular vein first branching at some distance before the externomedian . . . . 18. *E. Dohrnii.*

g^2. Scapular vein first branching but little before the externomedian.

h^1. Mediastinal and scapular branches with normal obliquity; internomedian branches frequent, with normal obliquity. 19. *E. didyma.*

h^2. Mediastinal and scapular branches very longitudinally oblique; internomedian branches exceedingly few and longitudinally oblique. 20. *E. bituminosa.*

f^2. Some apical branches of the internomedian vein compound. 21. *E. anaglyptica.*

d^2. Mediastinal area hardly reaching the middle of the tegmina.

[1] This is only conjectural in *E. mantidioides*, but indicated by the parts preserved.
[2] This is conjectural, but probable, in *E. ornatissima* by the brief extent of the scapular area.
[3] Conjectural again, but probable, with *E. ornatissima*.

e^1. Scapular vein in the middle of its course receding from the margin to reach the middle line of the tegmina . . 22. *E. leptophlebica.*

e^2. Scapular vein in the middle of its course hardly receding from the margin and nowhere nearly reaching the middle line of the tegmina . . . . 23. *E. flabellata.*

b^2. Tegmina distinctly more than three times as long as broad; internomedian area long and slender.

c^1. Internomedian area not nearly reaching the apex of the tegmina, with no extension by the distal sinuosity of the main vein.

d^1. Tegmina less than 20 mm. long; course of the main scapular vein distinctly sinuous, and at one point nearly reaching the middle line of the tegmina . . . . 24. *E. affinis.*

d^2. Tegmina more than 30 mm. long; course of the main scapular vein nearly or quite straight, at no point nearly attaining the middle line of the tegmina.

e^1. Tegmina subequal on distal half (apparently; the only specimen is broken), the externomedian vein with regular offshoots from the middle of the tegmina outward . . . . 25. *E. euglyptica.*

e^2. Tegmina tapering considerably throughout the distal half, the externomedian branches all arising close to the apex from two stems which unite at or before the middle of the tegmina. 26. *E. elongata.*

c^2. Internomedian area nearly reaching the apex of the tegmina by the distal sinuosity of the main vein.

d^1. Externomedian vein first forking well before the middle of the tegmina, with many branches; distal portion of anal area with numerous branches . . . . 27. *E. Stelzneri.*

d^2. Externomedian vein first forking at some distance beyond the middle of the tegmina, with few branches; distal portion of the anal area with few branches . . . . 28. *E. Weissigensis.*

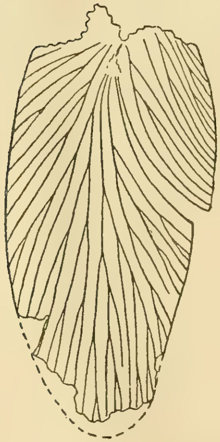


Fig. 1.

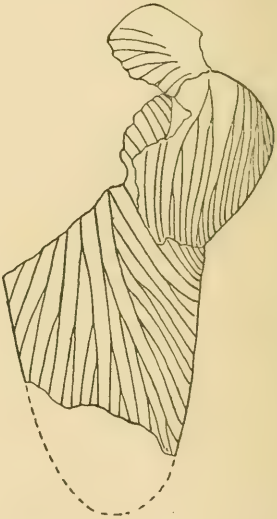


Fig. 2.

Etoblattina Deanensis, sp. nov. (Figs. 1 and 2.)

The fore wing has a very regular elongate oval form, tapering with considerable regularity beyond the middle third of the tegmina, the anal area by its fulness interfering a little with the regularity; it is a little more than two and a quarter times as long as broad; the costal margin has a very regular and moderately convex curve, while the inner margin, beyond the fuller and more convex anal area, is nearly straight; the tip is imperfect in the two specimens known. The veins originate slightly above the middle of the tegmina and at first all curve upward, but not so strongly as in *E. primæva*, to which this species is most nearly allied, so that the externomedian vein passes more nearly through the middle of the tegmina. The mediastinal vein passes in a scarcely sinuous course to somewhat beyond the middle of the front margin, emitting about half a dozen nearly straight simple or deeply forked branches. The scapular vein is broadly and gently sinuous, extending to the apical margin a very little above the apex, begins to fork before the middle of the proximal half of the tegmina, and has four subequidistant branches, of which the first is compound, the others forked or simple. The externomedian vein first forks near the middle of the tegmina, where it divides into two very similar, weakly arborescent, longitudinal stems carrying about ten or a dozen veinlets to the apical, and to the outer portion of the inner, margin. The internomedian vein is very regularly and rather gently arcuate, except for a slight apical sinuosity which carries it nearly to the apical sixth of the tegmina, and has about five nearly straight branches, some of the basal ones simply or doubly forked. The anal furrow is not very deeply impressed, very regularly but not very strongly arcuate, and ends at about the middle of the tegmina. The anal veins consist of two sets, rather widely separated at the base, the inner set consisting of a several-branched main stem subparallel to the anal furrow, the outer of four or five simply or doubly forked, approximated, slightly divergent nervules, more nearly longitudinal than the other set.

The two specimens known, one with its reverse, are coal black: one (Fig. 1) with its reverse is nearly perfect, having lost only the shoulder and the apical margin; the other (Fig. 2) consists of two tegmina, of one of which only the base and the anal area is preserved, and which lies partially concealing the reversed face of the other, of which the basal portion and considerable of the apex is lost. Excepting in the anal and internomedian areas the veins are pronounced, being deeply incised; in the internomedian area they are very delicate. Towards the apex of the tegmina an exceedingly delicate reticulation can be detected in the interspaces, which gives way in the centre of the tegmina to a very close series of dulled cross lines, and become in the scapular area parallel to the nearer margin.

Length of the tegmina, 38 mm.; breadth, 13·25 mm.

The two specimens differ from each other in hardly anything but the simplicity or complexity of the several branches of the main veins, particularly in the upper stem of the externomedian vein and the principal branches of the internomedian vein. In one, however, the costal margin appears to be distinctly more arcuate than in the other.

The species is plainly most nearly allied to *E. primæva*, from which it differs in its more elongate form, apical tapering, the lack of an extreme basal branch of the scapular vein, the far greater importance though later branching of the externomedian vein, the narrower and shorter internomedian area and its simpler apical branching, the more regular curve of the anal furrow, the entire system of anal veins, and the lower course of all the main veins through the middle area of the tegmina.

The specimen with reverse comes from Foxe's bridge, in the Forest of Dean, Gloucester, England. The other was collected by F. Stock at Crump meadow, in the Forest of Dean. Both are in the collection of Mr. R. D. Lacoe, in which they bear the No. 2132*a–b*, *c*.

A List of the Described European Palæozoic Cockroaches.

The species in this list are arranged alphabetically under each genus, but the genera are in a natural order. Several species, because too imperfectly known, are not mentionde, as they cannot be placed. Such are *Blattina ligniperda*, Kušta, from Lubná, Bohemia; *B. neuropteroides*, Göpp., and *B. rarinervis*, Göpp., from an unnamed locality; *B. Tischbeini*, Gold., from Hirschbach, Germany, and *B. venosa*, Gold., from Wemmetsweiler, Rhenish Prussia. *Etoblattina Peachii*, Woodw., from Kilmaurs, Scotland, is also omitted, as the undeveloped tegmina hardly allow it to be definitely placed.

Etoblattina affinis (Gold.), Löbejün and Wettin, Saxony.
,, *anaglyptica* (Germ.), Wettin, Saxony.
,, *bituminosa* (Kušta),[1] Lubná, Bohemia.
,, *carbonaria* (Germ.), Wettin, Saxony.
,, *Deanensis*, Scudd., Forest of Dean, Gloucester, England.
,, *Deichmülleri* (Gein.),[2] Weissig, Saxony.
,, *didyma* (Germ.), Wettin, Saxony; Manebach, Saxe Weimar.
,, *Dohrnii*, Scudd., Wettin, Saxony.
,, *dyadica* (Gein.),[3] Weissig, Saxony.
,, *elongata* (Gein.), Weissig, Saxony.
,, *euglyptica* (Germ.), Wettin, Saxony.
,, *flabellata* (Germ.), Wettin and Weissig, Saxony.
,, *intermedia* (Gold.), Wemmetsweiler, Rhenish Prussia.
,, *Johnsoni*, Woodw., Dudley, England.
,, *Labachensis* (Gold.), Labach, Rhenish Prussia.
,, *lanceolata* (Sterz.), Lugau, Saxony.
,, *leptophlebica* (Gold.), Löbejün, Saxony.
,, *Manebachensis* (Gold.), Manebach, Saxe Weimar.
,, *mantidioides* (Gold.), Durham, England.
,, *ornatissima*, Deichm., Grügelborn, Rhenish Prussia.
,, *parvula* (Gold.), Löbejün, Saxony.
,, *primæva* (Gold.), Saarbrücken, Rhenish Prussia.
,, *propria*, Kliver, Saarbrücken, Rhenish Prussia.
,, *russoma* (Gold.), Löbejün, Saxony.
,, *Steinbachensis*, Kliv., Steinbachthal, Rhenish Prussia.
,, *Stelzneri* (Deichm.),[4] Weissig, Saxony.
,, *Weissigensis* (Gein.), Weissig, Saxony.

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[1] *Blattina* (*Etoblattina*) *bituminosa*, Kušta.
[2] *Blattina* (*Etoblattina*) *carbonaria*, var. *Deichmülleri*, Gein.
[3] *Blattina* (*Etoblattina*) *flabellata*, var. *dyadica*, Gein.
[4] *Etoblattina flabellata*, var. *Stelzneri*, Deichm.

Gerablattina clathrata (Heer), Manebach, Saxe Weimar.
,, *Geinitzi* (Gold.), Löbejün, Saxony.
,, *Germari* (Gieb.), Wettin, Saxony.
,, *Goldenbergi* (Mahr), Manebach, Saxe Weimar.
,, *Mahri* (Gold.), Manebach, Saxe Weimar.
,, *Münsteri*, Scudd., Wettin, Saxony.
,, *producta*, Scudd., Wettin, Saxony.
,, *robusta*, Kliv., Wemmetsweiler, Rhenish Prussia.
,, *Rollei* (Deichm.),[1] Grügelborn, Rhenish Prussia.
,, *scaberata* (Gold.), Altenwald, Rhenish Prussia.
,, *Weissiana* (Gold.), Brücken, Rhenish Bavaria.
Anthracoblattina camerata, Kliv., Dudweiler, Rhenish Prussia.
,, *Dresdensis* (Gein.-Deichm.), Klein Opitz, Saxony.
,, *incerta*, Kliv., Dudweiler, Rhenish Prussia.
,, *Lubnensis* (Kušta),[2] Lubná, Bohemia.
,, *porrecta* (Gein.), Weissig, Saxony.
,, *Remigii* (Dohrn), Cusel, Rhenish Bavaria.
,, *Rückerti* (Gold.), Stockheim, Bavaria.
,, *Scudderi*, Gold., Wemmetsweiler, Rhenish Prussia.
,, *sopita*, Scudd., Weissig, Saxony.
,, *spectabilis* (Gold.), Weissig? and Löbejün, Saxony.
,, *Wagneri*, Kliv., Löbejün, Saxony.
,, *Winteriana* (Gold.), Dudweiler, Rhenish Prussia.
Hermatoblattina Kirkbyi (Woodw.), Fifeshire, Scotland.
,, *Labachensis* (Gold.), Labach, Rhenish Prussia.
,, *Wemmetsweileriensis* (Gold.), Wemmetsweiler, Rhenish Prussia.
Progonoblattina Fritschii (Heer), Manebach, Saxe Weimar.
,, *Helvetica* (Heer), Erbignon, Switzerland.
Oryctoblattina Arndti, Kušta, Třemošná, Bohemia.
,, *oblonga*, Deichm., Weissig, Saxony.
,, *reticulata* (Germ.), Wettin, Saxony.
Petrablattina gracilis (Gold.), Labach, Rhenish Prussia.
Leptoblattina exilis, Woodw., Dudley, England.
,, *insignis* (Gold.), Dudweiler, Rhenish Prussia.

III.—On Perlitic Structure.

By W. W. Watts, M.A., F.G.S.

I HAVE received from my friend Mr. W. F. Smeeth a paper entitled "A Perlitic Pitchstone from the Tweed River, New South Wales, with remarks on the so-called Perlitic Structure in Quartz," published by the Royal Society of New South Wales. While thanking him for his courtesy in making me acquainted with his views, I desire at the same time to express my sense of the kindly way in which he has criticized, though often adversely, certain statements already published by me.[3] It may be of interest to give to the readers of the Geological Magazine an abstract of the excellent piece of work which Mr. Smeeth has done, as well as to draw attention to the points in which he has compelled me to agree with him and to remark on those on which there is still some difference of opinion between us.

The glassy matrix of the rock, which is admirably perlitic, contains phenocrysts of quartz, sanidine, albite, and hypersthene. The last mineral is in small distinct grains of prismatic habit, which

[1] *Etoblattina Rollei*, Deichm.
[2] *Blattina* (*Anthracoblattina*) *Lubnensis*, Kušta.
[3] Quart. Journ. Geol. Soc. vol. L (1894), pp. 367–76.

contain inclusions of magnetite, zircon, and apatite, but none of the metallic-looking plates which are so common in this mineral; the magnetite grains, which occur at times in the glass of the rock and at times partly in the hypersthene and partly in the glass, Mr. Smeeth regards as derived from the hypersthene by solution. The presence of this mineral in so acid a rock, one which contains 75·5 per cent. of silica, is a remarkable feature. The bulk analysis shows that more than twice as much potash as soda is present, but the analysis of the matrix, after removal of the phenocrysts, proves that most of the latter oxide is in the glass, of the former in the porphyritic crystals. 1·3 per cent. of soda will be in the sanidine, and 1·9 of lime in the albite. The albite occurs in the glass as straight and forked microlites, the other constituents in the glass being crystallites, mainly in the form of a central axis with two, three, or four rows of globulites arranged along it.

The quartz crystals are traversed by curved cracks, so like those described by myself as perlitic that the author regards them as identical, and it seems to me quite rightly. He remarks, however, that "if 'perlitic' simply implies that a crack is curved and may reasonably be inferred to be due to contraction on cooling, then the majority of these cracks are undoubtedly perlitic," but adds later that he hopes to show "that typical perlitic cracks present well-marked characteristic features, which give them the right to be considered as forming a distinct and definite rock-structure, and which features are markedly different to those exhibited by the cracks in the quartz."

Mr. Smeeth then gives in some detail the method of producing artificial perlites in balsam, and insists on the necessity of using a ground glass surface in order to produce the cracks in perfection. On watching the process under the microscope, when it is allowed to take place slowly, a set of polygonal cracks is seen to make its appearance first, "and then each individual perlite springs suddenly into existence, producing the impression of a tremor in the little mass of balsam. The higher the balsam is heated and the more quickly it is cooled the smaller is the interval of time between the two sets of cracks, until it becomes imperceptible to the eye." It appears, though this is not clearly stated, that the crack begins at the exterior and travels to the interior, an important point being that the crack always tends to be a spiral. Artificial perlites being produced on the flat, Mr. Smeeth next inquires into the nature of the crack-surface in the solid, and shows that the lines revealed by thin sections are either spirals or closed curves resembling circles touching one another tangentially. From this he infers that as a coiled plane cannot possibly be such that all its sections shall be spirals, the simplest case will be where the plane is coiled about a stationary axis, and this case will become more complex when the axis shifts in the course of the growth of the perlite. From what will shortly be said it will be seen that sections of perlites conform to a great extent to these ideals, and Mr. Smeeth's illustrations give admirable examples.

As perlitic structure is by no means of constant occurrence, even in glassy magmas, the author seeks the reason from analogy with balsam and finds it in the friction due to the cooled surface; "doubtless these only occur where there are some particular relations between the strain and the viscosity, or brittleness, of the medium."

Turning now to the 'perlitic cracks' in the quartz, these differences are noticeable: "First, they do not lie in the meshes of a set of polygonal cracks, but on the contrary are often seen to be continuous with some of the polygonal cracks of the matrix. Second, instead of being segmental or touching each other tangentially they are almost invariably closed by abutting abruptly against each other." On the other hand, "perhaps the most obvious characteristic is that the curves constituting a (matrix) perlite never meet otherwise than tangentially, while another striking feature is the fact that the curves are so frequently segmental, the crack ending abruptly in the medium, and even curving round so as to run parallel with an adjacent crack instead of splitting into it." Mr. Smeeth therefore endeavours to imitate quartz cracks and succeeds very satisfactorily by cementing on the ground glass round slips of cover-glass and pouring balsam on both the smooth and rough glass. Then, on heating and cooling in the usual way, it is found that the cracks over the smooth glass are quite distinct from those over the ground glass, and the former present a very strong likeness to those seen in quartz. Anyone who compares the figure of this structure given by Mr. Smeeth on plate xlv of his paper with figure 2, p. 371, and figure 1, plate xviii of mine,[1] will be struck with the obvious points of resemblance between the cracks in quartz and those in the balsam. Unfortunately the balsam figure is not quite sufficiently distinct to institute a very minute comparison, and we cannot be sure that the cracks pass outward from the balsam over the smooth to that over the rough glass; apparently they do not. Again, none of the characteristic ground-glass cracks penetrate into the rest. These features are both very marked in the rhyolite of Tardree. I am, however, truly glad that Mr. Smeeth has shown that there is strong ground for believing that both types of cracks are due to shrinkage on cooling, and that they are the result of a single continuous process acting on the same type of material under slightly altered circumstances, though he does not seem to have followed this idea to its logical issue by indicating that these aberrant cracks will indubitably be produced at times in pure glass, and that such cracks in glass have often been referred to as perlitic. In conclusion the author points out that certain of the cracks described by me as occurring round, and often cutting, quartz grains are probably the result of shrinkage of the quartz alone, and, while cracks are likely to be produced in a homogeneous substance like quartz, he regards it as very unlikely that anything even so far approaching perlitic structure could ever be produced in a heterogeneous lithoidal ground-mass.

[1] *Op. cit.*, pp. 367–76.

I must take this early opportunity of stating that the slides from Tardree which I have examined do not exhibit anything like the perfection of perlitic structure seen in the well-known examples from Meissen, from Mexico, or even in the instances described by Mr. Smeeth, and it may at once clear the issue if I plead guilty to not having used the term perlite in the restricted sense favoured by this observer; my use of the term will be made plain shortly.

The main point that I had before me in writing my paper was this: to show that the fact that the matrices of many lithoidal felsites showed a rude perlitic structure was not in itself absolute and sufficient proof that the rocks had necessarily once been glassy in

Section of Perlitic rock from Jalisco, in Mexico.

texture. I hoped that I had proved the following points: (1) That curved cracks as perfect as those found in felsites occur in quartz and olivine. (2) That these and other curved cracks pass from one class of material to another, in this instance from quartz to glass and *vice versa*, with very slight deviation in direction. (3) That all the types of cracks which make up what I might call the 'perlitic system' of the particular glass in question were to be recognized in the quartz and in most cases passing from glass to quartz.

The first point, I take it, would not be disputed by Mr. Smeeth, although he remarks, and quite correctly, that a careful study would discriminate between the types of curves characteristic of quartz and those spiral ones formed when the structure is most favourably developed in glass. I may here state that, in a private letter to myself sent just after the publication of my paper, Mr. F. Rutley called my attention to this difference, insisting on the fact that whilst the cracks touched one another tangentially or at a low angle in glass, in quartz the angle was always a higher one. He kindly sent me a beautiful perlitic rock from Jalisco, in Mexico, which illustrates this admirably, and the annexed process-block, prepared from a photograph I took of the slide, will show the feature sufficiently well. However, it also draws attention to the fact that Mr. Rutley's description is a little more accurate, for this particular instance, than Mr. Smeeth's, for many of the circumferential cracks *do anastomose with one another* in a way that cannot be explained by the tangential touching of excentric circles. Indeed, so far as my experience goes, the cracks in glass rarely or never reach the high perfection of those in balsam.

With regard to the second point, so far as I am able to judge from his figure (*loc. cit.*, pl. xlv, fig. 4), I do not observe that there is much tendency in the artificial production of 'quartz perlites' for the cracks characteristic of one type of material (or method of production) to invade the neighbouring material.

In describing the Tardree rhyolite I used the term perlitic structure in a rather wide way to include the whole system of contraction cracks which are linked up by a common mode of origin. The following types of fissure were recognized: (*a*) polygonal cracks; (*b*) curved cracks; (*c*) radial cracks running approximately perpendicular to the polygonal fissures; to these I would now add (*d*) other radials joining one or two curved cracks with each other. Rarely only one of these types is present at a particular point of a slide, usually two or three, and occasionally all four types are present in one matrix perlite.

Taking these types in order and referring to the figures and plate given with my paper,[1] it will be seen that type (*a*) is present in quartz and matrix, type (*c*) in the latter and sometimes in the former (pl. xviii, fig. 3), and type (*b*) is ill developed in the matrix and absent from the quartz. Fig. 5 on the same plate gives a matrix perlite with curved (spherical or spiralloid) cracks (*b*) and radials (*d*) enclosed in a network of polygonal cracks (*a*); all three of these types of fissure traverse the quartz, two of them at least passing in from the matrix. Guided by the example of the balsam one would suppose that the polygonal cracks were the oldest and practically simultaneous in both constituents; the curved ones would follow, and, beginning in the glass, would cross the quartz and finish off in glass. In this case the whole system seems to be bound up in the two constituents.

Fig. 6, pl. xviii is a case in which the polygon enclosing a perlite is completed in quartz, and two radials at least of type (*c*) spring from that part of the crack which crosses the quartz. Again, if we agree with Mr. Smeeth that in such examples as those figured in figs. 3, 5, and 6, p. 370, and in pl. xviii, figs. 1 and 2, the cracks

[1] *Op. cit.*, p. 371 and pl. xviii.

are due to the contraction of the quartz and the direct strain thus brought to bear on the surrounding glass, we cannot but notice that these cracks undergo no change in direction or character when traced into the glass. So much is this the case that I think it would be very difficult for anybody to tell from the plate, the drawing, or the photograph, even indeed from the examination of the slide itself except in polarized light, where the quartz ends and the glass begins, so exactly alike are the cracks in the two substances; for this reason a small drawing (fig. 1*a*) was added to plate xviii.

There seems to me to be no reason why the two types of curved cracks which mainly characterize the quartz and matrix respectively should not be regarded as distinct, and even receive separate names; but it will have to be borne in mind that the quartz types can be artificially produced in structureless balsam, that they extend from quartz to matrix, and that they must undoubtedly occur independently in glass; and also that, on the other hand, the perlites of the type more characteristic of glass are often completed in quartz with little or no change in character. The main fact still remains untouched, that rectilinear and spherical contraction cracks indifferently traverse two distinct constituents of the rock, and that the 'little rift' is not solely the fault of either of the 'contracting parties.'

IV.—The Copper Deposits of Michigan.[1]

By M. E. Wadsworth, Ph.D.,
Director of the Michigan Mining School.

In looking at the map of the Great Lake region, you have all noticed the backward bending thumb of Michigan projecting into the icy waters of Lake Superior; yet but few of you, perhaps, have realized that extending along that thumb there runs a band or ring of native copper. It does not, like most gold or silver bands, extend around the finger, but along it—from the base of the hand to the end of the thumb—this central band lies embedded in the flesh binding all together. Shall we now dissect it, laying bare its flesh, muscle, and bone, and try to explain its marvellous organization?

To do this, it will be necessary to drop much of our simile and to make as clear as possible the geological structure of the district in question. Roughly, its central portion, extending from the south-west to the north-east, may be said to be made up of an elevated plateau, bearing upon its wrinkled surface protuberances or hills—locally called mountains—like warts upon a finger. Flanking both sides of this higher land lie lower lands extending down to the level of the lake. This lower level is formed of hardened beach muds, sand, and shingle, laid down on the shores of a tide-washed sea. We find in it the ripple marks made by the waves, the mud cracks formed when exposed to the drying sun, and the prints of the soft

[1] Read at the Annual Convention of the Michigan Bankers' Association, September 12, 1895.

raindrops that fell, at ebb, upon the gently sloping beach. This formation is known to you all through its affording the beautiful Portage Entry or red sandstone (Devonian), so much used now in building. It is, however, with the central higher or plateau region that we have the most to do with at present.

You are all familiar with the descriptions or with the sight of the lava beds of Vesuvius, or of Etna, or on Iceland, or on the Sandwich Islands. You know how the lava flows onward towards the sea, now rolling with a rough, ropy, clinkery surface ; and now gliding with a comparatively smooth one. This Lake Superior plateau is composed of a series of lava-flows like those of Kileaua, generally smooth but sometimes clinkery. Let us imagine a large sheet of ice extending over a lake—when from some cause a long fissure rends it open on one side, and the water wells up through the sheet and overflows the icy expanse. This overflow congeals ; the ice is again rent in twain ; a new overflow takes place, and so on until the ice continually sinking is piled up in successive thicknesses, hundreds or thousands of feet.

Let us now more exactly explain what has taken place in Northern Michigan. The present promontory of Keweenaw Point once formed the gently sloping tide-washed shores of a sea. Over this shore poured the vast floods of lava, the same kind as now flows out from Etna, Kileaua, and the majority of active volcanoes of the present day. These flows, like those of Kileaua, were apparently quiet, and not explosive like those of Vesuvius and Etna. At the time of the outpouring of these vast floods of lava, the shores were gradually sinking so that the congealed rock was exposed to the action of the sea-waves.

You all know of the effect of the storm-dashed waves upon a rock-ribbed coast—how the rock is torn down and worn away, and then piled up along the shores as a resulting mud, sand, gravel, and shingle. In like manner our lava-flows, along the shores of that great northern sea, where Lake Superior now is, were subject to the alternate tide and storm-waves, and to the action of sun, rain, wind, and frost. The result of all this must have been that the exposed portions of these flows were buried under their own débris, mingled with that of associated rocks. Besides the lava-flows before mentioned we find other flows and masses, similar in chemical composition to our granites, which, being much harder and more enduring than the basaltic lavas, make up by far the larger portion of the débris now visible.

This region, then, is composed of a series of interbedded basaltic lava-flows, with their associated shingle, sand, and mud now forming conglomerates, sandstones, and shales.

In order to show more clearly what has happened since, let us take a new metaphor, and look upon all these layers as forming a sort of marbled cake. Now let this cake be cut lengthwise along one side of the thumb-like mass, the cut extending north-east and south-west, nearer to the south-eastern side. Consider that the north-western part has been lifted up at a varying angle from

30° to 60°, and also cut across by fissures running north-west to south-east, and you have a fair idea of what has happened.

It is well known that in all regions where volcanic forces have been active, that when these forces die out, hot-water action is one of the last results, the waters gradually growing cooler until they are at the normal temperature, so that in time there is no evidence of the former hot state except that shown by its results on the rocks.

In the Lake Superior district the water action—mostly hot, sometimes cold—was strongly marked during the fissuring and movement, or, as it is technically termed, "faulting" of the rocks, as well as for a long time subsequently. During the time of this water action all the rocks, without exception, were penetrated by these percolating waters, much of their materials dissolved out, or chemically re-arranged, or removed and replaced by other elements. It was then that the native copper now found in the rocks was stored up on its present banks of deposits, from which it is now being rifled by means of the drill, sledge, and dynamite. Three different systems of local deposit have been employed by Dame Nature on Keweenaw Point. The profound and repeated fissuring previously spoken of caused huge vaults to be made where the percolating waters left, securely locked up, their treasures of copper; and here the largest single deposits were made, and the drafts have been fully honoured. The vaults extend mainly in a north-west and south-east direction, cutting across the country. These deposits are technically known as fissure veins; and as examples there may be cited the Central, Cliff, Phœnix, and other mines, mainly on the northern end of Keweenaw Point.

As one would naturally suppose, the various lava-flows would differ in thickness, owing to the varying amounts of volcanic material erupted, as well as to the inequalities of surface. Like variation would also exist in the extent and amount of deposited conglomerate, shale, and sandstone, on account of similar inequalities of the surface during its formation, and the area exposed to the tidal or wave action.

Returning to the lava-flows, it has been found that the thinner ones are more glassy, and hence more easily acted upon by the percolating waters; thus, large amounts of the original rock materials have been dissolved out, removed, and their places, as well as those of all other cavities, have been filled with deposits of copper and other mineral matter. These deposits are mined and form the melaphyre (locally called amygdaloid) mines, such as the Quincy, Osceola, Franklin, Atlantic, and Huron. These mines are worked on old lava-flows that have been impregnated with copper, the same as a flow from Mount Etna might be worked, if it were likewise filled with valuable mineral. Although it is usual to speak of these mines as worked upon veins this is an error, as they have neither the structure of a vein, nor any sign of a vein about them. They are simply flow deposits.

At the same time our fissure, or vein, and overflow deposits were formed, similar deposits were made in the interbedded detrital or sea-beach materials, or conglomerates. Here the percolating waters removed much of the cementing mud and the more easily soluble pebbles, filling in the places thus left with copper and other mineral matter. This form of deposit gives rise to our conglomerate mines, such as the Calumet and Hecla, Tamarack, Peninsula, and Allouez.

These mines are not worked upon veins, but upon old sea-beach shingle, the same as if any one of your beaches here, after having been covered up, should be worked for any mineral matter. They are not veins and they have no sign of a vein upon them; but they are simply bed deposits.

You may ask, whence came the copper now deposited in these three different kinds of safety vaults—vaults that were found by prehistoric man to be thoroughly fire-proof, but which are not burglar-proof, when attacked by the modern earth-robber with power drill and dynamite? No one can tell whence came this copper; he can only infer.

The largest amounts of copper are generally well within the series of lava-flows, and associated with or underlying the thicker and heavier beds. Further, it has been seen that the general course of the copper was downwards, as it extends frequently like icicles, from the overhanging bed into the one that is worked, while sheets of it are wrapped around the angles of the broken blocks, like paper around a grocer's package. These and numerous other facts show that the copper was deposited from water subsequently to the fracturing and faulting of the rocks; and that it was probably originally disseminated through the lava-flows, and has since been concentrated in the various banks of deposit by the percolating waters, which penetrate all rocks.

Did time permit, the evidence in behalf of all the statements made here could be laid before you: these evidences are picked up one by one by the earth's detectives, the geologists, who, like the Sherlock Holmes's, study the ashes, the mud, and every relic left by that thief, Time, in the depositories of old Mother Earth. As you read the story of each coin and bill, each check and draft, so we read the story of each pebble and rock; and learn to ferret out the secret deposit of Dame Nature.

V.—Recent Coast Erosion at Southwold and Covehithe.

By John Spiller, F.C.S.[1]

THE sixteenth of May last was a disastrous date for Southwold and the neighbourhood, for, owing to the prevalence of northerly winds on this and the two previous days, culminating in a moderate gale, the tides rose to an abnormal height, and this, combined with a rough sea, made fearful inroads upon the soft, sandy cliff and the shingle on the foreshore, washing away a large piece of land and creating a new cove at the northern boundary of the little town. The effect would have been worse but for the

[1] Read before Section C at the Ipswich Meeting of the British Association, 1895.

existence of a clay-footing and promontory at the extreme point, and two immense concrete blocks constructed a few years ago to act as a breakwater and give protection to this part of the cliff. These latter proved of temporary service, but became so shattered and disintegrated that they must be replaced, or a sea-wall built, to resist further inroads at the next high-flowing tide. Similar erosion has occurred on the face of Easton Bavents cliff and at Covehithe, and it is feared that the loss of land at those places will render Southwold all the more assailable in future. Upon two occasions during the winter of 1894–5 (December and January) the tide rose to even greater height, and inundated large tracts of salt-marsh around Southwold, making two ruptures in the railway embankment and stopping the trains for a few days, but as there happened fortunately to be no wind at the time the damage done to the sea-front was confined to the sweeping of the shingle further south, with comparatively little damage to the cliffs of Southwold. It became necessary, however, to remove all the boats and capstans from the beach and pull them up the cliff or drag them inland; and this had again to be done on the 15th and 16th May.

The Barometric and Weather Record for Southwold, as entered on the Royal National Lifeboat Institution's chart for the middle of May (8 a.m.) is as follows:—

1895.	Bar. in.	Direction and force of wind (0 to 12).		
May 13.	30·25	S.W.	3.	Gentle breezes, sunshine.
14.	30·25	N.E.	2.	Light breeze, sultry.
15.	29·9	N.	5.	Fresh breeze, gloomy.
16.	29·6	N.	7.	Moderate gale, cloudy, rain, snow, and hail.
17.	29·5	N.N.W.	6.	Strong breeze, ugly threatening weather.
18.	29·4	N.E.	4.	Moderate breeze, cloudy.

It was remarked that with a fresh breeze, northerly, on the 15th, the ebb tide was cut short or intercepted, and then came the gale which did the damage with vastly augmented tide on the 16th May. These are the conditions generally recognized on the East Coast as demanding watchful care on the part of the seafaring population, so that the event was anticipated and preparations made, as far as possible, to cope with the incoming tide on the second day. No injury was sustained by the fishing-boats, nor on the greater part of the sea-front—Centre Cliff and Gun-hill—which are protected by a sea-wall; but the North Cliff, not being so secured, suffered to the extent described; and a repetition of northerly gales and high winter-tides may be expected to do further mischief until the precautionary measures, for which Parliamentary sanction is required, are carried out in the coming year, either by prolonging the existing sea-wall or constructing an efficient breakwater at the northern extremity of the town.

The Memoir of the Geological Survey, by Mr. Whitaker, explanatory of "The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe," may be consulted with advantage by those desiring information on this all-important subject; and the waste of the coast during recent years is therein fully described. Thomas Gardner's map and historical account of Dunwich, dated

1754, Saxton's map of 1575, and earlier records, prove how great has been the loss since that town was the capital of East Anglia, and boasted of its mint and numerous churches, only one of which, All Saints, and the adjoining monastery, now both in ruins, yet remain on the high cliff as sole survivors of its ancient grandeur. Covehithe Ness has worked back about two miles; Easton Bavents about as much, and is no longer the most easterly point of England. Southwold also has lost nearly a mile. The coast-line, instead of showing a bold promontory at Covehithe and Easton, is almost reduced to a straight line on the present Ordnance Map, and the designation "Sole Bay" has thus become a misnomer, the northern limit being destroyed.

But to return to Southwold proper, and estimate the loss of land there by recent coast erosion, I have had the advantage of professional assistance kindly rendered by Mr. Eaton W. Moore, Surveyor and Land Agent, who has lived in Southwold nearly all his life, and remembers the sweeping away, in March 1862, of the coastguard house and beach-cottages which formerly stood on the shore below the East Cliff and Centre Cliff. This gentleman has measured the inlet, which I now propose to call North Cove, and gives me the following dimensions, viz.: 148 feet long by 60 feet mean depth, equal to 8880 square feet, or, roughly, one-fifth of an acre. And, if we add to this the loss of contiguous roadway, near the fishermen's huts, amounting to $396 \times 32 = 12{,}672$ square feet, we arrive at a sum total of 21,552 square feet, equal to *about half an acre*, of land actually washed away by the recent high tide. Not only is territory diminished to this extent, but there has been a great drifting away of loose shingle from the back of the shore, so that the path left remaining is "terraced" from four to six feet above the beach-level, instead of forming a gentle gradient from roadway to sea, as was the case prior to May 16th. By the removal of this thick shingle-bed and the erosion of the face of the cliffs beneath, the sections of Boulder-clay, sand, and loam, with a little bit of black peaty bed, and one or two pockets of shelly crag, have come prominently into view. A human skeleton also was found buried in a superficial accumulation made up partly of reassorted Boulder-clay, which at first was thought to be prehistoric, but this has been taken in hand by Mr. Walter Mawer,[1] and submitted to Dr. Garson and Mr. E. T. Newton, with the result that its primeval claims have been finally disposed of, and the cranium held to be that of a low, but ordinary, type of current humanity.

As if to compensate for the town's loss, the shingle-beds both to the north and south of Southwold have been considerably raised, and spread over a wider area of the marshes. This is apparent all round the "rocket staff" marked on the Ordnance Map, and the "brickmakers' pond" has also been partially filled up; moreover, another ditch, approached by a gate through which I passed last year, is now firmly silted up. A breach has likewise been made, to the extent of 74 feet, at the northern end of the straight dyke

[1] "The Southwold Skeleton": *East Anglian Daily Times*, June 7th, 1895.

wall indicated on the map as running north-east from the shore extremity of Buss Creek. This was broken through by the force of the incoming waves, and much shingle deposited in and behind the said beach. Much silting up also has occurred in front of Easton Broad, and in the two hollows that the pedestrian passes on his way there by the Easton Cliff, as indicated in the coloured plate, "Sections of Suffolk Cliffs," appended to Mr. Whitaker's Memoir. At the hollow close to Easton Broad the accumulation of shingle has all but exterminated the yellow-horned poppy, which was growing there in profusion last summer; and, of course, the channel or outlet to the sea, ever changing, was affected, and for nearly three months it became impossible to walk to Covehithe along the shore without wading through the watercourse, in which, by the way, I picked up (in June) a rounded lump of red hæmatite iron ore weighing 1 lb. Early in August this channel was again blocked, so that the way to Covehithe along the beach is once more restored.

Whilst all these changes have occurred, it is also manifest that the lines of high and low watermark have sensibly altered, so that in this respect the Ordnance Maps will need to be corrected by a fresh survey, and the configuration of the coast-line somewhat modified. The North Cliff bathing-station had to be moved, and the Gun Battery at Easton shifted back 34 feet; and further north the old path is seen in many places to lead over the edge of the cliff. In August last Mr. Horace B. Woodward and I carefully measured several spans of wasting cliff, the records of which were noted by Mr. Whitaker on his field copies of the Ordnance Map as having been taken by himself in 1882 and 1889. Here are the details for comparison:—

I. *Easton Bavents.*—"550 feet from hedge to cliff-top, at hedge on south-west of road. June 1889. Buildings gone. W. W."

This is now 530 feet. August 1895.

Loss in six years=20 feet.

II. *Easton High Cliff.*—"Edge of cliff from hedge running north and south, 130 feet. W. W. May 1882."

We found this to be 108 feet. August 1895.

Loss in thirteen years=22 feet.

III. *Covehithe Cliff.*—The distance from the hedge on the south side of the road, between the coastguard station and the cliff-top, was ascertained to be 90 yards in June 1889, by Mr. Whitaker.

Our measurement on 16th August, 1895, was 62 yards.

Loss in six years=84 feet.

Other observations and measurements made by us show that the general loss on Covehithe Cliff since the Ordnance Map was constructed (1882–3) has been about 50 yards.

The rate of demolition at points along the coast between Southwold and Covehithe appears, therefore, to vary considerably, and one is content to record the facts and figures for future use rather than proceed to draw inferences as to *annual rates of loss* from these recent observations.

To complete my tale, I should mention that the heavy rains of July last had a further disastrous effect upon the new faces of sandy cliff at Southwold, and again much loosened material has fallen, but this time not by direct marine agency. The worst feature of the case is the delay attendant upon Parliamentary proceedings to obtain the necessary sanction for carrying out the protective works, as another winter must inevitably intervene before they can be put in hand, and no temporary expedients of a satisfactory character have been suggested.

[The paper was illustrated by photographs and a water-colour sketch of the new cove at Southwold.]

VI.—The Southern Character of the Molluscan Fauna of the Coralline Crag Tested by an Analysis of its more Abundant and Characteristic Species.[1]

By F. W. Harmer, F.G.S.

THE close resemblance between the Molluscan fauna of the Coralline Crag and that of the Mediterranean at the present day has long been known and is universally recognized. It has been customary, however, to take the whole list of shells from this deposit, for the purpose of comparison, without reference to the greater or less abundance of the different species; but in discussing the affinities of the fauna from this, or indeed from any other horizon of the East Anglian Crags, it may be misleading to attach as much importance to the presence of a shell, of which only one or at the most a very few specimens have been discovered during so many years, as to the occurrence of forms which are found in such countless profusion as sometimes to compose a large proportion of the whole number of the shells present. Out of about 440 species of Mollusca from the Coralline Crag given by Mr. Wood in his well-known Monograph[2] (excluding varieties), nearly 90 are said to be represented by unique specimens only, while more than 100 others have very rarely been met with. It is true that some of these rarer forms may be only locally rare, although it is worthy of notice that, with few exceptions, the species which are common in the Diestien beds of Belgium,[3] believed to be approximately contemporaneous with the Coralline Crag, are also common in that deposit. On the whole, without ignoring altogether the existence of the rarer forms, it seems that a consideration of the general facies of the fauna of each of the different horizons of the Crag, and of its characteristic fossils, is more important and is likely to give more reliable results than an analysis of all the species of each bed, irrespective of the greater or less frequency with which they have been found.

[1] Read before Section C of the British Association at Ipswich, Sept. 12th, 1895.
[2] Palæontographical Society (1848, etc.).
[3] Van den Broeck, Introduction au Mémoire de M. P. H. Nyst sur la Conchyliologie des Terrains tertiaires de la Belgique. Bruxelles (1882).

The Southern character of the Molluscan fauna of the Coralline Crag and its exceedingly close resemblance to that of the Mediterranean is much more clearly shown when we take its abundant shells only as the basis of our analysis. Omitting from Mr. Wood's catalogue varieties, and those forms which are represented by unique specimens only, or which are very rarely met with, we have about 220 species which may be regarded as the representative shells of the formation. Of these 82, or about 37 per cent., are not, according to Mr. Wood, known to be living, and seven others may be, for our present purpose, regarded as extinct, as they have ceased to exist in European seas, and are only now found in distant parts of the world. Of the 132 species remaining, 119 occur in the Mediterranean at the present day, and twelve others in what Dr. Gwyn Jeffreys has called the West European area—that is, along the Atlantic coasts between the Straits of Gibraltar and the English Channel—provinces which he says cannot be regarded as zoologically distinct. There is thus only one among the characteristic Mollusca of the Coralline Crag, viz. *Buccinum* (*Buccinopsis*) *Dalei*, which does not live in seas to the south of the British Islands, and this species cannot be regarded as undoubtedly boreal, for it is given by MM. Dollfus and Dautzenberg, with a (?) however, as occurring in the Miocene beds of Touraine.[1] Mr. Wood, analyzing the entire list of Coralline Crag shells, gives 20 as British and not Mediterranean; but of these, 15 are very rare, and the others, with the exception of the species just named, are West European. The close connection between the fauna of the Coralline Crag and that of the Mediterranean is further shown by the fact that more than 30 of the *extinct* species of the former are said to occur either in the Pliocene beds of Monte Mario, near Rome,[2] or in those of Biot, near Antibes, in the South of France.[3] As to the Monte Mario beds, Sig. Ponzi and Meli remark that their Molluscan fauna would be identical with that of the Mediterranean at the present day were it not that some species have emigrated and some have become extinct. Out of 396 species of Mollusca found at Monte Mario, given in a list published by Cav. Zaccari,[4] more than 150 occur also in the Coralline Crag, a larger number than is common to the latter deposit and the Diestien beds of Belgium, contemporaneous deposits of the Anglo-Belgian Basin not more than 150 miles apart.

These facts—the close correspondence between the recent Molluscan fauna of the Coralline Crag and of certain Italian Pliocene beds with that now living in the Mediterranean and the West European areas, and the resemblance of these deposits, palæontologically, to each other—seem to point, not merely to the conclusion that there must have been free and direct communication between the sea of the Coralline Crag and the Atlantic, but also that at some period

[1] Étude préliminaire des coquilles fossiles des Faluns de la Touraine. Rennes: Paris (1886).

[2] Ponzi and Meli, Mem. R. Accad. dei Lincei, ser. 4, vol. iii, p. 672 (1887).

[3] A. Bell, Catalogue des Moll. Foss. des Marnes Blues de Biot, près Antibes: Journ. de Conch. Paris (1870).

[4] Zaccari, Catalogo dei Fossili del Monte Mario, Collezione Rigacci. Roma.

subsequent to the coming into existence of the present fauna there was more open connection between the latter and the Mediterranean than there is at present. The distinctively Southern character of the fauna of the Coralline Crag is further shown by the comparatively large proportion of its shells that do not now live so far to the north as the seas of Great Britain, but this also comes out more strongly when we confine our attention to its more abundant forms. While, as has been shown, there is only one among the 132 recent European Mollusca, representative of the formation, which is British and not Southern, there are 35, or 26 per cent., which are Southern and not British. But among the forms usually regarded as British, there are nine—viz.: *Cerithium Metaxa*, *Cæcum trachea*, *Modiola rhombea*, *Limopsis aurita*, *Scacchia orbicularis*, *Woodia digitaria*, *Donax politus*, *Thracia pubescens*, and *Poromya granulata*, characteristic shells both of the Mediterranean and of the Coralline Crag —which are either confined to the south-western portion of our seas, or have been included in lists of the British fauna because of the occasional discovery of some rare specimens on our coasts. If we regard these nine species as Southern, we have 44 out of 132, or more than one-third, which are Southern and not British. In a word, the abundant shells of the Coralline Crag which are now living in European waters are practically all Southern forms, though some of them range also into Northern seas, but the few shells which are exclusively boreal are, with the one exception named, exceedingly rare. It may safely be said that if it were possible to count shells instead of species, we should meet with some thousands of specimens of recent Southern Mollusca in the Coralline Crag for every recent boreal shell we could discover. We find also among the *extinct species*, abundant in the Coralline Crag, a greatly preponderating number of *genera* of a decidedly Southern character. Among these may be mentioned, *Voluta*, *Terebra*, *Cassidaria*, *Pyramidella*, *Nucinella*, *Scintilla*, *Erycinella*, *Panopæa*, and *Pholadomya*, the last of which is tropical, as is also the West Indian shell, *Erato Maugeriæ*, and both these are abundant.

On the other hand, no shell, in Mr. Wood's opinion, of an exclusively Arctic character has been discovered in the Coralline Crag, except a single valve, which he referred with a good deal of doubt to the species *Cerithiopsis lactea*; but among the extinct forms there is one, *Glycimeris angusta*, which is not uncommon, which belongs to a Northern genus.[1] Attention has been called to the profusion of the different species of *Astarte*, as giving a boreal

[1] Professor Prestwich gives a list of about a dozen species of Mollusca which he claims as Northern (Q.J.G.S., vol. xxvii, 1871, p. 135). Five of these, however, range to the south as well as to the north of our shores; and as to the rest, with the exception of the one already named (*Buccinopsis Dalei*), and another, *Trichotropis borealis*, which is very rare in the Coralline Crag, he follows Dr. Gwyn Jeffreys in considering shells regarded as extinct by Searles Wood and others as varieties merely of existing species. For example, he believes *Astarte Omalii* to be the equivalent of *A. undata*, an American shell, and *Tellina obliqua* that of *T. lata*, an entirely distinct form. Mr. Wood had the opportunity of weighing Dr. Jeffreys' views, and he has given in the Supplement to his Monograph his reasons for differing from them. I agree with Mr. Clement Reid and others in following Mr. Wood's opinion as to this.

facies to the fauna of the Coralline Crag. At the present day this genus undoubtedly is characteristic of Northern latitudes, but it is not confined to them. In the Eocene period, as Mr. Wood points out, four species of *Astarte* lived in these latitudes, in association with animals and plants of a tropical character. The *Astartes* of the Coralline Crag are all extinct, except two, which are Mediterranean species; and their occurrence, therefore, does not, I think, present any insuperable difficulty in the way of our accepting the strongly preponderating evidence that the climate of the period in question was considerably warmer than that of the present day.

Summary of the Abundant and Characteristic Species of Mollusca occurring in the Coralline Crag.[1]

Not known as living	(37 per cent.)		82
Living in distant seas—Pacific		3	
,, ,, Atlantic		1	
,, ,, West Indian		1	
,, ,, South African		1	
,, ,, North American		1	
		—	7
Living in the Mediterranean		119	
Not living in Mediterranean, but in West European area		12	
		—	131
Not known to range to the south of British seas ...			1
			221

Species of European Mollusca abundant in Coralline Crag.

Southern and not British...	(26 per cent.)	35	
British (rare) and Southern		9	
	(32 per cent.)	—	44
British (characteristic) and Southern			87
British and not Southern...			1
			132

Professor Prestwich, it is true, does not admit this view of the case, and claims that ice action had come into existence even at the commencement of the deposition of the Coralline Crag, resting his opinion on the fact that a water-worn block of porphyry was found in the basement bed at Sutton, which he considers must have been transported, either from Scandinavia or the Ardennes, by floating ice.[2] I differ with considerable reluctance from so eminent an authority, but I cannot help feeling that the evidence of this one block is insufficient to support the theory built upon it. No ice reaches our shores at the present day either from Norway or Belgium, and the winter temperature of Northern Europe would have to fall considerably before this could happen. The almost entire absence of recent Northern shells from the Coralline Crag, moreover, seems to imply either that the sea of that period was not open to the north, or that the temperature of the seas of Scandinavia were affected, as they are now, but to a greater extent, by the Gulf Stream; while as to Belgium, I am not aware that similar ice-borne débris occurs in the Crag beds of that country, nor are such boulders found in our own Red Crag, the climate of which

[1] The figures now given are slightly different to those originally stated, but the conclusions to be drawn from them are not affected by the alteration.

[2] Q.J.G.S., vol. xxvii, p. 134 (1871).

was colder than that of the Coralline. The occurrence of this one block, which was neither angular nor striated, and which might have reached its resting-place in some other way,[1] does not seem to me to justify the otherwise improbable hypothesis of floating ice during any part of the Coralline Crag period. The affinities of the Molluscan fauna of these deposits is clearly with the seas of Southern Europe, or even, as Mr. Wood suggested, of the Azores, rather than with those to the north of the Island. At the present time there is a difference of not less than 10° F. between the average yearly temperature, both of the atmosphere and of the ocean, in the British and Mediterranean areas.

VII.—Notes on Petrological Nomenclature: Schist, Slate, Phyllade, and Phyllite.

By A. R. Hunt, M.A.

In 1891 Professor A. H. Green wrote an interesting notice of two books, both of extreme value to the petrological student, viz. Cole's Aids in Practical Geology and Hatch's Introduction to the Study of Petrology. In the course of his review the Professor remarks: "In dealing with the foliated rocks, the author touches on the debated point of the 'true schists.' We are pretty well used to this phrase, and have waited long in the hopes of being told what constitutes a 'true schist,' but our patience has not yet met with the reward it merits. The author is of opinion that 'the alleged distinction between schist-like rocks and schists of pre-Cambrian age requires great delicacy of definition.' This is delicately put, and will command the assent of most geologists" (Nature, vol. xliv, p. 26).

In the following paper an attempt has been made to ascertain the different meanings attached by authors of repute to the terms Schist, Slate, Phyllade, and Phyllite. All the petrologists quoted are cited as authorities of equal value, and as evidence of the meanings actually current as to different technical terms at the time of writing. No attempt is made to show that one is more correct than another, nor is there any suggestion of such a thing. Webster's Dictionary is quoted, not as an authority on technical terms, but as the glossary of easiest access to the ordinary reader. Webster's definitions may be taken to be the interpretation of scientific terms as popularly accepted.

Schist, Slate, Phyllite, Foliation.—The confusion that has arisen in the use of the foregoing terms is due to the same words being used by geologists in two or more different senses.

Schist and slate are etymologically identical, absolutely synonymous and interchangeable. Both terms signify rocks that split. De la Beche commonly used the word slate, to the entire exclusion of schist. He tells us how a deposit of quartz, felspar, and mica would become gneiss; "while one formed only of grains of quartz and mica would become mica slate" (Geol. Obs., p. 705).

[1] Mr. C. Reid mentions that in some of the Coral islands of the South Seas, boulders which reach the shore on drift-wood are the perquisite of the chiefs.

Much perplexity has been caused by De la Beche describing gneiss among the South Devon metamorphic rocks; but, taking his own definition of that rock, it is not uncommon. If a rock composed of quartz and mica may become a mica-slate, the term slate clearly refers to structure and not to composition, as quartz is in no way argillaceous—the modern idea of a slate. If we turn to recent textbooks we find the meaning attached to "slate" entirely different from De la Beche's. For instance, Jukes-Browne tells us that a slate is "any argillaceous rock exhibiting well-marked cleavage" (Phys. Geol., p. 295); while Rutley describes clays, shales, and slates as "impure hydrous silicates of alumina" (Study of Rocks, p. 282).

Thus the idea conveyed to De la Beche by the term slate is that of the original word, the old English "sclate," a shiver or splinter, whatever the composition. The modern idea is an aluminous rock more or less cleaved, which De la Beche would have probably called a clay-slate.

The term "phyllite" presents even greater difficulties. According to Humble, it is a petrified leaf (Dict. Geol. and Min.). Webster, on the authority of Dana, defines it as "a mineral consisting chiefly of the hydrous silicate of alumina, iron, and manganese [*sic*], and occurring in thin scales or leaves." According to Bristow (Glossary of Mineralogy), phyllite is a magnesian mica, and a variety of ottrellite. Dana tells us that "phyllite occurs in the schist of Sterling . . . . Massachusetts, ... and the rock in consequence of it is called by Hitchcock 'spangled mica slate,' the phyllite being the mica of the schist" (Syst. Min. 1881, p. 506). On examining the analysis, phyllite proves to be a magnesia-potash-mica, manganese being an obvious clerical error.

The popular acceptation of the term phyllite founded on Dana is that it is a mineral, and a species of mica. English geologists, on the contrary, almost without exception, use the term phyllite to define a species of rock. Sir A. Geikie tells us that "by increase of its mica-flakes a clay-slate passes into a phyllite" (Class Book of Geol., p. 223). According to Jukes-Browne, phyllite is "a glossy slate, the metamorphism of which has probably been carried a little further than usual" (Phys. Geol., p. 296). Miss Raisin defines it as "a slate in which a large amount of microlithic mica is developed" (Q.J.G.S., vol. xliii, p. 717). Prof. Bonney speaks of a certain mineral in slate as "one of the hydrous micas which seem common . . . . to the phyllites" (Q.J.G.S., vol. xl, p. 17).

It is clear that the above authorities are at one in considering that a phyllite is a sort of slate. Phyllites pass into schists, for we find a rock described by Teall as "a schistose spotted rock intermediate between a phyllite and a mica-schist" (Proc. Somerset Arch. Soc. 1892, p. 211).

Phyllade is used by some geologists in lieu of phyllite. Professor Cole tells us that "minute mica scales may develop along the cleavage planes [of slate], and a wrinkling of the latter at the same time produces the link with mica-schist, called 'phyllade' by

D'Aubuisson" (Aids in Practical Geol., p. 256). In Lyell's Glossary we find—"Phyllade, D'Aubuisson's term for clay-slate, from φυλλας, a heap of leaves" (El. Geol. 1865, p. 727). Thus, according to Lyell, phyllade is a clay-slate; according to Cole, a link between mica-schist and slate, with a peculiar wrinkled structure.

A mineral often mentioned in connection with phyllite (anglice), is hydrous mica. Professor Judd, however, speaks slightingly of these micas, stigmatizing them as "so-called hydro-micas" (Proc. Roy. Soc., vol. lvii, p. 392).

It is almost certain that by "phyllite" geologists usually mean a rock in which mica has been developed *in situ*, and not slaty rocks in which the mica is detrital. For the latter there seems to be no term but micaceous slate, with all its uncertainties. It may be observed that on one occasion I sent a rock to a friend who described it as a phyllite; subsequently another specialist examined the same specimen microscopically, and pronounced the mica detrital.

But to return once more to the schists. We may dismiss at once the original meaning of a merely cleaved rock synonymous with slate, though on reading De la Beche it is essential to bear the latter definition in mind. According to Dana, "*slate* is an argillaceous rock breaking into thin laminæ; *shale* a similar rock, with the same structure usually less perfect, and often more brittle; *schist* includes the same varieties of rock, but is extended also to those of a much coarser laminated structure. The ordinary clay-slate has the same constitution as mica-slate. . . . . The two pass into one another insensibly" (Dana, Manual of Mineralogy, 1864, p. 357).

"Shale" has somewhat fallen into desuetude, but it is sometimes used for rocks which split in the planes of bedding, and not in planes of cleavage.

Webster describes schist as a rock having a slaty structure. Slate might with equal truth be described as a rock with a schistose character. Lyell tells us that mica-schist "passes by insensible gradations into clay-slate," which latter rock we are further informed is common to the metamorphic and fossiliferous series (El. Geol., p. 726). Daubrée writes of clay-schists (schistes argilleux) and slate-schists (schistes ardoisiers)—(Geol. exp., p. 398). A very concise definition of schists is that of Mr. Jukes-Browne, viz., "foliated rocks splitting into thin layers of different mineral matter" (Phys. Geol., p. 296).

Professor Bonney defines the term schist with much precision: "I apply the term schist only to *foliated* rocks. . . . . The lax use of the term by many Continental and some English petrologists (by whom it is made to include not only highly metamorphic rocks, but also some where the chemical and mineral changes are but slight) causes much confusion" (Q.J.G.S., vol. xl, p. 4).

In the above definitions of "schists," a new source of trouble is introduced in the word "foliated." One might suppose that the typical foliated rock would be the one like a "heap of leaves," *i.e.* a phyllade; but technically a phyllade is the very type of a non-foliated rock.

We now turn to Webster to ascertain the popular scientific meaning of "foliated." We find it to be "restricted to the variety of laminated structure found in crystalline schist." Now, if in Prof. Bonney's definition we substitute "crystalline schist" for "foliated rocks," it would read: "I apply the term schist only to crystalline schist"; and this, so far as I can ascertain, is the view accepted by British petrologists. If we are careful to remember that "foliated" does not merely mean having leaves or laminæ, and that schist does not merely mean being divided into leaves or laminæ, the modern British technical meaning of the word may be arrived at; but it is essential to remember that in France "schiste" and "feuilleté" are applied to "ardoise" (roofing-slate), and must be sharply distinguished from the modern British "schist" and "foliation." All three terms will be found in the letterpress of fig. 136 in Daubrée's Geol. experimentale, p. 395.

There seems to be no laxity in the use of "schiste" by French petrologists. The term defines a fissile rock. When used for a crystalline schist, the crystalline constituents are mentioned, *e.g.* "mica-schistes, talc-schistes," etc.; and "quartzites schisteux," whose "feuilleté" is caused by mica, chlorite, talc, or oligiste (Daubrée, *loc. cit.* p. 399).

The difficulty which arises from the definition of "schist" adopted by British petrologists is that of uncertainty. A "schist," say they, is a highly metamorphic rock where the mineral changes are great; not a rock in which the mineral changes are but slight. Clearly, then, there exists an intermediate debatable set of rocks, to which the term "schist" is not applicable. Who is to define the borders of this petrological "No man's land"—the area in which the rocks occur described by Mr. Teall as links between phyllites and mica-schists?

The true obstacle to the selection of a consistent nomenclature that will define the geologist's meaning, and not fly in the face of its own etymology, lies in the fact that two words of identical meaning, used indifferently by our early geologists, have assumed to themselves technical meanings which place them at the opposite extremes of the series of fissile rocks. Could English-speaking geologists revert to the old simple meaning of "schist," we might have some such series as "clay-schist," "sub-crystalline schist," and "crystalline schist"; in lieu of slate, phyllite, and schist. The name of the dominant mineral being prefixed would define the crystalline peculiarity; and if advisable, to distinguish detrital minerals from induced minerals, the words micaceous, talcose, hornblendic, etc., might be resorted to. "Slate," unfortunately, to the world means roofing-slate.

Under the present system it is often impossible to feel sure of a geologist's meaning; and it is equally impossible to describe a fissile rock with any certainty that the definition will be understood by others. A most remarkable instance of this difficulty is that of the Devonshire rocks, so long known as chlorite-schists. Mr. Teall has avoided giving them a specific name, and has simply called them green rocks. But to distinguish two sets of Devonshire rocks as "greenstones" and "green rocks," as I myself did in my own paper on the subject, is to make a very fine technical distinction, and one very likely to confuse the non-technical reader. It need scarcely be mentioned that the green rocks, like the greenstones, are often grey; and that some of the chlorite-schists, *alias* green rocks, are, to all appearance, neither green, chloritic, nor schistose: but this is a mere detail.

Postscript.—The foregoing notes were out of my hands before I had had the advantage of seeing Mr. L. Fletcher's recent work, "An Introduction to the Study of Rocks," in which the author classes phyllites with argillaceous schists, and proposes the term "mero-crystalline" to describe volcanic rocks which are not holo-crystalline. If "mero-crystalline" might also be applied to schists which are not holo-crystalline, it would greatly facilitate the description of certain intermediate rocks which have been hitherto indescribable. In Geol. Mag. 1892, Vol. IX, Pls. VII and VIII, two rocks are figured, and elsewhere described as a quartz-schist and a chlorite-schist. Both these are courtesy titles, as neither rocks are preeminently fissile; moreover, the one is not holo-crystalline and the other is not prominently chloritic. What is much wanted is a substantive to correspond with the adjective "schistose," a term often used to define fissile volcanic rocks which have no pretensions to the title "schist"; *e.g.* a "schistose diabase." "Schistoid" would be convenient, but barbarous. A "mero-crystalline quartz-schistoid with detrital quartz and tourmaline" would sufficiently define the prominent characteristics of the one rock above mentioned, whereas "an holo-crystalline albite-uralite-schistoid" would indicate the salient peculiarities of the other. In the one rock the description would suggest to the reader a sedimentary origin, and in the other a volcanic one, a result much to be desired in the cases in question.

REVIEWS.

I.—Report on the Department of Mines of Western Australia for 1894. Perth, 1895.

THE rapid progress and brilliant prospects of the gold-mining industry in Western Australia will cause this White-book to be carefully read by great numbers of people in this country. As was to be expected, there is much information given concerning the auriferous districts and the mines in them, over two-thirds of the reading matter consisting of a report by Mr. S. Göczel, the Assistant Government Geologist, on the goldfields of the interior. Mr. Göczel's facts are interesting, but he buries them beneath such a mass of stilted and redundant phraseology that the process of digging them out is far from enjoyable, and will hardly be a relaxation to the gold-miner. He tells us that Archæan rocks underlie the whole of the great interior tableland, and that they are covered here and there by thin cappings of unfossiliferous grits, sandstones, and conglomerates, which are said, on what appears to be somewhat slender grounds, to be of Cambrian age. Eruptive masses of diorite and schistose felspar-amphibolites have been forced through breaks in the Archæan rocks, and, at a somewhat later date, banded diabases were also intruded. The gold deposits generally occur in the stretches of country occupied by these old "greenstones," and were perhaps formed before the volcanoes became extinct. As Mr. Göczel puts it: "Doubtlessly [*sic*] the formation of lodes commenced with the first break in the lythosphere, but the formation of the bulk of primary gold deposits in this region is due to a hydrothermal gold emanation, most probably connected with and caused by volcanic subsidences during the late periods of the Palæozoic era." In future reports returns of the amount of machinery of all kinds on the goldfields will be made, so as to show the rate of progress. It would be useful if the output of the individual mines and districts were also tabulated.

The coalfields, on which the gold-mines will depend for their life, are dealt with by the Government Geologist, Mr. H. P. Woodward. He finds the coal in the Collie field, which seems to be of true Carboniferous age, to be a compact, splinty, bituminous coal of the non-caking class, containing 51 per cent. of fixed carbon, 32 per cent. of gas, 11·5 per cent. of water, and 4·3 per cent. of ash. The best sample of Collie coal was about equal for heating purposes to the average coals of New South Wales and Victoria. Mr. Woodward also examined the south-western portion of the colony with a view to the discovery of fresh coalfields, but he found no indications of any valuable deposits there. He gives, however, an interesting sketch of the geological history of the south coast, explaining the formation of the thin beds of sandy-brown coal, which have given rise to some hopes that workable coal would be found in that part of the colony.

II.—Palæontology of New York, Vol. VIII, Part II: an Introduction to the Study of the Genera of the Palæozoic Brachiopoda. By James Hall, assisted by John M. Clarke, Albany. New York, 1894, 4to, pp. 394, plates xxi–lxxxiv (Charles Van Benthuysen and Sons).

THIS, we regret to learn, forms the concluding volume of the "Palæontology of New York," a fine series forming part of "The Natural History of New York," inaugurated by Governor W. H. Seward during his administration 1839–42. In 1843 Prof. James Hall was placed in charge of the palæontology, and he has numbered many now well-known geologists and palæontologists among his assistants in the State Geological Survey during his half century of Directorship. In a preface dated Albany, December 1894, he gives an interesting account of the history and vicissitudes of this great work. Mr. J. M. Clarke joined in 1886, and aided in the preparation of volumes vii and viii, which latter was published in two parts as an "Introduction to the Study of the Genera of Palæozoic

Brachiopoda." The text of the second part, just issued complete, has already been noticed in this Magazine,[1] as it was circulated in two fasciculi among students on account of the long delay interposed in the printing of the plates, now most happily accomplished. They form a magnificent series, over sixty in number, with many hundreds of beautiful figures illustrating the Palæozoic Spiriferidæ, Rhynchonellidæ, and primitive Terebratulidæ, skilfully delineated by former assistants, Mr. R. P. Whitfield and Mr. E. Emmons, and finely lithographed by Mr. P. Ast. Each plate is accompanied by descriptions and legend, with a textual reference facilitating comparison. Nearly 468 preparations of internal structure were made by Prof. Clarke for this volume. Two figures are given on pl. lxxxiv—figs. 34 and 35 —of the new genus *Torynifer*, of which but a single fragment is known. It bears, however, the critical structure which separates it from other genera. The type, *T. criticus*, is from the Lower Carboniferous St. Louis group of La Rue, Kentucky. This genus, "with general relations less athyroid than orthoid," was thus briefly described in the "Annual Report of the State Geologist of New York" for 1893, p. 943, vol. ii, Palæontology: "The shells athyroid in external aspect, but with a well-defined cardinal area and a distinct spondylium in the pedicle valve supported by a median septum." The systematic classification finally adopted has also been already epitomized.[2] We now quote in full a frank additional statement appended on page $385\frac{1}{2}$ (vol. viii, pt. ii).

"The preceding table of Classification of the Brachiopoda is presented with many reservations and in deference to the general opinion expressed by brachiopodists at the present time; but the author believes that it is not the grouping which will be finally sustained. While much of it is an expression of the natural relations and succession of types, there are some portions which are not satisfactory. There seems a more natural succession in the line of the Pentameroids through the Amphigenidæ and the Rensselœridæ to the Centronellidæ than directly from the Rhynchonellidæ. There is also quite as much, or more, reason for believing the Rhynchonellids to be the progenitors of the spire-bearing forms than that they are the progenitors of the loop-bearing forms. The Rhynchonelloid type began early, is persistent and abundant through all the Palæozoic faunas, and, although the transition from these forms to the loop-bearers may be considered the more simple, there is yet much required to show the natural succession, which is more completely accomplished from the Pentameroids to the loop-bearing forms through *Amphigenia* and *Rensselœria*. That the brachia of Rhynchonellids may unite and form a loop seems a very natural inference, and in some forms is nearly accomplished. It would appear that in the Zygospiroids, which have externally a Rhynchonelloid aspect, the loop is completed by the formation of a jugum; but it goes still

[1] Geol. Mag., Dec. III, Vol. X, No. 353, p. 518, Nov. 1893.
Ibid., Dec. IV, Vol. I, No. 358, p. 172, April 1894.
Ibid., Dec. IV, Vol. II, No. 369, pp. 103–113, March 1895.

[2] Geol. Mag., Dec. IV, Vol. II, No. 369, pp. 103–113, March 1895.

farther, and from the junction of these crura are continued in one or two volutions. If such conditions occur in the older forms of the Zygospiridæ, there is no apparent reason why they may not occur elsewhere among the various spire-bearing genera which have a Rhynchonelloid aspect, and it seems a much more natural inference that the development should have been in the line of the Retziidæ or Rhynchospiridæ."

These remarks coincide with the genuine philosophic spirit which has throughout characterized a work which not only fitly illustrates the Natural History of New York State in long past ages, but forms a valuable addition to knowledge of the Brachiopoda in general, and one which cannot fail to exert an important influence on future researches throughout the world. It is given to few to witness the satisfactory completion of a great work conceived over half a century ago, and we offer the veteran State geologist and palæontologist of New York our heartiest congratulations on the successful termination of his lifelong labours.[1]

. . . .

The Brachiopoda of the early Cambrian faunas of the St. John group, New Brunswick, have also been studied with care by Mr. G. F. Mathew, who has described and figured several species in a valuable memoir entitled "The Protolenus Fauna," communicated to the Transactions of the New York Academy of Sciences in March of the past year.[2]

Mr. S. S. Buckman gave some instructive "Notes on certain Brachiopoda" from the Secondary deposits of England in his paper "On the Bajocian of the Mid-Cotteswolds," contributed to the Geological Society of London[3]—serial studies of considerable importance, chiefly relating to Rhynchonelloids.

Lastly, the number of genera and species of recent Brachiopoda has been augmented by Mr. W. H. Dall, who has described and figured several interesting forms dredged in deep water during the "Albatross" expedition, "chiefly near the Hawaiian Islands, with illustrations of hitherto unfigured species from North-west America," in the Proceedings of the United States National Museum.[4] This paper defines *Frieleia*—a new genus of the Rhynchonellidæ, with a spondylium and a smaller number of brachial coils than are present in *Hemithyris*, to which genus it bears most external resemblance. It also clears up misconceptions relating to previously described forms such as *Frenula Jeffreysii*, and gives valuable data on specific development.

Agnes Crane.

[1] We learn from a cosmopolitan list compiled by Mr. J. M. Clarke that 460 publications, relating to the Geology and Palæontology of the State of New York, were issued by various authors during the years 1876 to 1893 inclusive.

[2] Vol. xiv, pp. 101–153, pls. i and ii.

[3] Quart. Journ., vol li, pp. 445–462, pl. xiv, August 1895.

[4] Vol. xvii, pp. 713–733, pls. xxiv, xxx–xxxii. Report xxxiv.

III.—Triadische Cephalopodenfaunen der Ostsibirischen Küstenprovinz. Von Dr. Karl Diener, in Wien. Mit 5 Tafeln. Mémoires du Comité Géologique. Vol. XIV, No. 3. St. Pétersbourg, 1895.

The Triassic Cephalopod Fauna of the Coast Province of East Siberia. By Dr. Karl Diener, of Vienna.

In several localities on the Muravief peninsula, not far from the well-known Russian naval station of Vladivostock, some outcrops of Triassic rocks have lately been discovered by the Russian geologist D. L. Ivanow, which contain a series of Cephalopods, which are described and figured in this memoir by Dr. Diener. A particular interest attaches to some of these fossils, since they show definite relations to the Cephalopods in the Triassic rocks of the Himalaya, now also being critically worked out by the same palæontologist.

The Siberian forms indicate two distinct horizons. The newer of these, which apparently is of the age of the Muschelkalk, consists of a dark, rusty-weathering sandstone, containing *Monophyllites sichoticus*, sp.n., *Ptychites*, sp., and *Acrochordiceras*, sp. The occurrence of these together in the same beds is noteworthy, since both in Spitzbergen and in the Himalaya, *Monophyllites* more especially characterizes the lower division of the Muschelkalk and *Ptychites* the upper.

The large majority of the Cephalopoda are, however, from a distinctly Lower Triassic horizon; they are nearly all casts in a very hard, light-gray, calcareous sandstone. They comprise the following: *Nautilus* sp. aff. *N. quadrangulo*, Beyr., *Orthoceras* sp. aff. *O. Punjabiensi*, Waag., *Orthoceras* sp. aff. *O. campanili*, v. Mojs.; *Dinarites latiplicatus*, sp.n., *Ceratites minutus*, Waag.; *Danubites Nicolai*, sp.n., *Danubites*, sp.; *Ussuria Schmaræ*, gen. et sp.n., *U. Ivanowi*, sp.n., *Pseudosageceras*, gen.n., sp.ind., *Proptychites acutisellatus*, sp.n., *P. hiemalis*, sp.n., *Proptychites*, sp., *P. otoceratoides*, sp.n., *Xenaspis orientalis*, sp.n., *Ophiceras* cf. *Sakuntala*, Dien., *Meekoceras boreale*, sp.n., *Meekoceras*, sp., *M.* (*Kingites*) *Varaha*, sp.n., *M.* (*Koninckites*) *septentrionale*, sp.n.

The Ammonites in the above list chiefly belong to the Liostraca division; the Trachyostraca forms constitute but a small minority. As regards numbers, the genus *Proptychites* is the best represented, and the author proposes to distinguish the beds by the name of this genus, which, it may be noted, is also very abundant in the lower divisions of the Trias in the Salt Range. Whilst these Vladivostock beds have no species in common with the Triassic Olenek-beds of North Siberia, they contain two, if not three, species of Ammonites and a species of *Nautilus*, either identical with or closely related to forms in the *Otoceras*-beds of the Himalaya, and the author concludes that they may be regarded as belonging to the same horizon of the Lower Trias as these. This is lower than the Olenek-beds, and, in fact, the *Otoceras*-beds represent the oldest Cephalopod fauna of the Trias. The recognition of this marine zone of the Lower Trias on the Pacific coast is an interesting and important addition to our knowledge of the distribution of this formation. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "Additional Notes on the Tarns of Lakeland." By J. E. Marr, Esq., M.A., F.R.S., Sec. G.S.

This paper is supplementary to one by the author published in the Q.J.G.S., vol. li (1895). He gives additional notes on Wateredbath Tarn; describes Hard Tarn on Helvellyn, a pond whose outlet has gradually been diverted from a course over screes to one over solid rock; Hayeswater, a lakelet referred to by Dr. H. R. Mill as in some respects intermediate between the mountain-tarns and the valley-lakes; and Angle Tarn, Patterdale, a good example of a plateau-tarn. The results of his fresh observations tend to confirm the views expressed in his former paper.

2. "Notes on the Glacial Geology of Arctic Europe and its Islands.—Part I. Kolguev Island. By Col. H. W. Feilden, F.G.S.; with a "Report on the Erratic Boulders from the Kolguev Beds," by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

Kolguev Island, about the size of Norfolk, lies about 50 miles from Arctic Russia and about 130 miles south-west of the nearest part of Novaya Zemlya, with soundings not exceeding 30 fathoms between it and Russia, and probably not more than 75 fathoms between it and Novaya Zemlya. It is entirely composed of a vast accumulation of glacio-marine beds. The northern two-thirds of the island consists of an elevated ridged area with a maximum height of 250 feet. The author has been furnished with notes by Mr. Trevor-Battye concerning the geology of this region. It is inferred from his observations that this elevated region is composed of beds of sand with erratic boulders not less than 80 feet deep, resting on clays—the "Kolguev Clays." Mount Bolvana rises as a symmetrical cone above the tundra, detached from the northern plateau, pointing, in the opinion of the author, to the occurrence of marine erosion.

The southern portion of the island is tundra, a dead flat of grass, bog, and peat-levels reaching to the sea; good sections of the Kolguev Clays are exposed in the gullies traversing it near the sea on the western coast. In the vicinity of the Gobista river the Kolguev Beds consist of clays merging here and there into sands. They are charged with boulders often ice-scratched, indicating continuous deposition in a comparatively deep sea. The beds yielded many shells of Arctic mollusca, such as *Saxicava arctica*, *Mya*, etc., apparently dispersed from top to bottom. The ice-pack has forced many fragments of semi-fossil wood on to the shore, no doubt worked up from a bed immediately below sea-level. No deposit was met with in Kolguev Island precisely similar to what is called "Till" in Scotland, though there are many Boulder-clays in Britain which are in no measure superior in toughness to those of Kolguev—for instance, those of the Yorkshire coast and the Chalky Boulder-clays of Norfolk.

It is suggestive that all the glacial deposits met with by the author in Arctic and Polar lands (except the terminal moraines now forming above sea-level) should be glacio-marine beds.

Prof. Bonney in his report describes the rocks brought home by the author. They include granite-gneiss (very like Archæan rocks), grit, chert, limestone with *Favosites* (Silurian or Devonian), limestone with *Amphipora ramosa* (Devonian), limestone with *Lithostrotion irregulare* (Carboniferous), and a fragment of a Jurassic belemnite. The fossils have been examined by Mr. E. T. Newton, F.R.S.

II.—December 4, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read :—

1. "On the Alteration of certain Basic Eruptive Rocks from Brent Tor, Devon." By Frank Rutley, Esq., F.G.S.

Two microscopic sections of rocks occurring on the north side of Brent Tor were examined, and a cursory glance suggested at once the idea that they might originally have consisted to a greater or less extent of extremely vesicular basalt-glass. No unaltered vitreous matter, except perhaps mere traces, can now be detected in these specimens. the interest of which lies in the assemblage of alteration-products which they contain. A third section cut from a small chip collected at the southern side of the base of the Tor consists of a highly vesicular lava of a hyalopilitic character, which may be regarded as an amygdaloidal glassy basalt.

The author gives a detailed account of the microscopic characters of the three sections, and discusses the history of the rocks, comparing them with Tertiary basic glass, and with the Devonian rocks of Cant Hill, which he described previously. He brings forward evidence in favour of the view that the original alteration of both the Brent Tor and Cant Hill rocks was palagonitic; and that while in the Brent Tor rocks the subsequent alteration of the palagonite into felsitic matter, magnetite, secondary felspar, epidote, and probably kaolin, and some serpentine and chlorite, was complete, it was only partial in the case of the Cant Hill rocks. We may, therefore, assume that palagonite is not the ultimate phase of alteration in basic igneous rocks.

2. "The Mollusca of the Chalk Rock : Part I." By Henry Woods, Esq., M.A., F.G.S.

In the introductory part of the paper the author gives an account of the characters, distribution, and literature of the Chalk Rock. He points out that the Chalk Rock fauna may be recognized at the same level in Northern France, N.W. Germany, Saxony, Silesia, and Bohemia ; and on account of the wide distribution and distinctive features of this fauna, he suggests that the Chalk Rock merits a palæontological rather than a lithological designation, and proposes for it the term "zone of *Heteroceras reussianum*."

The main part of the paper is devoted to the consideration of the Cephalopoda, Gasteropoda, and Scaphopoda ; and is based largely on the collection from Cuckhamsley (Berks) made by the late

Mr. Montagu Smith; but for the loan of many specimens the author is indebted to Mr. R. M. Brydone, Mr. C. Griffith, Mr. W. Hill, Dr. J. Morison, and Mr. James Saunders. In addition to some genera, of which sufficiently good examples for exact determination have not yet been obtained, the following are represented: *Nautilus, Ptychoceras, Heteroceras, Baculites, Prionocyclus, Pachydiscus, Scaphites, Crioceras, Emarginula, Pleurotomaria, Trochus, Turbo, Crepidula, Natica, Cerithium, Aporrhais, Avellana,* and *Dentalium.* Some new species are described, and the synonymy and distribution of the others treated in detail, figures and descriptions being given of the forms not previously well known. The account of the Lamellibranchs and the general conclusions are reserved for Part II.

III.—December 18, 1895.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "The Tertiary Basalt-plateaux of North-western Europe." By Sir Archibald Geikie, D.Sc., LL.D., F.R.S.

The author in this paper gives the results obtained by him in the continued study of Tertiary Volcanic Geology in the seven years which have elapsed since the publication of his memoir on "The History of Volcanic Action during the Tertiary Period in the British Isles." His researches have embraced the western islands of Scotland, St. Kilda, and the Faroe Islands.

(1) In an account of the rocks of the basalt-plateaux attention is particularly directed in this paper to a type of banded basic lavas which play an important part in the structure of the volcanic districts both of the Inner Hebrides and of the Faroes. The banding sometimes consists in layers of more highly vesicular structure, sometimes in alternations of distinctly different lithological character, such as close-grained basalt and more coarsely crystalline dolerite. These banded rocks are more particularly developed in the lower portions of the volcanic series. At a distance they might be mistaken for tuffs or other stratified deposits. They occupy a conspicuous place in the great precipices of the west and north of the Faroe Islands.

Numerous examples are cited of the ending-off of basalt-sheets in different directions, indicative of many local vents from which the lavas issued. An account is also given of tuffs and other stratified intercalations which occupy a subordinate place in the structure of the plateaux.

(2) A number of examples is given of the volcanic vents which form a characteristic feature of the basalt-plateaux. A remarkable row of five such vents was met with by the author at the base of the great cliffs on the west side of Stromo, in the Faroe Islands. They are occupied with agglomerate, and their saucer-shaped craters have been filled in by successive streams of lava from neighbouring vents, the whole being buried under the great pile of basalt-sheets forming the island of Stromo.

An instance of similar structure is described from Portree Bay, the agglomerate in this case being connected with a thick and wide-spread sheet of tuff intercalated among the basalts. Another example is cited from the east end of the island of Canna, where the ejected volcanic blocks are associated with records of contemporaneous river-action.

(3) The paper describes in some detail the evidence for the flow of a large river across the lava-fields during the time when volcanic activity was still vigorous. Thick sheets of well-rolled gravel are intercalated among the basalts of the islands of Canna and Sanday. These masses of detritus consist mainly of volcanic material, but they include also abundant pieces of Torridon Sandstone and rocks from the Western Highlands. The current of water which transported them certainly came from the east. That it flowed while the volcanic vents continued in eruption is shown by the bands of tuff and the large blocks of slag contained in the conglomerates, as well as by sheets of vesicular basalt interstratified in the same deposits. From the terrestrial vegetation whereof the macerated remains are enclosed in the tuffs and shales, and from the entire absence of marine organisms, it may be confidently inferred that the water was that of a river. The large size of many of the rounded blocks that were swept along proves that this river must have been of considerable volume and rapidity. The stream probably drained some part of the Inverness-shire Islands, and wandered over the volcanic plain, following the inequalities of the lava-fields, sweeping away the loose detritus of volcanic cones, and being continually liable to have its course altered by fresh volcanic eruptions. An interesting section is cited from the island of Sanday, where what appears to be a portion of the ravine of one of the tributaries of this river, trenched in the basalts, filled with coarse shingle and buried under later basalts, remains in a picturesque sea-stack.

(4) Many additional details are given to illustrate the structure and behaviour of the basic sills which are so abundantly developed, especially at the base of the plateaux. Some of these sheets are of colossal proportions, as in the Shiant Isles, where a single, columnar bed is 500 feet thick. Others descend to extremely minute proportions, such as the slender layers and threads which have been injected into the coal and shale between the lower basalts in the Portree district. A remarkable instance of a sill traversing the centre of another is cited from the south-east of Skye, the younger sheet having a strongly developed skin of black glass on its upper and under surfaces. One of the most striking instances of a sill rising obliquely across a thick mass of the plateau-basalts is described from Stromo in the Faroe Islands.

(5) The author adds some additional particulars, more especially from Skye and St. Kilda, to his published account of the dykes which have taken so important a place in the origin and structure of the plateaux.

(6) Further observations are narrated regarding the great bosses of gabbro in the Inner Hebrides. In particular, the peculiar banded structure, already described from a part of the Cuillin Hills, is shown

to have a wide distribution in Skye, and to occur also in Rum. The remarkable alteration of the plateau-basalts as they approach the gabbros of Loch Scavaig is referred to, and the microscopic structure of these metamorphosed rocks is described in notes supplied to the author by Mr. A. Harker. An account is also given of the gabbros of St. Kilda, which display a considerable variety of texture and composition and include basalts and dolerites.

(7) The author, having been able to visit St. Kilda, describes the junction of the granophyre of that remote island with the basalts and gabbros. He brought away a series of specimens and photographs which demonstrate that the acid rock has been injected into the basic masses, traversing them in veins and enclosing angular pieces of them. The granophyre is precisely like that of Skye and Mull, and is traversed by veins of finer material, as in these islands. Where it has penetrated the basic rocks it sometimes forms a kind of breccia-matrix in which the pieces of dark material are enclosed. It has taken up a certain quantity of the basalt or gabbro, as is shown by the abundant brown mica and hornblende which have been developed in the acid rock, especially round the enclosed basalt fragments. The results of a microscopic examination of thin slices of the rock at the junction are furnished by Mr. Harker.

From Skye examples are given of triple dykes and sills, wherein a central band consists of granophyre or spherulitic felsite, while the two marginal bands are of basalt, diabase, or other basic material. There does not appear to be any ascertainable connection between the acid and basic parts of such compound intrusions. In some cases the basic, in others the acid, portion is the older.

(8) An account is given of the little islet of Hysgeir, about 18 miles to the west of the island of Eigg, which has been identified by Dr. Heddle with the rock of the Scuir of Eigg, and which the author has visited in two successive years. The "pitchstone" is precisely like that of the Scuir down to the most minute structure, as is shown by an examination of the rock under the microscope by Mr. Harker. There can be little doubt that this rock was a superficial lava like that of Eigg, and there seems every probability that it is really a westward continuation of the Scuir. The Hysgeir pitchstone everywhere slips under the sea, so that its bottom cannot be seen.

(9) By way of illustrating the probable history of the basaltic plateaux of North-western Europe, the author gives a short summary of the results of recent investigations of the modern volcanic eruptions of Iceland, especially by Th. Thoroddsen and A. Helland. He shows in how many ways the phenomena of that island explain the facts which are met with in the study of our Tertiary plateaux, and how, in some respects, the enormous denudation of these plateaux throws light on parts of the mechanism of the Icelandic volcanoes which are still buried under the erupted material.

(10) Reference is made to the evidence of considerable terrestrial movement since the Tertiary volcanic period, as shown by the

tilting of large sections of the plateaux in different directions, and also by the existence of actual faults. Besides the normal faults, which are not infrequent among the Western isles, there occur among the Faroe Islands instances of reversed faults, which probably indicate disturbance of a more serious character.

(11) The concluding section of the paper deals with the effects of denudation on the plateaux. With possibly some minor intervals of partial depression, the present Tertiary volcanic tracts of the British and Faroe Isles have remained as land ever since the volcanic period. Their valleys were probably begun before the close of the eruptions, and these hollows have been continuously widened and deepened ever since. The result is a stupendous memorial of the potency of the agents of geological waste. While the Inner Hebrides abound in most impressive illustrations of this denudation, they are inferior in that respect to the Faroes. The long level lines of basalt-sheets furnish, as it were, datum-lines from which the extent of erosion can be estimated and even measured. There is certainly no other area in Europe where the study of the combined influence of atmospheric and marine denudation can be so admirably prosecuted, and where the imagination, kindled to enthusiasm by the contemplation of such scenery, can be so constantly and imperiously controlled by the accurate observation of ascertainable fact.

2. "The British Silurian Species of *Acidaspis*." By Philip Lake, Esq., M.A., F.G.S.

In this paper descriptions are given of those species of *Acidaspis* in the Silurian of Britain which have hitherto been incompletely described. The British forms are compared with those from the same system in Sweden and Bohemia. Five, out of nine, are represented by the same or very closely allied species in Sweden; two in Bohemia. All the Swedish forms except one are represented in Britain, and one in Bohemia as well as in Britain.

CORRESPONDENCE.

THE FORMATION OF CHALK BOULDERS.

Sir,—I venture to think that the difficulties of the diminishing group of geologists who still reject the land-ice origin of the chief part of our British drift-deposits will not be greatly lessened by the two very interesting papers in your last Number—that by Prof. G. A. J. Cole on "The Destruction of the Chalk," and by the Rev. E. Hill on "East Anglian Boulder-clay." There is this common objection to both papers, as indeed to most of the arguments put forward to support the marine origin of the drifts, that while it is quite possible to ascribe certain observed phenomena to the action of floating ice, it is quite impossible to explain thus the whole group of facts presented by any district which is carefully and thoroughly examined. The 'extreme glacialist,' on the other hand, claims that the presence of an extensive ice-sheet, with its necessary accompaniment in this latitude of heavy streams and flood-waters, does afford a sufficient explanation of all the known facts.

The landslips of Chalk on the Antrim coast, described by Professor Cole, seem to me insufficient even to account for the masses of Chalk in the Drift at Cromer. It is quite certain that the explanation will not apply to the masses of Upper and Lower Lias shale which occupy similar positions amid the Basement Boulder-clay in Filey Bay and at Bridlington in Yorkshire, nor to the patch of Speeton clay which has surmounted the Chalk of Flamborough Head, nor to the isolated shreds of sea-bottom and fresh-water deposits contained in the Boulder-clay in numerous localities on the same coast.

The position and character of these masses render the landslip theory quite inapplicable to them; yet their position is so closely analogous to that of the Chalk boulders of Cromer that we are compelled to suppose a common method of transportation.

There is a slight inaccuracy of fact in the Rev. E. Hill's paper, which, though not of much importance as it stands, may as well be corrected at once lest it reappear unexpectedly as a corner-stone in the argument of another writer on the subject. After mentioning that chalk-drift is found in Leicestershire up to 800 feet, the author adds, "which is far higher than any Northern Chalk." But the Chalk Wolds in Yorkshire rise to slightly over 800 feet in Garrowby Hill (808 feet), and continue for several miles in that vicinity to reach elevations of between 750 and 800 feet.

Douglas, Isle of Man.
December 8*th*, 1895.

G. W. Lamplugh.

ZONES OF THE CARBONIFEROUS.

Sir,—British palæontologists, as well as stratigraphical geologists, will welcome the news of Messrs. E. J. Garwood and J. E. Marr (Geol. Mag., Dec. IV, Vol. II, pp. 550-552, December, 1895), that there is some hope of dividing the British Carboniferous Limestone into zones. But, when they direct the attention of local observers to note the accurate horizons and localities of fossils, why should they pass by the numerous Crinoidea of our own Mountain Limestone as unworthy of special attention? From a study of these animals in North America, many divisions and correlations have been made in the beds there called "sub-Carboniferous," and the biological results obtained have been most valuable. But in Britain, as I pointed out some years ago, a true palæontology of our numerous Carboniferous Crinoidea remains impossible so long as all specimens are labelled, like the vast majority of those in our rich national collection, "Carboniferous Limestone, Yorkshire?" I am certain that attention to the Crinoidea would render results quite as important as those to be derived from "the Corals, Trilobites, Brachiopods, and Cephalopods"; and if the committee referred to will only accept my services, I shall be pleased to have the chance of examining any specimens which have attached to them labels of scientific value.

F. A. Bather.

British Museum (Nat. Hist.), 3*rd December*, 1985.

PYROXENE AND SERPENTINE IN ASSOCIATION WITH EOZOÖN CANADENSE.

Sir,—I fear that in my short notice of the rock containing Eozoön at Côte St. Pierre, which was printed in last year's Volume (p. 292), I must have failed in clearness of expression, since my friend Sir William Dawson, in his interesting defence of "the animal nature of Eozoön," says (p. 505) there "seems to be no good evidence that any portion of the pyroxene has been changed into serpentine." But of that, as I endeavoured to intimate on parts of pages 297 and 298, I have as good evidence as is possible. My slices show every stage from an unaltered pyroxene (allied to malacolite) to serpentine. In one slice, where the "canal-system" is well preserved, a few residual bits of pyroxene remain among the serpentine; in all the close resemblance of the silicates indicates an identity of the origin, which can be proved in the case of some. His suggestion that the pyroxene may have originated from local showers of volcanic dust seems to me not very probable. Grains or crystals of pyroxene are, no doubt, ejected in fair abundance from certain volcanoes, but in company with basaltic scoriæ. It is difficult to understand how the latter could be sifted from the former, and if this has not been done, what has become of the abundant aluminous silicate? True, there is a little white mica in the crystalline limestone, but not enough to represent the ash even of a Limburgite. Moreover, I believe the augite of a basalt is generally the aluminous variety. Perhaps, however, he would appeal to an eruptive peridotite. Here almost all the material would ultimately produce serpentine; but, then, volcanoes discharging only olivine augite slag are extremely rare; indeed, I should hardly like to say as yet, notwithstanding Kimberley, that their existence has been proved.

T. G. Bonney.

SWEDISH GRAPTOLITES.

Sir,—The November Number of the Geological Magazine contains the conclusion of an English translation of Dr. G. Holm's paper "On *Didymograptus*, *Tetragraptus*, and *Phyllograptus*," upon which I trust you will allow me to make the following remarks:—

Speaking of *Isograptus gibberulus*, Nich., sp. (or, as he prefers to term it, *Didymograptus gibberulus*), Dr. Holm quotes a previous paper of mine, in which I have treated of this matter. In that paper I stated in the very beginning, in direct terms, that the fossil in question has two stipes. Further on a sicular appendage is mentioned which, at a long distance from the sicula, is not inconsiderably widening.

Now we have to remark that Hall (in his "Graptolites of the Quebec Group") has figured some specimens of *Tetragraptus Bigsbyi*, Hall, so placed on the slab that two stipes are wholly visible, while you can only see the profile of a third. Such a stipe affords some very remote resemblance to the appendage described, and in order to avoid the suspicion that my observations had been based upon specimens preserved in a similar manner, I have appended in a footnote this remark: "Since this dilatation (of the sicular appendage) never takes place except much outside the surrounding stipes, it is almost impossible to make the mistake of considering the appendage as part of a third branch." This statement was singularly misinterpreted by Dr. Holm in his paper "On *Didymograptus*, etc." But, as I thought I had expressed myself pretty clearly, and did not fear that any other Swedish reader might misunderstand the meaning, after having privately pointed out his error to Dr. Holm, I did not think it called for any public reply. I was therefore not a little astonished at finding that in the English version my statement was still further misrepresented. The English reader must be convinced that my assertions on two consecutive pages are contradictory. But my statement in the before-mentioned footnote is, as everyone can see, in full accordance with the views presented on the preceding pages, and totally contrary to the version given by Dr. Holm.

Hoping shortly to find time for working out a description of an interesting Graptolite-type, which I have met with, I will for the present refrain from making any further remarks about the genus *Isograptus*, which, I believe, should still be maintained.

Lund, 8*th December*, 1895. Joh. Chr. Moberg.

MISCELLANEOUS.

Further Notes on Eozoön Canadense by Sir Wm. Dawson, C.M.G.

Note to Second Article.—I should have mentioned in this article that Dr. F. D. Adams has shown, by comparison of a number of detailed analyses, that several of the gneisses of the Grenville Series have the chemical composition of Palæozoic slates, and thus that there can be no chemical objection to regarding them as altered sediments. This I consider a very important observation; and I may refer for details to his paper in the American Journal of Science, July 1895, vol. L, p. 58.

Note to Third Article.—The tubes penetrating some of the larger specimens of Eozoön may perhaps be compared with the central canal in the modern *Carpenteria*.—W.D.

Sections of Bunter and Keuper, etc.

During the construction of the Seacombe branch of the Wirral Railway the strata have been examined by Mr. T. W. Davies and Mr. T. Mellard Reade. Sections of Bunter, Keuper, and Glacial Drift are described by them. They note evidences of denudation of the Bunter prior to the accumulation of the Keuper. The Glacial Drift was found to comprise two beds of Boulder-clay separated in places by sand. In the Lower Clay abundant Foraminifera were discovered, while but few occurred in the Upper Clay. (*Proc. Liverpool Geol. Soc.*, vol. vii, part 3.)

Mr. R. Bullen Newton is continuing his useful work on the Eocene Mollusca, and has described a number of Gasteropods which have hitherto received only MS. names. (*Proc. Malacological Soc.*, vol. i, part 7.)

Fig. 1.

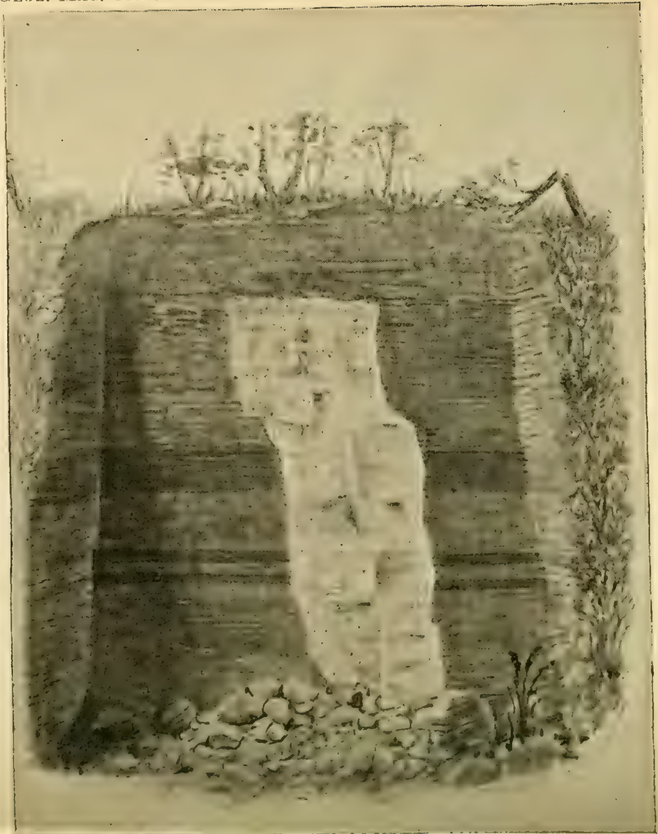

Fig. 2.

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ORIGINAL ARTICLES.

I.—On Dikes of Oligocene Sandstone in the Neocomian Clays of the District of Alatyr, in Russia.

By Dr. A. P. Pavlow,
Professor of Geology in the University of Moscow.

(PLATE V.)

THE part of the province of Simbirsk lying to the north of Alatyr, in the angle between the Soura and the Alatyr rivers, is formed of Lower Cretaceous strata, chiefly Neocomian clays, covered by Boulder-clay (which is not rich in boulders), and part by Glacial and Æolian sands. The same Neocomian clay expands widely to the south and to the east from the town of Alatyr. Upon the northern border of the Alatyr valley, and on the right side of the Soura river, these clays are covered by ancient alluvial sands, deposited probably at the time when the great ice-sheet dammed the course of the Soura in the lower part of its valley, and caused colossal overflowings of its waters, the traces of which are preserved in the great masses of alluvial sands covered with fir wood, and much resembling the "Haidesand" of Northern Germany.

Only to the south-west of Alatyr, at a distance twenty kilom., commences the region of the Upper Cretaceous beds, covered by sands and quartz-sandstones without fossils, defined as Tertiary from their resemblance to the Tertiary sands and sandstones of the southern parts of the province of Simbirsk. A small outlier of these sands is preserved also at a point to the north-west of Alatyr at the same distance.

I have been well acquainted with these general features of the geological structure of the region since my geological researches in this country in 1887. In 1892 I was once more in Alatyr, during the construction of a bridge across the Soura river for the Moscow-Kazan railroad. Mr. N. Th. Ditmar, a mining engineer then attached to this railroad, had drawn my attention to the sandstone brought by the countrymen of a neighbouring village, Yavley, which they found in a ravine ending in the Soura near this village. We went with Mr. Ditmar to this ravine, which cuts, from west to east, the high left border of the Soura valley, and I saw at a distance of about three kilos. from Yavley village a rare stratigraphical phenomenon—a vein of sedimentary rock which had filled up a nearly vertical fissure in another sedimentary rock, just as we see volcanic veins generally do.

To distinguish such veins and dikes from volcanic veins and dikes, I shall venture to call these cases by the brief appellation of Neptunic veins or Neptunic dikes.

The rock forming the Neptunic dike of Alatyr turned out to be a quartz sand mixed with glauconitic grains; the sandstone found here by the countrymen once formed a dike jutting out towards the ravine, and was only the locally indurated portions of this sand. At the time of my visit all these indurated portions of the dike had been already worked out. The remaining vein of sand, or very friable sandstone, cut a horizontally stratified mass of dark grey and black Neocomian clay, containing some gypsum and occasional beds of fine glauconitic sand with pyritic nodules. The soft clays were well exposed quite up to the vein, and showed no trace of induration. The thickness of the vein varies between 12 and 14 inches, its position is nearly vertical or slightly inclined (about 10–15 degrees) towards W.S.W., and its strike is about N. 15° W., *i.e.* nearly parallel to the general direction of the Soura in the neighbouring part of its course. From the direction of the ravine and from the vein being artificially cleared away, it was possible to see the vein exposed at both sides of the ravine. To follow the direction of the vein further across the land was impossible, owing to the superficial drift, as well as to the brushwood and forest of half-grown trees which covered the neighbouring land. Fig. 1 represents the vein cropping out at the left side of the ravine, and fig. 2 the same at the right side. The countrymen told us they have found several sandstone veins in this ravine, but when I visited the place, only one was to be seen, the others being probably concealed beneath the landslips and the superficial detritus.

The sandstone got from the dike occasionally includes small fragments of dark clay detached from the rock forming the walls of the dike, and is rather rich in fossils, well preserved but difficult to get from the hard rock. Shells of *Pectunculus* predominate among them.

I have previously defined, in 1892, a small number of species as characteristic of the Lower and partly Middle Oligocene.[1] Since that time our knowledge of the Lower Oligocene Mollusca has been much increased, especially by the publication of the last parts of the important Monograph of Prof. A. von Koenen,[2] and it has been possible for me to verify and rectify my former determinations; and, moreover, last summer I have had an opportunity of showing the fossils of this sandstone to Prof. A. von. Koenen, and of

[1] Comptes rendu des travaux du Comité Geologique en 1892, p. 10. Bull. du Comité Geologique, T. xii.

[2] Das Norddeutsche Unter-Oligocën und seine Mollusken-Fauna, Lief. V, 1893; Lief. VI, 1894. Abh. zur. Geol. Specialkarte v. Preussen und den Thüringischen Staaten, Bd. X. heft. 5–6.

availing myself of his advice and his large and fine collections. Prof. von. Koenen also recognized the fauna of Yavley as Lower Oligocene. I am able now to give the following list of the fossils of this fauna:

Voluta suturalis Nyst.

Pectunculus tenuisulcatus v. Koenen.

Astarte Bosqueti Nyst (v. Koenen), or another very closely allied species differing from *Astarte Bosqueti* only by the lateral teeth being somewhat shorter.

Ostrea; many small specimens partly resembling young specimens of *Ostrea flabellula*, and partly like the young of *Ostrea Queteleti* Nyst (v. Koenen).

Nucula, cf. *Bowerbankii* Wood (non Dixon).

Natica, cf. *hantoniensis* Pilk.

Acirsa, probably a new species allied to *Acirsa angusta* (v. Koenen).

Cases are well known in which small bands of sedimentary rock have been jammed between rocks of another geological age. Such occurrences have been observed in several countries by many geologists, especially in regions broken by numerous and compound faults, as for instance, in the cases of the bands and pieces of Jurassic, Cretaceous and Tertiary rocks jammed between the Triassic rocks of Middle Germany.

The Neptunic dike of Alatyr cutting an area of undisturbed stratification cannot be compared with such tectonic wedges, to which latter, indeed, the term Neptunic dike cannot strictly speaking be applied. We are acquainted with other types of veins or pockets cutting sedimentary strata and filled by another sedimentary or fragmental mass; such are the veins and pockets in the Cretaceous Limestone between Lausanne and Yverdon in Switzerland (Poches siderolitiques of Mouremont). Of similar character are the veins and dikes in the Carboniferous Limestone of the eastern border of the Mendip Hills filled by yellow marly conglomerate with Triassic fossils. In the same country (near Holwell, about five miles from Frome) there are still more interesting dikes cutting into the Carboniferous Limestone, formed of Liassic conglomerate with marine fossils. These latter were described by Mr. Charles Moore in the Quart. Journ. of Geol. Soc., vol. xxiii, 1867. They have been considered as fissures in the Carboniferous Limestone, when that rock formed first a shore pounded by the breakers of the Liassic sea and afterwards the floor with open fissures of this Liassic ocean.

Sandstone dikes, more or less closely resembling our Alatyr dike, have been described by many authors. Thus Mr. H. Strickland (Trans. Geol. Soc. Ser. ii, vol. v, p. 599) has described four dikes penetrating into Lias shale at Ethie, near Cromarty in Ross-shire, of which two are parallel to the stratification of the Lias shale, but the other two send off branches in various directions; no fossils have been noticed in the substance of the dikes, and the period of insertion of the sand into the fissures is undeterminable. Mr.

W. Cross describes (Bull. Geol. Soc. of America, vol. v, p. 225) intrusive sandstone dikes in granite occurring in the Pikes Peak region in Colorado; no fossils were found in the sandstone, the source of sand and the time of its intrusion not being defined. Mr. J. S. Diller refers, in Bull. Geol. Soc. of America, vol. i, p. 439, to many other cases of sandstone dikes discovered in many countries (by Ch. Darwin in California, by J. D. Dana in Oregon, by T. D. Whitney in California, by W. J. McGee in eastern-central Mississipi).

The features which distinguish the Neptunic dike of Alatyr from the above-mentioned are that the rock in which it is enclosed is soft, while the rock forming the dike itself is in some places a hard sandstone, and in others a friable sand.

Our Alatyr dike more closely resembles the sandstone dikes cutting Cretaceous shales in the north-western border of the Sacramento valley in California, carefully described by Mr. J. S. Diller.[1] These sandstone dikes, which are exposed in the valleys of several streams tributary to Cottonwood creek, strike to the north-east, are more or less parallel one to another, and in cutting the shales are inclined 15° to the north-east. The thickness of these dikes varies from two to fourteen or twenty inches, and the largest dike is fifteen feet thick. The sandstone forming the dikes is more or less homogeneous, and frequently includes small fragments of shale along their borders. The shales which contain the sandstone dikes are covered by the newer formations of the Sacramento valley. In explaining the origin of these dikes Mr. Diller calls attention to certain phenomena frequently associated with earthquake movements. Thus, during the great Calabrian earthquake of 1783 many fissures were formed in the ground, and from some of them great quantities of sand and water issued. After the flow ceased, the openings were left full of sand. Similar phenomena accompanied the earthquakes of New Madrid, Missouri in 1811–1813, of Valparaiso in 1822, of Sonora in 1887, etc.

The formation of a system of parallel fissures by earthquakes, and their being filled with sand forced up from below is, according to Mr. Diller's view, a phenomenon identical with the formation of the sandstone dikes of Sacramento region, these dikes thus being a record of ancient earthquake movement. A sandy bed of the same Cretaceous series, cropping out from under the shales which are cut by the dikes, about seven miles westward of the principal group of dikes, is considered to be the source of the sand in the dikes. Thus, according to Mr. Diller's view, the sand is carried up by an ascending current of water from a lower, *i.e.* from a more ancient bed. In the absence of fossils it was scarcely possible to prove this positively.

Is such an explanation applicable to our case? We must reply in the negative. Our case makes it possible to give a somewhat different explanation. Our conditions are more favourable, fossils being preserved in the rock forming the Neptunic dike of Alatyr. It can positively be decided whether the sandstone of the dike is

[1] Bull. of the Geol. Soc. of America, 1889, vol. i, pp. 411–442.

older or newer than the rock which encloses it. The facts are that the clay cut by the dike is of Lower Cretaceous age, while the sandstone of the dike is Tertiary, or to speak more strictly, Oligocene, and therefore considerably newer. The sand must then have been intruded into the clay not from below but from above. Now let us consider what were the circumstances of the formation of the dikes.

The formation of the fissures long before their infilling and the slow accumulation of sands in them, such as may have occurred in the case of the fissures in the Carboniferous Limestone of the Mendips, cannot be considered as probable, the clay being soft and the sandstone homogeneous, and the latter having none of the characters of a slowly accumulated deposit. We must conclude, therefore, that the fissure was opened and quickly filled with the sand which was on the spot ready to fill it.

We can represent to ourselves the march of events in the region of Alatyr before and after the formation of these dikes somewhat as follows.

The Lower Cretaceous sea deposits here a thick mass of clays interstratified with beds of glauconitic sand. The existence of Gault in the neighbourhood shows that these conditions were continued also into the Gault period. We may also suppose, with all probability, that during part of the Upper Cretaceous time this was a littoral part of the sea, because the northern boundary of the Upper Cretaceous beds does not pass far from here to the south. After Upper Cretaceous times, the region becomes dry land, and the Upper Cretaceous and Gault deposits are exposed to denudation. A new transgression of the sea begins in the Lower Oligocene time, during which the Oligocene sea covers the Lower Cretaceous clays and lays down its sandy sediments on their surface. While this Oligocene sand was still not too thick, an earthquake occurs and the seismic fissures tear the floor of the sea, penetrating into the Neocomian clay; and the Oligocene sand, containing many shells, quickly fills up the fissures. After a time the level of the sea falls, the dry land reappears in the region, the process of denudation recommences, and the Tertiary strata disappear almost entirely from the country. In Quaternary times a marginal part of the great ice-sheet passes through the country, and the old alluvial sands are deposited on the lower parts, and we should never have known that the Oligocene sea once covered this region, if a little sample of its sediment had not escaped destruction by being concealed deep in the fissures of the sea floor.

If this explanation be correct, we have here an interesting instance of the means by which nature notes the events of her history. The earthquake breaks for a moment the regular march of events, and the sea with its sandy floor becomes for the occasion a seismograph, and notes this event and the time at which it took place.

II.—On a Recent Boring in the Trias at Stratford-on-Avon.

By Horace T. Brown, F.R.S., F.G.S., F.C.S.

THE question of the water supply of the town of Stratford-on-Avon has for years past presented many difficulties. The town is situated on the uppermost beds of the Upper Keuper Marls, and the water derived from the wells sunk in these gypseous marls, or from the alluvial gravel of the river valley, contains an amount of solids equal to about 170 grains per gallon, of which about 125 grains consist of calcium sulphate. Up to a very few years ago this intensely hard water was alone available for domestic and manufacturing purposes, but the main supply of the town is now derived from catchment basins and reservoirs at Snitterfield on the adjoining hills about four miles north of Stratford. In years of average rainfall a fair supply of moderately soft water is obtained from this source, but it is one which, as regards organic impurity, bears unmistakable signs of its surface origin, and during dry seasons the town supply has to be supplemented with the hard well-water I have already referred to.

Quite recently Messrs. Flower and Sons, who were in search of a further supply of water of a softer character for their Brewery, have put down an Artesian boring through the Upper Keuper Marls, and have reached the Lower Keuper Sandstone, which is found to contain an inexhaustible supply of water of excellent quality, and similar in general composition to that of the Leamington water, which is derived from the same beds nearer their out-crop, at a point about ten miles N.E. of Stratford-on-Avon.

The position of the boring is about half-a-mile to the north of the town, and is 400 yards east of the junction of the Upper Keuper with the Rhætic Beds, the line of division here running almost north and south. If this is not a faulted junction, and there is no evidence of this, the boring must commence very nearly at the top of the Upper Keuper, so that the distance from the surface of the ground to the coming in of the Lower Keuper must approximate very closely, probably within 25 or 30 feet, to the total thickness of the Upper Keuper Marls in this part of the country.

After taking into consideration all the available geological data I considered it probable that the Lower Keuper Sandstones would be reached at a depth of 550 to 600 feet. The actual depth, as will be seen from the accompanying section, was 604 feet.

The following is a detailed section of the boring taken from samples and data carefully obtained by the contractors, Messrs. E. Timmins and Sons, during the progress of the work:—

No.		Feet.
1	Red Marl	45
2	Red Marl and Gypsum	15
3	Grey Marl and Gypsum	5
4	Red Marl and Gypsum	83
5	Plastic Red Marl	58
6	Red and Grey Marl and Gypsum	10
7	Red Marl and Gypsum	9
8	Grey Marl and Gypsum	20
9	Red Marl and Gypsum with a little sand	15

No.		Feet.
10	Plastic Red Marl	25
11	Red Marlstone with beds of White Sandstone	29
12	Red Marl and Gypsum	37
13	Red and Brown Marlstone with a little Gypsum	31
14	Red Marl with a little Gypsum	13
15	Brown Marlstone	31
16	Red Plastic Marl with a little Gypsum	74
17	Mottled Red Marl with blue veins	25
18	Red and Grey Marl	21
19	Sandy Red Marl	4
20	Red Marl with Gypsum	24
21	Marlstone	30
22	Brown Sandstone	3
23	Grey Marl	3
24	Fine light-red Sandstone	10
25	Grey Marl	3
26	Fine light-grey Sandstone	4
27	Grey Sandstone	48
28	Light Red Sandstone	5
29	Light reddish-grey Sandstone	7
30	Grey Sandstone	85
31	Red Sandstone	4
32	Grey Sandstone	28
	Bore terminates in No. 32 at	804

Summarizing the above details we have:

Upper Keuper Nos. 1-21		604
Lower Keuper Nos. 22-32		
Passage Beds (Marls and Sandstone) 22-25 ...	19 ft.	200
Sandstones 26-32	181 ft.	

The whole of the Upper Keuper was perfectly dry, but water was met with directly the Lower Keuper was touched at 604 feet. This increased in quantity as the boring penetrated further into the sandstones, and a supply of 8,000 gallons an hour is now being pumped, without any signs of exhaustion. The artesian head of the water is considerable and is sufficient to afford a natural flow of 1,800 gallons per hour at a height of 50 feet from the surface.

I here append an analysis of the water, and for purposes of comparison have also added the analysis of the water of a town well sunk in the Upper Keuper Marls.

	Bore Water Lower Keuper.	Well in Upper Keuper.
	(Grains per gallon.)	
Sodium Chloride	4·50	3·12
Sodium Nitrate	0·06	...
Sodium Sulphate	6·87	...
Sodium Carbonate	2·75	...
Potassium Sulphate	0·61	...
Magnesium Sulphate	...	6·95
Magnesium Carbonate	1·13	16·61
Calcium Nitrate	...	2·46
Calcium Carbonate	4·41	...
Calcium Sulphate	...	122·50
Silica	0·62	Trace
Alumina	0·08	Trace
	21·03	151·64
	(Parts per million.)	
Ammonia, free and saline	0·10	0·085
Ammonia, albuminoid	Faint trace	0·045
Oxygen, absorbed in three hours	0·18	0·029

Apart altogether from the question of water supply there are several points of considerable interest about this Stratford-on-Avon boring to which I must call attention.

In the first place it is noteworthy that the transition from the Lower into the Upper Keuper facies is much more abrupt than it is in Staffordshire, Leicestershire, Nottinghamshire, and other localities in which I have had an opportunity of examining the junction. As a rule there is nothing like a sharp line of demarcation between these two subdivisions of the Trias the Marls gradually becoming more predominant as we trace the beds upwards, and the Sandstones as we trace them downwards. The line of junction in mapping the beds in most parts of the country is always a more or less arbitrary one, but here at Stratford the transition from Lower to Upper Keuper is remarkably sharp, the "passage beds" (Nos. 22-25) with alternations of Marls and Sandstones, only occupying a thickness of 19 feet.

To the north and north-west of Stratford, in the neighbourhood of Henley in Arden, there is marked on the Survey maps the outcrop of certain beds of sandstone to which Mr. Howell called attention in 1859 in his Survey Memoir on the Warwickshire Coalfield. He describes these as consisting of from 15 to 20 feet of white micaceous sandstones, alternating with bands of green marl, and further states that they occur at about 250 feet from the top of the Red Marls and 350 feet from their base. About 29 feet of very hard thin micaceous and calcareous sandstones, corresponding to this description, were passed through in the Stratford-on-Avon boring between 290 and 319 feet from the base of the Upper Keuper, which is remarkably close to the position assigned to the the Upper Keuper Sandstone by Mr. Howell. The few fragments which were brought up by the boring tools were searched for *Estheria minuta* but without success.

Whether this 29 feet of Upper Keuper Sandstones is anything more than of local significance is uncertain, but there can be no doubt of the striking lithological similarity of the beds to certain thin sandstones of the Upper Keuper in Worcestershire, Staffordshire, and Nottinghamshire, and it is quite possible that when we have a complete re-survey of the Trias some of the beds of these various districts may be correlated. If this turns out to be the case we shall have, what is now sadly wanted by workers in the Trias, some definite horizons in the Upper Keuper to which observations can be referred with certainty.

The results of the Stratford boring have an important bearing on the question of the thinning out of the secondary rocks against the palæozoic east and west ridge which we have reason to believe underlies the secondary rocks of the southern counties. As far back as 1859 it was pointed out by Professor Hull, in a memoir on the South-Easterly Attenuation of the Lower Secondary formations of England (Jour. Geol. Soc. xvi, 68), that the direction of maximum attenuation of the Triassic rocks is along a line drawn S.E. from the estuary of the Dee, and passing near Nantwich, Stafford, and Warwick. In his subsequent Survey Memoir on the Triassic and

Permian rocks of the Midland Counties, 1869, he gives the following estimate of the thickness of the Keuper along this line:—

	Lancashire and W. Cheshire.	Staffordshire.	Leicestershire and Warwickshire.
Upper Keuper Marls ...	3,000 ft.	800 ft.	700 ft.
Lower Keuper Sandstone ...	450 ft.	200 ft.	150 ft.

Mr. H. H. Howell determined the thickness of the Upper Keuper Marls east of Coventry and Warwick by measuring them across the outcrop from their junction with the underlying Lower Keuper to the overlying Rhætic. He estimated the vertical thickness at 600 feet, and this estimate is strikingly confirmed by the results both of the Rugby and the Stratford-on-Avon borings. The Rugby boring was made in 1861, and, on reaching the Lower Keuper Sandstones at 1,140 feet, was abandoned on account of the highly saline properties of the water (see Rugby School Nat. Hist. Soc. Rep. 1868, p. 41). The Upper Keuper Marls were reached at 480 feet from the surface, and were found to be 663 feet in thickness.

Now, a line joining Rugby with Stratford-on-Avon intersects Professor Hull's South-Easterly line of maximum attenuation almost exactly at right-angles, and we should consequently expect the thickness of the Upper Keuper along this Rugby-Stratford line to be practically the same. Whilst at Rugby the thickness is 663 feet, at Stratford-on-Avon the new boring has proved the Upper Keuper to be 604 feet as a minimum. When to this we add the few feet representing the very uppermost portions of the Keuper Marls, which are not represented in the boring, and which probably amount to from 25 to 30 feet, we find a very remarkable agreement between the Rugby and Stratford data.

South of Stratford-on-Avon the Trias has been reached at two places by boring. At Mickleton in Gloucestershire, eight miles due S. the Upper Keuper was struck at 1,285 feet, and penetrated for 57 feet, when the boring was abandoned.

At Burford, Witney, 26 miles S. of Stratford, the Trias was reached at 821 feet from the surface, and red beds to a total thickness of 428 feet were passed through before the Coal-measures were entered. The available descriptions of these Marls, Sandstones, and Conglomerates, are unfortunately so vague that it is impossible with any degree of certainty to differentiate the subdivisions of the Trias, or to determine whether any portion of the rocks belong, as in all probability they do, to the Permian. The best information I have been able to obtain is derived from a paper by Mr. De Rance, Trans. of Manchester Geol. Soc., vol. xiv (1877-8), p. 438. If the cores of this boring, which was put down by the Diamond Rock Boring Company, are still in existence, it is highly desirable that the portion between the Rhætic and the Coal-measures should be subjected to a close examination by some geologist well acquainted with the Trias and Permian of the Midland Counties.

Mr. De Rance, from the particulars given to him, estimates the New Red Marls to be represented by 291 feet of the cores. Assuming this to be correct we can now estimate the rate of attenuation of these beds between Stratford and Burford, places lying 26 miles apart, on a line running due N. and S. As we have seen that the maximum attenuation takes place along a line running N.W. and S.E., by drawing a line at right angles to this (*i.e.*, N.E. and S.W.) through Stratford, and letting fall a perpendicular from a point represented by Burford, we find the length of this perpendicular to be about 22 miles, which represents the distance through which the Upper Keuper Marls have thinned out from about 640 feet to 291 feet. This gives about 16 feet per mile as the true rate of attenuation between Stratford-on-Avon and Burford. Mr. De Rance, by the use of Professor Hull's data, arrives at the conclusion that between the Liverpool district and Warwick the Upper Keuper thins out at an average rate of 23 feet per mile, a rate which we see is not maintained as we get further south.

The Stratford boring unfortunately does not give us the thickness of the Lower Keuper, but as this subdivision of the Trias was penetrated to a depth of exactly 200 feet and still maintained the same characters, I think it probable that it is at least 300 feet thick and perhaps more. It is at any rate of greater thickness than the Lower Keuper of Warwickshire, where according to Professor Hull it is represented only by 150 feet of rocks. This discrepancy is probably due to the local thinning out of the coarser sediment against the older rocks of the Warwickshire Coalfield. We have a good example of such a local attenuation of the Trias on the north-west side of the Leicestershire and South Derbyshire Coalfield just East of Burton-on-Trent, where the Keuper thins out against the Carboniferous Rocks, which here formed an old coast line in early Triassic times.

III.—The Destruction and Shattering of the Chalk of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

A SHORT time ago I read a paper before the Geological Society, of which an abstract appeared in the Proceedings, in which I discussed some questions of critical interest in the geology of East Anglia.

I am more than pleased to find that some of the conclusions I pressed, and which I had long ago reached, have been discussed by two such excellent geologists as Professor G. A. Cole and the Rev. E. Hill, whose papers were printed in the December Number of this Magazine (pp. 553 and 555).

That the Chalk of Eastern England was originally laid down in horizontal beds no one will, I presume, deny. That since it was so laid down it has been folded and bent into vast curves, no one who has studied either the surface contours or the well-borings will venture to question. That this folding of the Chalk into a series of wolds with intervening valleys must necessarily, unless the Chalk could slip over its lower beds, have been accompanied by enormous fractures and by the breaking up of large portions of it into fragments, is as clear as any mechanical problem can be.

When we turn from this *à priori* reasoning to the actual facts we can hardly doubt that the Chalk of Yorkshire, of Lincolnshire, and of East Anglia, which now exists in a disconnected and discrete form in these three areas, was once continuous, and that the vast mass of chalk rubble which exists in the chalky clay of the Eastern and Central Counties of England, is the result of the violent disintegration and dislocation of the beds once occupying large areas now denuded of their chalky covering, and notably of the depression in the Fenland. This dislocation and disintegration I hold to have been coincident with the spread of the chalky clay, and to have occurred, not in the older Tertiary times, but to have been the very last chapter of East Anglian geology.

Let me first partially clothe my heretic self in the garments of some orthodox men. Professor Seeley argues that before the Drift began a Cretaceous barrier dammed out the sea from the Fenland, extending from Hunstanton, in Norfolk, to Wainfleet, in Lincolnshire; and he further argues that before the Drift began this barrier was not broken through (Geol. Mag., Vol. III, pp. 1–3). Mr. Skertchly agrees in this, and says that before the Glacial age the site of the Fenland basin was very different from its present condition. The Chalk and other Cretaceous and Neocomian rocks stretched from Hunstanton to Lincolnshire, across what is now the mouth of the Wash (Geology of the Fenland, p. 217).

While the orthodox geologists are quite willing to allow this considerable denudation in comparatively recent times of the Chalk country of Eastern England, they mostly attribute it to the effects of either marine or fluvial denudation, or to the action of ice, and do not correlate it with the general alteration of the contour of the country by which the North-and-South-Chalk Wolds of Eastern England were formed.

The following sentence in a paper by Mr. Horace Woodward condenses the current view of the Uniformitarians on this point. "Mention," he says, "has previously been made of the connection of the Norfolk Chalk with that of Lincolnshire. In Miocene and Pliocene times, rivers may have commenced to erode their courses in it, making outlets to the sea. These actions (to quote Mr. Skertchly) resulted in reducing the barrier to outliers; one between the Witham and the three united rivers (Welland, Nene, and Ouse), the other between that united stream and the Little Ouse. As submergence went on, the sea added its powers to that of the rivers, and finally the Chalk disappeared entirely. The sea was now brought directly in contact with the widespread outcrops of the yielding Kimmeridge and Oxford Clays, and the denudation of the Fenland basin proceeded at a rapid pace." ("The Scenery of Norfolk": Trans. Norfolk Nat. Soc., iii, 445.)

Mr. Skertchly and others merely treat the chalk lumps as the débris of marine denudation.

It seems to me that whatever theory is adopted to account for the chalky clay itself and *its distribution*, it is impossible to attribute the disintegration of the chalky and oolitic débris which it contains to any such diurnal causes as are above mentioned. This chalky débris is nearly all angular or subangular, and absolutely different in kind to any marine shingle or river gravel in the world; and those who have handled, as I have done, many thousands of the lumps of the chalk (it is utterly wrong to call them boulders), with their angular edges and their contour like broken road-metal, cannot, it seems to me, without absolutely forsaking all inductive methods, see in them the débris of marine or fluviatile denudation.

Not only is the angular form of the pieces of chalk incompatible with a fluviatile origin, but the great masses of shifted chalk and oolite, to which I shall presently refer, are still more so; while as to the sea, not only do these same arguments apply, but we have no trace in the Fen country, or in the valley of Axholme and its borders, of the continued presence of the sea there consistent with slow marine diurnal denudation—no old sea margins or shingle beds, no rounded pebbles, except Tertiary ones, and no marine débris of the kind we should certainly find, while the whole of the deposits are entirely different to those of an advancing or retreating sea.

Other people have in these latter years attributed the breaking up of the Chalk to the action of ice, either to land-ice or icebergs or coast-ice. Mr. Jukes-Browne, Mr. Hill, and others have spoken strongly and well on the subject of land-ice, and shown how impossible it is to credit this stupendous denudation to ice in this form. In addition to what they say, we nowhere find glaciers breaking up their beds in this way, not even in Greenland or Alaska, nor is it credible that they should do so if the mechanics of the problem are for a moment considered.

The Chalk-stones, again, are quite different to ice-stones of all kinds known to me, and the occasional scratches on the pieces of chalk, which is a very soft substance, would be certainly caused by any movement in which one stone rubbed against another.

Again, as to icebergs, it is forgotten that it is only when grounded dynamically that they act in the way suggested. When they are floating they are buoyed up by the water, and their pounding action must be very slight. The intervention of coast-ice has been called in by Mr. Mellard Reade to account for the long chalk masses in the contorted drift at Cromer, but he overlooks the fact that similar shifted masses occur in Rutland and Lincolnshire formed of the local rocks there, where no old sea cliffs can be postulated.

Lastly, the suggestion that rocks might under the influence of alternate frost and thaw break up into such rubble as this, is again completely contrary to all experience of Chalk known to me (except on exposed cliffs, and even here very slightly indeed, as we can see by walking along any of the great escarpments which bound that deposit), nor can I see how the mechanical process could begin or go on in a substance with the structure of chalk. Besides, why should the frost have broken up the chalk in the low Fens and left it intact in the wolds, where it would be so much more exposed to its influence. The position is not arguable.

These various facts and arguments seem to me to converge upon one conclusion, namely, that the denudation of the Chalk and other beds in Eastern England was not and could not be the result of diurnal causes. Let us now try and examine the notion that the ruin of the Chalk was the result of the breakage and disintegration of the strata which occurred when the present contour was given to the country.

First, let us turn from the chalky rubble to the well-known gigantic masses of chalk and oolite which occur occasionally in the Eastern Counties, and to which I have referred. These have always been a crux to the advocates of diurnal methods of denudation. Rivers or sea-waves can hardly move about twenty square miles of Chalk *en bloc* over leagues and leagues of country, and those who believe that land-ice or glaciers could do this, must have some special acquaintance with the inner workings of ice which has not been given to those who have seen it at work in its own special home. To me, who am only a heretic, these great masses now found detached and isolated are not far-transported boulders at all, but are virtually *in situ*, the remains and relics of the once continuous strata which occupied the areas now largely denuded. If they have been moved, it has been a very short distance and by some tremendous motive force which may have temporarily lifted them and underlaid their edges with chalky clay, but otherwise they are at home where they were originally made and deposited, and are no vagabonds and wanderers. This conclusion I have long held, and it seems to me more consonant with probability than any other. As the matter is of more than usual importance I should like to enlarge a little upon it.

Writing in description of the Geological Survey Map, Sheet 64 (Rutland, etc.), Mr. Judd says: "The transported masses of local rocks are sometimes of enormous size, especially in the northern portion of this area and in that to the south. The attention of geologists was first directed to these great transported masses by Professor Morris, who found that at the south end of the Stoke tunnel on the Great Northern Railway an enormous mass of the *Lincolnshire Oolite limestone* lay on undoubted Boulder-clay. During the mapping by Messrs. Holloway, Skertchly, and myself, of the districts which I have indicated, we have found a number of such transported masses, some of them far exceeding in size that described by Professor Morris, and composed both of the Inferior Oolite and the Marlstone rock-bed. Their position is indicated upon the Drift map. They always appear to occur in the lower part of the Boulder-clay, and by the denudation of the softer surrounding material often make a distinct boss, rising above the general surface. Stone pits are often opened in them, and they sometimes give off springs at their base. The longest of these transported masses, that capping Beacon-hill in Sheet 70, is more than 200 yards across, and is composed of the Marlstone rock-bed. It is noteworthy that these masses always belong to the rocks which form the highest ground." (Geology of Rutland, etc., p. 246.)

When we turn to Professor Morris' paper on one of these famous boulders, it is interesting to see him suggesting that it was not a far-transported boulder, but *in situ*, or virtually *in situ*.

Professor Morris, speaking of these beds in Lincolnshire as long ago as 1853, says of the famous Ponton cutting: "The oolites are frequently dislocated, the dislocated portions lying at high angles, and are very irregular. . . . Emerging from the south end of the tunnel [at Great Ponton] . . . . *we see the drift on either side of the cutting buoying up an enormous irregular mass of oolitic rock* through which the cutting has passed. This mass of rock is 430 feet long, and at its deepest part 30 feet thick; it is much broken and disturbed, but the parts retain to some extent their relative position, and belong to the lower portion of the oolitic beds of this district. . . . The depth of the underlying drift exposed at the lowest part between the broken rock and the level of the railroad is about seven feet. . . . . *this great mass of disturbed oolite, which, although so distinctly isolated, retains sufficient uniformity of character to lead us to infer that it has not been far removed from its original site.*" (Q.J.G.S., vol. lx, pp. 318–320.)

These great masses of shifted rock, of course, occur elsewhere. The typical instances are those in the Norfolk cliffs—that in the Roslyn hole near Ely, the great Merton boulder in West Norfolk, and, more remarkable than all, the great mass of chalk, twenty miles square, recently found by Mr. Cameron on the borders of Huntingdonshire and Bedfordshire. These, and such as these, seem to me to be instances, not of vast transportation, but rather the remains of once continuous strata, and closely allied to the actual outliers found in the county of Cambridge, west of the escarpment of the chalk, and to testify to the once continuous Chalk having been dislocated *in situ* by some far-reaching subterranean force.

Let us now turn to the evidence that the Chalk has been so dislocated and broken in comparatively recent times.

In many places in Norfolk there have been found, as is well known, evidences, not only of chalk quite disturbed and disintegrated, and reduced to a rubbly condition, but also instances of its being curved and tossed up on end. These disturbances, in the view of some of the best observers, like Mr. Horace B. Woodward, Mr. J. E. Taylor, Mr. C. Reid, Mr. Jukes-Browne, etc., belong to the same date, and were caused by the same forces that made the Boulder-clay. As the matter is one of considerable importance to the argument, I propose to quote some of these cases as described in the Survey Memoirs and elsewhere.

In the Geological Magazine for 1865, Mr. J. E. Taylor described a saddle-shaped anticlinal or ridge in the Chalk at Whittingham. The beds, with conspicuous bands of flints, were so bent as to form an acute angle, which was very well defined. The layers of flint were not shattered, nor were the strata broken. At first Mr. Taylor attributed this disturbance in the Chalk to a time before the deposition of the Norwich Crag, but he subsequently (*id.* vol. vi) attributed the twisting and dragging up of the Chalk to the agent which formed the Upper or chalky Boulder-clay, a view in which Mr. Horace B. Woodward concurs (*id.* Dec. II, Vol. VIII, p. 93).

In 1866 Mr. Taylor called attention to a similar disturbance in a pit at Swainsthorpe. He tells us that on the left side of the pit the flint bands were nearly perpendicular, being somewhat contorted and leaning towards the right. On the right side the bands were somewhat more perpendicular, but still leaned towards the north. The contorted bands forming an anticlinal arch, the summit of which had been denuded. . . . . flint bands were shattered and broken as though by the influence of some sudden force. (Geol. Mag., Vol. III, p. 44.)

A similar disturbance occurs in the Chalk at Trowse, and was first pointed out by Mr. T. G. Bayfield. In this pit the Chalk, with layers of flints and paramoudras *in situ*, was inclined at an angle of from 35° to 40° in a south-easterly direction. Mr. Woodward found the bedded chalk pass into sandy and marly beds, and itself contained fractured flints with pebbles of flint and quartzite, which were dispersed throughout it. The flint layers gradually assumed a horizontal position in going downward. He adds—" From the fact that beds of the age of the Norwich Crag are disturbed together with the Chalk, it may be concluded that they were forced up in post-Pliocene times; and from the relations borne by the chalky Boulder-clay to the chalk in this immediate neighbourhood and in many pits round Norwich, I feel no hesitation in concluding that the disturbance was produced by the agent which formed this Boulder-clay." Similar disturbances have been reported by Mr. Wood at Litcham.

Mr. Woodward elsewhere describes a pit showing much disturbed chalk near Burham Abbey, chips of flint and flint nodules occurring in the mass of the rock, the disturbance reaching to a depth of ten feet. At West Rainham the Chalk shows signs of disturbance in an anticlinal arrangement of the flint layers, the fold trending east and west. (Geology of Fakenham, etc.)

Turning to the very important section at Trimingham, I feel constrained to quote Mr. Clement Reid's excellent description. " Northwest of Mundesley," he says, " the beds (contorted series) undulate a good deal, the disturbance gradually extending into the lower deposits and becoming more violent, till at last at Gimingham and Trimingham it affects the solid chalk. . . . . The normal position of the Chalk would be below low-water mark; but it has been thrown into a series of undulations which have the effect of raising it above the sea-level. . . . These undulations form definite anticlinal and synclinal folds, having their axes parallel with the coast-line, though minor flexures often obscure the structure where only a small exposure can be seen. The bending has been so violent as to squeeze up a ridge of chalk; of which, judging from the dips on the foreshore, the two chalk bluffs seen in the cliff seem to be the last remnants." Mr. Reid adds—" That this contortion is of Pleistocene age is proved by the similar disturbance of the overlying beds, and by the intrusion of tongues of Boulder-clay into the Chalk." This view confirms that of Lyell, who, as Mr. Reid says, " was fully aware of this conformity, and gave illustrations of it, mentioned the mixture of Chalk and Boulder-clay on the foreshore, and considered that the contortion must clearly have been formed subsequently to the deposition of the Drift" (Geology of Cromer, etc., p. 95). Again, the same author says: "The Boulder-clay under the folded Chalk is certainly connected with the contortion, as is also the case with the alternations and intrusive tongues of Boulder-clay seen on the foreshore. . . . . . . The contortion of the Chalk appears to have forced it into the overlying beds and compelled the boulder-clay to mould itself to all hollows and open fissures; it has even in some places caused the Drift to underlie in mass the inverted anticlinal of the solid chalk."

With these facts before us, it seems impossible to doubt the conclusions of Mr. H. B. Woodward and Mr. C. Reid, as related by them in the following words. The former says: "I have come to the conclusion that many of the contortions seen in the strata, whether Chalk, Crag or Lower Glacial, are chiefly due to the agent that brought the Boulder-clay; of the numerous cases where this positive evidence is wanting I know of no instance where the contortion might not have been produced at this period" (Geol. of Norwich, p. 137). The latter says: "The general structure of Norfolk and Suffolk appears to show that the whole of the contortions are of one age, that of the greatest glaciation, or of the great chalky Boulder-clay, and it is probably to this period that the disturbances on the coast may be referred" (Geol. of Cromer, p. 117).

While this conclusion seems inevitable, I cannot concede, even as a possibility, that these contortions have been caused by ice in any form. These contortions are, in fact, only subsidiary folds in the much larger folds which formed the plateau of East Anglia and the adjoining troughs on either hand, and seem unmistakably due to the operation of forces acting from below, or by earth-waves passing laterally through the strata as waves pass through the sea.

The only reason given by the opponents of these subterranean causes is, that the surface layers are alone contorted and puckered, while the deeper ones are not. It is forgotten that this very fact is most difficult, if not impossible, to explain by an ice theory, while, if the contortions are eventually due to the crumpling up of the strata, it will certainly follow that the highest layers will be under the greatest tension; but I have a notion that these folds are really the result of gigantic earth-waves, caused by some tremendous strain; and it will be remembered that in marine waves it is only the surface layers that are affected at all; at a very little below the surface the water is quiescent and still.

If we conclude that the disintegration of the Chalk was the result of subterranean movements, the next question is, When did this occur?

It seems to me impossible to carry back the breaking up of the Chalk strata to Tertiary times. If it had been in progress then in anything at all like the way in which we must postulate it to have occurred, if we are to judge by the lumps of chalk in the chalky clay, we should certainly find some of these angular and subangular pieces of chalk, some of these great masses of shifted Oolitic and Cretaceous rock, in the sands and gravels of the Crag; but nothing of the kind occurs in them, or in the so-called Chillesford and Westleton Beds. But this is incredible, if the Chalk had already begun to be broken up into this rubble. They come upon us suddenly in the beds above the Crag, and were doubtless the product of the same forces which contorted and faulted and broke the Chalk in so many places, as I have shown. I cannot see how we separate these dislocations from the forces which moulded the surface of East Anglia into its present contour of wold and dale. On this subject we are not entirely wanting in evidence: thus, it is hardly possible to conclude otherwise than that the present depression in the area occupied by the Fens, or the valleys of the Axholme and the Trent, did not exist when these beds were being laid down in the Crag areas, or else we should have had them developed in these hollow troughs more conspicuously than further east. The way in which the later Crag beds themselves occur at high levels above the sea, as at Norwich, and in other inland parts of East Anglia far above the present sea-level, unmistakably points again to the contour of the country having greatly altered since these submarine beds, the very latest so-called pre-Glacial beds, were laid down.

Again, if we travel northward, the position of the Crag beds in reference to the Forest bed points in the same direction. The Middle and Lower Crag, whatever their actual horizon, can hardly be placed above the Forest bed, yet we find in many parts of Suffolk these marine deposits at a considerable elevation above the sea-level, while the Forest bed itself occupies the strand actually below low-water mark. This assuredly points to a considerable dislocation since these beds were laid down. Again, there is another remarkable piece of evidence which has been overlooked —that presented by the well-borings at Boston in Lincolnshire, and at Yarmouth and elsewhere on the Norfolk coast—namely, that the great flexures of the Chalk which have rent it down there to a depth of several hundred feet, were clearly made at this time, since the hollows have been filled up with vast deposits of so-called glacial sands, etc., and with nothing else, showing that these synclinal hollows are among the very latest of geological phenomena.

As I have argued, its effect was to fold the Chalk into a series of anticlinal and synclinal curves, running more or less north and south, and marked by the wolds of Yorkshire and Lincolnshire and the plateau of East Anglia on the one hand, and the hollows of the Axholme valley of the Fens and that forming the southern part of the North Sea on the other.

Now this last hollow was clearly cut out and shaped since the Weald denudation. The denuded Weald area was originally lenticular in shape, like similar denuded surfaces in Western England and the Chalk districts of France. The eastern terminal apex of the original denuded area is still to be found on the other side of the Channel. It was athwart this formerly continuous valley of denudation that the great synclinal hollow of the North Sea was shaped or cut: a glance at the map will make this quite clear. And this was cut when the connection of England with the Continent was severed, that is, as I have argued in many places, when the Mammoth and its companions were destroyed and the Drift distributed.

This shows that the bending and moulding of the beds of Chalk in Eastern England into their present contours were comparatively recent events in its geological history, and coincident with the break up and disintegration of the Chalk beds. If this subsidence and bending had been slow and gradual, we should hardly have had the tremendous breakage and ruin of which the evidence is everywhere most plain. This shows that the breakage was rapid and cataclysmic, and the result of some great strain suddenly applied—such a strain as occurred frequently enough in the earlier ages of the world, as the interior skeletons of all our mountain ranges show, whenever we examine their crumpled, torn, and dislocated beds, often standing on end. It is strange that the moderate Uniformitarians should allow this in the older times, but be loth to admit it so late as Pleistocene times.

The conclusions I have here formulated were foreshadowed long ago by at least one writer. The Rev. W. B. Clarke, who wrote so well on Suffolk geology, says in the Geological Transactions for 1837: "While the Crag still lay under the sea, a violent catastrophe broke up many of the Secondary rocks, from the Chalk to the Lias inclusive. . . . . After this period, and probably in prolongation of the first great catastrophe, a series of shocks, acting from below, shattered the surface, and gradually elevated the whole district, including the Chalk, till the Crag obtained the height of nearly 100 feet above the sea-level; and by this movement were produced the valleys or lines of fissure through which the drainage of the country is effected." (*Op. cit.* second series, v, pp. 367, 368).

IV.—Post-Pliocene Submergence of the Isle of Wight.

By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S.

I AM tempted to offer a few notes with the conclusions I arrived at during some weeks residence this summer in the Isle of Wight, having been struck with the remarkably definite data which the island affords regarding the maximum depth of the submergence (or height of emergence) during the post-Pliocene period. The "plateau-gravels," which are the main factors in the determination of the amount of submergence, have now been mapped by the Geological Survey,[1] together with the other post-Tertiary deposits; but as regards their mode of formation the Survey (I believe) in its collective capacity refrains from expressing an opinion.[2] I, for my part, have no hesitation in bespeaking for them a marine origin—(1) because of their wide distribution; (2) because of their elevated

[1] Drift-Maps; Sheets 330, 331, 344, and 345.

[2] As stated by Mr. Whitaker in the discussion on Prof. Prestwich's paper on the "Westleton Beds," Q.J.G.S. 1890–91.

position, as shown by Mr. Codrington,[1] Prof. Prestwich, and other writers, which is far beyond the reach of the rivers past or present; (3) because of their stratified structure and their composition. There remain the two other hypotheses, both equally out of the question—that they are lake deposits, or that they are of glacial origin. The absence of shells in the higher levels, reaching to 300–500 feet, is easily explained, and is no argument against marine conditions of deposition, as the percolation of subærial waters through such open and porous beds must necessarily have dissolved away the material of which marine organisms are mainly formed. As regards the geological age of the plateau-gravels of the Isle of Wight and Dorset, there can be little doubt that they are post-Tertiary, as they are found resting indiscriminately on all Tertiary strata of those parts.[2] Prof. Prestwich classes them under the head of "Southern Drift," and distinguishes them from his "Westleton Beds" on the ground mainly of difference in the composition of their constituent pebbles, and their separation from the Westleton Beds of the East of England and the Thames Basin by a barrier along the Wealden ridge. But even admitting this separation, the beds may be representative as regards age; and as for the absence or presence of certain pebbles (such as white quartz, etc.), it can scarcely be expected that in any beds of conglomerate of wide extension there should be no variation in the composition of the constituent pebbles. Perhaps, on reconsideration, Prof. Prestwich might be inclined to admit that the plateau-gravel of the south and the Westleton gravel of the centre and east may be contemporaneous. With these preliminary observations, I proceed to the evidence of submergence and emergence afforded by these beds in the Isle of Wight.

As ably shown by Mr. Codrington, the plateau-gravel of the Isle of Wight originally formed a surface sloping from the south northwards towards the shore of the Solent. Subsequent denudation has largely modified the original range of this plateau; wide valleys, such as that of the River Medina, have been channelled through it, and in many places only outliers have been left, of which the most important is that of Headon Hill.[3] In a word, enormous changes in the physical features of the island have occurred since this wide-spread sea-bed was laid down, which were brought about during emergence in the first place, and afterwards by subærial agencies down to the present day.

Of the numerous disconnected patches of the plateau-gravel, I shall only refer specially to two—that of St. George's Down, south of Newport, and Headon Hill, overlooking Alum Bay at the western extremity of the isle.

St. George's Down.—This terrace is situated in the very centre of the isle, a little to the south of the Chalk ridge. Its upper surface

[1] Quart. Journ. Geol. Soc., vol. xxvi, 1870.

[2] Unless it should be assumed that they are of Pliocene age, of which there is no evidence or probability.

[3] The outlying patches of the plateau-gravel are shown on the new Drift maps of the Geological Survey above referred to.

is almost perfectly level, and it breaks off in a well-marked scarp overlooking the valley of the Medina at a level of (about) 350 feet above the stream; the upper surface of the plateau is about 403 feet above O.D.[1] The terrace is formed of rudely stratified beds of gravel and lenticular bands of yellow sand and loam; current lamination being slightly apparent in some places; the whole resting on the Lower Greensand. The pebbles, which are generally well rounded and waterworn, consist mainly of flint; but there are a few of grit, ironstone, and detritus of Lower Greensand. The whole deposit is about 50 feet thick, of which about half the thickness is laid open to view in the large gravel-pit above Blackwater station. On reaching the surface of the plateau one perceives, at a distance of half a mile, the rounded ridge of the Chalk rising slightly above it, and we easily recognize that we are walking on the floor of the old sea-bed which terminated against the uprising ridge of the Chalk, from which the materials were largely derived.

Headon Hill.—This remarkable outlier is described by Mr. Bristow[2] and other authors; and its relations to the terrace of St. George's Down can scarcely be mistaken. In composition, in altitude, and in its relations to the Chalk ridge, the conditions are almost identical, except that Headon lies to the north of the ridge, St. George's Down to the south of it. The distance between the two is about 17 miles, and the gravel-beds of Headon rest on the Upper Tertiary strata of the Isle of Wight series. Like the St. George's beds, the Chalk ridge formed the limit in one direction to the range of the gravel-bed; towards the north and west it breaks off in the well-known cliff of Alum Bay. The height of the summit is (according to Bristow) 370 feet; my aneroid measurement makes the height 388 feet; in either case the level approximates to that of St. George's Down; and the important point remains to be noticed, that once we reach the 400 feet level, and ascend the ridge of the Chalk downs, these beds of stratified gravel cease, and are replaced by local flint-gravel derived from the underlying Chalk, and left behind after the calcareous matter had been dissolved away by subærial agencies.[3]

It is unnecessary to go into further details in order to show that after the upheaval and denudation of the Tertiary beds of the Isle of Wight the district was submerged, beds of sand and gravel, derived mainly from the waste of the Cretaceous rocks, were laid down, and the whole were subsequently elevated to an extent of about 400 feet, as indicated by the levels of Headon Hill and St. George's Down. The relations of the gravel-beds to the older rocks enable us to fix definitely the amount of this elevation; and this is the point to which I wish particularly to call attention to in this short communication.

[1] By aneroid measurement. The gravel of St. George's Down has been described by Mr. Codrington.

[2] "Geol. of the Isle of Wight": Mem. Geol. Survey (1862), p. 104.

[3] The two varieties of gravel are very well shown on the Survey map already referred to.

V.—Note on the Affinities of the English Wealden Fish-Fauna.

By Arthur Smith Woodward, F.L.S., F.G.S.,
Of the British Museum (Natural History).

THE question of the affinities of the Wealden Vertebrate Fauna having been re-opened by Professor Marsh in his paper on the Dinosauria, read before the last meeting of the British Association at Ipswich,[1] it may be of interest to place on record a complete list of the species of fishes now known from the English Wealden deposits. This is more extensive than any previous list, being based on the unique collection in the British Museum, which has only lately been examined in detail. Unfortunately, however, none of the specimens, except a few examples of *Lepidotus*, are labelled to indicate the precise horizon from which they were obtained; and scarcely any of the names of localities are very definite. The various species may be enumerated in zoological order as follows:—

Hybodus basanus, Egerton, Quart. Journ. Geol. Soc., vol. i (1845), p. 197, pl. iv; A. S. Woodward, Catal. Foss. Fishes Brit. Mus., pt. i (1889), p. 273, pl. xii, figs. 1–5, and Proc. Yorksh. Geol. and Polyt. Soc., vol. xii (1891), p. 63, pl. i, pl. ii, fig. 1. Coast of Sussex and Isle of Wight.

Hybodus striatulus, Agassiz, Poiss. Foss., vol. iii (1837), p. 44, pl. viii*b*, fig. 1. Tilgate Forest.

Hybodus subcarinatus, Agassiz, *ibid.* p. 46, pl. x, figs. 10–12. Sussex.

Hybodus sp.: miscellaneous teeth, some named *Meristodon paradoxus* by Agassiz, *op. cit.*, vol. iii (1843), p. 286, pl. xxxvi, figs. 53–56, others figured in Catal. Foss. Fishes Brit. Mus., pt. i (1889), pl. xi, figs. 14–16. Tilgate Forest.

Acrodus hirudo, Agassiz, *op. cit.*, vol. iii (1839), p. 148, pl. xxii, fig. 27; A. S. Woodward, *op. cit.*, pt. i (1889), p. 296, pl. xiii, fig. 9. Tilgate Forest, and Telham, near Battle.

Acrodus ornatus, A. S. Woodward, *op. cit.*, pt. i (1889), p. 296, pl. xiii, fig. 10. Brixton, Isle of Wight.

Asteracanthus granulosus, Egerton, Ann. Mag. Nat. Hist. [2], vol. xiii (1854), p. 434, and Figs. and Descript. Brit. Organic Remains, dec. viii. (Mem. Geol. Surv., 1855), No. 1, pl. i. Tilgate Forest.

Lepidotus Mantelli, Agassiz, *op. cit.*, vol. ii (1833–37), pt. i, pp. 9, 262, pl. xxx, figs. 10–15, pl. xxx*a*, figs. 4–6, pl. xxx*b*, fig. 2, pl. xxx*c*, figs. 1–7. Including *Lepidotus Fittoni*, Agassiz (*ibid.*, p. 265, pl. xxx, figs. 4–6, pl. xxx*a*, excl. figs. 4–6, pl. xxx*b*, excl. fig. 2), and *Tetragonolepis mastodonteus*, Agassiz (*ibid.*, p. 216, pl. xxiii*e*, figs. 3, 4). Sussex.

Cœlodus Mantelli (Agassiz), Heckel, Denkschr. k. Akad. Wiss., math.-naturw. Cl. vol. vi (1856), p. 203; *Pycnodus Mantelli* and *Gyrodus Mantelli*, Agassiz, *op. cit.*, vol. ii, pt. ii, pp. 196, 234, pl. lxix*a*, fig. 18, pl. lxii*a*, figs. 6–14. Sussex.

Caturus sp., A. S. Woodward, *op. cit.*, pt. iii (1895), p. 350. Hastings.

Neorhombolepis valdensis, A. S. Woodward, *ibid.*, p. 356, pl. viii, fig. 5. Hastings.

Belonostomus sp., A. S. Woodward, *ibid.*, p. 439. Isle of Wight.

Oligopleurus vectensis, A. S. Woodward, Proc. Zool. Soc., 1890, p. 346, pl. xxviii, fig. 1. Isle of Wight.

Nine genera of fishes are thus represented in the English Wealden, and all, except *Caturus*, are known by sufficiently characteristic specimens to be determined with certainty.

Of these fishes, the three Elasmobranchs *Hybodus*, *Acrodus*, and *Asteracanthus* are essentially Jurassic. The beautiful examples of the skeleton of *Hybodus basanus* from the Sussex coast prove

[1] Abstract published in Geol. Mag. [4], Vol. III, pp. 1–9 (1896).

that this shark had a persistent notochord and other characters like the typical species of the genus in the Lower Lias of Lyme Regis. They show only one difference from the Liassic type, namely in the cephalic spines; the Wealden specimens not being barbed and never observed in more than one pair. In Cretaceous strata, on the other hand, there is no certain evidence of *Hybodus*. Most of the teeth commonly ascribed to this fish probably belong to another shark (*Synechodus*), which has well-developed vertebral centra and smooth dorsal fin-spines; while the ribbed dorsal fin-spines occasionally found in the English Gault, Cambridge Greensand, and Upper Greensand, may be referable either to *Hybodus* or *Acrodus*. Typical teeth of the latter occur rarely in the Gault of Folkestone, but are not known elsewhere. The tuberculated fin-spines of *Asteracanthus* are scarce in the Wealden, and have never been recorded from a higher horizon, unless a fragment described by Pictet from the Lower Neocomian of Switzerland [1] happens to be of a little later date.

Lepidotus Mantelli is most closely related to the species from the Lithographic Stone of Bavaria. Only few and fragmentary remains of the same genus are known from the Neocomian, and all fragments of later date are very doubtfully placed here. *Caturus* is also typically, if not exclusively, Jurassic; and the abraded skull in the British Museum from the Wealden of Hastings (No. P. 6360) cannot be generically distinguished from that of this fish. *Oligopleurus* is also known only from the Jurassic, occurring in the Lithographic Stone (Lower Kimmeridgian) of Ain, France, and in the Purbeck Beds of Dorsetshire.

Belonostomus ranges throughout the Upper Jurassic and to the Upper Cretaceous, with a very wide geographical distribution; but the only known specimens from the Wealden are too imperfect to determine whether they are most closely related to the earlier or to the later species. *Neorhombolepis*, however, although very rare, is an essentially Cretaceous fish, the typical species occurring in the Lower Chalk of Kent; and it is noteworthy that the most closely related genus, *Otomitla*, is found in the Neocomian of Mexico.[2] The Pycnodont *Cœlodus* is also typically Cretaceous, though represented occasionally in the Purbeck Beds and other formations on the horizon dividing the Jurassic and Cretaceous series.

The result is, therefore, that all the known English Wealden fishes are survivors of typically Jurassic genera, except *Neorhombolepis* and *Cœlodus*, and these are their little-modified representatives. None but *Belonostomus* appear to range throughout the Cretaceous. In fact, the Wealden estuary seems to have been the last refuge of the Jurassic marine fish-fauna in this part of the world, not invaded even by stragglers from the dominant race

[1] *Asteracanthus granulosus* (Agassiz), Pictet and Campiche, "Foss. Terr. Crétacé St. Croix," p. 98, pl. xii, fig. ii (1859).

[2] J. Felix, Palæontogr., vol. xxxvii, p. 189, pl. xxix, fig. iii, pl. xxx, figs. 3-5 (1891).

of higher fishes which characterized all the seas of the Cretaceous period. The Wealden river drained a land where a typically Jurassic flora flourished [1]; the only two known Mammalian teeth from the Wealden resemble those of a Purbeckian genus [2]; and now it is clear that the fishes agree both with these and the reptiles in their alliance with the life of the Jurassic era.

VI.—*Merocrinus Salopiæ*, n.sp., and another Crinoid, from the Middle Ordovician of West Shropshire.

By F. A. Bather, M.A.

In June, 1895, Mr. G. H. Morton, F.G.S., of Liverpool, submitted to me three specimens of Crinoidea, registered No. 681 in his collection. One of these specimens was a stem-fragment, impossible to determine; but the other two appeared of such interest that Mr. Morton very kindly allowed me to make a detailed study of them. The results, though not so complete as might be wished, are now submitted to geologists and zoologists, in order that the former may look out for further specimens, and the latter give us the benefit of their opinion.

Locality.—With regard to all three specimens, Mr. Morton writes, under date 24th July, 1895: "I obtained them 25 or 30 years ago at Mincop, the name of a farmhouse, at the north end of a low hill which ends there. being near the east end of a dyke marked red on the 1-inch map, 60, N.E. (Welshpool), on the S.E. of the map. They were collected in a small quarry, or rather large hole, in a field above the house, just inside the gate of the field. I went there seven years ago, but found the hole filled up and corn growing over the spot, so that there is no chance of obtaining any more specimens there. Mr. Watts told me that he had found the same bed on the strike, but I do not think any fossils."

Horizon.—On page 17 of "The Geology . . . of the Country around Shelve," issued at the end of Proc. Liverpool Geol. Soc., session x, 1869, Mr. Morton thus describes the beds: "In ascending order [the Priest-Weston sandstone] is succeeded by the strata of Mincop and Meadow Town, composed of hard light grey sandstones, interstratified with shales possessing an indurated appearance. These sandstones, which run in beds about six inches thick, contain very good examples of *Strophomena compressa*, *Orthis testudinaria*, *Beyrichia complicata*, *Trinucleus concentricus*, *Calymene brevicapitata*, *Diplograpsus pristis*, *Pyritonema fasciculus*, *Glyptocrinus basalis*, and others. The shales associated with the sandstones in many places contain innumerable trilobite impressions, *Asaphus tyrannus*." The name *Glyptocrinus basalis* in the preceding list refers, Mr. Morton tells me, to all three specimens. The stem-fragment presents some

[1] A. C. Seward, "Catalogue of the Mesozoic Plants, Brit. Mus.—The Wealden Flora, part ii," p. 240 (1895).

[2] A. S. Woodward, "On a Mammalian Tooth from the Wealden Formation of Hastings," Proc. Zool. Soc. 1891 (1892), p. 585; R. Lydekker, "On a Mammalian Incisor from the Wealden of Hastings," Quart. Journ. Geol. Soc., vol. xlix, p. 281 (1893).

resemblance to the stem of *G. basalis*, M'Coy, but not enough to warrant the use of the name. The two other specimens are certainly not *Glyptocrinus*. The rocks just described are part of the "Middleton Group," which is the middle of the Meadow Town Series, which is the middle of the Ordovician (see Prof. C. Lapworth. "Preliminary Note on the Ordovician Rocks of Shropshire," Geol. Mag., Dec. III, Vol. IV, p. 78, 1887). Older writers call them Llandeilo Beds.

Description.—The two specimens studied are in a dark, fine-grained, micaceous sandstone, and are in the form of moulds, the calcareous substance of the crinoid having been dissolved. They are therefore best studied from wax squeezes.

Specimen A.

The lower, or proximal, part of the Dorsal Cup is wanting. Of the basals (BB) a portion only is preserved. The radials (RR) appear to alternate regularly with the basals, and do not appear to be horizontally bisected. They are about as wide as high, depressed towards the interradial sutures, and projecting slightly in the median line towards the articular facet. The facet occupies the greater part, but not quite all, of the width of a radial, so that the arms clearly are separate from one another; in other words, the crinoid is an Inadunate.

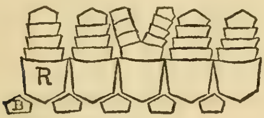
Of the Arms, four are visible. They appear to dichotomize pretty regularly, though the dichotomy is only seen clearly in the second from the left. This, which I take to be the left posterior arm, has brachials as follows: IBr, 5; IIBr, 8–8; IIIBr, 8·10–8·3 (preserved, ends not seen); IVBr, only traces seen. The next arm, *i.e.* the second from the right, appears to be the right posterior arm, since the first primibrach appears to be axillary, and supports a branch on the left, which I take to be the anal tube; of the right branch only three more brachials are preserved: in other words, four primibrachs in all are preserved. The arm on the right of the specimen appears to be the right anterior arm: it is difficult to decide whether the small branches that appear to be given off from its left side may not really be a single branch seen from the inner surface, at least for a distance of six ossicles, after which there are plainly two branches. In all the arms the proximal primibrachs seem rather wider than the distal primibrachs. Each brachial seems to be slightly wider at its distal end, so that the arms tend to have an imbricated appearance.

The Anal Tube (*t* in Fig. a), arising from the left upper slope of IBr_1, is thinner than the arm-branches at corresponding levels, and shows no signs of further dichotomy. Its exposed side shows a longitudinal series of rounded ossicles, of similar appearance to the brachials. The distal end is not seen.

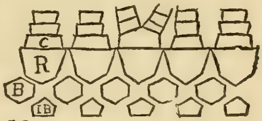
Measurements: total height of specimen, 9·0 mm.; width of cup at level of top of RR, about 1·5 mm.

Systematic position of Specimen A.—The relation of arms to cup shows that this specimen belongs to the Inadunata. The absence of the base does not enable us to refer it to either Monocyclica or

Dicyclica with certainty, though the regularity of the cup is in favour of the latter. A similar disposition of the anal tube is found, among Monocyclica, only in *Iocrinus*; among Dicyclica, only in *Merocrinus*. So far as geological horizon is concerned, the specimen might belong to either of these genera. *Iocrinus* is at present known from the Hudson River Group of Ohio and from the Trenton Limestone of New York. *Merocrinus* has been found only in the Utica Shale of Ohio and in the Trenton Limestone of New York. Neither genus has hitherto been recorded from Europe.



Iocrinus



Merocrinus

Comparing specimen A with *Iocrinus* and *Merocrinus*, we note that the anal tube of *Iocrinus* is composed of numerous hexagonal plates, set along the sides of the mid-rib, as one may call it, that starts from the arm. Specimen A, however, shows no traces of these lateral plates, although it is so preserved as to have done so had such been present; on the contrary, the anal tube appears to have been a simple narrow tube, precisely as in the known species of *Merocrinus*. All known species of *Iocrinus* further resemble one another in the marked imbrication of the brachials; while the species of *Merocrinus* have as a rule smooth brachials, although *M. curtus*, as figured and described by Ulrich ("*Dendrocrinus curtus*," Journ. Cincinnati Soc. Nat. Hist., II, p. 18, pl. vii, fig. 14, 1879), has brachials "prominent at the superior lateral angle." The very slight development of this feature in the Mincop specimen is therefore characteristic of *Merocrinus* rather than of *Iocrinus*. In other respects the specimen might belong to either genus; but the balance of evidence favours its reference to *Merocrinus*.

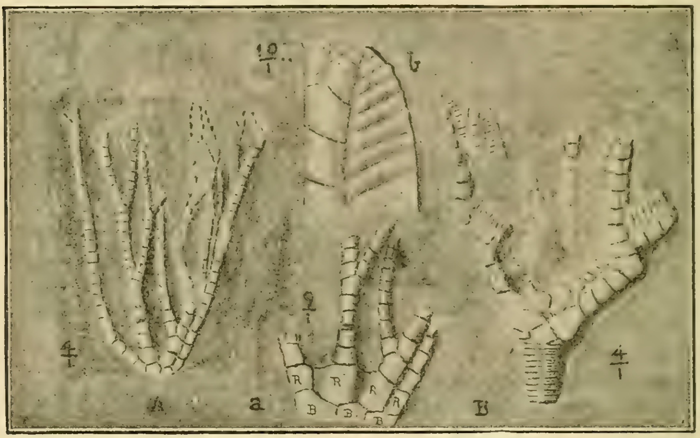
In minor characters specimen A differs from the known species of both *Iocrinus* and *Merocrinus*. From *Iocrinus crassus* and *I. subcrassus* it is distinguished by its less robust appearance, less wide radials, and less imbrication of the arms, as well as by the above-mentioned character of the anal tube. In a less degree the same characters separate it from *I. trentonensis*, a species which, according to Walcott's figure (Regent's Report, N.Y. State Mus., XXXV, p. 210, pl. xvii, figs. 7 and 8, 1884), further differs in the possession of a slight ridge along the back of the radials and primibrachs.

From *Merocrinus curtus* specimen A is clearly distinguished by the regular dichotomy of its arms, for in *M. curtus* there are simple armlets, "about half as stout as the main arm from which they spring." The cup is also lower in *M. curtus*. It was doubtless a mere slip that made Mr. Ulrich describe the anals of this species as rising from the right side of the right posterior arm, instead of from the left side. *M. typus* is a species of totally different appearance, owing to all its cup-plates and brachials being considerably wider than high. To *M. corroboratus*, the preserved portion of specimen A presents a close resemblance; the basals, however, appear to have been higher in proportion, the arms are a trifle more slender in the proximal region, and their distinct though slight imbrication constitutes an appreciable difference.

Therefore, although Mr. Morton's specimen 681A is imperfect, the preceding facts, combined with the absence of other known representatives of *Merocrinus* on this side of the Atlantic, justify its being taken as the type of a new species, which may be named after the county of its origin, and thus diagnosed:—

Merocrinus Salopiæ, n.sp.

RR and BB as high as wide. Arms slender, bifurcating at intervals of eight or more ossicles. Br wider, or with a slight cornice, at their distal margin.



A. *Merocrinus Salopiæ*, 4 times nat. size. a. Lower portion of same specimen, 9 times nat. size.
B. An undetermined Inadunate Crinoid, 4 times nat. size. b. Portion of the arm, 10 times nat. size.

The drawings were made from wax squeezes, by Miss G. M. Woodward and the author.

SPECIMEN B.

The plates of the Dorsal Cup are disturbed. A basal and two radials can be distinguished. The radials are comparatively large, and seem irregular in shape.

The relation of the Arms to the cup seems to be that of an Inadunate crinoid. The arms appear to have been regularly dichotomous. That on the right of the drawing has IBr, 4; IIBr, 7 in the left branch, the axillary of which (IIAx) bears one IIIBr on either side. The evidence of the specimen is rather against there having been any branches beyond IIIBr, or at least beyond IVBr. The branches seem to have diverged at rather a wide angle.

The most remarkable feature of the arms are the structures that seem to spring from the side of the brachials, and somewhat resemble pinnules (see enlarged figure b). The only known structures with which they can be compared are either pinnules or covering-plates. But they are not pinnules; for they are more numerous than the brachials, and are not regularly disposed with regard to them. And they are not covering-plates; for in that case the covering-plates would be wider than the arm, which is impossible. In the actual specimen they present the appearance of fluted impressions, the flutings being parallel to one another, and inclined upwards at rather less than a right angle to the arm. About two flutings go to a brachial. It is impossible to tell whether the elements represented by the flutings were separate from one another, or fixed by their adjacent sides. Neither is it certain whether the element represented by each fluting was in one piece, or composed of a series of ossicles, as would be the case with a pinnule. In fine, they are mysterious structures, and I don't understand them.

Of the Stem, the proximal 2 mm. are preserved. It consists of low ossicles, alternating in height, and the higher ones projecting slightly beyond the others. The width where it joins the cup is 1·5 mm., and thence it tapers slightly distalwards.

The crushed state of preservation and imperfection of the specimen prevent one from referring it to any known genus, and still more from founding a new genus for its reception. But the peculiar and novel features that it presents have led me to publish this description.

Wax squeezes of these specimens are preserved in the Geological Department of the British Museum (Nat. Hist.), where any student can see them on application; they are registered E 6484 and E 6485, respectively.

VII.—On the Comrie Earthquake of July 12, 1895, and on the Hade of the Southern Border Fault of the Highlands.

By Charles Davison, M.A., F.G.S.;
Mathematical Master at King Edward's High School, Birmingham.

In Mallet's great "Catalogue of Recorded Earthquakes," the name of Comrie first appears under the date September 2, 1789, and, from that time until the present day, the village has been widely known as a centre of earthquake shocks and sounds. For many years past, however, they have become more and more rare: the shocks, when they have occurred, have been exceedingly slight, and the disturbed areas correspondingly small. Several persons living but a few miles from Comrie inform me that they have never felt a shock; and those who reside in the village itself often speak of "hearing" the earthquakes, as if the vibrations did not generally exceed that limiting degree when they are perceptible only to the ear.

On the 12th of last July, at about 7.40 a.m. (G.M.T.), a slight but undoubted shock was felt at Comrie and for a few miles around. Houses are unfortunately somewhat widely scattered in the district, and it has been difficult to collect as many records as could be desired. I have succeeded in obtaining only 21 observations from 19 different places, and even this number would have been smaller had it not been for the kindly assistance of Mr. T. Boston, of Balmuick, who supplied me with the names of several observers, and also with three or four records of considerable value. In addition to the above places, I have received information from 17 others, where, so far as is known, no trace of the earthquake was perceived. These are of some assistance in drawing the boundary of the disturbed area, though less than is usually the case, either on account of their outlying position or of the small number of inhabitants they contain.[1]

On the accompanying map (Fig. 1), a small disc with a cross through it indicates that the shock was felt and the sound heard, a small circle with a cross that the sound was heard but the shock not felt, a cross that the sound alone was observed, and a circle that no trace of the earthquake was perceived.

The continuous line represents the isoseismal line corresponding to intensity III of the Rossi-Forel scale. The area enclosed by it is $5\frac{1}{2}$ miles long, $4\frac{1}{6}$ miles broad, and contains $18\frac{1}{2}$ square miles. Its centre lies $\frac{1}{4}$ mile south-west of Comrie, or half-way between Ross and Dalginross.

Outside this line the shock was certainly felt at two other places, at Easter Ballindalloch very slightly, and rather more strongly at Westerton. At several other places outside the isoseismal III the sound only was observed. This was the case at Braefordie, Carroglen, Glenturret Lodge, Wester Dundern, and Easter Dundern, but at the last-named place, it should be mentioned, the observer was at work in the open air, and therefore in a most unfavourable position for detecting a weak tremor. Similar observations to the south of the disturbed area are not forthcoming, but it is clear that, to the north and west at any rate, the sound-area overlapped the disturbed area.

[1] Authorities.—Aberuchill, Mr. M. M'Intosh; Ardvorlich, Col. J. Stewart; Auchnafree, Mr. A. Richards; Balmuick, Mr. T. Boston; Bishopsfauld, Mr. T. K. Robertson; Braefordie, Mr. J. Stewart; Carroglen, Mr. T. Boston; Clathick, Capt. W. C. Colquhoun; Comrie, Mr. S. Campbell, Rev. W. Hall, Rev. A. C. Watt; Culty-Craggan, Mrs. Finlayson; Crieff, Mr. G. Straithairn; Dalchruin, Mr. W. Cairns; Dalchonzie, Miss Newbigging; Easter Ballindalloch, Mr. J. Campbell; Easter Dalginross, Mr. D. W. Kemp; Easter Dundern, Mr. P. M'Laren; Fairness, Mr. W. Bell; Foulis, Rev. T. Hardy; Garrichrew, Mr. J. McLaren; Gilmerton, Rev. G. Henderson; Glenample, Mr. T. Walters; Glenturret Lodge, Mr. T. Boston; Innergeldie, Mr. J. Craig; Laggan, Mr. D. Ewing; Lawers, Col. D. R. Williamson; Little Port, Mr. J. Morrison; Locherlour, Mr. S. Campbell; Madderty, Rev. L. C. M. Wedderburn; Ross, Mr. R. M'Laren; St. Fillans, Rev. T. Armstrong: Tyghnablair, Mr. P. M'Intyre; Tomanor, Mr. A. McNaughton; Wester Ballindalloch, Mr. T. Boston; Wester Dundern, Mr. P. M'Ara; Westerton, Mr. D. Keith Murray.—I beg to offer my hearty thanks to the above ladies and gentlemen, and also to Mr. J. Robertson, of Coupar Angus, who kindly sent me early notice of the occurrenc of the earthquake.

The shock was an exceedingly slight one. Its intensity was greatest at and near Comrie, but even here it was less than IV, that is to say, it was not strong enough to make doors, windows, etc., generally rattle, though in isolated cases this may have happened. At Comrie it consisted of a slight uninterrupted tremor, lasting two or three seconds, accompanied by a rumbling sound like the passing of a heavy carriage or the discharge of stones from a cart.

The beginning of the sound preceded that of the shock at Dalchonzie, Easter Ballindalloch and Tomanor; coincided with it

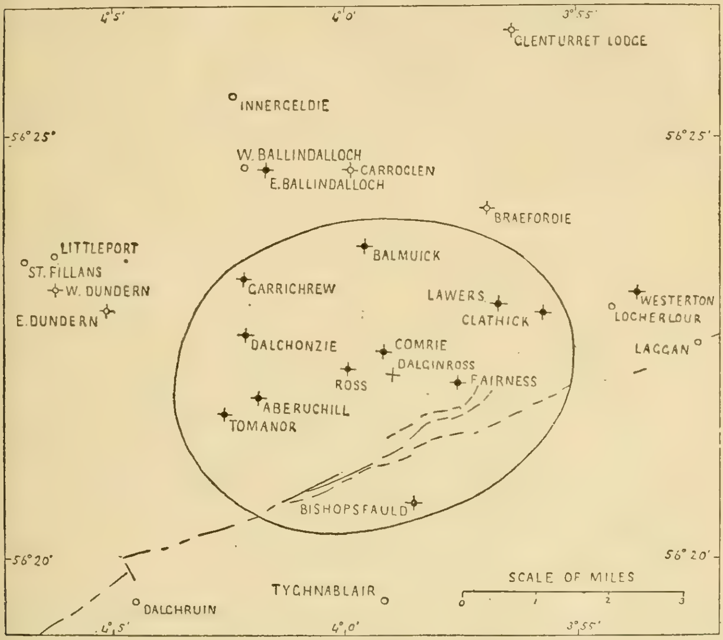


FIG. 1.—Diagram-map of the Comrie Earthquake.

at Comrie and possibly also at Bishopsfauld; and followed it at Ross. The end of the sound preceded that of the shock at Easter Ballindalloch, and followed it at Bishopsfauld and Ross.

The broken line on the map indicates the course of the great southern border fault of the Highlands. It has always been customary to associate the Comrie earthquakes with movements taking place along this fault. The evidence, so far, has perhaps hardly been sufficient to amount to a proof of the supposed connexion, but in the present case the position of the disturbed area and the direction of its longer axis seem to me a strong argument in its favour. In the case of so slight a shock, the phenomena are of the simplest possible character, but, so far as I know, there is nothing inconsistent with the view that the earthquake was caused by a slight slip of one of the system of faults taking place in the immediate neighbourhood of Comrie.

My object in drawing special attention to this shock is not on account of any peculiar interest which it in itself possesses, so much as from the evidence it supplies as to the direction in which the great fault hades. "There is," as Sir Archibald Geikie has kindly informed me, "no sufficient section of the Highland Border fault to show its hade. Normally, of course, it should be to S.E., and perhaps it is so on the whole. But there are traces of great and irregular disturbance along the line, so that the hade may here and there be to N.W." The seismic evidence in the present case of course applies only to the Comrie district, but, if I am right in associating the recent earthquake with a slip of the fault, there can be little doubt I think that the fault near there hades to the north-west, and that it is therefore in this part a reversed fault.

As this conclusion is of some importance from a geological point of view, it may not be out of place to refer briefly to the evidence in its favour.[1]

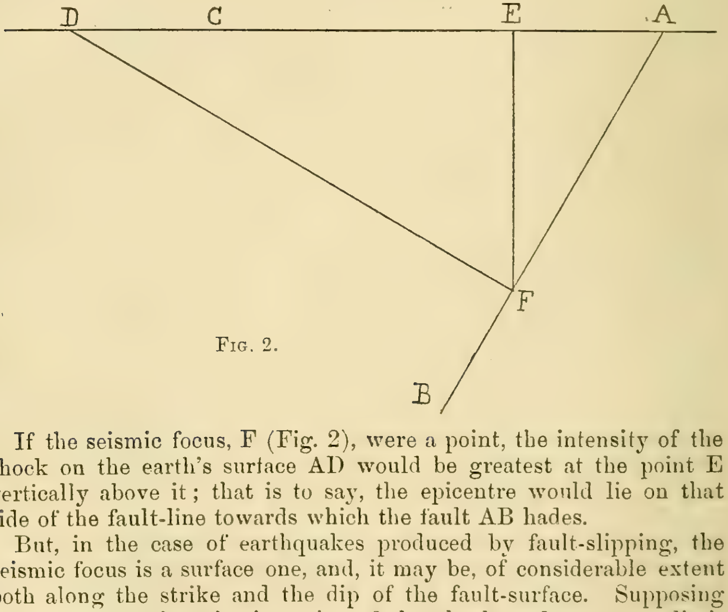


Fig. 2.

If the seismic focus, F (Fig. 2), were a point, the intensity of the shock on the earth's surface AD would be greatest at the point E vertically above it; that is to say, the epicentre would lie on that side of the fault-line towards which the fault AB hades.

But, in the case of earthquakes produced by fault-slipping, the seismic focus is a surface one, and, it may be, of considerable extent both along the strike and the dip of the fault-surface. Supposing for a moment that the intensity of the shock undergoes no diminution as the distance from the focus increases, it is evident that the intensity at any point on the earth's surface will be greater the shorter the duration of the shock. Now, the duration will be least at the point D, where the line perpendicular to the fault-surface through the centre F of the focus meets the earth's surface.[2] But

[1] In a future paper I hope to enter more fully into this question, as well as to summarize the evidence in favour of the fault-slip theory of earthquakes.

[2] The argument may also be stated as follows: The point D is that which is affected simultaneously by the disturbances proceeding from a larger part of the focus than any other point on the earth's surface.

as the intensity does diminish as the distance increases, the maximum intensity will occur at a point C somewhat nearer the fault-line. Thus the centre of the disturbed area should lie on the side of the fault-line towards which the fault hades, and the greater part of the disturbed area should also lie on the same side of the fault-line.

Referring to the map (Fig. 1) it will be seen that by far the greater part of the area disturbed by the earthquake on July 12 lies on the north-west side of the fault-line, leading to the inference that the hade is also in this direction. It is perhaps unnecessary to accumulate evidence on this point, but it may be mentioned that it is at Comrie itself, also on the same side of the fault-line, that the majority of slight shocks and sounds have been in times past observed.

VIII. — Phyllade, Phyllite, and Ottrelite.

By Prof. Grenville A. J. Cole, M.R.I.A., F.G.S.

In his article in the last number of the Geological Magazine[1] Mr. A. R. Hunt points out a number of differences in the use of the terms "schist, slate, phyllite, and foliation." The usage of English-speaking peoples has long ago restricted the word "schist," so that it is no more an equivalent of the French "schiste" and of the German "schiefer" than "mutton" is of "mouton." Prof. Bonney's position is, however, one of exceptional restriction, as he himself has always carefully pointed out. The terms "phyllade" and "phyllite" are surrounded by less controversy. I regard both as unnecessary, seeing that we cannot have names for every gradation from a clay-slate to a mica-schist; but it is fairly clear that the original "phyllades" were slates containing some mica. The term was used in 1813 by Brongniart ("Essai d'une classification des Roches mélangées," p. 35), who ascribes it to the joint authorship of himself, Brochant, and D'Aubuisson. He gives as a synonym, "Thonschiefer mélangé des minéralogistes allemands," and defines the rock as having a ground of clay, with mica, quartz, felspar, amphibole, chiastolite, etc., in it, either together or separately; "structure feuilletée." None of the types which he describes are free from mica. D'Aubuisson de Voisins ("Traité de Géognosie," tome ii, p. 93) in 1819 devoted one of his elaborate disquisitions to Phyllade, giving as synonyms "Thonschiefer; Clay-slate; Ardoise, schiste de Saussure et des anciens minéralogistes; Schiste argileux de M. Brochant." D'Aubuisson objects to the restriction of "schiste" to any one species of rock, and keeps phyllade distinct from those clays which are derived as detritus from pre-existing rocks. He says that the surface of phyllade is sometimes smooth, sometimes deeply striated, as if puckered up ("froncée"); and he shows how the true type of the rock is approached by gradations from mica-schist, until the mica and quartz are so finely divided as be indistinguishable, save for some

[1] Geol. Mag., 1896, p. 31.

flakes of mica and granules of quartz embedded in the apparently homogeneous ground. The justification for using "phyllade" as a term intermediate between mica-schist and common slate is to be found in the passage (p. 97) "Le phyllade passant du schiste-micacé à l'ardoise, par des nuances insensibles et diversifiées sous tous les rapports, le nombre de ses variétés est presque indéfini." D'Aubuisson believed the fissile structure to be parallel to the stratification, and combated the acute views of Voigt, who had observed a strong divergence between the two structures in Thuringia.

Brongniart, in 1827 ("Class. et caract. min. des Roches homogènes et hétérogènes," p. 88), refers "phyllade" to D'Aubuisson only, and states that this rock is "composé essentiellement de Schiste argileux comme base, et de Mica . . . . . c'est le véritable *schiste micacé.*" "Schiste argileux" (p. 61) is with him a common clay-slate, and he swallows up "mica-schist" now altogether in "phyllade." This introduces sufficient confusion, when we remember that D'Aubuisson, on the other hand, allied "phyllade" more to the clay-slates than to the mica-schists. Coquand, in 1857 ("Traité des Roches," p. 307), grouped together as "argiloschiste" all the clayey "schistes" of metamorphic origin in which the constituents were very finely grained, and gives the term "phyllade" as a synonym. Our latest glossary (L. Lessing, "Petrographisches Lexicon," 1894, p. 177) gives "Phyllit" as a translation of "Phyllade," due to Naumann, and defines both rocks as micaceous "Thonschiefer." It is clear, then, that these two terms, if required at all, should be used in the sense in which they are already generally accepted. I have shown that D'Aubuisson himself, with a foresight that is not accidental, distinguishes between "phyllades" and detrital rocks; for him, phyllades were allied to granite and not to clays. The minerals in them had arisen *in sitû*, a view which the study of metamorphism has since led us to support. Mr. Hunt's comments on this point seem perfectly correct.

We need not discuss the mineral styled "phyllite" by Thomson in 1828 (Annals of the Lyceum of Nat. Hist., New York, vol. iii, p. 47), but for its bearing on chloritoid and ottrelite. Only the strict respect for priority entertained by the late Prof. J. D. Dana caused the name to be retained as that of a mineral species. Mr. Hunt surely does not find it in "popular" use, and it is given as a mere synonym of ottrelite in the revised edition of Dana's "System of Mineralogy," 1892. But this raises another point that is well worth settling—is oxide of manganese or of magnesium really present in ottrelite and in Thomson's "phyllite"? "Manganese" is not so obvious a clerical error in the description of "phyllite" as Mr. Hunt suggests, since the relation of the mineral to typical ottrelite depends on the presence of this constituent. *Manganese,* not magnesia, is ascribed to "phyllite" in the famous fifth edition of Dana's "System," and in the new edition of 1892. Hintze ("Handbuch der Mineralogie") gives the same figures for *magnesia.* Mr. F. W. Rudler has kindly looked up Thomson's original paper for me, and informs me that Hintze is correct.

J. D. Dana, but for this slip, would probably have classed "phyllite" as a common chloritoid, instead of with the manganiferous ottrelite. Lacroix, in 1886, urged the practical identity of ottrelite and chloritoid, and these names appear as synonyms in Lévy and Lacroix, "Minéraux des Roches," p. 171. Descloizeaux and Damour, however (Ann. des Mines, 1842, tome ii, p. 359) found over 8 per cent. of manganous oxide in the ottrelite of Ottrez, and recorded no magnesia. Hintze, in his "Mineralogie," quotes no analyses of chloritoid with more than 1·30 per cent. of MnO, few containing this oxide at all. Hence I fancy that the name ottrelite will be worth keeping for chloritoids with more than 5 per cent. of manganous oxide and little or no magnesia. This would exclude some substances that have recently been styled ottrelite, and would necessitate a modification in the treatment of that mineral in my "Aids in Practical Geology" (second edition, p. 157), where I have regarded it as synonymous with chloritoid proper and have made no mention of the distinctive manganese.

REVIEWS.

I.—Mining Handbook to the Colony of Western Australia, written especially for Prospectors. By Harry P. Woodward, J.P., F.G.S., F.R.G.S., F.I.Inst., Government Geologist.[1] Second edition. Perth, Western Australia, 1895.

THE value of mining handbooks to the pioneers engaged in opening up the mineral resources of a new country has long been recognized. Much depends on the industry and skill of these men, and all possible help should be given to them, as they do work which would be none too easy to a trained geologist, armed with all the resources afforded by a chemical laboratory and a technical library. Whether it is to be deplored or not, it is certainly true that pioneers have usually more courage and energy than scientific attainments, and a really satisfactory handbook is therefore of paramount importance to them. It must be comprehensive, concise, and easily intelligible to ordinary readers; no technical or scientific knowledge on the part of its readers must be taken for granted, and, on the other hand, useless information must be rigidly excluded. The volume under review is an excellent example of the best type of such books. It is brief, yet clear; full of details, yet interesting; accurate, but not defaced by a multitude of technical terms.

It begins with a slight sketch of the colony, giving some account of the towns, population, climate, water supply, timber, etc. The intending immigrant would perhaps like to hear more about the climate, especially as to the daily and monthly range of temperature in different districts, and would possibly be curious respecting insect life, which is not touched on; but generally the information is wonderfully full and varied. The difficulty as to water supply in the interior is insisted on, and Mr. Woodward points out that the numerous lakes shown on the maps must not be relied on to furnish

[1] See also p. 96 of the present Number Geol. Mag.

any useful supplies. These lakes are usually dry salt wastes, which are occasionally covered by a few inches of water after heavy rains, although even then the water is salt. At Coolgardie the water in the wells is almost a saturated solution, containing 40 ounces of salt to the gallon, as compared with $5\frac{1}{2}$ ounces in a gallon of sea water. Mr. Woodward considers that the best means of obtaining fresh water in the district will be by constructing large dams to save the rain water thrown off the granite hills.

The geology and mineralogy of the country are next dealt with, each section being preceded by a short general account of the science in question. These accounts are in the main excellent, but it may well be doubted if the two pages devoted to chemistry will serve any useful purpose. More than half of them consist of a complete list of the elements, including the rarest, and even some whose existence is doubtful, together with the atomic weights, correct to the second or third decimal place. While useful to the chemist, it is probable that the exact meaning of this table would escape the "practical man." Until recently the geological formations were supposed to consist of either granite or sand, but Mr. Woodward has shown that this is not the case, although the absence of natural sections makes a complete study somewhat difficult. "Speaking roughly," he says, "as a whole, the country may be described as one large table-land, rising to an elevation of from 1000 ft. to 2000 ft. above the sea, and covered for the most part with sandy deposits, which have resulted from the denudation of the Desert Sandstone Series," of Mesozoic age. "Underlying this Desert Sandstone formation there is a series of belts of metamorphic and granitic rocks, the former of which are intersected by numerous diorite dykes and quartz veins, which are proving to be very rich in gold." The auriferous metamorphic rocks are partly Silurian, partly Cambrian, but mainly Archæan. There are six of these belts in all, consisting of highly-contorted rocks striking north and south and having a nearly vertical dip. The fourth and sixth belts, counting from west to east, consist of schists intersected by the gold-bearing veins, whilst the third and fifth consist of barren granite, which long acted as a barrier, discouraging prospectors from pursuing their researches farther into the interior. The disposition of these belts is clearly shown on the capital geological sketch map included in the volume.

In the succeeding pages there is a very useful description of the minerals occurring in the gold-fields, together with directions for identifying them. It may be gathered from the section on metallic gold that Mr. Woodward holds the view that alluvial gold consists of particles derived from the denudation of auriferous lodes, a view which, whether it be correct or not, is not an advantageous one for the prospector to hold, since it often leads to vain searches after lodes where none can exist. Moreover, it would perhaps be better if, instead of the comparatively inefficient iodine test of the presence of traces of gold in rock, the easier and more certain tests by chlorine, bromine or cyanide of mercury were described. But these slight blemishes, if indeed they are blemishes, detract but little from the value of the mineralogical compendium, one of the most important parts of the book to the prospector.

The greater part of the remainder of the volume is devoted to a detailed account of the various gold-fields, and of the copper, lead, tin, and coal deposits, this account being certainly by far the best which has yet appeared. The description of the coal-fields, on the value of which the development of the colony in no small measure depends, is mainly taken from Mr. Woodward's last annual report, lately noticed in these pages. Three appendices follow, containing those laws and regulations which are of importance to prospectors, some advice as to their outfit and mode of operation, many useful tables, a glossary of scientific and mining terms, and full information on shipping and railway matters. As already stated, the whole book is highly creditable to Mr. Woodward and to the Government Department represented by him. Not a page is wasted, and hardly a page could be added to it with advantage. It need hardly be added that it will be indispensable to every visitor to the colony, to say nothing of the prospectors. T. K. R.

II.—The Fauna of the Bohemian Gas-coal. "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens." By Dr. Anton Fritsch. Vol. III, part 4. Pp. 105–132, pls. 123–132, with Title-page and Index to Vol. III. (Prague: Fr. Rivnac, 1895.)

WITH the exception of a brief supplement, Dr. Anton Fritsch has now completed his description of the fossil vertebrata of the Permian formation of Bohemia. The latest instalment, received in the middle of December, concludes the third volume of his great work and deals with the Palæoniscid fishes which remained to be treated after the issue of the preceding part a year ago. The systematic descriptions are continued in the usual manner, and there is appended a useful summary of the chief points in the structure of the Palæoniscidæ as the author has observed them.

Most of these fishes discovered in the Bohemian Permian belong to the genus *Amblypterus*, as now generally defined, and Dr. Fritsch recognizes seven species, one of these with no less than six named varieties. *Amblypterus Feistmanteli* and *A. Zeidleri* are described as new species in the part of the work before us. There are beautiful figures of the ornamented head-bones of the variety *A. Rohani* (Heckel); while restored figures of this form, of *A. luridus* (Heckel), *A. obliquus* (Heckel), and *A. Reussi* (Heckel) are also given. The latter are in some respects tentative and incomplete, and we would question the accuracy of the drawing of the anterior dorsal fin-rays in *A. luridus*, as also the diminutive proportions of the circumorbital ring in the same fish. Most welcome additions to our knowledge of details in the osteology of the genus appear throughout the descriptions and figures; and the discovery of tritoral teeth on one of the inner mouth-bones in *A. Feistmanteli* is particularly interesting.

Two small and one large species are doubtfully referred by Dr.

Fritsch to *Acrolepis* (*A. Krejcii, A. sphærosideritarum*, and *A. gigas*, Fritsch). The latter is a fine fish considerably more than a metre in length, and the largest known Palæoniscid; Dr. Fritsch even suggests that it is the largest known Palæozoic fish, but it must have been much surpassed in dimensions both by *Rhizodus* and by *Megalichthys intermedius.* A plaster cast of this unique specimen is exhibited in the British Museum (Natural History).

Some fragmentary specimens bearing much resemblance to *Elonichthys* and *Rhadinichthys*, too imperfect (in our opinion) for generic determination, are regarded as indicating a hitherto unknown genus *Pyrogyrolepis*, with the single species *P. speciosus.* This is defined thus:—"Similar to the genus *Gyrolepis*, but dentition with large pointed teeth, between which are small teeth in irregular rows; the large teeth smooth at the apex, beautifully striated at the base, with large pulp-cavity; anterior rays of pectoral and dorsal fins not articulated."

The name *Hemichthys problematica* is proposed for a small skull of doubtful relationships, which may even belong to a Labyrinthodont. A detailed description is promised in the supplement to the next volume.

In his concluding observations on the Palæoniscidæ, Dr. Fritsch particularly emphasizes the difficulty of regarding the degree of arching of the back as a specific character. He instances the variations in this feature in the common carp, which depend much upon the locality and surroundings. He also adds a warning as to the displacement of the fins by different kinds of crushing. In the head he finds that the cranial bones are thickest when least ornamented; thinnest and most irregular when the ganoine is best developed. Large otolites appear in at least one species of *Amblypterus.* With regard to calcified vertebræ, he now considers that his former determination of such elements in the supposed *Phanerosteon* and *Sceletophorus* is very doubtful.

The new part of the "Fauna der Gaskohle" thus equals in interest its predecessors, and bears witness to the same laborious and patient research and attention to minute detail, which characterize the whole of the work. A. S. W.

III.—Memoirs of the American Museum of Natural History. Vol. I, part 2. August, 1895, pp. 74, plates iv to xiii.

In this finely illustrated Monograph Prof. R. P. Whitfield, Curator of palæontology in the American Museum of Natural History in New York City, gives a second instalment of the republication of descriptions of fossils from the Hall collection, from the Report of progress for 1861 of the Geological Survey of Wisconsin, by James Hall. The type specimens, now figured for the first time, are chiefly derived from the Trenton group in Wisconsin. They comprise algae, some of which were previously confounded with Graptolites, such as the noteworthy *Buthograptus laxus*, "an *articulated* marine form" much resembling the living *Caulerpa plumaris* of the Florida coasts; a crinoid, a crustacean (*Illaenus* *taurus*), Lamellibranchiata, Gasteropoda, and Cephalopoda. This memoir is published, Mr. Whitfield states, with a view of avoiding a redescription under other names than the original ones, as it is deemed advisable to illustrate these types from the specimens originally used, a course which has been now followed with three exceptions. In Part I of Vol. I Mr. Whitfield, it will be remembered, gave descriptions and figures from the types of Lower Carboniferous Crinoids in the "Hall" collection, of which he is Curator. A. C.

REPORTS AND PROCEEDINGS.

Zoological Society of London.

December 17th, 1895.—Sir W. H. Flower, K.C.B., LL.D., F.R.S., President, in the Chair.

Mr. F. A. Bather read a paper on a remarkable and very beautiful form of fossil crinoid, without a stalk, named *Uintacrinus*. The paper attempted a complete morphological description of *Uintacrinus socialis*, based on specimens from the Upper Cretaceous Beds of Western Kansas, now in the British Museum. The deficiencies of previous accounts were made good, and their errors corrected; this was specially the case with regard to the interbrachials, interpinnulars, brachials, pinnules, and joints. The comparison with other crinoids, thus rendered possible, showed that *Uintacrinus* could not be related either to the Camerata or to the Ichthyocrinidæ. It must therefore be related either to the Palæozoic Inadunata, or to their Mesozoic descendants, the Canaliculata. Among these a process of comparison and elimination left behind only the ascending evolutionary line that contained *Encrinus*, *Dadocrinus*, *Pentacrinus*, and *Apiocrinus*. A simple inspection enabled one to fix on *Dadocrinus* as the one among all known genera that was most nearly related to the ancestor of *Uintacrinus*.

Geological Society of London.

I.—January 8, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "A Delimitation of the Cenomanian, being a Comparison of the Corresponding Beds in Southern England and Western France." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and William Hill, Esq., F.G.S.

The object of the authors is to compare the beds which form the lower part of the Upper Cretaceous Series in those parts of Southern England and Western France which are nearest to one another. They briefly trace the history of English and French geological research, and remark that even at the present time French geologists are not agreed as to the beds to be included in their "étage Cénomanien."

The authors feel justified in taking the English succession as a standard, and endeavour to show that the French succession is in accord with it, believing that the confusion of French geologists has arisen from their having taken a set of arenaceous shallow-water beds as the standard of their Cenomanian stage, in a district where these form the local base of the Cretaceous System, and where the typical Albien fauna does not exist.

Commencing with the English sections, they describe such as serve to establish the succession in the Isle of Wight, Dorset, and Devon, pointing out that the Gault and Upper Greensand are everywhere so inseparably united that it is difficult even to assign limits to the component zones; further, that the Lower Chalk is clearly marked off from this group, and that no classification can be accepted in England which does not recognize the clear and natural line of division at the base of the Chalk.

In Devonshire the representative of the Lower Chalk is found in a set of arenaceous deposits which contain a remarkable fauna, some of the fossils being such as occur in the Upper Greensand, some in the Chalk Marl, while many have not been found elsewhere in England, but occur in the Cenomanian of France and in the Tourtia of Tournay. This Devonshire "Cenomian" includes the beds numbered 10, 11, 12, and 13 by Mr. Meÿer in his Beer Head section, Quart. Journ. Geol. Soc., vol. xxx (1874), p. 369.

Passing over to France, the fine section in the cliffs between Cap la Hève and St. Jouin is described in detail, and the bed which is regarded as the base of the Cenomanian by M. Lennier and Prof. A. de Lapparent is shown to be the representative of the Chloritic Marl of the Isle of Wight; the Greensand and the Gault below forming, as in England, a separate and independent group of beds.

An account is then given of a traverse made through the departments of Calvados and Orne as far as Mortagne; succeeded by a brief account of the lateral changes which take place as the Cenomanien is traced through the Sarthe, this being derived from the publications of MM. Guillier and Bizet.

A critical study of the fossils found in Devonshire and Normandy follows, with tabulated lists comparing the Devonshire fauna with that of the French Cenomanian, and the fossils of the Norman Cenomanian with those of the Warminster Greensand and of our Lower Chalk. In this part of the work the Authors have received much assistance from Mr. C. J. A. Meÿer and Dr. G. J. Hinde.

Finally, they claim to have defined the limits of the Cenomanian stage in Western France, and to have shown that this group of beds is simply a southern extension of our Lower Chalk, formed in a shallower part of the Cretaceous Sea and nearer to a coast-line.

2. "The Llandovery and Associated Rocks of Conway." By G. L. Elles and E. M. R. Wood, Newnham College. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.)

The discovery of beds with *Phacops appendiculatus*, Salt., near Deganwy, and of shales with a fauna of Upper Birkhill age close to the town of Conway, indicates that the break between Ordovician and Silurian is smaller in this area than has hitherto been supposed.

In the paper a full description of the representatives of the Birkhill, Gala (Tarannon), and Wenlock beds is given, and the distribution of the fossils (chiefly graptolites) in the various subdivisions is recorded. Many of the graptolites are forms which have been described from Swedish deposits, but have hitherto been unrecorded in this country.

3. "The Gypsum Deposits of Nottinghamshire and Derbyshire." By A. T. Metcalfe, Esq., F.G.S.

The gypsum deposits of these counties occur in the Upper Marls of the Keuper division of the Triassic system. The Author describes their occurrence in thick nodular irregular beds, large spheroidal masses, and lenticular intercalations, and their association with satin-spar, alabáster, selenite, and anhydrite.

II.—January 22nd, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Speeton Series in Yorkshire and Lincolnshire." By G. W. Lamplugh, Esq., F.G.S.

Further work on the Speeton section, while extending our knowledge of the palæontological details, has fully sustained the results of the Author's previous investigations. The rapid attenuation and final disappearance of the Speeton Series in a westerly direction in Yorkshire is discussed, and though the available evidence is held to be insufficient to demonstrate the exact conditions, it is shown that, contrary to the accepted view, the lower zones are probably the first to die out, and are overstepped or overlapped by the higher divisions, since at Knapton, fourteen miles inland, only the upper zones of the coast-section can be proved to occur, as shown by the presence of marls with *Bel. minimus* passing upward into the Red Chalk, and by the fossils preserved in the Old Collection which include *Hoplites Deshayesii* under the name of *Amm. Knaptonensis*, Bean MS., and a few others.

The ferruginous sands locally occurring beneath the Red Chalk on the western edge of the Yorkshire Wolds are recognized as agreeing in all respects with the Lincolnshire Carstone; and Mr. A. Strahan's conclusions as to the relations of this division to the Red Chalk are confirmed both in Yorkshire and in Lincolnshire.

In Mid-Lincolnshire all the palæontological zones of Speeton are identified and traced, the presence of the leading zonal types of the Cephalopoda readily establishing the general correlation proposed by Professor A. Pavlow and the Author, in spite of the greatly modified lithological aspect of the deposits, and the corresponding modification of their fauna. The chief features of this correlation, which differs in many respects from that adopted by Professor Judd and the Geological Survey, are as follows:—(see table on p. 88).

Kimmeridge Clay.

In Lincolnshire in at least one instance the boundary of a palæontological zone, which is the true synchronal line, is shown not to pursue the same stratigraphical horizon throughout its course, proving that sediments of different character were accumulated at the same time in comparative proximity to each other. The inherent divergence between the stratigraphical and palæontological methods in geology is thus once more illustrated.

It is suggested that the derivative character of the band of phosphatic nodules at the base of the Spilsby Sandstone is not well established, and that the fossils of the 'so-called' pebbles probably represent an original fauna poorly preserved in nodules formed during a temporary pause in the sedimentation.

The 'Zone of *Bel. lateralis*' (*Série Speetono-russe* of Pavlow) is shown to bridge the space between undoubtedly Jurassic and undoubtedly Lower Cretaceous strata; but according to the recent results of Professor A. Pavlow, if the accepted classification of other areas is to be upheld, the division between the two systems must be placed high enough to include this zone in the Jurassic, in spite of the local inconvenience of this arrangement.

Speeton.		Lincolnshire.
RED CHALK.		
Zone A. Passage Marls	=	Carstone (? in part or wholly).
B. Zone of *Bel. Brunsvicensis*	=	Tealby Limestone and its southerly equivalents (also ? the lower part of the Carstone).
C. Zone of *Bel. jaculum*	=	Tealby Clay of the Wold escarpment (the lower portion of the zone doubtfully represented).
D. Zone of *Bel. lateralis*	=	'Tealby Clay' of the outliers west of Spilsby (Hundleby Clay), Claxby Ironstone and Spilsby Sandstone.
E. 'Coprolite-bed'	=	Nodule-bed at base of Spilsby Sandstone.

2. "On some Podophthalmous Crustaceans from the Cretaceous Formation of Vancouver and Queen Charlotte Islands." By Henry Woodward, LL.D., F.R.S., P.G.S.

This paper contains descriptions of several Crustaceans from the Cretaceous Coal-bearing strata of Vancouver and Queen Charlotte Islands, sent to the Author by J. F. Whiteaves, Esq., F.G.S., Palæontologist to the Geological Survey of Canada, und two from the Museum of the Geological Society of London.

After giving a brief notice of the deposits from which the nodules containing these crustacean fossils have been derived, and the authors who have written upon them, Dr. Woodward describes (1) a new *Callianassa* which he names *Callianassa Whiteavesii*; (2) an Anomalous Brachyuran, which he names *Homolopsis Richardsoni*; (3) a new Corystid, named *Palæocorystes Harveyi*; and (4) a new Cancer, named *Plagiolophus Vancouverensis*.

3. "On a Fossil Octopus, *Calaïs Newboldi* (J. de C. Sby., MS.), from the Cretaceous of the Lebanon." By Henry Woodward, LL.D., F.R.S., P.G.S.

The specimen to which the Author's attention was obligingly drawn by Mr. C. Davies Sherborn, F.G.S., is in the Museum of the Geological Society, and was obtained by Major Newbold, and named in 1846 in MS. by the late Mr. J. de Carle Sowerby, *Calaïs Newboldii,* who added on the label:—"Ceph. Octopoda. Genus ineditum. Abdomen alis triangularibus instructum. E. strato calcareo (*tertiario*) Montis Libani a (D.) Newbold effossum.—1846. J. de Carle Sowerby."

The Author described the specimen in detail, and retained for it the genus and species proposed by Mr. Sowerby.

4. "On Transported Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

The 'mid-glacial' sands of the cliffs between Yarmouth and Lowestoft are overlain at Corton by Chalky Boulder-clay. But further north than Corton some masses of the same clay occur in the interior of the cliffs, surrounded by the sands in undisturbed stratification, but passing into them by strings and patches such as suggest the melting off of enveloping ice. They have probably been floated and dropped there.

Again, gravels lying in a valley of Chalky Boulder-clay in West Suffolk (Cockfield, etc.), and indicating considerable denudation of the Clay, yet have some patches and sheets of that Clay overlying them as if carried down or slipped down from higher ground.

This may explain some anomalous positions of Boulder-clay noted by writers. The Lowestoft observations suggest that Chalky Boulder-clay was being manufactured in one locality simultaneously with 'mid-glacial' sands in another.

CORRESPONDENCE.

A GEOLOGICAL SURVEY OF EGYPT.

Sir,—When passing recently through Cairo, I was informed by Lord Cromer of the intention of the Egyptian Government to undertake a Geological Survey of that country, and a few details of the proposed work may not be without interest to your readers. I may state in the first place that this survey is to be undertaken independently of any anticipation of the discovery of valuable minerals; in fact, quite independently of any utilitarian object, but with a desire to advance the interest of science in Egypt, and to put that country in line with other civilized States. At the same time should the survey result in the development of mineral substances, this will be so much gain. The first chief of this new department will be Captain Lyons, R.E., F.G.S., who, as your readers will recollect, recently read a suggestive paper before the Geological Society of London on Egyptian Geology,[1] and who, while carrying out the duties of his position as an officer of the Egyptian army, has taken advantage of every opportunity to extend his knowledge of the geological structure of the Nile Valley and the adjoining desert

[1] "On the Stratigraphy and Physiography of the Libyan Desert of Egypt," Q.J.G.S., No. 200 (Nov., 1894).

tracts. I understand that Captain Lyons intends to visit England early in the ensuing summer in order to select a staff of young geologists to work under him in Egypt. Ample provision has been made in the estimates for equipment, tents, camels, and attendance. It will of course only be possible to carry on outdoor work during six months in the year; but the geological structure of the country is of great interest, though on the whole, simple; and the formations are distributed on a large scale. For young geologists who wish to extend their knowledge of other countries the work ought to prove attractive, and with due care, will be healthy. Camping in tents in the desert is, as I can state from experience, exceedingly enjoyable, and when to this is added the delight of riding on camels and donkeys, there is nothing more to be said in order to secure numerous volunteers for the work! EDWARD HULL.

ERRATUM AND NOTE TO ARTICLES ON EOZOÖN.

SIR,—I observe in the beginning of the second paragraph of my Article in December 1895, p. 545, an error which may puzzle some readers. The words "*old calcite and serpentine lagoons*" should be "calcite and serpentine layers." A less important error is the substitution of the name "Lorne" for "Lowe" in the description of Fig. 2 in my first Article in October 1895, p. 447.

In the second Article I should perhaps have mentioned that in the Glauconite Limestone of Levis (Ordovician), and in that of Kempfen, Bavaria (Eocene), as well as in Cretaceous and Modern greensands, while some grains of glauconite fill cavities of fossils, others, and often the great majority, are independent and amorphous. Thus in mode of occurrence the hydrous silicates of later limestones do not differ from that in the Grenville Limestone.

January 3, 1896. WM. DAWSON.

ON THE TRUE MEANING OF THE TERM BOLDERIAN.

SIR,—Professor Dewalque, of Liége, in a letter you have lately published (1st December, 1895), criticizes the use I made of the term "Bolderien," established by Dumont, for some beds of the Belgian Tertiary formation. But this courteous censure seems to me without sound ground, and I think he has misunderstood Dumont's statements.

If we turn to the Journal of the Royal Academy of Brussels, for 1849, where Dumont created the term "Bolderian," we read: "The Bolderian system is divided into two stages; one is a marine stage in which the lower part consists of glauconiferous sands, and the upper part is composed of yellow sands, in these come, in order, the fossiliferous sands of the Bolderberg; the other stage is a fresh-water formation, consisting of sands and lignite, of which traces are found under the Campinian deposit."

There is no doubt about this, the type of the Bolderian system, in its lower part, is indicated as composed of marine fossiliferous sands found in the hill of Bolderberg, near Hasselt, and includes the fossiliferous bed so well known in that locality.

This opinion is repeated in various other publications; we can see in the explanation of the geological map of Belgium, published by Dumont, in 1892, the following lines: "Miocene=System Bolderian — gravels, glauconiferous sands, white sands, shelly gravels, and various other sands."

In Dumont's private notes, published not many years ago by M. M. Mourlon, we find the same version. Dumont says in his description of the Bolderberg Hill: "This gravel contains pebbles of flint from the size of a nut to the size of an egg, and a great many shells more or less well-preserved; they were living during the time of the deposition of the sand in which they are found."

We could multiply these quotations, but when Mr. Dewalque says that the Bolderian is a white unfossiliferous sand, he speaks of *his* Bolderian, but not of the original Bolderian of Dumont. On the other hand, the Bolderberg fauna is clearly Upper Miocene, we find that this fauna is extremely close to the fauna of Edeghem sands, near Antwerp, of which the malacological fauna has been described by Nyst, in 1861, as true Miocene. More than 90 per cent. of the species are common to the two localities, and we think there is good ground to say that the Bolderian was contemporaneous with the Anversian. The term Anversian was introduced into the science by Mr. Cogels, in 1879, to indicate the level of the Edeghem sand, or lower black sands of Antwerp.

We will give the names of some of the most typical shells found in the Bolderberg:—

Murex aquitanicus, Grat.	*Conus Dujardini*, Nyst.
Terebra Basteroti, Nyst.	*Voluta Bolli*, Kock.
Cancellaria cancellata, L.	*Ancillaria obsoleta*, Br.
,, *acutangularis*, Lk.	*Oliva Dufresnei*, Bast.
,, *imbricata*, Hoernes.	*Turbo muricatus*, Duj.
Dipsaccus Brugadinus, Grat.	*Natica Josephinia*, Risso.
Pleurotoma asperulata, Lk.	*Venus multilamella*, Lk.
,, *denticulata*, Bast.	*Cytherea chione*, Lk.
,, *ramosa*, Bast.	*Corbula carinata*, Duj.
,, *festiva*, Dod.	*Corbulomya complanata*, Sow.
Pectunculus pilosus, L.	*Ostrea crassissima*, Lk.

It will be at once clear to any geologist that the age of this fauna must be Miocene; it certainly cannot be Oligocene. This is a warm (southern) fauna, very distinct from the cold or temperate fauna of the Diestian deposits. The scruple of Mr. Dewalque is based on the fact that in the Bolderberg Hill, the fossiliferous bed (sometimes ferruginous) rests upon a thick mass of white sand, and is covered by a great mass of ferruginous sandstone pertaining to the Diestian formation, and Mr. Dewalque does not seem perfectly sure whether the fossiliferous bed pertains to the lower mass, or to the upper one. But we have seen that the old stratigraphists, such as Dumont, had classified the fossiliferous beds with the white sands; and since that time the best contemporary geologists, as Mr. Gosselet, have adopted the same conclusion, saying that the fossiliferous sands have nothing to do with the Diestian or upper beds.

More recently Mr. Van den Broeck discovered at Waenrode, near

Diest, in the Bolderian white sands, a fossiliferous bed not near to the top of the formation. Last summer the Belgian Geological Society made an excursion to those localities, with a view to observe again the exact position of the fossiliferous bed. The sections were exposed afresh, and all the geologists present, Mr. Lorié, from Utrecht, Mr. Lohest, pupil of Mr. Dewalque, Mr. Vincent, palæontologist, and many other distinguished Belgian geologists, also the writer of the present letter, came to the same conclusion, namely, that the fossiliferous bed is inclosed in the white sands, exactly as had been stated by Dumont many years ago.

When my honoured friend, Prof. Dewalque, says that in the eastern direction, near the valley of the Rhine, the white Bolderian sands contain Tongrian fossils, this is only an affirmation, but no evidence in favour of this statement has ever been produced. We should be very pleased to make the acquaintance of any geologist who has been so fortunate as to follow step by step the Bolderian sands from Hasselt to the Rhine!

The most recent observations seem to prove, on the contrary, that Dumont made in his Bolderian a great inversion; his Upper fluvio-marine stage is really the Lower one, and the marine shales are the Upper. The fluviatile Bolderian has been recognized in boring under Campine and Limbourg, and probably it is associated with the Rhenan lignites; it might take the name of Aquitanian. But this question is not yet perfectly solved. Last month Mr. Van den Broeck came to the conclusion that the Bolderian sands were very close to the Upper Rupelian sands, and that all these sands were united, by repeated alternation, with the Rupelian clay (*Argile de Boom*) and by no means form a good horizon. But even if the fluviatile Bolderian is not valid and is a bad subdivision, containing sands which can be better classified in three or more different stages, it remains always a good marine Bolderian, a sound type well characterized by its palæontology, and indicated by its stratigraphy. We think that we can, without any hesitation, maintain the old name of "Bolderian" in its true, original acceptation.

G. F. Dollfus, F.C.G.S.
Président de la Société Géologique de France.

Paris, 10 *Janvier*, 1896.

OBITUARY.

HUGH MILLER, F.R.S.E., F.G.S.

Born July 15th 1850. Died January 8th, 1896.

It is with great regret that we record the death of Mr. Hugh Miller, F.R.S.E., F.G.S., of the Geological Survey of Scotland. Bearing the same name as his distinguished father, the author of "The Testimony of the Rocks," "The Old Red Sandstone," etc. Mr. Hugh Miller inherited a taste for geological pursuits, and joined the Geological Survey in 1874. Labouring at first among the Carboniferous Rocks and Glacial Drifts of Northumberland, he was subsequently transferred to the Geological Survey of Scotland, and worked at the Old Red Sandstone around Cromarty, rendered classic by the researches of his father. Later on he mapped portions of the Ancient Schists, Old Red Sandstone, and Drifts of Eastern Sutherlandshire. He was author of the picturesquely-written book entitled "Landscape Geology," and of papers on River Action and Glacial Phenomena. Among the more important of these papers the following may be mentioned:—"Tynedale Escarpments: their Pre-glacial, Glacial, and Post-glacial Features," 1880; "River Terracing: its methods and their results," 1884; and "On Boulder-Glaciation," 1884." All who enjoyed Mr. Miller's friendship will feel that they have lost a kind-hearted, though keenly sensitive, friend. Strongly imbued with a love of Nature and natural phenomena, he at the same time kept himself in touch with the intellectual life of our time. He leaves a widow and a son, fifteen years of age, who is being educated at Fettes College.

PROFESSOR LUDWIG RÜTIMEYER, M.D.

Foreign Member of the Geological Society of London.

BORN 1825. DIED NOVEMBER 26TH, 1895.

HERR PROFESSOR DR. LUDWIG RÜTIMEYER was born at Biglen in the Commenthal, Canton Bern, in 1825. His father was a parish clergyman, and afterwards Superintendent of the Orphanage at Bonn. Ludwig was educated in the High School and Gymnasium of that town, and in 1842 went to the University of Berne, where he studied theology, with the intention of following his father's profession. Having developed a taste for comparative anatomy, no doubt partly through the influence of his friend Peter Merian, the Basel Palæontologist, he forsook his theological studies, and took up medicine. Afterwards he visited many of the chief European cities, and in Paris in 1850 he became acquainted with Elie de Beaumont, and in 1852 he came to London, which he again visited in 1877, In 1854 he took up academical teaching in the Berne University, and in the following year accepted the newly established Chair of Zoology and Comparative Anatomy at Basel, where he remained till his death.

His first work, "Vom Meere bis nach den Alpen," was published on his return from his travels in 1854; after this he issued a long series of Memoirs, characterized by the great accuracy and detail of their observations, and the wide philosophical grasp and far-reaching deductions made from them.

Some of the more important of these memoirs are:—"Untersuchungen der Thierreste aus dem Pfahlbauten in der Schweiz," 1860, in which he gives an account of the earlier races of some of the domestic animals, and shows that while in the Lake-dwellings of Stone Age the remains of wild animals predominate, showing that the inhabitants lived mainly by the chase, in the later settlements, made after the use of metal was discovered, the inhabitants relied chiefly on various domesticated animals for food.

Another important paper is "Beitrage zur Kentnisse der Fossilen Pferde und zu einer Vergleichenden Odontographie der Hufthiere in Allgemeinen," 1863; this may be regarded as laying the foundation of that detailed comparative morphology of the teeth, in which the homologies of the several cusps is considered, and from which the American palæontologists have been able to draw very important conclusions as to the phylogeny of many groups of mammals.

In a paper entiled "Ueber die Herkunft unserer Thierwelt eine Zoogeographisch Skizze," 1867, Rütimeyer gives a masterly account of the distribution of the mammalia, showing the relations of the fossil faunas to one another and to the recent forms. It is a testimony to his sagacity that the great additions to our knowledge of this subject have confirmed most of his conclusions, and have rendered very few untenable.

He was elected a Foreign Member of the Geological Society of London in 1882.

Up to the time of his death Prof. Rütimeyer maintained a lively interest in all scientific researches, and carried on his correspondence to the last. He died at Basel on 26th November, 1895.

E. A. WÜNSCH, F.G.S.

BORN 1822. DIED NOVEMBER 19TH, 1895.

THIS gentleman was one of the original members of the Glasgow Geological Society, which was founded in 1858, and he has served the office of Vice-President several times from 1858 to 1881, when he left Glasgow to reside at Carharrack, Scorrier, Cornwall, where he died November 19th, aged 73 years.

The most important service which he rendered to geological science was his discovery in 1865 of *erect trees buried in volcanic ash at Arran.* These trees were discovered in the Lower Carboniferous strata of the north-eastern part of Arran in the sea-cliff, about five miles north of Corrie, near the village of Laggan. Here strata of volcanic ash occur, forming a solid rock cemented by carbonate of lime and enveloping trunks of trees, determined by Mr. Binney to belong to the genera *Sigillaria* and *Lepidodendron.* Sir Charles Lyell mentions that he visited the spot in company with Mr. Wünsch in 1870, and saw that the trees with their roots, of which about fourteen had been observed, occur at two distinct levels in volcanic tuffs, parallel to each other, and inclined at an angle of about 40°, having between them beds of shale and coaly matter seven feet thick. It is evident that the trees were overwhelmed by a shower of ashes from some neighbouring volcanic vent, as Pompeii was buried by matter ejected from Vesuvius. The trunks, several of them from three to five feet in circumference, remained with their stigmarian roots spreading through the stratum below, which had served as a soil. The trees must have continued for years in an upright position after they were killed by the shower of volcanic ash, giving time for a partial decay of the interior, so as to afford hollow cylinders into which the spores of plants were wafted. These spores germinated and grew, until finally their stems were petrified by carbonate of lime, like some of the remaining portions of the wood of the original *Sigillaria* tree-trunks.—"Lyell's Students Elements," 4th edition, 1885, pp. 496, 497.

The Hon. Walter B. D. Mantell, F.G.S.—We regret to record the loss of this excellent naturalist and geologist, who died at Wellington, New Zealand, September 7th, 1895, in his 75th year. He was the eldest son of the well-known geologist, Dr. G. A. Mantell, F.R.S., and settled in New Zealand in 1840, where he was for years a member of the Colonial Government. We hope to give a fuller notice of his work later on.

MISCELLANEOUS.

Search for Coal in East Anglia.—The Eastern Counties Coal Boring Association has abandoned the hope of finding coal at Stutton on the Stour, where the bore has been carried down 1,525 feet. The consulting geologists and the mining engineer expert are agreed that the rocks reached are evidently older than the Coal-measures. The next trial bore is likely to be made either some ten miles to the north, about Bramford, in Suffolk, or the same distance to the south, near Bentley or Weeley, in Essex. At present the latter site seems to be most in favour.—*St. James Gazette*, November 28th, 1895.

Geology of the San Francisco Peninsula. — Observations made by Mr. A. C. Lawson on the geology of the San Francisco Peninsula show the presence of seven groups of rocks or "terranes." (1) Crystalline limestone, of unknown age; (2) Granite, referred to as the Montara granite, which is intrusive in the crystalline rock, is perhaps of post-Jurassic age, and is spoken of as "a great batholite, which has invaded the crust from below"; (3) The Franciscan series, probably of Cretaceous age, in which there are not only grits, conglomerates, shales, great beds of sandstone, and some volcanic rocks, but also foraminiferal limestones, and peculiarly-bedded Radiolarian cherts; (4) Sandstone of Eocene age; (5) Monterey series (Miocene); (6) Merced series (Pliocene); and (7) Terrace formations (Pleistocene and later). The Radiolarian cherts of the Franciscan series are hard, flinty, siliceous rocks, of varied colour, and they occur in thin sheets (two to four inches thick) with partings of shale; but they are not of great extent. The beds are, in places, several hundred feet thick, and they are interbedded with sandstones. In many cases the cherts are true jaspers, and sometimes they pass into a quartz-rock resembling vein-quartz. The Radiolaria appear as minute dots quite distinct from the matrix. The suggestion that these cherts are deep-sea deposits is negatived by their interbedding with sandstones. Nor can they be considered as mainly organic. The silica of the cherts seems to have been originally an amorphous chemical precipitate, deposited at local centres on the sea-bottom, in which Radiolarian remains were sporadically entombed. The most probable origin of the bulk of the silica is considered by Mr. Lawson to have been sub-marine siliceous springs of solfataric character. (*American Geologist*, June, 1895.)

Western Australia.—Mr. Harry Page Woodward, J.P., F.G.S., F.R.G.S., F.I.Inst., Assoc. Memb. N. of Engl. Inst. Mining and Mech. Eng., formerly Assistant Government Geologist, South Australia, and who for the past eight years has filled the important post of Government Geologist for Western Australia, has resigned the Government Service and joined the staff of Messrs. Bewick, Moreing, and Company, Mining Engineers, of London and Western Australia. Mr. Woodward's services will be available for reporting and advising on all Western Australian properties through Messrs. Bewick, Moreing, and Co.—"Mining World and Engineering Record," January 11th, 1896, p. 57. "The British Australasian and New Zealand Mail" of January 9th, writes as follows:—"When I was in Western Australia in 1891, I had the pleasure of seeing a good deal of Mr. Woodward, and a more efficient public official I never met with. Apart from his professional qualifications he is a man of fine physique, inured to fatigue, and of most agreeable manners. Nobody understands the Colony geologically and otherwise better than he does, and there can hardly be an acre of the settled districts which he has not inspected. The worst of it is Governments cannot, or will not, pay efficient officers at the same rate which private firms are able, and indeed compelled, to offer for first-class services, and as a natural result the tendency is to rob the Civil Service of its brightest ornaments. However, the services of Mr. Woodward will not be lost to the Colony, and their value may be even increased now that with his great abilities he has a free hand. I heartily congratulate Messrs. Bewick, Moreing, and Co. on their latest acquisition."

New Geological Survey Map.—The Geological Survey has just issued, for the first time, a map *printed in colours.* This is Sheet 12 of the four-mile to one inch map of England and Wales. It includes the London Basin and great part of the Wealden area. As previously published, coloured by hand, the price of this sheet was 10*s.* 6*d.* The price is now 2*s.* 6*d.* This will in itself be an advantage to purchasers; and moreover there is another advantage, and it is that colour-printed maps, when carefully prepared, are accurate and uniform; whereas in hand-coloured maps uniformity in colouring cannot be rigidly maintained, and the colourist may, at times, omit to colour certain outliers and inliers. We understand that Her Majesty's Stationery Office has issued this new map as an experiment, and that if successful the companion sheets of this useful map of England and Wales, will likewise be printed in colours, with a corresponding reduction in price. We should like to see the system of colour-printing adopted with regard to the new series of one-inch maps now in course of publication by the Geological Survey, for the system is almost universally adopted abroad, and with success.

THE MERJELEN LAKE AND THE ALETSCH GLACIER.

THE

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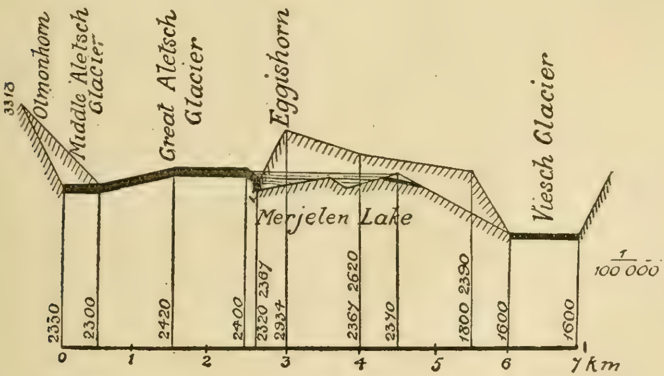
ORIGINAL ARTICLES.

I.—The Merjelen Lake (Aletsch Glacier).

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.C.S.

(PLATE VI.)

THE Merjelen or Maerjalen Lake, situated at an altitude of 2367 metres (7750 ft.) above sea-level at the western flank of the Great Aletsch glacier, belongs to the class of glacier lakes which are found in depressions or valleys barred by glaciers whose direction of flow is more or less at right angles to the same. Like the majority of glacier lakes, it has the shape of an irregular triangle, the length being about 1·5 kilometre (nearly a mile), its greatest



width 0·5 kilometre (550 yards), and its mean depth 28 metres (92 ft.). Hence its superficial area amounts to 375,000 square metres (438,000 square yards), and its volume at high-water level to about 10 million cubic metres or tons.

As is shown in the section reduced by the writer from the Swiss Contour Map, the lake is shut in by the Eggishorn to the south and by Strahlhorn to the north, while at its western or broader end it is barred by an ice-wall 500 metres (550 yards) in length and about 50 metres (164 ft.)[1] in depth, formed by the Aletsch glacier. The cross valley or depression in the gneiss formation between the Aletsch and Viesch glaciers was, in times of more extensive glaciation, evidently filled by an offshoot of the former glacier into the Viesch valley, although the fine mud which covers the bottom of the lake is not, as has been averred, old moraine,[2] but simply deposit of the particles held in suspension by the lake. Under the glacial conditions of the present day, the Aletsch glacier is unable to invade and fill the lake basin, the more so as the lake is, in addition to glacier water, fed by spring water, and notably from a small tarn on the Merjelen Alp about 760 ft. above the lake-level, so that the water in the lake is kept in motion, and permanent congelation is thus prevented. Indeed, the melting power of the lake water is evidenced by the fact that, although the surface of the Aletsch glacier slopes gently into the lake, the slope is, below the water's edge, undermined and melted down to a vertical wall or cliff. The glacier thus acts as a retaining wall to the lake, while the latter retains, that is, prevents the intrusion of, the glacier.

The natural outlet of the lake is to the west, through the Aletsch glacier; but when the lake exceeds a certain level, it has at its eastern or narrow end an additional outflow to the Viesch glacier, over a low divide or saddle which, at ordinary level, separates it from the drainage area of that glacier. The lake thus possesses the peculiar feature of having two outlets in opposite directions.

In addition to its contiguity to the Aletsch glacier, and to the intensely, almost unique, greenish-blue colour of its water,[3] the Merjelen lake possesses, as is well known, the further peculiarity, not only of sudden fluctuations of level, but of emptying itself at irregular intervals, and sometimes within the space of eight or twelve hours, through a temporary passage in the glacier wall, the phenomenon being on certain occasions accompanied by a great noise, which is sometimes heard at a distance of no less than six miles, and is produced partly by the overhanging roof of the glacier falling in and partly by the rush of water through the glacier.

This remarkable Alpine phenomenon recurred during the night from Monday to Tuesday, 23rd to 24th September last. Already, in the autumn of 1894, a partial emptying had taken place, the lake being then reduced to about one-third of its volume at high water. As is usual in the case of partial emptying, there remained two lakelets or tarns—an upper, smaller and shallow one, and a lower, larger one, deepening rapidly towards the glacier end, the two basins being divided by a path which leads to Concordiahütte and is submerged when the lake is at high level. During the hot and dry summer of 1895 the lower basin rose again; at the end of August

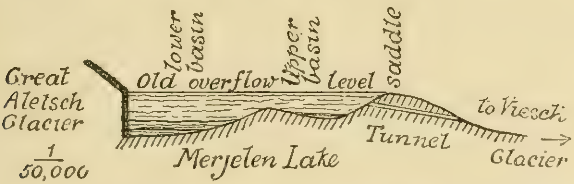
[1] The exact depth deduced from the Swiss Contour Map is 47 metres (154 ft.), while that measured by Prof. Ramsay in 1858 was 157 ft.

[2] Ph. Gosset, Jahrbuch S.A.C. 1887–8.

[3] This colour appears to correspond approximately to shade v of Prof. F. A. Forel's scale of eleven shades of lake waters.—F. A. Forel, "Le Léman," vol. ii, p. 464. Lausanne, 1895.

the two basins were again united; and by the 20th of September the lake had risen further 2·5 metres (8 feet), when along the glacier wall there appeared a distinctly marked water-line, which afforded unmistakable proof that the lake-level was again beginning to drop. On that day it fell 10 centim. (4 inches); on September 21st, 30 centim. (12 inches); on the 22nd the fall was 2 metres (6·6 feet); on the 23rd the total fall reached 6 metres (20 feet); and during the night the lake emptied itself so completely that on the following morning the glacier wall was exposed to view to its full depth of about 50 metres (165 feet), and exhibited a large number of ice-caves and perpendicular fluted fissures, while the bottom of the lake was strewed with blocks of ice which, as is characteristic of the Merjelen lake, had been floating on its surface, or had recently fallen, and were still falling, from the undermined, and therefore overhanging, roof of the glacier projecting into the lake. The spectacle of the stranded and still falling masses of ice, but more especially that of the ice-cliff exposed in all its freshness, is one of exceeding grandeur, although this freshness completely disappears after a few days owing to the action of the air.

On comparing this occurrence with the one of July 19th, 1878—the only one of which detailed record exists[1]—the writer finds that on the latter occasion the lake-level began to drop in the morning of July 18th, the drop being only one metre (about three feet) during



that day, further 3 metres (10 feet) during the night, and 40 metres (130 feet), or practically to the bottom, during the day of the 19th July. On both occasions, the phenomenon, therefore, occurred under very similar conditions, the only difference being that in 1878 the initial drop took about twenty-four, and in 1895 about 48 hours, whilst the time within which the lake emptied itself did, in both cases, not exceed twelve hours. The bulk of the water thus abstracted from the lake, after finding its way through fissures in the glacier, discharges by the Aletsch glacier stream called the Massa torrent, into the Rhone near Naters, about 2·5 kilometres (1·5 mile) above Brieg. The occurrence of 1878 caused the Rhone at Brieg to rise about 1·5 metre (5 feet) above its, then fortunately, low level.

[1] A short notice of this occurrence is given by F. v. Salis in the Jahrbuch of the Swiss Alpine Club, 1878 to 1879. Prof. T. G. Bonney ("Nature," 1867, xxxvi, p. 612) in August, 1858, also saw the lake full one day and empty the next, the emptying having taken place during the night. On the other hand, in 1890, according to Prince Ronald Bonaparte, the emptying of the lake did not take place till five days after the initial fall ("Archives de Genive," xxiv, 1890, p. 401).

The emptying of the Merjelen lake recurs at irregular, and not at all, as is popularly assumed, at regular intervals.[1] It has been explained by the existence of a tunnel in the glacier,[2] which is supposed to widen, narrow, or close entirely, according as the glacier shifts its position, the total emptying, the partial emptying, or the rise to overflow level of the lake being the result. But this explanation is far from satisfactory. During a period of growth of the glacier, the supposed tunnel would move downward at the rate of about 50 metres per annum, or half a foot per day (viz. at about half the speed of the glacier at its axis); hence, in ten years it would travel the whole length of the bar of 500 metres, and the supposed tunnel would then become inoperative so far as the lake is concerned.

The theory of this mysterious tunnel, whose connection with the stream flowing at the bottom of the glacier has, moreover, never been explained, may therefore be discarded; and, in my view, the phenomenon of the lake rising to its maximum level is due essentially to meteorological causes, while the emptying is produced by mechanical agency. In other terms, the rise to the maximum level is due to the rate of ablation or melting of the ice at the glacier wall being, at certain periods, *e.g.* during a hot and dry summer or during the prevalence of hot southerly winds (Foehn), largely in excess of the ordinary outflow through small fissures in the glacier wall; while the emptying of the lake in the space of ten or twelve hours is due to the largely increased pressure of the volume of water against the glacier wall,[3] whose porous condition, produced by the process of ablation, facilitates the formation of large fissures, through which the efflux of the water takes place. The fact of the level of the lake at first falling comparatively slowly, say about six feet in twelve hours, and then rapidly, or about 160 feet in the same period, is easily explained by the gradual yielding of the ice to the pressure of the water, until the rent or orifice enlarges and the rate of efflux is thereby accelerated.

The drainage area of the lake is about 3 square kilometres, or 1·15 square mile, which, at an annual rainfall of 3 metres (10 feet), and allowing 45 per cent. for absorption and evaporation, yields about 5 million cubic metres or tons per annum. The lake may therefore be said to contain its normal volume when it is about half full. To keep it at this normal level, the requisite outflow is only 0·04 cubic metre, or 1·4 cubic foot, per second, and this, at a mean head of

[1] The lake is said to have emptied itself formerly every seven years, latterly every three years.

[2] Ph. Gosset, Jahrbuch S.A.C. 1887 and 1888, p. 350.

[3] The pressure of a head of water of 50 metres (164 feet) is equal to five atmospheres or 73 lbs. per square inch; and the pressure of the whole volume of the lake on the porous glacier wall is no less than $\frac{10,000,000}{500 \times 50} = 400$ tons per square metre, or 37 tons per square foot, viz. five times the pressure allowed for the walls of large reservoirs.

water of 14 metres (46 feet), requires an orifice of only 23 square centimetres,[1] or 3·6 square inches, so that a very small fissure in the ice-wall suffices for the ordinary drainage of the lake through the glacier. When the lake, swelled by water derived from the glacier, reaches its maximum level (viz. contains 10 million cubic metres or tons, or double its normal volume), and then empties itself, the discharge of about 1 million cubic metres during the first twelve hours corresponds to 23 cubic metres (805 cubic feet) per second, or, at a mean head of 25 metres (82 feet), to an orifice of 1 square metre (10·7 square feet); and the discharge of 9 million cubic metres in the following twelve hours corresponds to nine times as much—that is, to 208 cubic metres per second, and to an orifice of 9 square metres, or about 100 square feet. The outflow of about 200 cubic metres per second is larger than the average volume of the Rhone at its inflow into the lake of Geneva (150 cubic metres per second); but the pressure, and hence the velocity, of the discharge from the Merjelen lake is, of course, so much greater, that a much smaller sectional area is required. It is thus seen that the fissures or rents through which the lake empties itself are by no means of extraordinary dimensions. The whole process is, in fact, precisely like that of an ordinary reservoir discharging its contents through a rent gradually formed and widening in a saturated dam; in both cases, the discharge takes place at the point of least resistance.

There are no exact data to show how much time the lake requires to refill to its normal level (about half full); but it is evident that this operation is performed very gradually, and chiefly in winter and early spring, when, owing to the stoppage of ablation, the glacier wall becomes again compact, and the lake is fed by increased precipitation in its drainage area. The greater frequency of the partial or complete emptying of the lake within the last twenty years coincides with the ascertained general recession or shrinkage of the Great Aletsch glacier since 1873[2]; and there is, possibly, a relation between the two phenomena, since both are, in the main, the effects of meteorological causes.

Owing to the conflict of evidence, it is extremely difficult to obtain authentic information respecting the partial or complete emptying of the lake and the exact dates of the phenomenon. This much, however, is certain, that a partial emptying produced by the forcing of a passage at a point above the base of the glacier wall is of much more frequent occurrence than a total discharge of the lower basin. Even in the latter case a pool always remains in the upper or shallow basin. Moreover, the mere fact of the lake having

[1] The sectional area is given by the volume divided by the velocity, and the velocity is given by $\sqrt{2gh}$, g being the acceleration due to gravity = 10 (metric), and h the mean head of water.

[2] Like the majority of Alpine glaciers, the Aletsch glacier increased during the first half of this century; its decrease began about 1860, and has become more marked since 1873. In 1893 it receded five metres or seventeen feet, according to Prof. F. A. Forel's "Variations Périodiques des Glaciers des Alpes" for that year.

been seen empty at any time, is *per se* of no value unless it is also shown that it was seen full the day or a few days before; otherwise it may, according to the season, have been empty for months. The following are the years (since 1870) in which the phenomenon has been recorded,[1] the total emptyings in eight to twelve years being marked with an asterisk, while the cases of the lake being seen about half full are omitted, because this, as already shown, is its normal condition. It will be observed that the phenomenon occurs always between June and September, an additional proof that it is essentially due to meteorological causes:—1871. August, 1872. 1873.* July, 1878.* June, 1882. August, 1884. August, 1885. September, 1887.* June, 1889. July, 1890.* July, 1892. September, 1894. September, 1895.*

Until recently, when the lake exceeded its ordinary maximum level before it had forced a passage through the Aletsch glacier, an overflow took place over the low saddle to the east towards the Viesch glacier, about 770 metres or 2540 feet below the level of the lake. In both cases the sudden rise either of the Aletsch or of the Viesch torrent occasionally flooded part of the Rhone valley above Brieg;[2] and it is with the view of eliminating this danger that the outlet of the lake to the Viesch valley has recently been artificially lowered about 7 metres, or 23 feet, by a tunnel driven through the low divide, about 700 yards in length and two square metres (21·4 square feet) in section, which is intended to drain and discharge on the Viesch glacier the overflow as soon as the lake rises about three metres (ten feet) above the level at which the lower and upper basins unite. The overflow of which the lake will thus be relieved is about three million cubic metres, equal to about one-third of its volume at maximum level.

It is, however, evident that although this artificial drain will greatly mitigate, if not altogether prevent, the contingency of damage, a discharge through the Aletsch glacier will always be liable to occur whenever the ice-wall has become sufficiently porous or undermined to yield to the pressure of the water.[3] Thus, while rendered practically harmless, the Merjelen lake will still retain the special feature which makes it unique among the glacier lakes of the Alps.

[1] The data up to 1890 are derived from the lists given by M. Ph. Gosset and by Prof. F. A. Forel (Jahrbuch Swiss Alpine Club, 1887 to 1890, p. 356, and 1890 to 1891, p. 358); those up to 1895 are collected by myself.

[2] Formerly, the cowherd who first arrived in the Rhone valley with the news of the lake having emptied itself (the distance from the lake to Brieg being about nine miles) was rewarded with a pair of new shoes.

[3] This actually happened on the 23rd September last, when the lake had risen to within 50 centimetres (1·6 foot) of the floor of the overflow tunnel, and then, as if to show its contempt for this work of man's hand, emptied itself again through its natural channel, the Aletsch glacier. The committee of inspection which was on its way from Brieg, expecting to see the overflow tunnel in operation, arrived on the 24th September only to find the lake empty.

SCENE OF THE ICE-AVALANCHE, ALTELS GLACIER, GEMMI PASS, BERNESE OBERLAND, SWITZERLAND.

[*To illustrate Dr. Preller's paper*, GEOL. MAG. 1896, *p.* 103.]

The dotted line indicates the area of the Ice detached from the Glacier.

II.—The Ice-Avalanche on the Gemmi Pass (Switzerland).

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.C.S.

It is a noteworthy fact that, although Alpine glaciers have, during the last few years, not shown any very marked oscillations,[1] the Central Alps have, since the year 1892, been annually visited by a disaster caused, directly or indirectly, by the bursting or falling of a glacier. Thus, in 1892, the Tête Rousse glacier of the Mont Blanc group swept away the Baths of St. Gervais; in 1893, the village of Taesch, between Viess and Zermatt, was devastated by the torrent of the Weingarten glacier, not far from the village of Randa, which

Fig. 1.

was destroyed by a glacier avalanche in the year 1819; again, in 1894, the torrent of the Crête glacier (Grand Combin group, Rhone valley) suddenly poured its flood into the river Dranse, and thereby endangered the town of Martigny; while last year the record was swelled by the avalanche of the Altels glacier on the north side of the Gemmi Pass, in the Bernese Oberland.

The scene of this last catastrophe is at an altitude of about 1950 m. (6400 ft.) above sea-level, nearly midway between Kanderstag and the summit of the Gemmi Pass, familiar to tourists crossing the

[1] Official measurements made in 1893, after a dry and hot summer, showed that out of 28 glaciers in Canton Valais (Rhone valley), 14 had receded 3 to 28 metres, 3 had remained stationary, 10 had advanced 2 to 30 metres, and only one (Zigior glacier, Mont Collon group) had advanced 100 metres, or about 1 ft. per day.

Aare and Rhone divide by the Kander valley and the Baths of Louèche.

As is seen from the plan, Fig. 1, three glaciers descend from the summit of Altels, 3636 m. (11,926 ft.) above sea-level—one in a northerly, another in a south-westerly, and a third, the middle one, in a north-westerly direction. It is this last, a so-called suspended or overhanging glacier, which, about 5 a.m. on the 11th of September, detached itself from the upper end at an altitude of 3300 m. (10,823 ft.), or about 1000 ft. below the summit, swept down a declivity 1400 metres in vertical depth, was thrown up 400 m. (1300 ft.) to the summit level of the precipitous mountain ridge on the opposite side of the valley, and thence rebounding, fell on, and spread in fan-shape over a rich and extensive pasture

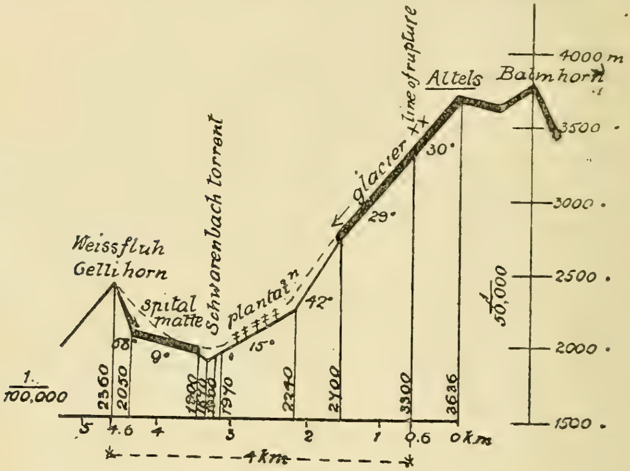


Fig. 2.

known as the Spitalmatte, which is now buried under ice and rock débris over an area of two square kilometres (nearly one square mile) to an average depth of two metres or 6·6 ft. The disaster involves, besides the ruin of the valuable Alpine pasture and the destruction of several châlets, the loss of six lives and upwards of 150 head of cattle.

The cross-section of the valley (Fig. 2) prepared by the writer from the Swiss Ordnance Contour Map, 1 in 50,000, shows the course of the avalanche, the entire distance covered by the latter, including the rebound, being about five kilometres or three miles. As is seen from the same section, the angle of inclination of the glacier itself was about 30 degrees, that of the declivity immediately below it is 42 degrees, while the upward slope of the Spitalmatte is 9 degrees, and the inclination of the Weissfluh and Gellihorn ridge is no less than 58 degrees. The line of rupture of the glacier below the summit of Altels is distinctly visible in the shape of an ice-wall about 40 m. (130 ft.) in depth, having the form of a concave curve, while the opposite mountain ridge bears, up to its crest-line, numerous traces of the avalanche having been dashed against it and hurled up to its summit level.

The remarkable features of this ice-avalanche, and the conclusions which I have drawn from them, may be summed up as follows :—

1. The rupture of the glacier appears to have been produced by two separate cross-rents, which, during the hot and dry summer, extended and finally joined. The altered condition and appearance of the glacier was noticed from a distance the day before the ice-avalanche. The lower part of the glacier was probably set in motion by the unusually rapid melting of the ice due to the hot southerly wind (Foehn) which blew during the night. The disaster was thus produced essentially by meteorological causes.

2. In its descent from Altels, the avalanche crashed through, and carried bodily along with it, an extensive plantation, a fact which shows once more, if proof were wanted, that forest plantations are no effectual protection against avalanches.

3. The avalanche, in its descent, completely cleared the Schwartsbach torrent, which shows that it moved practically as a solid mass. Moreover, in its rebound from the opposite mountain ridge, and in its fall on the Spitalmatte, it buried the Gemmi bridle-path, but stopped short of the torrent, thereby fortunately preventing the formation of a temporary lake which would have endangered the Kander valley below.

4. The prodigious velocity of the avalanche and the pressure of the column of air displaced by, and pushed in front of it, are attested by a distinct blast-zone of débris, such as the remains of châlets, human bodies, cattle, etc., blown to a considerable height and distance.

5. The volume of the detached glacier and rock débris, about 100,000 square metres and 40 metres in average depth, is about four million cubic metres or tons, which estimate agrees pretty accurately with the volume of débris deposited on the Spitalmatte, viz. about two square kilometres to a depth of two metres. If we consider the avalanche as a moving mass possessing momentum, its kinetic energy is given by the formula—

$$\tfrac{1}{2}\, m\, v^2, \text{ in which } v^2 = 2\, g\, h\,; \text{ or } v = \sqrt{2\, g\, h}\,; \text{ and } m = \frac{\text{weight}}{10}$$

The mean depth of fall (h), measured vertically, being 3000—1900 m. =1100 m., the kinetic energy was 4400 million metre-tons. Assuming that half of this energy was expended in overcoming the various resistances in the descent, the remainder was still more than ample to raise the mass to a height of 400 metres on the other side of the valley.

6. The velocity of the fall, measured vertically, and without taking into account the various retarding resistances, works out 148 m. (485 ft.) per second, and that of the rise 90 m. (295 ft.) per second. Hence the avalanche, in falling, covered a distance of three kilometres (on an incline of 42 deg., or about 1 in 1) in 20 seconds ; in rising, a distance of one kilometre in 10 seconds ; and in rebounding, also

one kilometre in 10 seconds: total about 40 seconds. If to this we add 50 per cent. for the various retarding resistances, the estimated time within which the ice-avalanche did its work of destruction is not more than one minute.

It is a singular coincidence that a similar ice-avalanche occurred at the same spot over 100 years ago, on the 18th August, 1782. As in the year 1895, so also in the year 1782, great heat prevailed in the months of June, July, and August, and the rupture of the glacier was therefore in both cases due essentially to meteorological causes.[1] The present disaster falls short of the rock-fall of Elm (in the Glarus Alps) which occurred in 1881 on the same day, the 11th September, and caused the loss of 114 lives and 79 buildings, the volume of the débris being about double that of the Altels ice-avalanche. It also falls short of the ice-avalanche which destroyed the village of Randa in the Visp valley in the year 1819, the volume of glacier débris being in that case nearly four times that of the Altels avalanche. Still, the magnitude of the latter, and the scale on which Nature works in the Alps, may be gathered from the fact that the detached glacier swept down a declivity whose vertical height is thirteen times that of St. Paul's Cathedral (365 feet); that it was then hurled up to a height four times the elevation of that building; and that the volume of its débris under which the Alpine pasture is now buried, would suffice to cover to a depth of three feet the combined area (about 1000 acres) of Regent's Park, Hyde Park, and Kensington Gardens.

III.—On the Physical Conditions under which the Old Red Sandstone of Scotland was Deposited.

By Peter Macnair and James Reid.

I. Introduction.

The physical conditions under which the Old Red Sandstone of Scotland was formed is a subject that has long occupied the attention of many of our leading geologists, from the time of Hugh Miller and Sir Roderick Murchison down to those of the present day. It has been variously regarded as of fresh-water and marine origin, as having been thrown down in lakes and in the open sea, or in inlets of the latter. But as yet the whole matter seems to remain an open question, which the unique physical and palæontological elements of the formation make difficult of solution.

This contribution to the controversy does not attempt to untie the Gordian knot, but is simply to show that much of the evidence freely assumed to be in favour of a fresh-water and lake origin for these deposits may or may not admit of proof, while on the other

[1] The precise date of the avalanche of 1782 is fixed by a public document, which was discovered through the efforts of Prof. Forel, of Morges, in the archives of Louèche, and enumerates the loss of life and property sustained on that occasion: "per terribilem et stupendam de summitate montis prolapsam glaciei quantitatem." On that occasion four men, who were crossing the Spitalmatte on their way home, and ninety cattle, were killed.

hand the evidence which is in favour of its entire extension over Scotland, and of its marine origin, has either been entirely overlooked or so minimized as not to be taken at its real value.

The first discoverers and workers amongst these rocks, Hugh Miller and Sir Roderick Murchison, firmly believed in its marine origin, and though Hugh Miller was not so much of a stratigrapher as a palæontologist, yet he clearly realized the fact that the Old Red Sandstone must have at one time covered the whole of the Scottish Highlands, as in his "Old Red Sandstone"[1] he speaks of a sea that extended from Ben Lomond to the maiden paps of Caithness. Sir Roderick Murchison, on the other hand, entered into a detailed study of its stratigraphical and physical structure and relationship, and it is mainly to his views we are persuaded the students of the Old Red Sandstone rocks of Scotland must finally return.

Stratigraphically, Murchison divided the Old Red Sandstone rocks of Scotland into three members—the upper, the middle, and the lower, each characterized by a distinctive fauna:—the lower group, as seen in Scotland, being principally developed in Forfarshire and Perthshire, and characterized by *Cephalaspis* and *Pterygotus*; the middle group, seen in Caithness, and containing *Dipterus*, *Osteolepis*, etc.; while the third or upper group, well developed in Dura Den, and containing *Holoptychius* and other characteristic forms, passes up conformably into the basement beds of the Carboniferous formation, there being always a decided break between the upper member and all the older rocks. He also correlated the Scottish Old Red Sandstone with its deep-water equivalent, the Devonian of England and Russia, pointing out that in the latter country the Devonian rocks containing marine shells were also interstratified with red sandstones, in which no shells were found, but which were replete with the piscine fauna common to the Scottish rocks.

Latterly, however, and principally through the work of Godwin-Austen, Ramsay, and more particularly Sir Archibald Geikie,[2] the Old Red Sandstone of Scotland came to be looked upon as a fresh-water deposit accumulated in isolated basins. The researches of the two first writers were principally directed to the petrological characters of the rocks. The latter was the first to isolate the Scottish areas of Old Red Sandstone into separate basins of deposit, with the distinctive names Lake Orcadie, Lake Caledonia, Lake Lorne, and Lake Cheviot. He believes they were all contemporaneous, doing away with the existence of the Caithness rocks as a middle group, and explaining the discrepancy of their fossil contents on the grounds that they are no greater than those of contiguous fresh-water basins at the present day. In his "Scenery of Scotland" he also presents some of the physical problems connected with the Old Red Sandstone; consequently it is mainly to the statements of Sir Archibald Geikie we now propose to revert, as being the principal authority for the isolated lake and fresh-water origin of

[1] "Old Red Sandstone," 7th edition, p. 53.

[2] See "The Old Red Sandstone of Western Europe"—Trans. Roy. Soc. of Edinburgh, vol. xxviii; and "Text Book of Geology."

these deposits. We propose to discuss the various points in the following order: first, the early Palæozoic mountain chain, in which we will give a resumé of what is known of that old continent upon which the later Palæozoic rocks were deposited as a nucleus; second, we will consider the general, physical, and stratigraphical evidence in favour of the marine and continuously ascending order of these deposits in Scotland through a lower, middle, and upper series. Under the division of the petrological consideration we will discuss those questions relating to the conditions under which these rocks were deposited, the almost universal presence of peroxide of iron in the rocks and their consequent barrenness of molluscan remains, and finally the palæontological evidence in favour of a marine origin for the organisms found in these deposits. We also in the course of the paper propose to show the "Character of the Strata" is entirely against its supposed deposition in small inland fresh-water lakes; that the absence of unequivocally marine fossils is not so complete as supposed, neither is it fatal to their marine origin; that land plants occur freely in undoubted marine strata; and that the existence of the representatives of ganoid fishes in the rivers and lakes of the present day is entirely out of evidence when we consider the immense number of these fossil fishes found in undoubted marine deposits both in England and Russia, and of their wide distribution over the continents of Europe and America.

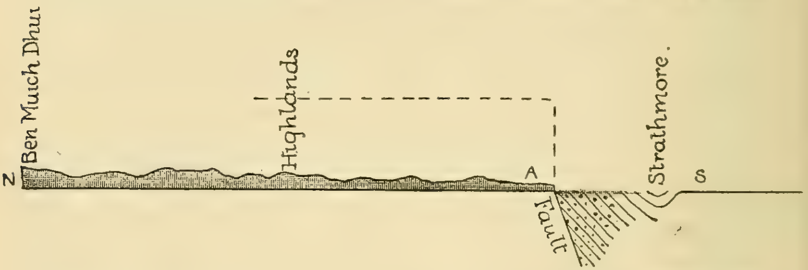
II. The Early Palæozoic Mountain Chain.

Before passing on to discuss the physical, petrological, and palæontological evidence in favour of a marine origin for the Old Red Sandstone of Scotland, it would be here useful to give a brief recapitulation of the physical conditions of our country prior to the deposition of these later Palæozoic deposits. It is generally believed that in early Palæozoic time the main land mass must have lain somewhat to the north-west of the present continent of Europe, and may have partly existed in what is now the deep basin of the Atlantic. The old Archæan gneiss of the islands and northern Highlands seems to represent part of the primitive core round which the later Palæozoic rocks were accumulated. We do not now propose to discuss these early Palæozoic rocks, but to us those massive red sandstones and conglomerates of Loch Torridon only shadow forth the same physical processes that were at work in the still later Old Red Sandstone age; lying as they do upon the older Archæan rocks, they are the undoubted littoral accumulations along that ancient coast-line which are invariably seen to accompany a great period of mountain-building, indicating that a rapid process of subaerial denudation must have been at work in the higher regions, the detritus being swept out through the old river courses and subsequently rearranged along the shore line by the action of the sea. But to this point we propose to return later on. Immediately on the top of these Torridon sandstones and conglomerates, and separated by a strong unconformability, we find a great series of metamorphosed rocks of Cambrian, Ordovician, and Silurian age, forming the main mass of the Scottish Highlands. In the intervening period which elapsed between the deposition of the lowest member of this group and the highest, the whole series of beds were subjected to a great process of upheaval into a mountain chain of elevation. It seems to have received its maximum of corrugation and plication in that difficult and complex area in the north-west of Sutherlandshire. Receding to the south-east we find the curving of the beds become more and more gentle till they reach the comparatively unaltered rocks of the southern uplands. The great mass of this mountain chain, then, must have lain to the north-west of the present Old Red Sandstone area, and we now proceed to show how after this long period of upheaval the mountain mass once more began to sink below the level of the sea, and that gradually the waters of the Old Red Sandstone sea levelled it down to the very core.

III. Physical and Stratigraphical Considerations.

We now pass on to notice some of the physical and stratigraphical aspects of the matter. A consideration of the deposits lying immediately upon the metamorphosed rocks which then formed land leads us to the conclusion that the whole of this continental area must have been in a gradually sinking condition, and that these huge masses of conglomerate, lying at the local base of the Lower Old Red Sandstone wherever the latter is exposed, point unmistakably to the existence of a great series of unstable sea margins, slowly creeping backwards upon the main mass of the gradually sinking land. Along the flanks of the Grampians, and now exposed by a powerful fault, we have a great mass of conglomerate, consisting in some cases of boulders nearly six feet long. The conglomerates range across the country from shore to shore; in some cases north of the line of fault we have these conglomerates still occupying their normal position upon the older schists and grits. If the effect of this fault were undone, and these conglomerates were raised to their original position, they would stretch far over the Grampians along with the higher deposits of sandstones and their fish remains, which now occupy the central valley of Strathmore. The following diagram, drawn to scale, will show this very clearly (see p. 110).

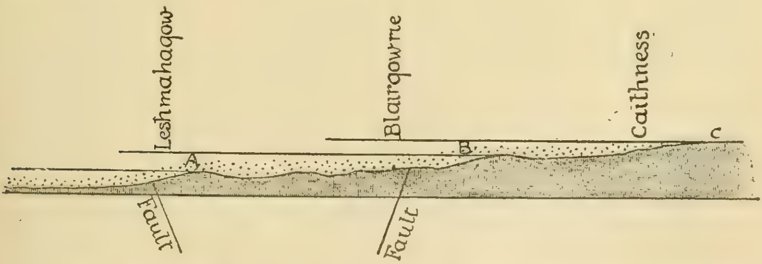
The dark part of the section to the north represents the present elevation of the Highlands above the level of the sea drawn to scale, and culminating in Ben Muich Dhui. To the south of the line of fault are shown the massive beds of Old Red Sandstone conglomerates dipping at high angles to the south-east, and estimated to be about 20,000 feet in thickness, about four times the present height of Ben Muich Dhui. At the point *A*, immediately to the north of the line of fault, and resting directly upon the old crystalline schists, are often to be found patches of the basal conglomerate of the Lower Old Red Sandstone still occupying its normal and unaltered position, so that if the effect of the great fault were undone, and the whole Old Red Sandstone deposits of Strathmore were upraised to their original position, they would overlook the Highland area to an altitude of four times its present highest elevation. Of course we do not mean to say that the Highlands have not suffered any denudation since its mantle of Old Red Sandstone rocks was swept from it; but what we do mean to maintain is, that supposing the original mountain chain was as high as the present Alps, still these deposits would have swept over it and united the so-called basins of Lake Orcadie and Lake Caledonia. It is impossible to seriously consider the idea that these basins continued to sink *pari passu* with the deposition of their sediments, the narrowness of the ridge separating them entirely precluding the idea, as the bottom beds would be contorted and folded long before the upper beds of the 20,000 feet of sediment were laid down, whereas we do not find a break in the whole series. On the other hand, it would be nigh impossible to exclude the sea from such a sinking area and for such a length of time. As if to make their original connection quite sure, outliers and fragments are found on the ridge of crystalline rocks, as at Mealfourvonie to the height of 2,284 feet, at Tomintoul and Rhynie, right on what must have been



the centre of the ridge, had separate basins existed, and where there could have been no deposits. Sir A. Geikie[1] accounts for these by supposing them to have been little isolated basins or arms of the lake running into the separating ridge. But this method of argument is exceedingly specious; it would be much more scientific to consider them as outliers of a great deposit that once covered the Highlands, the remainder of which has now been entirely swept away. Again, in Caithness there are many evidences of the denudation of these basal conglomerates from the surface of the old marine plain upon which they were laid down. In Ben Gnam the conglomerates cap the top of a mountain 1,936 feet above the sea-level; the conglomerate is exceedingly coarse, sometimes the boulders being two feet in length, the total depth of the sandstone formation on this mountain being estimated by Geikie at 1,000 feet. Another instance is mentioned by Sir A. Geikie[2] in his Memoir on the Old Red Sandstone of Western Europe, where he says he was informed by Mr. Crawford, Tongue House, that on Ben Armunin, a mountain rising to a height of 2,338 feet, in the heart of Eastern Sutherlandshire, conglomerate occurs. There can

[1] "Scenery of Scotland," 2nd edition, p. 141.
[2] Trans. Roy. Soc. of Edinburgh, vol. xxviii, p. 383.

be little doubt, as the older geologists believed, that the whole of the Highlands of Scotland were at one time covered with a vast thickness of Old Red Sandstone rocks. The period at which this denuding process must have begun would of course be subsequent to the metamorphism of the lower Palæozoic rocks themselves, and was probably contemporaneous with the deposition of the higher members of the Upper Silurian age. That this is so is evident from the manner in which the latter pass up conformably into the lower Old Red Sandstone at Leshmahagow, in Lanarkshire. They there contain an abundant supply of Upper Silurian forms, and undoubtedly go to prove that the work of carving out the great chain of upheaved and metamorphosed older Palæozoic rocks had already commenced along the skirts of the chain. These deposits seem to us to represent somewhat of a deep-water aspect, and it is very probable that the corresponding littoral deposits of conglomerate may lie somewhere beneath the later Carboniferous formations of the midland valley. Along the northern margin of the midland valley no evidence has yet been found of the Upper Silurian rocks as seen at Leshmahagow, though some of the basal conglomerates may be upon the same horizon, representing the littoral deposits to the north of the Leshmahagow beds on the south. The occurrence of *Pachytheca* in the sandstones at Murthly seems to indicate that the old Upper Silurian flora had not yet passed away when these rocks were deposited. The discrepancies between the fossils of Lanarkshire and Forfarshire on the one hand, and between the fossils of Forfarshire and Caithness on the other, are so great that we are driven to the conclusion that the three must represent different horizons of a gradually ascending and overlapping series of beds, each marked by a distinctive fauna and flora, and also by strong lithological differences. The following section will better explain our position.



During Upper Silurian times, the mountain chain was depressed as far as the point marked *A*, these deposits being now shown passing up into the Old Red Sandstone. By the time the chain had been depressed as far as *B*, the Silurian types had passed away, and were now represented by those organisms found in Forfarshire. Finally, the whole mountain mass was so far depressed as to cover the entire highland area as seen at *C*, when the Forfarshire types had, in their turn, been superseded by those of Caithness.

Subsequent to this, the midland valley was depressed between the powerful trough-faults; the upturned edges at the south showing Silurian types, and to the north, those of Old Red Sandstone times. Had these rocks been deposited in a basin, we should have expected the strata to be more or less homologous on each side of the basin; but this, as we have shown, is decidedly not the case. Jukes-Browne,[1] in his "Building of the British Isles," makes some very pertinent remarks upon this subject. He says: "From the proofs which have been adduced of the original wide extension of the Old Red Sandstone, it might be thought that the three principal basins could hardly have been separate lakes, but must have been inlets proceeding from one large inland sea, the greater part of which lay to the east of Scotland." And, indeed, so far as the stratigraphical evidence goes, this would be the most natural conclusion, for the lithological differences between the strata of the several basins are hardly greater than the differences which exist between the Lanark and Forfar types in the Caledonian basin. The palæontological differences are, however, very much greater; the piscine fauna of the Forfar and Caithness flags being so distinct, that Sir R. Murchison thought they could not be of the same age, and was led to suggest that the Caithness flags formed a middle group distinct from the Lower Old Red, and of younger date than the flags of Arbroath, in Forfarshire. Further on, he says, there is less evidence for regarding the Cheviot basin as distinct from the Caledonian, as no fish have yet been found in the Cheviot district, and we do not know how far the Lower Old Red originally stretched over the southern uplands. We have lately been examining the Lorne basin, and nothing will persuade us that it is other than an outlier removed and preserved from the main mass by the effects of some powerful faults. The presence of such extremely large boulders in its massive conglomerates as that seen in the base of the well-known Dog-stone of Dunnoly, entirely precludes the possibility of its being formed in a basin only a few miles wide. The stratigraphical evidence from the volcanic phenomena we also consider is strongly against the basin origin of these deposits; for instance, a great mass of volcanic rock forming the Sidlaws and Ochil hills is found interbedded with the sediments of the so-called Lake Caledonia basin, at a height of several thousand feet above the base. Now in the whole of the 16,000 feet of Lake Orcadie this volcanic zone is entirely absent, which, I think, points to the fact that these two basins could not have been contemporaneous, for had that been so, further evidence of this extensive volcanic activity would have been found in Lake Orcadie when we consider the narrowness of the ridge that must have separated the two basins.

The process which metamorphosed and plicated these lower Palæozoic rocks into a true mountain chain also upheaved them above the general level of the surrounding sea, when they immediately became the prey of the subaerial denuding agents. Then followed a long and intense period of subaerial and marine

[1] "Building of the British Isles," p. 61.

denudation, commencing in Upper Silurian times and lasting all through the long period of the Lower Old Red Sandstone age. It is evident from a consideration of these Upper Silurian and Lower Old Red Sandstone deposits that the old Palæozoic mountain chain was gradually sinking along its flanks, and that the sea, slowly advancing upon this sinking land, laid down these deposits, the first and lowest of which we see in the south of Lanarkshire, and the highest and latest in the topmost beds of the Lower Old Red Sandstone as developed in Caithness. It has generally been believed that all the stratigraphical evidence has been in favour of these separate areas of Old Red Sandstone being also separate basins of deposit, but it will be found that however difficult it may be to explain the exact condition under which these rocks were accumulated, one thing is certainly evident, and that is that they were not deposited in isolated basins as maintained by Godwin-Austen, Ramsay, and Geikie.

In Sir Archibald Geikie's "Scenery of Scotland"[1] will be found the most detailed work that has yet been done with regard to the physical evolution of our country, the opinions contained in it being those generally accepted and followed by present-day geologists. Referring to the second edition of that work at p. 137 on the chapter dealing with the tableland of the Highlands, he says: "The long flat surfaces of the Highland ridges cut across the edges of the vertical strata mark, I believe, fragments of a former base level of erosion; in other words, they represent the general submarine level to which the Highland region was reduced after protracted exposure to subaerial and marine denudation. . . . . . And in this rolling plain we should find a restoration of the bottom of a very ancient sea." He further goes on to say: "The first fact which a study of the topographical features and geological structure of the Highlands establishes is, that the ancient land formed after the stupendous movements that gave the rocks of the region their present character was worn down by prolonged denudation. Its mountains were levelled, its valleys were planed down, and finally the region was reduced to a base level of erosion beneath the waves either of a group of great lakes or of the sea."

Let us now examine more carefully, and in greater detail, these statements of Sir Archibald Geikie. The latter part of the paragraph just quoted seems to us to indicate in a few words the rather indefinite idea which Sir Archibald Geikie gives in his "Geology and Scenery of Scotland" of one of the most important points in the physical evolution of our country. He says that the old crystalline or metamorphosed Lower Silurians were reduced to a base-level of erosion, beneath the waves, either of a group of great lakes or of the sea. Sometimes in the course of this chapter, we would think it was the sea. For instance, as in the sentence just quoted, where he says, "In this rolling plain we should find a restoration of the bottom of a very ancient sea." Again, in a few

[1] "Scenery of Scotland," 1st and 2nd editions, under the heading 'Tableland of the Highlands.'

sentences previous to this, he says they represent the general submarine level to which the Highland region was reduced. Once more, as before quoted, he does not seem to be very sure as to whether this base-level of erosion was the action of a group of lakes or of the sea. In trying to fix the geological date of this vast denudation, he says that it must have been accomplished between the time of the Lower Silurian and that of the Lower Old Red Sandstone system. Probably the waste began in the Lower Silurian period and continued during the vast series of ages that extended into the period of the Old Red Sandstone. Here again, we would think he was referring this immense denudation to the group of fresh-water lakes, as he refers to it as being continued during the vast series of ages that extended into the period of the Old Red Sandstone.

We must confess to having a great difficulty in following Sir A. Geikie's description of the succession of physical events that took place immediately after the plication and upheaval of the old Palæozoic mountain chain. But we think the following may be taken as a fair representation of his meaning—That after the plication and metamorphism of the crystalline rocks of the Highlands, the whole mass was reduced to a plain of marine denudation by a sea which has left no traces whatever of this immense denudation in the shape of later deposits, and that afterwards this plain of marine denudation was depressed into regions occupied by fresh-water lakes which, creeping backwards, threw down the deposits now known as the Lower Old Red Sandstone formation. Generally speaking, the whole tenour of the chapter dealing with the tableland of the Highlands seems to indicate that an extensive marine denudation reduced the massive mountain chain of the Highlands to a base-level of erosion altogether distinct from the later denudation which threw down the massive conglomerates of the Old Red Sandstones with its 20,000 feet of sandstones and shales.

Now we would maintain that this first marine denudation, which levelled down the old Palæozoic mountain chain, was identical with the deposition of the Upper Silurian and Lower Old Red Sandstone rocks, pointing out that, though Sir Archibald Geikie believes that it was the sea which levelled down the old continent, he cannot show us anywhere the remains of this immense denudation, all the later rocks lying upon it being of Old Red Sandstone age, and consequently having a fresh-water origin. Further, we cannot see how, if the whole land surface were reduced to a level plain first by marine denudation, this plain could be now preserved, seeing that subsequently it was ridged up into isolated basins to hold the fresh-water lakes. It is evident, then, that Ramsay, Geikie, and their followers distinctly recognize two periods of denudation after the plication of the Lower Silurian rocks into a mountain chain. The first period of denudation cut down this mountain chain to a dead level of erosion, called by them a plain of marine denudation, which was produced by the action of the sea. This period, however, strange to say, seems to have left no traces behind in the shape of marine deposits, for immediately resting upon this ancient plain, wherever it has been preserved, we have the great basal conglomerates of the Old Red Sandstone, which they all agree in referring to a lake or fresh-water origin.

The amount of misconception that exists as to the succession of events after the plication of these early Palæozoic rocks is indeed wonderful, and may be traced principally to these theories of the physical and geological development of our country given in Sir A. Geikie's "Scenery of Scotland," the following being a very fair example. Prof. Davis,[1] of Harvard University, in a paper on the rivers of England contributed recently to the Royal Geographical Society's Magazine, speaking of the marine plain of denudation, as described in the aforementioned work, says: "Although perhaps not absolutely stated, it is clearly implied that it was Devonian erosion by which the once low and comparatively even surface of the now uplifted and dissected Highlands was produced; it is plainly manifest that Devonian erosion consumed a great volume of the contorted and overthrust rocks of the Highlands: witness the great volume of the Devonian strata lying unconformably upon the Highland rocks, and the identity of the Devonian conglomerate pebbles with the rocks of the older terranes. It may indeed be well argued from Sir A. Geikie's essay on the Old Red Sandstone of Western Europe that a vast denudation was accomplished in earlier times than the Old Red Sandstone period, and that by the close of that period the Highland region must have been truly a diminished lowland, a peneplain of small area and moderate relief." This is a very good example of the misconception and general indefiniteness which accompany Sir A. Geikie's description of the physical events following the plication of the crystalline rocks of the Highlands, for Prof. Davis speaks of Devonian seas having cut down the Highlands to their base-level, and of conglomerates belonging to that age resting upon them, and then of Old Red Sandstone conglomerates, as if there were two distinct sets of rocks in Scotland, one marine and Devonian, the other fresh-water and of Old Red Sandstone age. Of course the error is quite excusable in one who has never studied the rocks of our country, but only read of them in the "Scenery of Scotland."

IV. Petrological and Other Considerations.

We have already noticed the strong similarity between the conglomerates of the Torridon Sandstones and those of the later Old Red Sandstone rocks. Both of them show evidence of glaciation, and, as has recently occurred to us, this may be connected in some way with the fact that they are both seen to follow a great process of mountain-building. This fact, we think, would indicate that the great mountain mass had been upheaved above the limit of the snow-line. The consequent descent of glaciers having played an important part in contributing their morainic débris to the formation of these massive conglomerates now lying at the base of both the

[1] Geographical Society's Journal for 1895.

Pre-Cambrian and Old Red Sandstone deposits, their origin is not, we believe, to be sought for in any lacustrine deposit, as has been maintained by Ramsay, Geikie, and Hull. They are rather types of a great series of shore deposits gradually accumulating along the margin of a slowly sinking continental area, which in its upper regions is rapidly undergoing subaerial denudation. This type of deposit it not uncommon all through the geological scale, and to it we believe the Old Red Sandstone conglomerates of Scotland belong. Prof. Bonney[1] makes interesting remarks upon this point in his address to the British Association in 1886. He there says that "Pebbles indicate the action of the waves of the sea or of strong currents, marine or fluviatile." Further he continues: "The waves of lakes have also some rounding effect, but this, except in the case of very large lakes such as Lake Superior, is not important, and such cases are, of course, not of common occurrence." As we have already pointed out, the massive conglomerates of such a small basin as we are led to believe Lake Lorne must have been, and, what is still further in evidence, the much smaller basins that are alleged to have existed on the separating ridge between Lake Caledonia and Lake Orcadie, entirely preclude, even from a petrological point of view alone, the possibility of their being other than outliers from the main mass. The whole petrological aspect of the Old Red Sandstone rocks, as seen in Scotland, is, of course, highly indicative of their littoral origin; the entire absence of any of the deeper oceanic types of sedimentation, such as shales and limestone, also confirming this view. The rocks as seen in Caithness, Forfarshire, and Perthshire, and generally in the valley of Strathmore, mainly consist of great beds of grey and red sandstone, with occasionally local deposits of conglomerate, the great feature of the whole being their characteristic red colour. Now we think that this red colour, due to the presence of the red oxide of iron in the rocks, cannot be fairly claimed as an argument for the fresh-water origin of these deposits. Prof. Gosselet has shown that in the Devonian basin of Dinant, the same beds are in one part red and barren of organic remains, and in another part of the same area are of the usual colour and are full of marine fossils. With Sir Charles Lyell[2] we ask the question, Why should shells and corals be generally wanting in all sedimentary rocks, the colour of which is determined by the red oxide of iron? and we believe that the answer cannot lie in the assertion that they are all fresh-water deposits, seeing that even in such undoubted marine deposits as the Devonian, Carboniferous, and Permian formations, it is common in the ordinary beds to find corals and shells, while those coloured with peroxide of iron are entirely barren of organic remains. The solution of the problem rather lies in the fact that the presence of peroxide of iron in these rocks is inimical to the preservation of fossils with a calcareous test, and that more especially in the case of sandstones, which even when composed of pure silica are well known to be a bad medium for the preservation of molluscan and other similar organic remains.

[1] British Assoc. Report, 1886. [2] "Elements of Geology," 3rd edition, p. 435.

IV.—Woodwardian Museum Notes.

Notes on the Evolution of the Genus *Cheirurus*.

By F. R. Cowper Reed, M.A., F.G.S.

THE genus *Cheirurus* offers an interesting study in evolution. Barrande, in his monumental work on the Silurian System of Bohemia,[1] drew up a classification of the genus based principally on the character of the pleural grooves. Thus he divided the species into two sections—

Section I. Pleural groove parallel to the borders and slightly marked. 10–12 segments to the thorax.

Section II. Pleural groove oblique and deep. 11 segments to the thorax.

The first section he subdivided into three groups according as the species had 10, 11, or 12 thoracic segments. The second section he split into two groups: (1) with glabellar side-furrows not united on the axis; (2) with glabellar side-furrows united on the axis. This last group corresponds with Salter's subgenus *Crotalocephalus*. Another provisional group was made to contain several forms whose position could not be then established.

The restriction of Section I to the Lower Silurian and of Section II to the Upper Silurian and Devonian is also commented on by Barrande, as well as the almost complete limitation of the second group of Section II to the Devonian. The relationships of the various species are also minutely discussed; and on plate vi of the Atlas there is given the complete series of modifications in the pleuræ between the extreme terms represented by *Ch. claviger* of Section I and *Ch. gibbus* of Section II.

Schmidt[2] has more recently discussed the affinities of the various species and divided the genus into two sections, the first of which is characterized normally by the possession of eleven thoracic segments, each pleura being divided by a constriction into an inner and an outer portion. The inner portion is marked by a longitudinal or a diagonal furrow, and is also possessed of a narrow articulating band along its anterior and posterior borders, which terminates at the constriction in a recurved, swollen, hook-like process. A similar band with hook-like process is found on each side of the axial portion of the head-shield along its posterior border. To this section belong *Cheirurus* (*sens. str.*) and *Cyrtometopus*. These two forms mark two groups.

Group 1 of this section of Schmidt consists of *Cheirurus* (*sens. str.*) (type *Ch. exsul*, Beyr.). All the species have a diagonal furrow on the inner portion of the pleura, and the outer portion is swollen at its base. The marginal furrows of the head-shield are always distinct, and run into the axal furrows without interruption; the latter diverge more or less in front. The glabella

[1] Syst. Silur. Bohême, vol. i: Trilobites (1852), p. 770; and Suppl. to vol. i (1872).

[2] Revis. d. Ostbalt. Silur. Trilob. 1881, pt. i, p. 121.

is almost rectangular or slightly wider in front, and the side-furrows are distinct. From the first side-furrow of the glabella a prominent ridge runs to the eye. The eye is for the most part large, situated in the middle of the cheek, with rounded triangular eye-lobe without an oblique furrow at the base. The genal angles are produced into long horns.

Group 2 consists of the somewhat heterogeneous subgenus *Cyrtometopus.* All the species have a longitudinal furrow on the inner part of the pleuræ. The marginal furrows of the head-shield do not run into the axal furrows, or only pass feebly over the anterior wing of the fixed cheek. This swollen anterior wing of the fixed cheek on the inner side of the anterior branch of the facial suture is an important feature. The shape of the glabella varies considerably: thus, in *Cyrto. Plautini* (Schmidt) it is parallel-sided, reminding one of *Cheirurus* (*sens. str.*), while in *Cyrto. clavifrons* (Dalm.) and *Cyrto. affinis* (Ang.) it is oval. The side-furrows of the glabella are always distinct, and the basal lobe is incompletely circumscribed, except in *Cyrto. pseudohemicranium* (Nieszk.) which has a broad and deep third side-furrow completely surrounding the basal lobe. This species also has an almost obsolete first side-furrow to the glabella.

The strange subgenus *Sphærocoryphe* (which probably ought to take generic rank) is closely linked on to the true *Cyrtometopus* by *Cyrto. pseudohemicranium* and *Cyrto. aries* (Eichw.); but the extraordinary inflation of the anterior position of the glabella, the teeth on the lateral margin of the head-shield, and the reduction in the number of the thoracic segments (8–11? but commonly 9), sufficiently distinguish it.

Section II of the whole genus *Cheirurus*, according to Schmidt, includes three subgenera—*Nieszkowskia*, *Pseudosphærexochus*, and *Eccoptocheile.* The subgenus *Nieszkowskia* is made by Schmidt to receive certain species which had been placed by Nieszkowski in the genus *Sphærexochus*, and by Angelin in *Cyrtometopus*. *N. cephaloceros* (Nieszk. sp.) may be taken as the type.

The characters common to the whole section are the possession of twelve thoracic segments; the absence of any constriction of the pleuræ, so that they lie close to one another along their whole length; the presence of a longitudinal row of puncta[1] instead of a furrow on the inner portion of each pleura; the presence of a narrow articulating band on the anterior border of the inner portion of each pleura; and the abrupt termination of this band without a hamate process. There is a feeble indication of this band on the posterior border of the head-shield. The three subgenera form three groups.

Group 1 consists of the subgenus *Nieszkowskia*. In this subgenus the glabella is swollen posteriorly, and often passes into a hump or spine. All the side-furrows are directed backwards, and the third side-furrow, which is stronger than the other two, runs in a curve towards the neck-furrow, but does not reach it. The free cheeks

[1] In *Pseudosphærexochus* these puncta are very faint or absent.

are triangular and small, since the posterior branch of the facial suture cuts the outer margin far forward. The genal angles are produced into long divergent horns. The pleuræ have a weak fulcrum, and while the inner portion has a longitudinal row of puncta, the outer portion is smooth and produced into a sword-shaped point. The pygidium is always four-pointed, and the posterior pair of points is embraced by the larger anterior pair.

Group 2 of Section II is formed by *Pseudosphærexochus*, the type of which is *P. hemicranium* (Kut. sp.). The glabella resembles that of *Sphærexochus*; the first side-furrow stands almost vertical to the axal furrow; the third side-furrow, which is much stronger than the two first, is also almost vertical to the axal furrow for part of its length, but then bends back and becomes weaker, reaching the neck-furrow only as a faint groove. The free cheeks are large and form almost the whole side of the head-shield, for the outer limb of the facial suture cuts the margin only a short distance before the genal angle. (In *Sphærexochus* this outer limb reaches the margin at the genal angle.) The pleuræ have a distinct fulcrum; the inner part of each pleura is swollen, and possesses either an almost obsolete row of puncta or no puncta or groove at all; the outer part is long and conically pointed. The pygidium has four pairs of pleuræ with free pointed ends.

Eccoptocheile is not described by Schmidt, since it does not occur in the Silurian of the East Baltic provinces; but he alludes to the English species *E. Sedgwicki* (M'Coy) as belonging to this section.

The earliest type of *Cheirurus* in Britain occurs in the Upper Tremadoc of Portmadoc, and was placed by Salter in the subgenus *Eccoptocheile.* This species [*Ch.* (*E.*) *Frederici*, Salter], though undoubtedly closely allied to the members of Section II in Schmidt's classification, yet shows some important points of difference to the typical *Eccoptocheile.* The Tremadoc form has eleven or twelve[1] thoracic segments, each of which is deeply grooved along its middle almost to its free end. There is no row of puncta in the groove. The great length of the groove, the absence of puncta in it, the loosely-built structure of the thorax, and the close similarity of the pygidial to the thoracic segments, look like primitive characters. I am inclined to think that this species is sufficiently distinct from the typical *Eccoptocheile* to warrant the creation of a new subgenus for its reception. This subgenus may be termed *Anacheirurus.*[2]

The next species as we ascend the stratigraphical series is *Ch.* (*Eccopto.*) *pectinatus* (Salter MS.), of the Lower Llandeilo or Arenig of Shelve; the only specimens with which I am acquainted are in the Museum of Practical Geology, Jermyn Street, and no description of its characters has been published. It seems closely allied to the

[1] The type specimens on which the species was founded are not sufficiently well preserved for one to be sure of the number of segments—a point Salter notices.

[2] The pygidium with seven segments ascribed to this species (Salter, Mon. Brit. Trilob. Pal. Soc., pl. v, fig. 21, p. 75) probably belongs to a distinct species, or even subgenus; but our ignorance of the other parts of the trilobite to which it belonged prevents us coming to a decision about its exact position.

better known *Eccoptocheile Sedgwicki* (M'Coy), which occurs in the Upper Llandeilo of Wales. The latter species shows on each of its twelve thoracic pleuræ a longitudinal groove extending fully three-fourths of the whole length of the pleura, and furnished with a row of puncta lying in it. The pygidium, while showing four segments on the axis, has only three pairs of pleuræ, indicating a condensation and abbreviation of this part of the body. The pygidial pleuræ are closely similar to those of the thorax, preserving the longitudinal groove and row of puncta. M'Coy's original figured specimens of this species are in the Woodwardian Museum, as well as those of *Ch.* (*Anach.*) *Frederici.* The presence of the row of puncta in the longitudinal pleural groove, and the shortening of the latter, are characters intermediate between those of *Ch. Frederici* and the next group of species. This group, which represents the next stage in the development of the genus, includes several Bohemian species (*e.g. Ch. claviger*, Barr., *Ch. pater*, Barr., etc.).[1] The longitudinal pleural groove is reduced in length so as to furrow only about half the pleura, which can therefore be considered to consist of two portions —an outer ungrooved portion and an inner grooved portion. A row of puncta is present in the groove. The Bohemian forms, however, have curiously only ten thoracic segments, which probably points to an arresting of the process of segmentation at a pre-adult stage. The preservation of an adolescent character in the adult is, of course, well known in many groups of organisms, and I do not attach any subgeneric importance to it. The pygidium resembles in the number of the pleuræ and condition of the axial portion that of *E. Sedgwicki*, but the greater dissimilarity of the pygidial to the thoracic pleuræ points to a further specialization of the pygidium. The head-shield demands no special notice, since its characters are essentially the same as those in *E. Sedgwicki*. *Ch. claviger* occurs in Dd 3 and Dd 4, but principally in the latter, which corresponds with the lower part of our Bala. The allied *Ch. scuticauda* (Barr.), which shows a slightly greater reduction in length of the pleural groove and line of puncta, has the atavistic character in the pygidium of four pairs of pleuræ, which, nevertheless, by their form, etc., show some specialization. A reversion to more primitive and ancestral conditions in the case of the pygidium is by no means rare in this genus, as we shall see. *Ch. scuticauda* occurs in Dd 3 of Bohemia. *Ch. pectinifer*, Barr., of Dd 5, with its Cyrtometopian head and reduced pleural groove, appears to belong to about this stage.

The species which comes next in the series is *Ch. tumescens* (Barr.). It seems to be closely related to *Ch. scuticauda*, for it possesses a very similar pygidium, and also commences on the same horizon (Dd 3), though ranging up to Dd 5. In this species also only ten thoracic segments are present. The chief advance is shown in the constriction which occurs between the outer and inner portions of

[1] It is remarkable that this group, which includes the earliest members of the genus occurring in the Bohemian basin, has not yet been found in northern Europe (see sequel).

the pleura, and the greater development of the articulating band on the inner portion of the pleura. Closely allied forms are *Ch. insocialis*, Barr., and *Ch. gryphus*, Barr., of Dd 4 and Dd 5. In all these above-mentioned species the basal lobe of the glabella is incompletely separated, for the third glabellar side-furrow does not unite with the neck-furrow. If we regard the head-shield as composed of several fused segments, we must look upon this non-union as a primitive feature. The presence of an anterior wing to the fixed cheek not crossed (or only very feebly) by the marginal furrow is also a noticeable character in all the *Eccoptocheile* group. About this point the main stem seems to give off two branches which lead to such diverse forms as *Pseudosphærexochus* and *Crotalocephalus* respectively.

Turning first to the branch that ends in *Crotalocephalus*, we find that we are leaving Section II of Schmidt and entering upon his Section I through a considerable number of intermediate forms linking *Eccoptocheile* with *Cyrtometopus*. The subgenus *Cyrtometopus*, with its rather heterogeneous and ill-defined characters, first demands our attention. In it the number of eleven thoracic segments, characteristic of Schmidt's Section I, with constricted pleuræ, is met with. The pleural groove is confined to the inner portion of the pleura, and is longitudinal; the basal lobes of the glabella are incompletely separated (except in *Cyrto.*? *pseudohemicranium*, Nieszk., which belongs to a minor lateral branch); the fixed cheek has an anterior wing not crossed (or only feebly) by the marginal furrow just as in the typical *Eccoptocheile*. The type of the subgenus is *Cyrto. clavifrons* (Dalm.). The pygidium varies somewhat, but most commonly its anterior pleuræ are enlarged and project behind the posterior ones, which are of smaller size. There are normally only three pairs of pleuræ with free ends in the pygidium, but the fourth pair is represented by a single median terminal piece.

Ch. juvenis (Salter), which was placed by its author in the ill-defined subgenus *Actinopeltis*, has close affinities to a true *Cyrtometopus* in the characters of the head-shield and pygidium, but the complete separation of the basal lobes from the glabella by the third side-furrow is a distinguishing feature, and suggests an alliance with *Cyrto.*? *pseudohemicranium* (Nieszk.). The position of the side-furrows and course of the facial suture in some specimens show some similarity to those of *Pseudosphærexochus*, but I strongly suspect that two or more distinct species, and perhaps even different subgenera, have been included under the specific title of *Ch. juvenis*.

The two species *Cyrto.*? *pseudohemicranium* (Nieszk.) and *Cyrto.*? *aries* (Eichw. sp.) may ultimately need the creation of a new subgenus intermediate between *Cyrtometopus* and the strange *Sphærocoryphe*.

The reasons for the removal of these forms from other subgenera are at present (1) the complete separation of the basal lobes by the strong third glabellar side-furrow joining the neck-furrow, and the smaller elevation of these lobes than the rest of the glabella;

(2) the very weak development of the two anterior side-furrows. Though in *Cyrto.*? *aries* the basal lobes are not completely circumscribed, yet the whole head-shield resembles in many important features *Cyrto.*? *pseudohemicranium*, and Schmidt (*loc. cit.* p. 123) holds that they are closely allied. Eichwald[1] considered *Cyrto.*? *aries* to be a species of *Sphærocoryphe*; Hoffmann[2] held it to belong to *Sphærexochus*; and Nieszkowski[3] and Steinhardt[4] also place *Cyrto.*? *pseudohemicranium* in *Sphærexochus*. The pygidium ascribed to *Cyrto.*? *pseudohemicranium* also shows quite peculiar characters. *Hemisphærocoryphe* would be a suitable name for these forms. They have some points of similarity to *Ch. globosus* (Barr.) from Dd 4 and Dd 5 of Bohemia, a point noticed by Schmidt (*loc. cit.* p. 123). This Bohemian species, while possessing eleven segments, the number typical of Schmidt's Section I, and constricted pleuræ with hamate processes to the articulating bands, has merely a longitudinal row of puncta on the inner portion of each pleura instead of a furrow. It has also an apparently complete communication of the marginal with the axal furrow, and the basal lobe of the glabella is cut off by the union of the third side-furrow with the neck-furrow. Its pygidium is, however, very different from those of *Cyrto.*? *pseudohemicranium* and *Cyrto.*? *aries*, being furnished with four pairs of pleuræ with free terminations, allying it to *Ch. tumescens* and other Bohemian species. I am therefore inclined to think that *Ch. globosus* belongs to a small side branch, and is not in the direct line of ancestry of later forms.

Cyrto.? *pseudohemicranium* and *Cyrto.*? *aries* form a connecting link between *Cyrtometopus* and *Sphærocoryphe*, as before mentioned. The latter subgenus has, in common with *Cyrto.*? *pseudohemicranium*, the inflated anterior portion of the glabella, the separated basal lobes, and the faint first and second side-furrows; and, so far as is known, the pleuræ are similar in both cases. But the reduction in the number of the thoracic segments to eight or nine (according to Angelin), the much greater inflation and protuberance of the glabella, and the lateral teeth to the head-shield, are important differences. The pygidium has three pairs of pleuræ according to Kutorga, and has the appearance of considerable deviation from the ordinary types in the genus *Cheirurus*. *Sphærocoryphe*, in fact, appears to be at the end of a highly specialized small side-branch, which died off in Silurian times.

The *Staurocephalus*? *unicus*, described first by Wyville Thomson[5] from the Bala beds of Ayrshire, is really a *Sphærocoryphe*, and seems to be the only British representative of the subgenus. On the Continent the subgenus is confined to Ordovician strata.

[1] Eichwald. Lethæa rossica, 1860, p. 1408, T. lii, fig. 31.

[2] Hoffmann. Sammtl. Trilob. Russl. in Verh. d. mineralog. Gesellsch. 1858, p. 30, T. i, fig. 5.

[3] Nieszkowski. Zusätze z. monogr. d. Trilob. d. Ostseeprov. im Archiv. für Naturk., Liv. Ert und Kurt, 1858, Ser. I, Bd. ii, p. 376, T. ii, figs. 7 and 8.

[4] Steinhardt. Die in preuss. Geschr. gef. Trilob. in Beitr. z. Naturk. Preussens. D. phys. ökonom. Gesellsch. z. Konigsb. 1874, p. 60, T. iv, fig. 17.

[5] Quart. Journ. Geol. Soc., vol. xiii (1857), p. 209, pl. vi, figs. 13 and 14.

Returning now to *Cyrtometopus* proper, we find it is succeeded by *Cheirurus* (*sens. str.*), the characters of which have been already given. The connecting link, so far as the pleuræ are concerned, is indicated by *Cyrto. Zembnitzki* (Eichw. sp.), in which the pleural groove has a slightly diagonal direction. In the characters of the glabella and head-shield, *Cyrto. Plautini* (Schmidt) shows some approach to *Cheirurus* (*sens. str.*), while *Ch. gelasinosus* (Portl. sp.) has not the marginal furrow communicating with the axal furrow, as it does in typical members of the subgenus *Cheirurus* (*sens. str.*). In the pygidia of *Cyrtometopus* and this subgenus there are striking points of similarity, for the anterior pair of pygidial pleuræ in many species of *Cheirurus* (*sens. str.*) is greatly enlarged and elongated so as to embrace the two posterior pairs, and the fourth pair is represented by a single median terminal piece.

With regard to the pygidium, it is noticeable that the species of *Cheirurus* (*sens. str.*) fall naturally into two groups when this portion alone of the body is considered, viz.: (1) the species with Cyrtometopian pygidia as just described, of which an example is *Ch. exsul* (Beyr.);[1] and (2) the species with three almost equal-sized pairs of short pleuræ, with a short single median or bifid piece representing the fourth pair. Such a condition exists commonly in *Ch. bimucronatus* (Murch. sp.), though many specimens from the Wenlock Limestone show a more or less marked enlargement of the first pair of pleuræ.

As regards these pygidial characters, the Russian species appear to belong entirely to the first group; in Bohemia the second group preponderates, as it does in Britain; while in Scandinavia the Russian type is in a majority. The period to which *Cheirurus* (*sens. str.*) is restricted extends from the middle part of the Ordovician to the upper part of the Silurian. Thus, while it commences during the reign of *Cyrtometopus*, it lives on after that subgenus has dwindled away or disappeared.

In Britain *Cheirurus* sg. is represented by *Ch. bimucronatus* (Murch. sp.)—with its three varieties, *bimucronatus* and *centralis* of Salter, and *acanthodes* (Marr and Nicholson)[2]—ranging from Bala to Ludlow beds; *Ch. gelasinosus* (Portl. sp.), from the limestone of the Chair of Kildare, on the same horizon probably as the Keisley Limestone, from which come also *Ch. glaber* (Angelin) and *Ch. keisleyensis* (Reed MS.). *Ch. cancrurus* (Salter), which occurs in the Kildare and Keisley limestones, may belong to this subgenus; but though the head figured by Salter[3] undoubtedly belongs to this subgenus, it is very doubtful whether it is rightly associated with the extremely atavistic pygidium on which the species was originally founded.

[1] A case of extreme specialization in this group is *Ch. subulatus* (Linnarsson), in which the pygidium has only two pairs of free pleuræ.

[2] Marr and Nicholson. The Stockdale Shales: Quart. Journ. Geol. Soc. 1888, vol. xl, p. 722, pl. xvi, figs. 7 and 8.

[3] Salter. Mon. Brit. Trilob.: Pal. Soc. 1864, p. 72, pl. v, fig. 16.

(*To be continued in our April Number.*)

REVIEWS.

I.—Catalogue of the Fossil Fishes in the British Museum (Natural History). By Arthur Smith Woodward, F.G.S., F.Z.S. Part III. 1895. 8vo, pp. xxxii and 544, with 18 Plates and 45 Illustrations in the text. Dulau & Co., London.

THE appearance of the third part of Mr. Smith Woodward's Catalogue of the Fossil Fishes in the British Museum will be welcome, not only to those who have occasion to busy themselves with the determination of genera and species, but to all who are interested in the classification of fishes in general, and in the fascinating problems connected with the evolution of this great class of Vertebrata. The time is surely now come for "biologists" to give some attention to palæontological as well as to embryological development, instead of looking upon fossil forms, as only too many seem to do, as something altogether outside the sphere of their work and interest.

This part, dealing mainly with the fishes ordinarily known as the "Lepidosteoid Ganoids," has taken four years in preparation; not too long a time when we consider the magnitude of the task of revising and rectifying such an enormous mass of genera and species, but also of tracing the true and natural affinities of forms and families, whose relationships have been in the past so obscured by the lingering influence of Agassiz, which has induced, and still induces, authors to place undue value upon characters of absolutely secondary importance, instead of boldly assigning the proper weight to those which are of a more deeply seated and genuinely morphological nature.

While much had been done by previous writers in the way of freeing Palæozoic Ichthyology from the "dermal character" incubus, Mr. Smith Woodward has had the work of elucidating the true morphological relations of the Mesozoic Semi-heterocercal Ganoids very much more to himself, for it cannot be said that recent attempts to systematize these fishes have been very successful. And the result is one of which neither the author nor the great national institution of which he is a prominent official need be ashamed.

The present part commences with the consideration of certain Mesozoic representatives of the Acipenseroidei, or, as the author prefers to call them, "Chondrostei," left over from last volume. Here, as previously indicated, Mr. Woodward includes the semi-heterocercal *Catopterus* and the abbreviate diphycercal *Belonorhynchus*, placing more weight upon the structure of the median fins than on the degree and manner of the caudal extension of the body-axis. The families treated of here are the Catopteridæ, Belonorhynchidæ, Chondrosteidæ, Acipenseridæ, and Polyodontidæ. Although Prof. von Zittel still "does not seem to see it," at least with the requisite clearness, it is gratifying to find that Mr. Woodward does not cease to support strongly the close relationship between the recent Acipenseroids and the extinct Palæoniscidæ and Platysomidæ, which was pointed out by the present writer in 1877.

With the dismissal of the Chondrostei the special interest of the present volume commences, as in the treatment of the typical Mesozoic Ganoids—be it remembered that "Ganoid" is now only a conventional term—a considerable amount of "redistribution of seats" takes place with regard to forms with which the general palæontologist is already familiar. As co-ordinate with Chondrostei, the author here deals with two further suborders of the Actinopterygii, viz. the Protospondyli and the Ætheospondyli, and part of a third, the Isospondyli.

Protospondyli.

The Protospondyli, abbreviate heterocercal fishes, with complex mandible, no interclavicular plates, and having the vertebral axis represented by a persistent notochord or by vertebræ which, at least in the caudal region, have the pleurocentra and hypocentra distinct and alternating, are, in fact, nearly the equivalent of what since Huxley's time have been called Lepidosteidæ or Lepidosteoidea, but with *Lepidosteus* left out and *Amia* included. For the disappearance of the "Amioidea" as a suborder I have long been prepared by the obvious similarity in cranial characters between *Amia* and such genera as *Lepidotus* and *Eugnathus*. And yet these have osseous, rhombic, brilliantly ganoid scales, while those of *Amia* are rounded, thin, and flexible—are, in fact, "cycloid" in the most Agassizian sense of the word. The condition of the squamation as an ordinal or subordinal, or even family characteristic, here receives its crowning blow, after having been utterly shaken by the occurrence of Palæoniscidæ with round, imbricating scales (*Trissolepis*, Fritsch, *Cryphiolepis*, Traquair); and a still further interesting case is afforded by Mr. Woodward's Semionotid genus *Æthiolepis*, in which the body-scales are rhombic, while those towards the tail are "cycloidal."

The families included by Mr. Woodward under Protospondyli are the Semionotidæ, Macrosemiidæ, Pycnodontidæ, Eugnathidæ, Amiadæ, and Pachycormidæ. In the first of these families we have deep-bodied "Stylodonts" like *Dapedius* included along with fusiform "Sphærodonts" like *Lepidotus*, for the mere shape of teeth is as of little classificatory importance as that of scales. Then as regards the Pycnodontidæ, Mr. Woodward has made a special and elaborate study of this remarkable family, bringing out many new and important structural facts, such as the fusion of the pterygo-palatine arcade with the base of the skull, etc. As regards the systematic position to which he has assigned these fishes, I have every reason personally to be gratified with his results. It is now many years ago since I imagined that I had successfully combated the idea of Egerton that the Platysomidæ were structurally related to the Pycnodontidæ, maintaining as I did that while the former were of Acipenseroid affinity, and indeed close to the Palæoniscidæ, the structure of the internal skeleton in the latter (Pycnodontidæ) pointed rather to their place being in "the great Lepidosteoid series of Ganoids" than in any other. Nevertheless, in his most recent systematic work Prof. von Zittel still maintains that the Pycnodontidæ are probably the descendants of the Platysomidæ, and asserts that they differ principally in the dentition and in the condition of the jaws![1] It is to be hoped that Mr. Smith Woodward's emphatic declaration that the "Platysomidæ never make the faintest approach to the Pycnodontidæ in a single essential character," as well as the systematic position to which in the present work he has assigned the last-named family, will lead the distinguished palæontologist of Munich to reconsider a position which still retains us in the Agassiz-Egertonian period of palæichthyological science.

ÆTHEOSPONDYLI.

We have already seen that Mr. Woodward excludes *Lepidosteus* from the assemblage of semi-heterocercal rhombic-scaled fossil forms, with which it has been associated since the publication of Huxley's famous Essay on the Classification of the Devonian Fishes; and his reason is the structure of the vertebræ, which never, even in the caudal region, show separate and alternating pleurocentra and hypocentra. This character is shared also by *Aspidorhynchus*, though the vertebral centra are here ring-shaped or biconcave, instead of opisthocœlous as in *Lepidosteus*. The suborder of Ætheospondyli therefore includes the two families of Aspidorhynchidæ and Lepidosteidæ.

These two families are certainly closely related to the fishes brought together by Mr. Woodward under Protospondyli, by the complexity of the mandible and other characters, and it may indeed be a matter of opinion as to whether the condition of the vertebræ justifies their separation. The author himself states that "the recognition of this group is a confession of ignorance"—that is, ignorance of the immediate relationships of the two families therein included.

ISOSPONDYLI.

The third group after Chondrostei, which Mr. Woodward commences in this Part, is that of the Isospondyli, a term instituted by Professor Cope for a large and closely related series of recent "Teleostei," including the Clupeoids, Salmonoids, etc., and in which he also placed many of the Mesozoic "Ganoids," dealt with by our author in the previous pages of this volume. The Isospondyli are, however, distinguished from the Protospondyli and Ætheospondyli by the more simply constituted mandible, which, as in modern bony fishes generally, does not consist of more than two or three pieces, except perhaps in *Arapacina*. Only three families of Isospondyli are treated of in the present Part, namely, the Pholidophoridæ, Oligopleuridæ, and Leptolepidæ.

With the inclusion, already proposed by Cope, of fishes like *Pholidophorus* in one "suborder" with *Clupea* and *Salmo*, the "Ganoidei" of Agassiz may be said to have disappeared, and with them the "Palæichthyes" of Günther. Strange it is that after having been led so long an excursion by the illustrious founder of fossil ichthyology, our Ganoids should have got back pretty much to where they were—close to the Herrings!

[1] "Grundzüge der Palæontologie," München and Leipzig, 1895, p. 574.

Included in the "Addenda et Corrigenda" at the end of the Part is a notice of the hitherto problematic genus *Platysiagum*, Egerton, of the Lower Lias, which Mr. Woodward proposes to refer to the Palæoniscidæ. Certainly the osteology of the head of *Platysiagum* is palæoniscoid in the highest degree, and I should myself have referred it to this family twenty years ago had I not seen in the collection of the late Lord Enniskillen a specimen, now in the British Museum, in which the upper lobe of the tail seemed to be decidedly *non*-heterocercal. Mr. Woodward says, however, that the upper lobe of the tail is unknown, and my remembrance of the specimen is that the tail is so twisted that it is hard to know which is upper and which lower. At the same time I have many a time carefully examined the fish with the hope of finding myself mistaken in the orientation of its caudal lobes, but always with the same result. If Mr. Woodward's reading be correct, then the apparent anomaly of a fish with such a very palæoniscoid head and a non-heterocercal tail will be removed.

It would be impossible, within the limits usually allowed for a review of this kind, to enter into any more minute analysis of the contents of the volume now before me. Let me conclude by saying that the task of preparing this Part must have been a most arduous one, and that Mr. Woodward has performed it in a manner well deserving of the grateful and appreciative recognition of his fellow-workers in science.

Eight beautiful restored drawings of Mesozoic fishes are given in the text, which will surely be of more use to the textbook-makers than the antiquated Agassizian figures which down to the present day are so often copied and re-copied. As to the eighteen lithographic plates, it is sufficient to say that they, as well as the restored drawings, are from the accomplished pencil of Miss G. M. Woodward, and that, as might be expected, they occupy a place in the first rank of palæontographical work.

R. H. Traquair.

II.—Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Natural History). "The Wealden Flora. Part II: Gymnospermæ." 8vo, pp. 260. With Twenty Plates and Nine Figures in the Text. By A. C. Seward, M.A., F.G.S. London: Dulau & Co., 1895.

The present volume completes Mr. Seward's excellent account of the fossil plants of the British Wealden formation. Unfortunately no remains of Angiosperms have, so far, been found in these beds, so the ascending series closes with the Coniferæ. The book, with the aid of the numerous and admirable plates (chiefly drawn by Miss Woodward), gives a clear picture of the *facies* of the Wealden Flora, and it would be difficult to speak too highly of the scientific judgment shown by the author in estimating the affinities of the various fossils.

Cycadean remains, or at least specimens most naturally referred to the Cycadaceæ, constitute an important feature of the Wealden

Flora. It is remarkable, however, to find how little evidence there is to prove that these various remains really belonged to plants like the Cycads of the present day. As the author says (p. 240): "We must remember that the so-called Cycadean fronds from Mesozoic rocks are nearly always found apart from the stems and reproductive structures, and we are still to a large extent in the dark as to the exact nature and structure of these extinct Cycadean plants."

In his introductory remarks Mr. Seward points out the frequent difficulty in distinguishing for certain between leaves of ferns and Cycadaceæ, and briefly discusses the evidence for the existence of Palæozoic members of the latter family. Some of the Carboniferous specimens, such as *Pterophyllum Fayoli*, Ren. and Zeill., have, he thinks, a strong claim to be regarded as Cycadean plants. Among the beautiful fronds from the Wealden figured in this book, many, and notably those referred to *Cycadites* and *Dioonites*, show a striking similarity to the leaves of recent genera. As regards *Cycadites*, the author indicates certain sources of error in determining whether the pinna has a single vein, the most critical point in determining the relation to the genus *Cycas*. No one can doubt the Cycadean *affinities* of the fronds and stems described here (with the exception of such doubtful genera as *Nilssonia* and *Anomozamites*). The difficulty is that fructifications are rare, and those which we know best (*Bennettites*) are quite different from any flowers of recent Cycads. Thus, we can never say for certain whether a given fossil, with Cycadean habit, really belonged to the family Cycadaceæ, in the comparatively narrow sense of recent Botany, or to the Bennettiteæ, a related, but perfectly distinct group.

The author recognizes scarcely any characteristic Cycadean fructifications among the specimens examined by him. So doubtful is he about forms hitherto referred to *Cycadeostrobus*, that he revives Sternberg's old genus *Conites* for their reception, thus avoiding any expression of opinion as to their true position. The only example of a true Cycadean fructification described is *Androstrobus Nathorstii*, sp. nov., which bears much resemblance to a male flower of this family, and in some specimens shows with great clearness the scars of numerous pollen-sacs on the lower surface of the scales.

Among stems of Cycadean habit, a new species of *Fittonia* is described, with the leaf-bases remarkably well preserved. The author regards certain Wealden stems formerly referred to *Dracæna* as being much more probably Cycadean, and points out their resemblance to some species of *Zamia*. He finds no evidence for the existence of Monocotyledons in the English Wealden.

A full account is given of that most interesting of all Mesozoic genera, *Bennettites*, which the author identifies with *Williamsonia*. The internal structure of the fructification of this extraordinary plant, which, to a certain extent, combines Cycadean with Angiospermous characters, is now well known owing to the classical researches of Carruthers and Solms-Laubach, and, more recently, those of Lignier. The author describes some very interesting specimens from the Wealden, which he refers to another species, *B. Carruthersi*.

The internal structure is not preserved, but the habit of the fruit is excellently shown, as the plates testify. The author's careful comparison with the more completely known species leaves no doubt as to the essential identity of structure.

Mr. Seward considers that we are still without any very satisfactory evidence as to the nature of the male inflorescence, all the well-investigated specimens being apparently female.

The author founds a new genus (*Withamia*) for a remarkable fossil, much resembling the *Cycadorachis* of Saporta. He shows that there is no real similarity to the rachis of any Cycad, and defines the new genus as follows: "A woody axis bearing two rows of spiny appendages, in the axils of which are borne flat leaf-like appendages." There is at present no clue to the affinities; the comparison with *Phyllocladus* is perhaps as instructive as any.

Mr. Seward says that, "as a general rule, fossil Conifers are perhaps the most unsatisfactory plants with which the palæobotanist has to deal." Consequently he treats the fossils referred to this order with special caution, though he has some beautiful specimens to record. So far as the remains justify any definite conclusion, it would appear that the principal tribes of the order were already developed in the Wealden epoch; Araucarieæ, Abietineæ, Taxodineæ, Cupressineæ, and Podocarpeæ all have fairly accredited representatives. A new species, *Pinites Solmsi*, is founded on excellent fertile specimens, which strongly suggest the recent genus, though neither the exact morphology of the cone nor the insertion of the leaves can be determined with certainty.

Brachyphyllum spinosum, sp. nov., with its great rhomboidal leaf-scars and spinose branches, is a most striking plant, which we would gladly know more about.

In his concluding remarks the author says (p. 240): "Looking at the Wealden plants collectively, we notice a very striking agreement with the flora of the underlying Jurassic strata, and it would be difficult to point to any well-marked or essential difference between the plant-life of the two periods. The evidence of palæobotany certainly favours the inclusion of the Wealden rocks in the Jurassic series."

Both the author and the Museum are to be warmly congratulated on the completion of this book. If all writers on fossil botany had shown the same sound and cautious judgment which characterizes Mr. Seward's work, the subject would now be in a much more advanced position than it is.

D. H. S. Scott

III.—Memoirs of the Geological Survey of the United Kingdom. "The Jurassic Rocks of Britain. Vol. V: The Middle and Upper Oolitic Rocks of England (Yorkshire excepted)." By Horace B. Woodward, F.G.S. 8vo, pp. xiv and 499; 145 Figures and Map. London: Dulau & Co., 1895.

The previous volumes of this important work have from time to time been noticed in the Geological Magazine, and we now have to congratulate Mr. Woodward on the appearance of the fifth volume, which completes the Memoir on the Jurassic Rocks of England. The Survey, however, promise us a concluding volume, relating to the Jurassic Rocks of Scotland and Ireland, after those of Scotland have been mapped in detail.

As in the previous volumes, Mr. Woodward avails himself largely of the published observations of other workers in the same field, and he has also received considerable assistance at various times from local geologists. All these are duly acknowledged. The fossils collected during the progress of his work have been named by Messrs. Sharman and Newton, whilst Mr. Teall has examined and described microscopic sections of the rocks.

The Upper Jurassic (Middle and Upper Oolites) in this country is essentially a pelolithic deposit, which in the East Midlands is scarcely relieved by any shelly limestones; whilst in the West Midland and Southern Counties two great calcareous deposits (Corallian and Portlandian), each supported on an arenaceous base, serve to relieve the monotony of these extensive clay formations.

As regards the uppermost limits of the system, Mr. Woodward observes that the general relationship between the Purbeck and Wealden strata has led many geologists to group them together. He also considers that the local evidence would not justify us in parting them, and it is only on wider grounds that the division between Jurassic and Cretaceous is taken between the two. Thus, he says, "We may be content to allow the claims of general convenience and of palæontological succession established in Europe to rule the limits of our principal chronological systems."

However, he goes on to say that as regards the several subdivisions the case is different; such formations must be based on their stratigraphical features, and he justly insists on the importance of maintaining the original divisions of our strata as taken from the typical localities. The following general arrangement is adopted:—

Upper Oolites.	Purbeckian	Upper Purbeck Beds Middle Purbeck Beds Lower Purbeck Beds	Spilsby Sandstone.
	Portlandian	Upper Portland Beds. Lower Portland Beds and Hartwell Clay.	
	Kimeridgian.	Kimeridge Clay.	
Middle Oolites.	Corallian	Coral Rag and Coralline Oolite Calcareous Grit	Upware Limestone and Ampthill Clay.
	Oxfordian	Oxford Clay. Kellaways Beds.	

Oxfordian.—The author recognizes three palæontological horizons in descending order, viz.: *Ammonites cordatus*, *Am. ornatus* (perhaps a generalized term), and *Am. Calloviensis*. He gives a useful summary, and many details are now for the first time published. As a rule, Oxfordian beds, south of the Humber, do not afford many prominent features, so that their lithology and palæontology must be worked out, for the most part, in brickyards, well-sections, and railway-cuttings. It was a grand time for collectors when the *ornatus*-clays of Christian Malford were cut through in making the Great Western Railway.

For many years subsequently little was added to our knowledge of the Oxford Clay. But latterly the subject has again attracted attention. The author and his colleagues, for instance, have carefully investigated the strata at Kellaways itself. Moreover, the well-sinking at Swindon added largely to our knowledge of Oxfordian beds. This operation was watched and reported upon by the author and Mr. E. T. Newton, with very complete results. To the *cordatus*-zone was assigned 288 ft., to the *ornatus*-zone 220 ft., and to the *Calloviensis*-zone 62 ft. The evidence agrees with that furnished in other localities, that the Kellaways Rock is but an irregular and sandy, impersistent bed towards the base of the Oxford Clay, locally fossiliferous. The tendency to form great doggers on this horizon in certain localities is well exhibited in a railway-cutting near Cirencester. The total thickness assigned to the Oxfordian beds at Swindon is 572 ft., being considerably in excess of Prof. Prestwich's estimate of 300 ft. at Oxford.

Passing on to the East Midlands, Mr. Woodward has had the advantage of being able to consult Judd's "Geology of Rutland," as well as the works of the late Thos. Roberts, who possessed a most accurate and extensive knowledge of the fossils of the Upper Jurassic clays. Several other members of the Survey have also contributed of late years to our knowledge of Oxfordian beds in Lincolnshire.

Corallian.—It is not a little singular that the term "Corallian," which, strictly speaking, is of French origin, should in some quarters be falling into disuse in that country, and that "Rauracien" and "Sequanien" more or less occupy its place. However, in England the term is exceedingly applicable for the variable series of strata that occur between the Oxford and Kimeridge Clays. Messrs. Blake and Hudleston supplemented the work of the older writers on this formation, and Mr. Woodward has in many cases adopted their local stratigraphical divisions. His general grouping is as follows:—

Upper Corallian	Upper Calcareous Grit, Upper Coral Rag and Ironstone, Coral Rag, and Coralline Oolite	Zone of *Ammonites plicatilis.*
Lower Corallian	Lower Calcareous Grit	Zone of *Ammonites perarmatus.*

This arrangement differs from the original Survey mapping of the strata from Dorsetshire to Berkshire, where a tripartite division was maintained, the highest beds being called "Upper Calcareous Grit"—a name borrowed from Yorkshire. Certainly, the highest Corallian beds in Dorsetshire, and to a less extent in Wiltshire, present marked peculiarities, such as extensive ferrugination, in some cases amounting to an iron-ore. Moreover, the fauna is peculiar, though this is to some extent due to physical differences. Hence these beds are in a certain sense Kimeridgian, and it is just possible that the Abbotsbury Ironstone is on the horizon of the "Pterocerian" beds, though the *Pteroceras*-fauna is wanting in this country.

There can be no doubt that the Corallian series as developed at Weymouth and Osmington presents many attractions, both to the stratigraphist and the collector. It is so varied, so accessible, and so fossiliferous, and there are such excellent sections on the coast, that the geologist is invited, as it were, to bring out his hammer, his compass, and his tape, and try what he can make of the exposures. The very fact of the whole series occurring in duplicate, *i.e.* on either side of the Weymouth anticline, renders the study of these rocks all the more interesting. Mr. Woodward's measurements differ somewhat from those of Blake and Hudleston, but in all other respects he confirms their work. An ample list of fossils from the Corallian rocks near Weymouth, including the Abbotsbury iron-ore, concludes this part of the subject.

Full details of the Corallian beds are given as they are traced towards the north-east, until their final disappearance in a distinct lithological form in Oxfordshire. The subject of the Ampthill Clay may detain us for a moment. Although this argillaceous equivalent of Corallian beds was first indicated by Prof. Seeley, it is to the labours of the late Thomas Roberts that we owe most of our knowledge of its contents. The subject, like that of all Fen clays, is a difficult one, and distasteful to many; but Roberts' singular knowledge of Upper Jurassic fossils enabled him to grapple with it successfully, and the readers of the Quarterly Journal may remember that he ventured to map this Corallian clay in Cambridgeshire and Lincolnshire.

Kimeridge Clay (*Kimeridgian*).—The term "Kimeridge strata," we are told, was employed in 1812 by Thomas Webster, and in 1818 the term "Kimeridge Clay" was used by Buckland. In England the beds of this age are mainly clays. When we bear in mind that this formation varies in thickness from 1200 feet in the great Kimeridgian trough of the south of England to less than 100 feet in the neighbourhood of Oxford, and that it includes a variety of zones recognized on the Continent, some based on Cephalopoda and others on different orders of Mollusca, it must be admitted that an author in Mr. Woodward's situation has unusual difficulties to contend with. There is even a further trouble, viz. how to distinguish between Kimeridgian clays and Portlandian clays, in cases such as Hartwell, where no lithological indications of a separation between the two present themselves. To show such a Portlandian clay on a map would be next to impossible: indeed, the only place in England where a palpable Portlandian clay is clearly separated from the Kimeridge Clay by beds whose fauna and lithology are distinct, occurs at Swindon.

Agreeing with Prof. Blake that there is no need in this country to divide the Kimeridge Clay into more than two zones for general stratigraphical purposes, Mr. Woodward adopts the following arrangement (see table on page 133) :—

It has generally been considered that the Lower Kimeridge of Dorsetshire represents in the main the "Virgulien" of foreign authors, and casts of *Ex. virgula* are said to have been found as low down as the Abbotsbury iron-ore. But Mr. Woodward finds this fossil, together with *Am. longispinus*, also in the Upper beds. These latter, between 600 and 700 feet thick in some places, are exceptionally developed in Kimeridge Bay and throughout the Isle of Purbeck, where the dark bituminous and paper shales of Chapman's Pool, etc., charged with *Lucina minuscula* and *Discina latissima*, are of immense thickness. The most curious feature of the whole is that, although there is a complete sequence between these clays and the Portland beds of St. Albans Head, yet the so-called Middle Portlandian fauna of Swindon and Hartwell has not yet been discovered in that locality.

Kimeridge Clay.

Zones.	Subzones.
Am. biplex.	*Discina latissima.*
	Exogyra virgula.
Am. alternans.	*Ostrea deltoidea.*

Away from the coast we are mainly dependent upon brickyards, etc., for our knowledge of the Kimeridge Clay, so that the divisions cannot be made out with certainty in all places. Of course it is obvious that the fauna of Hartwell, for instance, differs entirely from that of Ringstead Bay, although for purposes of mapping both are included in the Kimeridge Clay. We quite agree with the author that "it is not possible to be consistent in all our dealings with these formations without detailed and long-continued hunting for fossils." Even then much remains to be explained.

In the East Midlands the observations of Blake have been supplemented by those of Roberts, and it is to the palæontological researches of these writers that we are indebted for most of our knowledge of the Kimeridge Clay in the counties of Cambridge, Norfolk, and Lincoln. In the Isle of Ely, Roberts recognized 15 ft. of Upper Kimeridge with *Discina latissima* and *Exogyra virgula*, and 80 ft. of Lower Kimeridge with *Ammonites alternans*, *Astarte supracorallina*, and *Ostrea deltoidea*. It is noteworthy that here *Exogyra virgula* is regarded as an Upper Kimeridge form.

Portland Beds (*Portlandian*).—Declining to accept the term "Bolonian" for any of these beds, Mr. Woodward adopts the following grouping:—

Upper Portland Beds	Portland, Tisbury, and Swindon Stones.
Lower Portland Beds	Portland Sand, Swindon and Hartwell Clays.

He further remarks that the zones of the Portland beds most generally adopted are those of *Am. giganteus* and *Am. gigas*, the leading fossils of each, some of them being taken to indicate subzones, being mentioned. Owing to the earlier incoming of "Portlandian conditions" in some parts of the Continent, we consider that the beds so identified are partially homotaxial rather than synchronous; this is particularly well seen in the case of certain *Trigoniæ* and other characteristic shells of the more estuarine beds. The zone of *Am. gigas* in this country is a conventional one, and if we must have an Ammonite to represent the *Astarte Sæmanni*-beds of Swindon, *Am. pectinatus* would seem more appropriate.

The local details of the Portland beds vary greatly in the several districts; yet, notwithstanding certain differences in lateral development, these beds have been correlated by Prof. Blake. The building stones are not always on the same horizon; the main building stones of the Vale of Wardour, for instance, occupying a lower position than those of the Isle of Portland. The Isle of Purbeck presents us with the most massive development of Portland rocks, but they are less interesting from a palæontological point of view than those of Portland Isle and the Vale of Wardour, whilst the Upper Portland beds of Swindon are quite abnormal in their development. Again, a very distinct type of beds, smaller in volume but often richly fossiliferous, occurs in Buckinghamshire. It has always seemed to us that there are evidences of considerable wasting of Portland beds, very noticeable in the Isle of Purbeck and in the Vale of Wardour, before the Purbeck strata were laid down: these evidences Mr. Woodward seems inclined to minimize.

Purbeck Beds (*Purbeckian*).—These attracted the notice of geologists at an early period, so that there is a considerable literature on the subject. The present volume supplies us with a useful summary, besides including many details now for the first time published. The author, no doubt, rejoices that at length he is free from the necessity of recognizing Ammonite-zones, though, as he remarks, "our Purbeck strata may be equivalent to beds on the Continent with a marine fauna and grouped in the zone of *Am. transitorius*." In the Alpine region we may regard them as corresponding in the main with the Upper Tithonian, whilst in the north-east of England "they may be in part equivalent to the zone of *Belemnites lateralis* of the Spilsby Sandstone and Speeton beds." This latter correlation was indicated by Pavlow, and seems a very reasonable supposition.

The chief points of a controversial character in connection with the Purbecks are: (1) the exact nature of their relationship to the underlying Portlands, and (2) where to draw the line between Jurassic and Cretaceous in the great fresh-water series, which, in this country, occupies an episodal interval between the marine beds of these two great systems. On this latter point the correlation of the Purbeck beds of the English Channel with those of other localities opens up some interesting questions. This is especially the case as regards the Vale of Wardour, where Messrs. Woodward and Strahan demur to the conclusions of Messrs. Andrews and Jukes-Browne to the effect that strata hitherto regarded as Wealden should be classed with the Upper Purbeck.

Not the least interesting portion of the volume is that relating to the "underground" Oolitic rocks, whose existence has been indicated of late years over a considerable area by boring operations. In the map forming the frontispiece is shown the area occupied by Oolitic rocks which are directly covered by Neocomian or Cretaceous beds, whilst certain areas are left uncoloured where it is probable that Palæozoic rocks directly underlie the post-Jurassic strata. If the author be correct in his delineations, the area of "underground" Oolitic rocks fully equals, if it does not exceed, the outcrop. The Purbeck beds of Battle are indicated, we presume, on the map by three little inliers, whose total outcrop must be very small. Many diagrammatic sections also illustrate this portion of the work.

As regards illustrations generally, this volume is not more fortunate than its predecessors in the series. The figures of fossils are numerous, and, on the whole, fairly characteristic, but in some cases they are indistinctly printed, and the same may be said of many of the sections. But the rendering of several of the photographs is positively disastrous: such cuts as Figs. 80, 92, and 102 are mere smudges, and there are others almost as bad.[1] On the other hand, the "Fossil elephant" at Portisham comes out pretty well. We may feel sure that these shortcomings are not due to any fault on the part of the photographers; can it be that such unhappy results are owing to the parsimony of the "Lords Commissioners of Her Majesty's Treasury"?

In all other respects the volume is most satisfactory. The scenery, economic products, and water supply of the Middle and Upper Oolites come in for their share of attention. Exhaustive lists of fossils are given, and the promised bibliography of the Jurassic rocks of the British Isles is now published. Nothing has been omitted on the part of Mr. Woodward and his colleagues to render the "Jurassic Rocks of Great Britain" a work of the highest utility and importance. The author of this latest volume is especially to be congratulated on the accuracy of his observations, on the impartiality of his decisions, and on the many proofs which the work affords that he possesses a grasp of the subject such as constant application in the study and long experience in the field alone can give.

IV.—Fishes, Living and Fossil: an Outline of their Forms and Probable Relationships. By Bashford Dean, Ph.D. Pp. xiv, 300, with 344 Woodcuts and Frontispiece. New York and London: Macmillan & Co., 1895.

PALÆONTOLOGY is gradually beginning to occupy a prominent position in biological textbooks. Zoologists and botanists of the rising school are more and more convinced of the impossibility of arriving at the fundamental principles of the world of life merely by reference to its surviving representatives. To Dr. Bashford Dean, however, we are probably indebted for the boldest acknow-

[1] The Stationery Office has reprinted Figs. 80 and 92.—*Reviewer.*

ledgment that has hitherto been made of the prime importance of the succession of life in geological time in determining questions both of morphology and of classification. We have before us his new volume on fishes, just issued in the Columbia University Biological Series, which not merely associates the living and fossil forms in its title, but is permeated throughout with a philosophy which no amount of study of existing fishes would suggest. This is as it should be, and we are delighted to welcome a departure which is likely to be followed by many similar essays.

Ichthyology, of course, does not strictly fall within the province of our pages, but we are especially concerned with the palæontological basis on which it must rest; and readers of the GEOLOGICAL MAGAZINE will find many features of great interest in this latest contribution from the University, which the late Dr. Newberry's writings have made famous in the annals of Geology and Palæontology. We propose to review the work from the palæontological point of view, referring more particularly to the original matter which Dr. Dean himself has added to his summary of previous research.

A brief introductory chapter on the adaptation of fishes to life in a watery medium is followed by a table of classification closely resembling that adopted in the British Museum Catalogue of Fossil Fishes. Next comes a second table showing the distribution of fishes in geological time, mainly based on Zittel's well-known "Handbuch." In this, however, a few small errors have escaped correction, notably the extension backwards of the Acipenseroids and Lepidosteoids to the Upper Silurian, the Clupeoids to the Trias, and *Pristiophorus* to the Trias and Permian. Nor are any undoubted Arthrodira known above the lowest Carboniferous. In fact, in some of these respects the table does not agree with statements in the text further on.

After these preliminaries Dr. Dean considers the evolution of the structures characteristic of fishes, and again makes numerous references to the facts of palæontology in their bearing on the subject. This chapter is for the most part admirable and well up to date in every respect. besides containing important new facts concerning the fin-structures of the primitive Carboniferous shark, *Cladoselache*, to our knowledge of which Dr. Dean has already made several contributions. We have only minor faults to find with the author's treatment of the subject. The researches of Jaekel, for instance, now make it doubtful whether the Permian Pleuracanths had more than five branchial arches (p. 16). Fig. 33 (p. 39) represents a dorsal fin-spine of the Carboniferous *Lepracanthus*, not *Hybodus* as labelled. The spine marked R in the fin of *Parexus* (fig. 51) is a dermal structure not homologous with the cartilages similarly lettered in the accompanying figures; but here Dr. Dean appears to frame an hypothesis that cartilages are clustered in its interior. Finally, we have never observed the pineal foramen in *Ctenodus* and *Palædaphus* noticed on p. 55.

The Lampreys and their allies form the subject of chapter iii.

Here Dr. Dean definitely places the remarkable Devonian fossil *Palæospondylus Gunni,* which "seems undoubtedly a Lamprey." The Ostracoderms are also provisionally associated with these primitive vertebrate animals, and they are arranged in accordance with the British Museum Catalogue. Dr. Dean points out the close resemblance between the labial plates of *Pterichthys* and the form of the sides of the mouth in the Lamprey. He also makes the interesting announcement that from personal observation he considers the so-called paired fins of *Palæaspis* (Claypole) are "merely Elasmobranchian (Chimæroid?) spines, in crushed condition, accidentally associated with the head region of the fossil." The figures illustrating this section, however, are less satisfactory than they might have been. The restoration of *Pteraspis* does not show the strongly convex ventral shield; and the figures of *Pterichthys* do not exhibit the correct position of the labial plates or the large proportions of the caudal fin. There is also a misapprehension in the statement (p. 69) that the paired appendages of *Pterichthys* "are now known to be nothing more than the lateral head angles produced and specialized (*i.e.* jointed for locomotion)." The appendages in question never have any connection with the head-shield, but are fixed to a thickened part of the body-armour.

The sharks, as might be expected, are very fully treated from the palæontological aspect in chapter iv. The most important perhaps of all Palæozoic sharks, *Cladoselache,* from the Lower Carboniferous of Ohio, occupies the foremost place. All the known species of this shark are of relatively small size, varying in length from two to six feet. In general aspect it is much like a modern shark, with a small horizontal keel on each side at the base of the tail. In many ways, on the other hand, it is the most generalized of known sharks:—"Its paired fins are but the remnants of the lateral fold, serving as balancers; the tail, curiously specialized, is widely heterocercal, its hinder web lacking supports in the upper lobe; the vertebral axis is notochordal; and the writer now finds that an exceedingly simple condition existed in the neural and hæmal arches; they prove to be of moderate size and thickness, each a tapering rod of cartilage, forked at its base; each body segment contains a single neural and hæmal spine, closely alike in size. Unlike modern sharks, *Cladoselache* was without claspers: its eggs must have been fertilized after their deposition, as in the majority of fishes other than Elasmobranchs. The gill openings, at least seven (probably nine) in number, appear, as in the restoration, to have been shielded anteriorly by a dilated dermal flap. A spiracle was probably present. The jaws were slender, and apparently hyostylic; the teeth are of the pattern of shagreen denticles, but occur in clusters ('*Cladodus*'). The mouth was terminal in its position. The nasal capsule was apparently not connected with the mouth by a dermal flap. The eye was protected by several rings of rectangular plates, clearly shagreen-like in character. The integument was finely studded with minute lozenge-shaped denticles, and was everywhere lacking in membrane-bones. The lateral line retained its groove-like character."

Cladoselache is the type of a new order, Pleuropterygii, and that of Acanthodii immediately follows in Dr. Dean's classification. We do not agree with this association, but there is perhaps much reason for differences of opinion in the present state of knowledge of the endoskeleton of all these early Palæozoic fishes. We are, however, certain that in his amended restoration of *Acanthodes*, Dr. Dean has made the eye very much too small; and there is another unfortunate mistake in his emendation of Fritsch's figure of *Pleuracanthus*, where a large coprolite (specially noted by Fritsch) is made to do duty for the pelvic cartilage. From an examination of the original specimen, we are also convinced that the so-called "dermal bones of the head roof of *Pleuracanthus*," copied from Davis in fig. 90B, are merely an imaginative reconstruction of an indeterminable fossil, which may or may not be part of an Elasmobranch skeleton. The general results of modern research, however, are admirably summarized in the letterpress, and the general conclusion is arrived at that "of all known stems that of the shark is most nearly ancestral in the line of jaw-bearing vertebrates."

The chapter on Chimæroids is naturally brief, and contains no new matter; but there are two original restorations of the head of *Squaloraja* and *Myriacanthus* to show the position of the peculiar rostral spine. The fossil genera referred to the Dipnoi and the doubtfully distinct Arthrodira, are treated more from personal observation. There is a good new restoration of the Devonian Dipnoan *Dipterus*, another of *Phaneropleuron*; a modified restoration of *Coccosteus*, in which the upper dorsal fin-supports are made to form a slight lobe, while the tail is nearly diphycercal; an entirely new restoration of *Dinichthys* much on the plan of *Coccosteus*, and a page of sketches of the mandible of Arthrodira, from the Cleveland Shale of Ohio. The latter are particularly interesting as showing the remarkably varied modifications of the teeth in these old armoured fishes. *Mylostoma*, for instance, with loose grinding teeth, is now definitely proved to belong to this group, although most of the genera have either conical or shear-like teeth. On the whole Dr. Dean is inclined to believe that the Arthrodira differed more widely from the typical Dipnoi than did these from the ancient sharks. They may, he thinks, be ultimately regarded as worthy of rank as a class.

The Teleostomi seem to be less satisfactorily treated than the previous groups. This is probably due to their great numbers and innumerable variations. They are subdivided into Crossopterygii and Actinopterygii, and Dr. Dean admits that the former may have been ancestral, not only to the latter, but also to the Dipnoi. A slightly amended restoration of *Holoptychius* is given, and there is a copy of Whiteaves' restoration of *Eusthenopteron*; but the other two figures illustrating the more primitive Crossopterygians are unfortunately Pander's restorations of *Gyroptychius* and *Osteolepis*, which modern researches have proved to be in many respects inaccurate. There is also the first attempt at a restoration of *Cœlacanthus*, based on the fine specimens from the Coal-measures of Ohio; and another less satisfactory restoration is given of *Diplurus*, from the Trias of New Jersey. The Actinopterygians are merely subdivided into the Chondrosteans (Ganoids) and the Teleocephali (Teleosts), an arrangement scarcely adequate to our present knowledge of the subject. Of Mesozoic Actinopterygians good figures are copied from Traquair and Zittel, but the series is spoiled by the insertion of three very erroneous early attempts by Agassiz to show the principal features of *Rhabdolepis macropterus*, *Caturus furcatus*, and *Leptolepis sprattiformis*. The last two figures, as also those by Pander, are wrongly ascribed to the writer of this review. So little is known of the ancestry of the groups of true bony fishes, that Dr. Dean makes little or no reference to the fossil forms, merely attempting a theoretical diagram to illustrate their evolution. The final chapter of the book, however, shows that the extinct forms must be relied upon almost entirely to determine this evolution; for, in treating of the development of fishes, the author particularly emphasizes the fact that their embryology seems to afford scarcely any clue to the solution of problems of descent. The latest results from the study of the embryos of many groups are all, indeed, very inconclusive, and most of them are not even suggestive. As Dr. Dean remarks, "adaptive characters have entered so largely into the plan of the development of fishes, that they obscure many of the features which might otherwise be made of value for comparison."

The work concludes with an extremely useful and carefully prepared bibliography, a list of derivations of proper names, and a number of diagrams and tables of fish anatomy, to show at a glance the differences between one group and another. It is a volume indispensable to all who desire a general acquaintance with the subject of which it treats, and students are much indebted to the author for having furnished them for the first time with a thoroughly up-to-date handbook.

A. Smith Woodward.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 5th, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Morte Slates and Associated Beds in North Devon and West Somerset.—Part I." By Henry Hicks, M.D., F.R.S., F.G.S.

In a paper read before the Society in 1890 the author stated that he had found the Morte Slates to be fossiliferous, and had come to the conclusion that they were the oldest rocks in the North Devon area, and had been thrust over much newer rocks, producing a deceptive appearance of conformity; and that there was not a continuous upward succession in the rocks from the Bristol Channel to the neighbourhood of Barnstaple. Since that paper was read, the author has obtained much additional evidence bearing on the succession, which is given in the present paper so far as the position and age of the Morte Slates in the Ilfracombe area are concerned.

The author describes the lithological characters and fossil contents of the Morte Slates, and their relationship to the Pickwell Down Sandstones and Ilfracombe Beds, treating of the development of the rocks in four areas, viz.: Morthoe and Woolacombe to Bittadon; Rockham Bay, Bull Point, Lee, and Slade; Mullacott, Shelfin, and Ilfracombe; and Woolscott Barton, Smithson, and Berry Down. The great abundance of detrital mica in the Ilfracombe Beds and Pickwell Down group, and its almost entire absence from the Morte Slates, are noticed. The faulted junction of the Pickwell Down Sandstones and Morte Slates is described, and it is held that the faulting has not thrust older beds over newer, as maintained by Jukes, but that the order of succession is the original one, whereas the overthrust fault separates the Morte Slates from the now underlying though newer Ilfracombe Beds, which often dip away from the Morte Slates, while different members of the Ilfracombe series abut against the Morte Slates, so that the latter form a complex group of older rocks bounded on either side by newer strata. The author states that the fossils found in the Morte Slates belong to several horizons, some probably as low in position as the base of the Silurian (Upper Silurian of the Geological Surveyors), while none of the beds of the series appear to be newer than the older Devonian. In some places newer rocks may occur amongst them as the result of faulting or unconformity, but not in order of succession.

A description of the species found in the Slates is appended to the paper.

2. "Evidences of Glacial Action in Australia in Permo-Carboniferous Time." By Prof. T. W. Edgeworth David, B.A., F.G.S.

The author, after summarizing the work of previous observers, gives an account of recent observations made by himself.

In Hallett's Cove, near Adelaide, the pre-Cambrian rocks are strongly glaciated, striæ being seen when the overlying glacial beds are removed, as sharply cut as though caused by recent glacial action, and trending nearly north and south, the ice having come from the south. The overlying glacial beds are in places fairly stratified, while parts contain abundance of well-striated boulders: these beds are from 23 to over 100 feet thick. Proofs were obtained that in this case the glaciation occurred in an age intermediate between Miocene and pre-Cambrian, and probably did not antedate the close of the Palæozoic period.

In Wild Duck Creek, near Heathcote, Lower Silurian (Ordovician) beds exhibit strongly-grooved, polished surfaces, the grooves being from S. 5° E. to N. 5° W., the ice probably having come from the south. They are succeeded by Permo-Carboniferous glacial beds, consisting chiefly of mudstones with well-glaciated boulders.

At Bacchus Marsh, Ordovician beds are also well striated and polished, and more or less *moutonnée*. Here also the ice came from a southerly point. These beds are succeeded by Permo-Carboniferous glacial beds having an approximate thickness of at least 2000 feet, consisting of mudstones with well-glaciated boulders.

It is extremely probable that the glacial beds of Bacchus Marsh, Wild Duck Creek, and Springhurst in Victoria were of homotaxial if not contemporaneous origin, and they may probably be correlated with the glacial conglomerates at Mount Reid in Tasmania, these correlations being mainly based on lithological evidence. The evidence for the correlation of the Bacchus Marsh glacial beds with the erratic-bearing Permo-Carboniferous mudstones of Maria Island, One Tree Point, and Bruni Island in Tasmania, of Maitland, Branxton, and Grasstree in N.S. Wales, and of the Bower River coalfields in Queensland, is that the genus *Gangamopteris* is distributed somewhat abundantly throughout the formations in all these localities.

This glaciation was probably homotaxial with that of the period of the Dwyka Conglomerate and Ecca Beds of Southern Africa, and of the Talchir Group of the Salt Range of India, the Boulder Beds in Western Rajputana, and the Panjáh Conglomerates of Kashmir. In the case of Southern Africa and India, as in that of Australia, the general direction in which the ice moved appears to have been from south to north. In the Bacchus Marsh beds there are at least nine or ten distinct boulder-beds separated by sandstones and conglomerates; this may possibly indicate a sequence of glacial periods separated by milder interglacial periods. The glacial conditions in Australia may have been prolonged into early Mesozoic times, as indicated by the Mesozoic facies of certain plants in the uppermost glacial beds of Bacchus Marsh.

Royal Physical Society of Edinburgh.

February 19th, 1896.—Prof. Struthers, M.D., LL.D., in the Chair.

Mr. J. S. Flett, M.B., B.Sc., read a paper on his "Discovery in Orkney of the John o' Groat's Horizon of the Old Red Sandstone." The strata examined and described in this paper were in the parish of Deerness, on the mainland of Orkney, and from them he had obtained *Microbrachius Dicki* (Peach), *Dipterus macropterus*, Traq., and *Tristichopterus alatus*, Egert., species which had hitherto been found only in the John o' Groat's beds in the north-east of Caithness. The identification of these fishes was confirmed by Dr. Traquair, to whom Mr. Flett had submitted his specimens for examination.

Geologists' Association.—At the Annual Meeting of the Association, held on Feb. 7th, 1896, Mr. E. T. Newton, F.R.S., was elected President, and Mr. H. W. Monckton was elected Excursion Secretary in the room of Mr. T. Leighton, who for a number of years has filled that arduous office with great success. The retiring President, Lieut.-General C. A. McMahon, read an address on "Some Structural Characteristics of the Granite of the N.W. Himalayas," illustrated by numerous lantern-slides.

CORRESPONDENCE.

HEIGHTS OF CHALK.

Sir,—I am glad that Mr. Lamplugh has corrected me as to the greatest height of the northern Chalk. Garrowby Hill seems to lie near the edge of the elevated area; in going over the sheets of the Ordnance Map I had not noticed its exceptional height; I have never been in that part of the district.

Besides this correction another has to be made. I wrote: "Mr. Deeley tells us that Chalk-drift is found in Leicestershire up to 800 feet." But his actual words are:[1] "At Tilton, one of the highest points in East Leicestershire"; he makes no definite statement of height. The ground at Tilton rises to 700 feet; the figures 800 are a slip of my own memory. So I have not only made an incorrect statement, but made Mr. Deeley seem responsible for it.

January 24th, 1896. E. Hill.

ON THE APPENDAGES OF TRILOBITES.

Sir,—At the present time, when the important researches on the structure of Trilobites, recorded of late years, have highly excited the interest of palæontologists upon this subject, I hope you will permit me to call attention to an observation on the antennæ of these fossils made by Linnæus upwards a hundred and forty years ago, and, as far as I know, never referred to. In the Proceedings of the Swedish Academy of Science ("Svenska Vetenskaps-academiens Handlingar"), vol. xx, issued in 1759, Linnæus communicated an article entitled "Petrificatet Entomolithus paradoxus, sådant, som det finnes uti Hans Excellence Riks-Rådets Högoälborne Herr Grefve C. G. Tessins Samling." A specimen of *Parabolina spinulosa*, Wahlenb., is there figured, tab. i, fig. 1, showing one pair of antennæ at their true place; and from the accompanying description it appears that the author attached due importance to the presence of these organs. His words relative to them (pp. 21, 22) run thus, translated into English: "Fig. 1 is one of the clearest specimens I ever saw among so many thousands. Most remarkable in this specimen are the antennæ in the front, which I never saw in any other example, and which clearly prove this fossil to belong to the insects" (=Arthropoda). The specimen in question had been found by Dr. Tidström, and was shown to Linnæus, as seen above, by the Count C. G. Tessin. This reference to an old observation can by no means abate anything of the value of the brilliant discoveries of our days, but justice demands this discovery of Linnæus to be rescued from the oblivion into which it seems to have sunk.

Sv. Leonk. Törnquist.

Lund (Sweden), *February*, 1896.

[1] Quart. Journ. Geol. Soc., vol. xlii, p. 463.

THE NAMING OF NEW SPECIES.

SIR,—Has not Mr. Bather made a slip in the construction of the specific name for the new Crinoid described in your February Number? If he means to connect it with the county of Shropshire, as having been found on Salopian soil, surely the name should be *Merocrinus Salopicus*, just as we have *Megaceros Hibernicus*. *M. Salopiensis* would not, I think, be incorrect, but *M. Salopiæ* means that it is named after some fair nymph or lady of the name of Salopia.

I am glad that Mr. Bather preferred to associate the fossil with the district in which it was found rather than to pay its finder the doubtful compliment of naming it after him; and I would take the present opportunity of pointing out to those who feel compelled to associate a man's name with any new species they have to describe, that the adjectival form of a proper name is not only more correct, but is generally much more euphonious. Thus, if it is desired to commemorate someone of the name of Jones, *Jonesianus* is much better than *Jonesii*; and if the name were Bell, *Bellinus* would pass, while everyone would shrink from *Bellii* or *Belli*.

For my own part, I made a vow long ago that I would never attach a man's name to a new species, and I have kept it.

TEIGNMOUTH, *February* 6*th*, 1896. A. J. JUKES-BROWNE.

OBITUARY.

SEKIYA SEIKEI.

BORN IN 1855. DIED JANUARY 9TH, 1896.

ALL who are interested in volcanic and seismic phenomena will learn with regret that on January 9th, after an illness the first symptoms of which showed themselves in 1876, Professor S. Sekiya breathed his last. He was born in 1855, the year of the Ansei earthquake which devastated the Tokio plain. His attention was first directed to the serious study of earthquakes about 1880, and in 1886 he was appointed to the newly created Chair of Seismology in the Imperial University of Japan. Although he wrote much in Japanese, his publications in English, which for the most part appeared in the Science Journal of his own College and in the Transactions of the Seismological Society, in themselves testify to his industry and ability. The construction of a model to show the motion of an earth particle at the time of an earthquake is an indication of his originality and ingenuity. By his influence and persuasive power he did much towards the distribution of seismographs throughout his own country, and the extension of a seismic survey which at the time of his death boasted of no less than 968 stations at which earth shakings are recorded.

One thing in which he was interested, and in which he took part, were experiments to determine forms of construction most suitable for earthquake districts; and although he did not live to see the ultimate results of these investigations, he saw that earthquake effects had already been diminished and that in future the loss of life and property would be further minimized.

His kindly disposition made him the friend of all who had the pleasure of his acquaintance, whilst the straightforward manner in which he never failed to express his ideas gained their admiration.

J. M.

MISCELLANEOUS.

A Glossary of the names of geological formations (*Piani e sotto-piani in Geologia*: Calabria, 1895) has been compiled by Signor U. Botti. It includes such terms as Albien, Algonkian, Sequanien, Toarcien, etc. In the preparation of his work the writer consulted a number of publications, but he seems mainly indebted to the "Tableau des terrains" of Mayer Eymar. We thus have a number of terms which have been formulated or modified by that particular author, but have never (or hardly ever) been used in geological literature: *e.g.* Bagshotin, Dartmouthian, Davidsin, (for St. David's beds—? meant for Davidsian), Llamberison (? Llanberisian), Llandeilian, Londinien, etc. We also make acquaintance with Anteparadoxidien, Bégudien, Boomin, Carcassien, Coutchiching, Dellysien, Devillien, Eobiotic, Falaisin, Frigidiano, Hydroplastic, Mibiélin, Nervien, Nicéen, Psychozoic, Etage de Sötern, Spanweton, Stampien, and Virgloriano—names which we give according to the spelling of Signor Botti. The work, though far from complete, will be useful to those who are perplexed about the meanings of some of the numerous terms of modern days: it will be useful also to those who are given to naming formations or groups of strata, as it may help them to avoid using a term already occupied. Thus we learn that the term Georgian (from Georgia) was introduced by Walcott in 1891, for the Lower Cambrian *Olenellus*-beds; but we may inform the writer of the Glossary that the term Georgian (from the districts bordering St. George's Channel) was suggested in 1885, by Dr. Hicks, for the rocks usually grouped as Cambrian.[1]

Svenska Växtvärldens Historia i korthet Framställd, af Gunnar Andersson. 8vo, pp. 106, 1 Map and 53 Figs. in the text. Stockholm: P. A. Norstedt and Sons.—Though this little book deals largely with the recent distribution of plants in Sweden, so much space is devoted to the past history of the flora, as preserved in peat-mosses, clays, and travertines, that it should not be overlooked by geologists. Dr. Andersson has done such excellent work in collecting and studying the fossil plants of Sweden, that we are glad to see his and Prof. Nathorst's leading results embodied in a truly scientific history of the origin of the Swedish flora. The author, being equally at home with the recent and fossil plants of Sweden, can trace the influence of bygone climatic changes, and can give interesting illustrations of the past and present distribution of certain of the species.

[1] Geol. Mag., Dec. III, Vol. II, p. 359.

THE

GEOLOGICAL MAGAZINE.

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No. IV.—APRIL, 1896.

ORIGINAL ARTICLES.

I.—Note on the Pelvis of *Cryptoclidus Oxoniensis* (Phillips).

By C. W. Andrews, B.A., B.Sc., F.G.S.,
Assistant in the British Museum (Natural History).

AMONG the Plesiosaurian remains recently mounted for exhibition in the Reptile Gallery at the Natural History Museum is a very fine pelvic-girdle belonging to a species of the genus *Cryptoclidus* (Seeley), and forming part of the same skeleton (Leeds Coll., R. 2616) as the pectoral-girdle recently described and figured by the present writer.[1] These specimens are perhaps the most perfect known, the bones being quite uncrushed, free from matrix, and, except that they are cracked and broken to a slight degree, in much the same condition as if they had been obtained by maceration from a recent reptile. They clearly belonged to an old individual in which ossification had nearly reached its maximum: this is shown (1) by the complete union of the coracoid and scapula with one another in the middle line closing the coraco-scapular foramen; (2) by the sharpness of some of the edges of the bones, *e.g.* of part of the anterior border of the pubis; (3) by the great solidity of the bones, and by the accuracy with which the pectoral and pelvic elements fit together to form the glenoid and acetabular cavities respectively, showing that the cartilage which separates them in the young animal had been ossified.

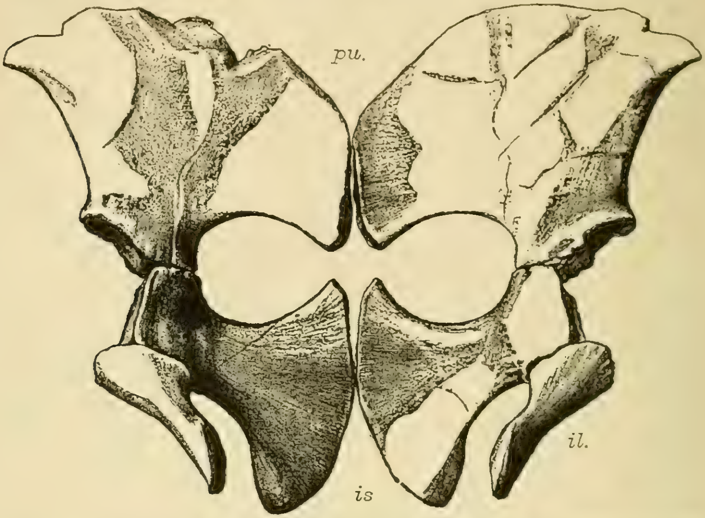
A mounted pelvis of *Murænosaurus* has been already described and figured,[2] and if the present specimen be compared with it, it will be seen that the differences between the two genera in this part of the skeleton are considerable. Some of the more important of these differences are pointed out below.

Pubis.—The pubis is proportionately much wider from side to side and shorter from before backwards than that of *Murænosaurus*. Its anterior convex border is thin, except near the outer angle, where it is thickened and produced into a short stout process, which is

[1] "On the Development of the Shoulder-girdle of a Plesiosaur (*Cryptoclidus Oxoniensis*, Phillips, sp.) from the Oxford Clay": Ann. Mag. Nat. Hist., ser. 6, vol. xv (1895), pp. 335–40, figs. 1 and 2.

[2] "On the Pectoral and Pelvic Girdles of *Murænosaurus plicatus*": Ann. Mag. Nat. Hist., ser. 6, vol. xvi (1895), pp. 432–4, figs. 2 and 3.

separated from the inner portion by a notch. This process is also present in *Muraenosaurus*, in which, however, it is much less prominent and does not stand out beyond the level of the acetabulum to nearly the same extent; it appears to be homologous with the lateral pubic process (ectopubis of Baur) of the chelonian pubis.



Pelvis of *Cryptoclidus oxoniensis* (Phillips) from above, from the Oxford Clay, Fletton, near Peterborough. *pu.* pubis; *is.* ischium; *il.* ilium. One-seventh natural size.

The symphysial surface is much shorter than in *Muraenosaurus*, but at the same time much deeper. It is spindle-shaped, about 16 cm. long and 6 deep, the bone being very thick at this point. The curvature of the symphysial border shows that the two pubes were only in actual contact (if at all) at one point, in front of and behind which they were separated by wedges of cartilage. The anterior cartilage (epipubic) was probably small and continuous with that fringing the anterior border; while the posterior was thick and no doubt continuous with that between the anterior ends of the ischia, which were separated from the pubes by an interval of about 2 cm. This median bar of cartilage, which divided the *foramina obturatoria* and most likely persisted even in the oldest individuals, corresponds with the similarly situated cartilage (mesogastroid of Baur) in many chelonian pelves.

The concave posterior border thickens gradually from within outwards to the ischial surface. This latter is nearly semicircular, the diameter of the semicircle forming the line of division between it and the acetabular surface, the length of which from before backwards is about 8 cm.

Ischium.—The ischium is of the usual hatchet shape. The anterior portion of its median border is thick and bears a spindle-shaped surface for the cartilage of the symphysis; behind this the bone thins suddenly, thickening again towards the posterior angle. The two ischia were separated in front by cartilage which, as already mentioned, was probably continuous with that between the pubes; posteriorly there was, no doubt, a small "hypogastroid" cartilage.

The articular end of the ischium is extremely massive, measuring about 7 cm. in thickness at the acetabulum. As in *Muræenosaurus*, it bears three articular surfaces: of these, the anterior, for the pubis, is nearly semicircular; the median, forming the middle part of the acetabulum, is roughly rectangular, and measures 6 cm. from before backwards; the posterior, for the ilium, is about 5 cm. long, and looks backwards and only slightly upwards, the ilia being directed much more backwards than in *Muræenosaurus*.

The dimensions of the ischium are—

	cm.
Width from acetabulum to middle of symphysial surface	22
Length between the anterior and posterior inner angles	21
Width of neck at narrowest point	6·8
Circumference ,, ,, ,, ...	16

Ilium.—The ilium is a very stout, slightly curved rod of bone. Its lower end is greatly thickened, and is truncated by an oblique oval surface, the long diameter of which is 7·5 cm. in length; the short, 4·5 cm. The inner two-thirds of this nearly flat surface articulate with the iliac surface of the ischium, while the outer third forms the posterior wall of the acetabulum. The outer angle of the acetabular region is occupied by a small surface for cartilage, which probably capped this portion of the bone and was continuous with that lining the acetabulum. The middle of the ilium is contracted and is slightly oval in section. The upper portion is compressed and somewhat like the blade of an oar. The anterior border of this expanded region is thin and sharp, the posterior thick and rounded; its upper edge is curved and bears a surface for cartilage. The inner face of the upper portion of the ilium is flat and shows scarcely any trace of its union with the sacral ribs, to which it was probably only loosely attached by ligaments. The distance between the upper ends of the ilia is about 23 cm. The length of the ilium is 20 cm., the width of its upper end 6 cm., and the circumference of the shaft at the narrowest point about 11 cm. The lower end of the left ilium has been restored in plaster.

Looking at the pelvis as a whole, it will be seen that it presents some peculiar characters. The pubes and ischia of the opposite sides do not make a distinct angle with one another; on the contrary, their middle portions are almost in the same plane, and the visceral surface of the pelvis is only gently concave from side to side. This, combined with its great width, gives the whole pelvis a peculiar appearance of extreme shallowness and expansion. From before backwards the visceral surface is strongly convex, its highest point between the acetabula being only about 8·5 cm. below a straight line joining the middle points of the upper borders of those cavities. In front of and behind this point it slopes away towards the anterior and posterior borders of the pelvis.

Another point worthy of notice is the extreme backward slope of the ilia. This is so great, that if, when the ischia and pubes are resting on a plane surface, a line be drawn along the long axis of the ilium, it makes an angle of little more than 30° with that surface. In many lizards and chelonians the ilia are directed backwards to a considerable extent, but in none, as far as I am aware, to such a degree as this. It seems not improbable that in the living animal the ventral surface of the pelvis sloped downwards and forwards, so that the position of the ilia would be less oblique to the vertebral axis than might be supposed.

The causes of the peculiar structure of the acetabulum and of the great backward slope of the ilium must, no doubt, be sought in the mechanical conditions under which the animal existed, and although these conditions are too little known and too complex to permit of a complete solution of the problem, the following tentative explanation may be offered. It is generally admitted that the Plesiosaurs are descended from land reptiles, in which, of course, one of the chief functions of the skeleton would be to support the soft parts, and in the case of the pectoral and pelvic girdles to transmit the weight of the body to the supporting limbs: in this case the thrust on the heads of the humerus and femur is mainly a vertical one. When such an animal becomes wholly aquatic in its habits these conditions are completely changed. In the first place, the body is supported on all sides by the pressure of the water; in the second, the limbs no longer bear up the body weight, and if, as in the Plesiosaurs, they are used as paddles, there would be a nearly horizontal (forward) thrust of the heads of the humerus and femur at each stroke. In the case of the pelvic-girdle of the Plesiosaurs the result is exactly what, *a priori*, we should expect from such change of conditions. The upper end of the ilium is a fixed point (to the sacral vertebræ), about which the forward thrust of the femur would tend to produce rotation leading to the backward slope we have seen actually exists. In the next place, the same force would produce the elongation from before backwards of the acetabulum; and this elongation, together with the backward rotation of the ilium, seems to have led to the separation of the latter bone from the pubis, and the result is an elongated acetabulum constituted by the articular surfaces of the pubis, ischium, and ilium, arranged in a linear series from before backwards. As to the means by which this has been brought about, opinions will differ, but in any case it seems at least highly probable that the change in the conditions of life has resulted in the peculiarities above described. In this connection it is interesting to notice that among the Chelonia, certain of which show greater similarity to the Plesiosaurs in their pelvic-girdles than any other reptiles, the marine forms, such as *Chelone*, have backwardly directed ilia, while the exclusively terrestrial ones, such as *Testudo pardalis*, have those bones nearly vertical; in the fresh-water tortoises both types occur.

II.—The Mineral Springs of the Baden District (Switzerland).

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.C.S.

As is well known, there are in Switzerland a good many cold mineral, but very few powerful thermal springs,[1] a fact which is in a great measure due to the scarcity of the younger series of eruptive rocks, such as give rise to the abundant hot springs of Bohemia, the Taunus and Eiffel districts, Auvergne, the Pyrenees, and other localities possessing similar geological features.

The only really powerful and abundant thermal, but non-volcanic, springs in Switzerland are those of Pfävers (Ragatz) in the Rhine valley, of Louèche in the Rhone valley, and of Baden in the Limmat valley. At Pfävers, as at Louèche, the springs are confined to one locality, whilst the Baden district comprises, besides the springs of Baden proper, a whole cluster of different mineral springs, spread over an area of about ten square miles. It is this area which the writer has lately had an opportunity of examining.

At first sight, it seems remarkable that so great a number and variety of mineral springs should be met with in the Molasse formation, which, broadly speaking, constitutes the Subalpine hills east of the river Aare; but on closer examination, it is found that all those springs are situated along the same zone—to wit, at the base of an isolated Jurassic ridge which lies between the Jura range and the Central Alps, and, like these two mountain chains, was raised and folded in Miocene times. The Jurassic outcrop extends for about sixteen miles from the left bank of the river Aare, near Aarau, to about seven miles beyond Baden, its strike being south-west to north-east, that is, in the main parallel to the strike of the Jura and the Central Alps.

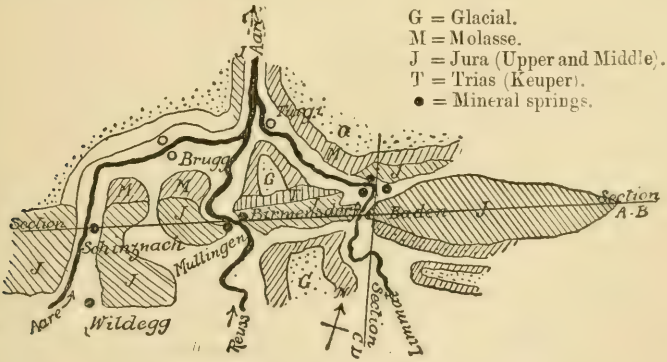


Fig. 1.—Plan of the Baden District. $\frac{1}{250000}$.

As is seen from the plan and longitudinal section (Figs. 1 and 2), the Jurassic ridge rises at both ends to the considerable elevation of

[1] Among the cold mineral springs, the most notable and abundant are those of St. Moritz and Tarasp, in the Engadine, and of Rheinfelden, near Bâle.

730 and 860 metres (2,400 and 2,830 ft.) above sea-level, and at its north-west end, near and beyond Baden, constitutes the so-called "Laegern" ridge, whose altitude exceeds that of the surrounding Molasse hills by fully 800 feet. In its central portion, the ridge is intersected at right angles by the rivers Limmat, Reuss, and Aare, at a distance of about four miles from their confluence near Turgi.

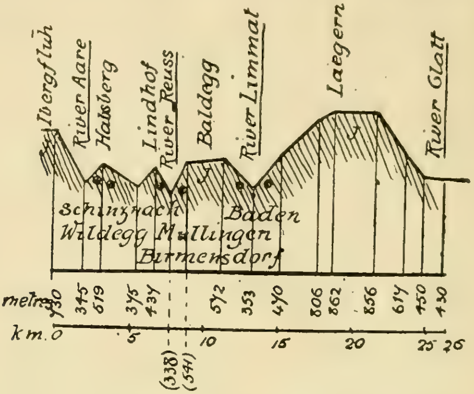


FIG. 2.—Longitudinal section. Schinznach–Birmensdorf–Baden. Horizontal $\frac{1}{500000}$; vertical $\frac{1}{50000}$.

It is at the point of intersection of those rivers that the mineral springs of Baden (Limmat valley), of Birmensdorf and Mullingen (Reuss valley), and of Schinznach and Wildegg (Aare valley) rise to the surface, their position coinciding in the main with the anticlinal axis of the Jurassic fold, as is shown in the plan and longitudinal section.

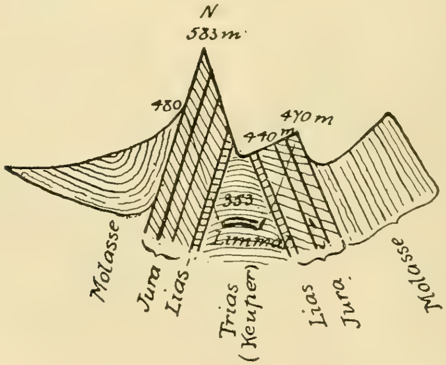


FIG. 3.—Transverse section. Baden. Horizontal $\frac{1}{100000}$; vertical $\frac{1}{10000}$.

A typical transverse section of the ridge is the one exposed at Baden (Ennetbaden), on the right bank of the river. It is represented in Fig. 3, and is about 1·6 kilometre, or one mile, in length, the outer strata on each side of the fold being composed of Upper or white Jura (Malm) and of Middle or brown Jura (Dogger), the intermediate strata of Lias, and the central or lowest strata of Keuper (Trias), which last-named therefore lies in the axis of the anticlinal fold. The more or less uniform character of this section throughout the ridge is attested by the fact that the various mineral springs rise from along the line of junction of the Keuper and the younger strata.

The distinctive features of the four varieties of mineral springs in the district, and of their occurrence, may be briefly stated as follows:—

1. *Baden Springs*, 360 metres (1180 ft.) above sea-level.[1] As is seen from the plan, Fig. 4, all the Baden springs rise in a sharp

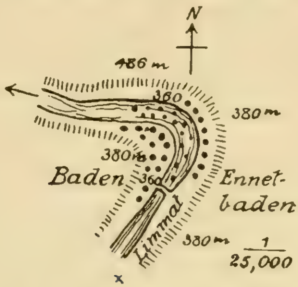


Fig. 4.—Mineral springs of Baden, Switzerland.

curve of 60 degrees formed by the Limmat at a point where the river has eroded the glacial gravels of the valley to a depth of about 20 metres, or 66 ft., down to the Keuper, which at this point crosses the bed of the river. The springs issue through fissures between the Keuper and the Jurassic strata which, as already shown in the transverse section, cross the valley in two separate ridges, forming the Baden basin. On the left bank of the river, the Keuper is overlain by about 30 ft. of clay and marl, which, somewhat further down the river, are overlain by sand and glacial Nagelfluh to a depth of about 66 ft. On the right bank, the same clay and marl, alternating with gypsum bands, are about 50 ft. in depth, and overlie a compact dolomite.

The springs on both sides of the river number twenty-one, while about fifteen more issue in the river-bed and are lost. The principal mineral constituents of the water are, in 1,000 parts: sulphate of sodium, 1·842; chloride of calcium, 1·3; chloride of sodium, 0·3; bicarbonate of magnesium, 0·3; and some free sulphuretted hydrogen. As is seen, these constituents are the products of the decomposition and reaction upon each other of the principal compounds composing the rocks characteristic of the Middle Keuper formation—to wit, gypsum (sulphate of calcium), common salt (chloride of sodium), and dolomite (carbonate of magnesium).

[1] These springs have been known for nearly 2,000 years, Baden having been, like Windisch (Vindonissa), near Turgi, four miles below Baden, occupied by the Romans as early as 61 B.C.

The springs have a temperature of 46° C. (115° F.), and are not affected by the rise or fall of the river Limmat, but vary according to the rainfall at different seasons, a fact which shows that they are derived from atmospheric water percolating through the various strata. The fact that the chemical composition of all the twenty-one springs is fairly uniform, warrants the conclusion that they all rise from one source or collecting-basin. Assuming the temperature of the atmospheric water at the surface to be 10° C., and the increase of temperature to be 1° C. every 30 metres, the temperature of the Baden springs corresponds to a depth of the subterranean reservoir of $(46 - 10) \times 30 = 1{,}080$ m., or about 3,500 ft. The probable seat of the reservoir is therefore not below the Keuper or upper member of the Trias. The average yield of the springs is in the aggregate no less than 1,000,000 litres (222,000 gallons) in 24 hours. Both in yield and temperature, the Baden springs vie with other celebrated thermal springs, such as those of Pfävers and Aix-les-Bains, which have a temperature of 36° C. (97° F.) and 45° C. (113° F.) respectively.

2. *Birmensdorf and Mullingen*, 340 metres (1,115 ft.) above sea-level. These are cold springs, containing chiefly sulphate of magnesium, sulphate of sodium, and sulphate of calcium, from the dolomitic and gypsum strata. In addition to the natural springs, mineral water is produced by leaching the strata in tanks formed in pits at a depth of 100 metres (330 ft.) below the surface. The springs and tanks are capable of yielding about 1,000,000 litres (220,000 gallons) per annum, but the abundance of gypsum dykes, which have already been worked for more than 70 years, is such that the production can be largely increased.

The Birmensdorf water has a temperature of 15° C. (59° F.), and a specific gravity of 1·17. In mineral composition it compares as follows with the well-known similar waters of Friedrichshall and Hunyadi Janos :—

	In 1,000 parts.			
	Sulphate of Magnesium.	Sulphate of Sodium.	Sulphate of Calcium.	Chloride of Sodium.
Friedrichshall	5·15	6·05	1·34	7·96
Birmensdorf	12·04	16·56	—	1·30
Hunyadi Janos.........	24·35	22·55	0·32	—

The mineral water of Mullingen is very similar to that of Birmensdorf, being derived from the same Triassic and Jurassic strata which are intersected by the river Reuss.

3. *Schinznach*, 343 metres (1,125 ft.) above sea-level. This is an abundant thermal spring, somewhat similar to the springs of Baden, and rises from the dolomitic and gypsum strata about 30 ft. below the surface. It contains, in 1,000 parts : carbonate of calcium, 0·25 ; carbonate of magnesium, 0·12 ; sulphate of calcium, 1·10 ; and some free sulphuretted hydrogen. The spring has a temperature of 35° C.

(95° F.), and yields about 720,000 litres (160,000 gallons) in 24 hours, which quantity is, however, easily capable of being trebled.

The Schinznach spring bears analogy more especially to the springs of Louèche (1,415 m. or 4,641 ft. above sea-level), which contain, in 1,000 parts, 1·48 sulphate of calcium and 0·23 sulphate of magnesium, but have a higher temperature, viz. 45° C. (113° F.), while their considerably larger aggregate yield amounts to 6,000,000 litres (1,312,000 gallons) in 24 hours.

4. *Wildegg*, 356 metres (1,168 ft.) above sea-level. This is a saline spring, rising at the bottom of an artesian well at a depth of 256 m. (about 840 ft.) below the level of the river Aare. In addition to chloride of sodium, it contains, as characteristic constituents, iodine and bromine. The temperature of the spring is 15° C. (59° F.), and its present yield is only about 75,000 litres (17,000 gallons) per annum.

Appendix.

In the following Table the writer has determined by calculation the probable depths below the surface of upwards of 30 well-known or otherwise remarkable thermal springs, with the great majority of which he is acquainted, and whose temperatures, according to official statistics or otherwise authentic records, range from 20° to 90° C., or 68° to 194° F. The formula used is that already given for determining the depth of the Baden springs—

$$(\text{Temperature of spring} - 10^\circ \text{ C.}) \times 30 = \text{depth in metres.}$$

If no allowance be made for the initial temperature of the atmospheric water percolating through the rocks down to the collecting-basin—in other terms, if the temperature at the surface be taken at 0° C. (32° F.), the depths given in the Table have to be increased by 300 metres, or 1,000 ft.

Depth of Thermal Springs having Surface-Temperatures of 20° to 90° C. (68° to 194° F.).

No.	Name of Spring.	Country.	Temperature at surface. Cent.	Fahr.	Depth below surface. Metres.	Feet.
1	Matlock	England	20°	68°	300	984
2	Munster (Crenznach)	Germany	23	73	390	1279
3	Buxton	England	28	82	540	1771
4	Montecatini	Italy...	30	86	600	1970
5	Royat	France	35	95	750	2461
6	Schinznach	Switzerland ...	35	95	750	2461
7	Pfävers (Ragatz)	Switzerland ...	36	97	780	2558
8	Baden (Vienna)	Austria	36	97	780	2558
9	Poretta	Italy...	36	97	780	2558
10	Wildbad...	Germany	37	98	810	2657
11	St. Gervais	France	38	100	840	2755
12	Neuenahr	Germany	39	102	870	2854
13	Nauheim	Germany	39	102	870	2854
14	Teplitz	Austria	40	104	900	2953
15	Vichy	France	43	109	990	3248
16	Aix-les-Bains	France	45	113	1050	3444
17	Louèche...	Switzerland ...	45	113	1050	3444
18	Baden	Switzerland ...	46	115	1080	3542

No.	Name of Spring.	Country.	Temperature at surface. Cent.	Fahr.	Depth below surface. Metres.	Feet.
19	Ems	Germany	48°	118°	1140	3739
20	Bath	England	49	120	1170	3838
21	Luchon	France	50	122	1200	3936
22	Bormio	Italy...	50	122	1200	3936
23	Plombières	France	52	126	1260	4133
24	Aix-la-Chapelle	Germany	55	131	1350	4428
25	Warazia...	Austria	56	133	1380	4526
26	Carlsbad (Sprudel)	Austria	60	140	1500	4920
27	Aqui	Italy...	64	147	1620	5314
28	Wiesbaden	Germany	68	155	1740	5708
29	Baden-Baden...	Germany	68	155	1740	5708
30	Gastein	Austria	70	158	1800	5906
31	Ischia (Gurgitello)	Italy...	70	158	1800	5906
32	Chaudes-Aigues (Par)	France	87	188	2310	7577
33	Peters-Spring (Caucasus) ..	Russia	90	194	2400	7872
34	Las Trincheras	Venezuela ...	90	194	2400	7872
Intermittent Springs.	Geysers of Iceland	Iceland	100 mean temp.	212	2700	8856
	,, New Zealand ...	New Zealand				
	,, Yellowstone Park	U.S.A.				

It is seen that out of the 34 permanent thermal springs enumerated in the Table, 19, or more than half, have temperatures ranging from 30° to 50° C. (86° to 122° F.), and corresponding to a depth of 600 to 1,200 metres, or about 2,000 to 4,000 feet below the surface, while the average temperature of the Geysers, viz. boiling-point, corresponds to a depth of 2,700 metres, or about 9,000 feet. Great as these depths appear, even the maximum is less than one-third of the aggregate thickness (commonly computed at about 30,000 feet) of the successive formations composing the earth's crust down to the Archæan rocks, and only 0·04 per cent. or $\frac{1}{2370}$th of the radius of the globe (about 4,000 miles).

III.—On the Sandstones in the Upper Keuper in Warwickshire.

By the Rev. P. B. Brodie, M.A., F.G.S.

I HAVE read with much interest Mr. Horace Brown's account in the Geological Magazine for February, 1896, of the boring for water in the Trias at Stratford-on-Avon. In it he makes brief allusion to the sandstones in the Upper Keuper, and refers to Mr. Howell's statement of the occurrence of certain sandstones near Henley-in-Arden. He does not seem to be aware that similar sandstones are more or less widely spread over a considerable area in some parts of the Midlands, north and north-east of Henley and north-west of Warwick at a higher level, the highest point being 445 feet above the level of the sea. Many years ago I noticed some sandstone in Miss Phillips' park at Edstone not given in the Survey Map, and I informed my friend the late Professor Ramsay of the fact. These sandstones may also be seen in many places, especially in the parish of Rowington. They are exposed on the banks of the canal and along the road leading to Warwick, and were formerly obtained from quarries in the parish now long ago filled up, according to certain old documents in our parish chest, which gives an account of payments made for stone from this place, and our fine church and others in the neighbourhood and some old houses are built of it. When the Great Western Railway was made here a deep cutting through the sandstones was exposed along the line at Finwood in this parish; and lately they were detected when the new line to Henley was constructed. All the higher ridges in this district—they can hardly be called hills—are composed of the sandstones, the lower ground, where the marls and sandstones have been denuded, being formed of the red marls below. Sections are generally rare, as the stone is seldom employed except at Shrewley quarry near here, where the best section of the Upper Keuper beds are exposed. There are about two beds of useful stone: the upper one is inferior to the lower or bottom rock, which is a hard sandstone of some thickness and makes a good building stone, and is used by the Canal Company. This quarry is famous for many interesting fossils so scarce in the Trias, and is noted for the remains of fish, viz., *Semionotus*, *Acrodus* (spines and teeth), footprints of *Labyrinthodon*, and, the rarest of all, moulds of several species of mollusks, the only British locality where any shells have been found. I may add that the wells in the parish are fairly supplied with water from the sandstones, but it is hard and more or less charged with sulphates.

Note.—All the type and unique specimens lately in my collection from the Warwickshire Trias, especially Shrewley and Coten End, are now in the British Museum (Natural History), South Kensington.

IV.—On the Old Red Sandstone and Carboniferous Rocks of the North-east of the Island of Arran.[1]

By James Neilson,
Vice-President of the Glasgow Geological Society.

In the third edition of his Text-Book of Geology, Sir Archibald Geikie has discussed the question whether fossils can be wholly depended upon to indicate the age of rocks when similar or representative species are found in areas wide apart. Thus he tells us (p. 665) that in Bohemia and Russia some of the most characteristic Upper Silurian organisms are found beneath strata replete with Lower Silurian life. Again, speaking of the close of the Silurian period, he says (p. 760): "There is every reason to believe that for a long time the marine sedimentation of Upper Silurian type continued to prevail in some areas, while the probably lacustrine type of the Old Red Sandstone had already been established in others." He also tells us (p. 828) that "In the West of Scotland there occur among the red sandstones (some of which contain Old Red Sandstone fishes) bands

[1] Read before the Glasgow Geological Society on 17th October, 1895.

of limestone full of true Carboniferous Limestone corals and brachiopods." Again (p. 665), he draws our attention to the statement that "In Australia a flora with Jurassic affinities and a Carboniferous Limestone fauna were contemporaneous"; while we may conclude our extracts by one which says: "At the present day the higher fauna of Australia is more nearly akin to that which flourished in Europe far back in Mesozoic time, than to the living fauna of any other region of the globe."

The above quotations and extracts show the way in which palæontological evidence may be treated by those who strictly follow Prof. Huxley's views on homotaxis; and without offering any opinion on other matters, I propose to proceed to the consideration of that part which concerns the West of Scotland, viz., the question whether marine Carboniferous Limestone fossils are found in Old Red Sandstone strata.

Again, I quote (p. 801) from the chapter on Old Red Sandstone:—"In the Upper Old Red Sandstone of the Firth of Clyde *Bothriolepis* (*Pterichthys*) *major* and *Holoptychius* occur at the Heads of Ayr; while a band of marine limestone, lying in the red sandstone series of Arran, is crowded with ordinary Carboniferous Limestone shells, such as *Productus giganteus*, *P. semireticulatus*, *P. punctatus*, *Chonetes hardrensis*, *Spirifer lineatus*, etc. These fossils are absent from the great series of red sandstones overlying the limestone, and do not reappear till we reach the limestones in the Lower Carboniferous series; yet the organisms must have been living during all that long interval outside of the Upper Old Red Sandstone area. Not only so, but they must have been in existence long before the formation of the thick Arran limestone, though it was only during the comparatively brief interval represented by the limestone that geographical changes permitted them to enter the Old Red Sandstone basin and settle a while on its floor. The higher parts of the Upper Old Red Sandstone seem thus to have been contemporaneous with a Carboniferous Limestone fauna, which, having appeared beyond the British area, was ready to spread over it as soon as the conditions became favourable for the invasion. It is, of course, obvious that such an abundant and varied fauna as that of the Carboniferous Limestone cannot have come suddenly into existence at the period marked by the base of the limestone. It must have had a long previous existence outside the area of the deposit."

Sir Archibald Geikie also returns to the subject when treating of the Carboniferous system, thus (p. 828): "Hence it is evident that the Carboniferous Limestone fauna had already appeared outside the British area before the final cessation of the peculiar conditions of sedimentation of the Old Red Sandstone period."

The fact is, that no Old Red Sandstone fishes have been recorded, and, so far as we are aware, none have ever been found in Arran. The fishes referred to by Geikie were, I presume, those from the Red Sandstone south of the Heads of Ayr, on the mainland of Scotland, some twenty miles distant from the Arran limestone.

Arran is classic ground to the geologist, and its fame has travelled far beyond the limits of the United Kingdom and has engaged many pens. In particular, Sedgwick and Murchison,[1] A. C. Ramsay,[2] Dr. James Bryce,[3] and others, have written of these particular rocks, and all recognized, not only Old Red Sandstone, but also Carboniferous rocks, and their writings on the subject are full of most interesting facts, with carefully reasoned deductions.

The northern half of the Island of Arran consists, first, of a central granite nucleus of somewhat circular form, which embraces all the higher hills. This granite nowhere reaches the sea, being surrounded by a complete ring of slate and schistose rocks. These are overlain by another series of rocks, among which red is the prevailing colour; but the latter only form three-fourths of a circle. Previous writers on Arran had assigned these latter rocks partly to the Old Red Sandstone and partly to the Carboniferous formations, and it is to them that we wish to direct attention, with the view of going over the evidence already recorded, and also of adding any observations we ourselves have been able to make. Observation here is very much facilitated by the fact that the intrusion of the granites (or final intrusion, if there were more than one) occurred subsequent to the deposition of the highest of the sedimentary rocks, which are elevated all round the coast, and their edges being exposed by the tides afford unrivalled opportunities for geological investigation.

As was first pointed out by Sedgwick and Murchison, the lowest of these Old Red Sandstone rocks on the beach are seen at North Sannox, where there is an anticline from which the rocks dip respectively to the north and south. They consist mostly of red sandstones and conglomerates, and, as will readily be acknowledged, the rocks north of the anticline correspond with those to the south. Sedgwick and Murchison set down these rocks as Old Red Sandstone, which, according to them, extended for about three miles along the shore, the northern junction with the Carboniferous occurring to the north of the fallen rocks, and the southern a quarter of a mile north of Corrie.[4] These rocks are then overlain by Carboniferous rocks for several miles both north and south, and are finally overlain by rocks of the New Red Sandstone age. Ramsay also supports this theory, and Bryce only differs from it in referring the uppermost rocks to the Upper Carboniferous instead of the New Red Sandstone. The writer's own observation has led him to the conclusion that these writers were mainly correct, and, although aware of Sir A. Geikie's views, he yet did not feel justified in questioning them till he had an opportunity of again traversing the ground.

[1] Proceedings of Geological Society of London, vol. i, p. 41 (1828). This appears to be only an abstract of their paper.

[2] "Geology of the Island of Arran," by (Sir) Andrew Crombie Ramsay, 1841.

[3] "Geology of Arran and other Clyde Islands," by James Bryce, M.A., LL.D., 4th edition, 1872.

[4] That is, 100 yards north of the great split boulder which forms such a conspicuous object on the shore.

No time need be lost in discussing the beds described by Sedgwick and Murchison as Old Red Sandstone—that point is admitted on all hands; the question is, whether the beds considered by them and subsequent writers to be Carboniferous, are really so, or Old Red Sandstone as Sir A. Geikie contends. For this purpose we come to the junctions of these formations, and find that both on the north and south the Old Red Sandstone conglomerates are succeeded by calcareous conglomerates and limestones (cornstones), alternating with sandstones. These strata overlie the Old Red Sandstone conglomerates conformably, and if Arran alone had been in question it is doubtful whether the line would have been drawn here. Unfortunately the strata at the south end are cut off about 40 yards from this junction by a dike whose cross section extends over 320 yards along the shore, and as it seems to us that this dike marks a fault cutting off a considerable thickness of strata we are compelled to fill in the gap by reference to the corresponding northern section, where we find this same cornstone series overlain by beds of sandstone, black shale, and volcanic ash. This shale contains charred plant-remains belonging to *Calamites*, *Lepidodendron*, *Lepidostrobus*, also a species of *Spirorbis*, besides, what is even of more interest, it contains the remains of fishes. These have been submitted to Dr. Traquair, whose report is to the effect that, while the specimens were too fragmentary to identify specifically, still one basal part of a tooth probably belonged to the genus *Rhizodus*; another tooth resembled *Strepsodus striolatus*, Traq. There are also an imperfect Rhizodont scale, and some scales probably belonging to *Rhadinichthys*, Traq. He concludes his report as follows: "Although the specimens are, unfortunately, not such as to permit me to give any list of species, it is to be noted that they exhibit an unmistakably Carboniferous facies."

Overlying this shale is a bed of volcanic ash, also containing *fish*-remains, consisting of fragments of bones and scales—some pretty large, but I was not fortunate in finding anything in a condition to admit of being named. The information with regard to this latter bed was obtained from Mr. James Thomson, F.G.S., whom I believe to be the discoverer, and it was in searching for it that I stumbled across the black shale above mentioned. It speaks volumes for the accuracy of the old writers that here, within a few yards of the line they drew as separating the Old Red and Carboniferous formations, should be found a bed charged with characteristic Carboniferous fossils. This is also the lowest horizon, so far as I am aware, where Carboniferous fossils have been found, and, as will afterwards be shown, it occupies a position several hundred fathoms below the marine limestones which were formerly grouped with the Old Red Sandstone formation.

Proceeding onwards, it should be remembered that owing to the anticline the rocks dip away from the observer in the direction in which he is travelling, so that he sees first only the upturned edge of the rock. It will thus be evident that each bed met with is higher in the section than the preceding bed, and as the strata dip at angles of from 20° to 70°, a mile along the shore represents a considerable thickness of strata. From this point onwards for a distance of about three miles the red colour of the rocks is very exceptional indeed, and not until one passes the Salt Pans does he come again to the predominating red rock, and then, as will afterwards be shown, at a horizon several thousand feet higher up in the geological scale.

Succeeding and overlying the fish-beds is a great thickness of white calciferous sandstones, till at Millstone Point, about one mile north of the fallen rocks, black shales are met with full of plant-remains in the condition of anthracite. The observer next reaches the sections of trap and ash beds, interbedded with shales and thin seams of coal, among which the late Mr. E. A. Wünsch made his interesting discovery of a forest entombed in volcanic ash, yet in such a way as to preserve the minute structure of the plants.[1] Mr. Wünsch recorded the disinterment of fourteen large tree stems, and some more were dug out during the meeting of the British Association in Glasgow in September 1876.

Dr. Bryce (p. 127) also records the finding of a palatal tooth of *Ctenodus cristatus*—surely a Carboniferous fish. The plants recorded from this bed are: *Sigillaria*, *Halonia*, *Lepidodendron*, *Lepidostrobus* (3 species), *Antholithes*, *Sphenopteris*, *Stigmaria*, and *Strobilites*. Mr. Wünsch estimated the thickness of the igneous rocks, with interbedded shales, etc., at about 1000 feet, and between these and the Old Red Conglomerate there will be, I should think, at least as much more.

The limestones (which are reached after passing some white or grey sandstones) follow next in succession, so that there are here some 2000 feet of strata underlying the fossiliferous limestone. I do not hesitate to assign these strata to the Calciferous Sandstone series, and the great thickness of the igneous rocks among which Mr. Wünsch's discovery was made, to the great outburst of Trap which extends over Scotland, and has given origin to the Trap hills of South Bute, Little Cumbrae, North Ayrshire, Kilpatrick, Campsie, Fifeshire, and the Lothians.

The fossiliferous limestone which occurs about 100 yards north-west of the shepherd's house at Laggan is undoubtedly the same as that at Corrie, and contains the same fossils, the prevailing one being *Productus giganteus*, which is extraordinarily abundant. The peculiarity about these is that the shales are black, while at Corrie they are red, thus showing that the red colour is merely a local phenomenon, even in Arran.

These limestones are succeeded by white and grey sandstones and black shales alternating. Some of the shales are charged with the usual marine Carboniferous fossils, and extend along the shore to Salt Pans, where they are succeeded by beds of a different character;

[1] Trans. Geol. Soc. Glasgow, vol. ii, p. 97. For descriptions of new species from this deposit, see Mon. Palæont. Soc. 1870; Geol. Mag. 1865, p. 474; *ibid.* 1867, p. 551.

but, as these beds are not represented on the southern part of the district, I propose to defer their consideration till I take up the others.

To return now to the consideration of the similar beds at the southern portion of the section, viz. at the 320 yards broad dike, whose southern edge terminates on the shore, opposite the school grounds at Corrie. As already stated, this dike marks a great fault. I am rather surprised that it should not have been recorded before, as the evidence seems clear enough. The cornstones occur immediately to the north of it, while the marine limestones are only a few hundred yards south; so that this fault cuts off all the strata represented, along about two miles of shore on the northern section, *i.e.* from the cornstones north of the fallen rocks to the shepherd's house at Laggan, *i.e.* nearly all the Calciferous Sandstone series: a displacement which may be roughly estimated at about 300 fathoms.

The beds known as the Corrie Limestone consist of twenty-two beds of limestone, interstratified with beds of red shale; the total thickness of limestone being about twenty feet. These beds are referred to by Sir A. Geikie as follows (p. 801): "A band of marine limestone, lying in the red sandstone series in Arran, is crowded with ordinary Carboniferous Limestone shells, such as *Productus giganteus, P. semireticulatus, P. punctatus, Chonetes hardrensis, Spirifer lineatus*, etc."

The latter part of this quotation I very heartily endorse. The strata, consisting of sandstones, shales, etc., are mostly red. Even the limestone fossils are as red as the sandstones themselves. They are crowded with fossils; *Productus giganteus* exists here by the million. Owing to a great upthrow these same limestones appear on the northern flank of the hill called Maoldon.

Three other upthrows of the same limestone occur further to the south, but it is unnecessary here to refer to them. There can be no doubt that these are the same limestones, previously observed on the north shore, near the shepherd's house at Laggan. Generally speaking, the fossils are the same, as is also the character of the limestone and interbedded shale, in all but the colour.

There can be no question that the red colour is due to the presence of hematite iron-ore distributed through the strata, and many seams hold this mineral to such an extent as to soil the hands—which some of the fossils will do even after years of exposure to the weather. These ores also appear sometimes as seams of red ironstone, and at other times the ironstone is segregated into detached nodules or into nodular bands. Good examples of both kinds are to be seen in the old quarries, on the hills behind the village, and also on the shore at Corrie; but, although the prevailing colour is red, this is not by any means universal, and white sandstones are, and have been, quarried behind the village of Corrie, both above and below the limestones—*e.g.* in a quarry behind Corrie Hotel, where a white sandstone may be seen overlain by a bed of fireclay, containing the usual Stigmarian rootlets.

As has already been shown, the same limestone and shales and sandstones, which are red at Corrie, are respectively black and white at Laggan: I submit that the redness is only a local peculiarity.

Taking up the quotation at the point left off, Sir A. Geikie writes (pp. 801, 828): "These fossils [*i.e. the limestone fossils*] are absent from the great series of red sandstones overlying the limestone, and do not reappear till we reach the limestones in the Lower Carboniferous series: yet the organisms must have been living during all that long interval outside of the Upper Old Red Sandstone area."

I admit that the limestone fossils are absent from the great series of red sandstones; but when Sir A. Geikie infers that these red sandstones contain Old Red Sandstone fishes, I can but ask for the production of even a single Old Red Sandstone fish from any part of the Island of Arran. That marine fossils should be "absent from the great series of red sandstones overlying the limestone" was to be expected, the fossils found in Carboniferous sandstones elsewhere being exclusively plant-remains, and I am only aware of one bed of sandstone in the West of Scotland containing marine remains, and that is in the Upper Limestone series.

Plant-remains are even commoner in Arran than I have seen them elsewhere, a fact already sufficiently recorded by previous writers, and which may be easily verified by anyone who walks along the shore at Corrie, where they protrude every here and there from the sandstone, while one sandstone intercalated between the limestones in front of Corrie Hotel is packed with rootlets of plants. Plant-remains are also abundant all along the northern sections and also towards the south in the cliffs of Maoldon.

(*To be continued.*)

V.—Woodwardian Museum Notes.

Notes on the Evolution of the Genus *Cheirurus*.

By F. R. Cowper Reed, M.A., F.G.S.

(*Continued from the March Number, page* 123.)

ALONG the branch which is marked earlier by *Cyrtometopus* and *Cheirurus* (*sens. str.*), the last stage of development corresponds with Salter's subgenus *Crotalocephalus*. This is almost entirely restricted to Devonian beds, but it is linked to *Cheirurus* (*sens. str.*) in time and zoological characters by *Ch. Sternbergi* (Boeck) and *Ch. Quenstedti* (Barr.), in which the glabellar side-furrows hardly meet in the middle of the glabella. The important subgeneric characters of *Crotalocephalus* are the continuous first and second side-furrows, the triangular basal lobes which nearly or quite meet in the centre of the glabella at their apices, and the nearly straight obliquely-directed third side-furrows of the glabella. The earlier forms of the subgenus have their triangular basal lobes still separated by a median portion of the glabella, as in *Ch. Quenstedti*, from E'tage E. This species has a rather curiously specialized kind of pygidium, with only two pairs of long spinose pleuræ: the third pair is very short and rudimentary, and of the fourth pair there is no trace. It is a noteworthy point that the pygidia of this subgenus are, as a rule, almost identical with those in the group of *Cheirurus* (*sens. str.*), with three equal pleuræ with free ends (*vide antea*), and do not show the enlargement of the first pair, as in the Russian *Cheirurus* (*sens. str.*).

The fullest development of the special features of this subgenus is found in the Devonian species, such as *Ch. gibbus* (Beyr.). The English forms are *Ch. Pengellii* (Whidborne) and *Ch. Sternbergi* (Boeck), from the Middle Devonian limestones. No members of the genus are known above the Devonian, so that stratigraphically, as well as in points of anatomical structure, *Crotalocephalus* is the highest in the series.

Returning now to the point where the main stem gave off the *Crotalocephalus* and *Pseudosphærexochus* branches, we find the latter branch arising from the neighbourhood of *Ch. claviger* (Beyr.) and leading first to the subgenus *Nieszkowskia*, which, by the number of its pleuræ (12) and the absence of a constriction on them, as well as by the presence of a row of puncta instead of a furrow, and the weakness of the fulcrum, shows the persistence of certain primitive characters, and its close connection with *Eccoptocheile*. But in the pygidium we find a very considerable amount of modification, and in fact *Nieszkowskia* shows a more specialized pygidium than any member of the whole genus. This indicates that the evolution of the different parts of the body did not proceed at equal rates; and we have seen throughout that the pygidium is the part which suffers the most diverse, irregular, and non-consecutive changes, being in one case of a reversionary type, while in a closely-allied species it has characters far in advance of the amount of specialization shown by the rest of the body.

In *Nieszkowskia* the pygidium possesses only two pairs of pleuræ, and these end in free points; the anterior pair is of huge size and usually three or four times as large and long as the posterior pair, which it completely embraces laterally.

The head-shield of this subgenus also shows a remarkable kind of development, for the glabella is inflated posteriorly and rises into a hump, or is produced into a spine. The side-furrows resemble those of its immediate predecessors, and the very forward position of the posterior branch of the facial suture, and the small free cheek, likewise recall the characters of *Eccoptocheile*. The type of the subgenus is *Ch.* (*N.*) *cephaloceros*, and Angelin's *Cyrtometopus tumidus* and *Cyrto. gibbus* also belong to it. *Nieszkowskia* occurs in the lower part of the Ordovician of Russia and Sweden.

The last stage of this line of development is shown by the subgenus *Pseudosphærexochus*, which in its glabella resembles *Sphærexochus*, though the basal lobe is not so strongly or so completely marked off. The posterior branch of the facial suture cuts the outer margin of the head-shield such a short way in front of the genal angle that it prepares us for the state of things in *Sphærexochus*, where the suture cuts the genal angle itself. The pleuræ, with a nearly obsolete line of puncta or with a plain surface, likewise are preliminary to the smooth pleuræ of *Sphærexochus*. The presence of a distinct fulcrum is an advance on *Nieszkowskia* and the non-fulcrum-bearing pleuræ of *Eccoptocheile*. The four pairs of pleuræ to the pygidium with free ends are reversionary, and again point to the independent evolution and modification of the pygidium. In England the only species so far recognized are *Ps. conformis* (Ang.) and *Ps. subquadratus* (Reed MS.) from the Keisley Limestone, and *Ps. moroides* (Marr and Nicholson) from the Stockdale Shales.[1]

A small group of species, of which *Ch. octolobatus* (Salter) is an example, stands apart from those above described, by a combination of characters showing widespread and complex affinities. The smooth pleuræ and the glabellar furrows resemble those of *Pseudosphærexochus*, while the very small free cheeks and position of the facial suture ally Salter's species (*Ch. octolobatus*) with *Nieszkowskia*. But several features of the head-shield, pleuræ, and pygidium seem to link it to the Bohemian species *Ch. neglectus* (Barr.) and *Ch. completus* (Barr.) of Dd 5, and through them to the transitional forms between *Eccoptocheile* and *Cyrtometopus*.

The relationship of *Ch. trispinosus* (Young), of the Penkill mudstones of Girvan and the Silurian of Gothland, is doubtful; but its discoverer, Prof. Young, suggested that it might be necessary to create a special genus for its reception,[2] and Lindström[3] has recently done so, and placed it in a new genus, *Youngia*, along with two new Gothland species—*Y. inermis* (Lindstr.) and *Y. globiceps* (Lindstr.).

The American species of *Cheirurus* have not been taken into account in the foregoing sketch of the affinities and evolution of the species of the genus, because specimens of them are not sufficiently common nor their characters adequately known in this country to admit of speculations of any value.

Distribution in Space.

The theory of the existence of North and South European provinces for trilobites, at any rate during a great part of Lower Palæozoic time, seems to rest on a considerable accumulation of evidence, and in the case of *Cheirurus* we can clearly perceive several facts in its support.

Firstly, we find that the *Cyrtometopus* group attained a greater development in the north of Europe than in the south; its species were much more numerous and its diversity of form much greater.

Secondly, we find that southern Europe was characterized by the absence of the northern forms *Nieszkowskia*, *Pseudosphærexochus*, and *Sphærocoryphe*.

Thirdly, we find that the *Cheirurus* (*Eccopto.*) *claviger* group is confined to the south. This group of species contains the earliest members of the genus in Bohemia, and in that country alone a fairly

[1] Quart. Journ. Geol. Soc., vol. xliv, 1888, p. 722, pl. xvi, fig. 9.
[2] Young. Proc. Nat. Hist. Soc. Glasgow, 1868, I, pt. i, p. 171, T. i, figs. 4, 6*b*.
[3] Lindström. Förteckning pa Götland Siluriska Crustacéer, in Ofversigt Kongl. Vet. Akad. Förhandl. 1885, No. 6, p. 50, T. xiii, figs. 11, 12.

consecutive series of transitional forms can be traced upwards from it to *Crotalocephalus.*

The stratigraphical gap between Étages C and D in that area may account for the absence of the *Anacheirurus* and early *Eccoptocheile* forms.

In the northern province, on the other hand, the zoological hiatus occurs between the early *Eccoptocheile* and its nearest ally, *Nieszkowskia,* on the one side, and *Cyrtometopus* on the other side. The Bohemian *Ch. claviger* group supply the missing links, and we may not unreasonably suppose that there was some communication, if only occasional and intermittent, between the two provinces. The manner in which the *Cyrtometopus* branch is connected with the earlier forms of the whole genus seems to indicate this. It does not appear improbable that a few migrants of the *Ch. claviger* group wandered north from Bohemia, and, meeting with changed conditions and a new environment, developed rapidly into the peculiar northern species of *Cyrtometopus,* and branched off into the *Nieszkowskia, Sphærocoryphe,* and *Pseudosphærexochus* types; while their southern contemporaries and congeners, under less variable and more uniformly changing conditions, pursued the steady, undeviating march of direct development without giving off side-branches.

The physical or biological conditions of northern Europe, moreover, appear to have affected the pygidia in a special way, leading to the formation of the Cyrtometopian type, which is common to the majority of the northern species of the subgenus *Cheirurus*; while in Bohemia the same subgenus has pygidia closely resembling those of the ancestral *Eccoptocheile.* An intercommunication of the two provinces is suggested by the presence of some southern types in the north, especially in Great Britain, where the southern type of pygidium in the subgenus *Cheirurus* is predominant.

The subgenus *Crotalocephalus,* with its uniform characters throughout North and South Europe, appears to have had its birthplace in the southern province in Silurian times, and to be a direct offspring of the typical southern forms of *Cheirurus* (*sens. str.*). In the Devonian period it overspread the northern area as well, but did not suffer any further modification in spite of this enlargement of its area of distribution.

LIST OF PRINCIPAL EUROPEAN SPECIES OF THE GENUS *CHEIRURUS.*

Cheirurus (*Anacheirurus,* nom. prop.) *Frederici* (Salter). British only: Upper Tremadoc, North Wales.

Cheirurus (*Eccoptocheile*) *Sedgwicki* (Salter). British only: Llandeilo Flags, South Wales.

„ („) *claviger* (Beyrich).
„ („) *Guillieri* (De Tromelin).
„ („) *pater* (Barrande).
„ („) *marianus* (De Verneuil).
„ („) *perlata* (Hawle and Corda).
„ („) *curta* (Hawle and Corda).
„ („) *Durocheri* (Ronault).

Cheirurus (*Eccoptocheile*) *scuticauda* (Barrande).
,, (allied to *Eccoptocheile*) *insocialis* (Barrande).
,, (,, ,,) *gryphus* ,,
,, (,, ,,) *pectinifer* ,,
,, (,, ,,) *tumescens* ,,
,, (,, ,,) *comes* ,,
,, (,, ,,) *neuter* ,,
,, (,, ,,) *globosus* ,,
,, (,, *Cyrtometopus*) *neglectus* ,,
,, (,, ,,) *completus* ,,
,, (,, ,, etc.) *octolobatus* (M'Coy). British only: Bala.
,, (,, ,, ,,) *latilobus* (Linnarsson).
,, (*Cyrtometopus*) *clavifrons* (Dalman). ? British: Keisley Limestone, [Keisley, etc.
,, (,,) *affinis* (Angelin).
,, (,,) *Zembnitzki* (Eichwald sp.).
,, (,,) *verrucosus* (Brögger).
,, (,,) *longispinus* (Angelin).
,, (,,) *diacanthus* (Angelin).
,, (,,) *Plautini* (Schmidt).
,, (,,) *Rosenthali* (Schmidt).
,, (,, ?) *juvenis* (Salter). British only: Bala.
,, (*Hemisphærocoryphe*, nom. prop.) *pseudohemicranium* (Nieszkowski sp.).
,, (,, ,,) *aries* (Eichwald sp.).
,, (*Sphærocoryphe*) *cranium* (Kutorga sp.).
,, (,,) *platycranium* (Kutorga sp.).
,, (,,) *euurus* (Kutorga sp.).
,, (,,) *Hubneri* (Schmidt).
,, (,,) *granulatus* (Angelin).
,, (,,) *dentatus* (Angelin).
,, (,,) *unicus* (Wyville Thomson sp.). British only: Bala, [Wales; and Girvan.
,, (*Nieszkowskia*) *cephaloceros* (Nieszkowski sp.).
,, (,,) *tumidus* (Angelin).
,, (,,) *variolaris* (Linnarsson).
,, (,,) *Kochii* (Boll).
,, (,,) [= *Cyrtometopus gibbus* (Angelin)].
,, (*Pseudosphærexochus*) *hemicranium* (Kutorga sp.).
,, (,,) *conformis* (Angelin sp.). In Britain: Keisley Limestone, Keisley, and Chair of Kildare.
,, (,,) *Roemeri* (Schmidt).
,, (,,) *Pahnschi* (Schmidt).
,, (,,) *moroides* (Marr and Nicholson). British only: [Stockdale Shales.
,, (,,) *laticeps* (Linnarsson sp.).
,, (,,) *approximatus* (Eichwald sp.).
* ,, (,,) *subquadratus* (Reed MS.). Keisley Limest., Keisley.
,, (,, ?) *tenuispinus* (Linnarsson sp.).
,, (,, ?) *octacanthus* (Angelin sp.).
,, (,, ?) *Wegelini* (Angelin sp.).
,, (,, ?) *granulatus* (Angelin). (*Sphærexochus granulatus*.)

Group I, with Cyrtometopian pygidium.

,, (*Cheirurus*, sens. str.) *exsul* (Beyrich).
,, (,,) *gladiator* (Eichwald).
,, (,,) *macrophthalmus* (Kutorga).
,, (,,) *scutiger* (Eichwald sp.).
,, (,,) *spinulosus* (Nieszkowski).
,, (,,) *aculeatus* (Eichwald sp.).
,, (,,) *approximatus* (Eichwald sp.).
,, (,,) *glaber* (Angelin). In Britain: Keisley Limestone, [Keisley.
,, (,,) *ingricus* (Schmidt).
,, (,,) *ornatus* (Dalman).
,, (,,) *punctatus* (Angelin).
,, (,,) *speciosus* (Hisinger).

Cheirurus (*Cheirurus*, sens. str.) *Gotlandicus* (Lindström).
,, (,,) *propinquus* (Münster).
,, (,,) *subulatus* (Linnarsson).
* ,, (,,) *keisleyensis* (Reed MS.). Keisley Limestone.
,, (,, ?) *gelasinosus* (Portlock sp.). British only: Bala; Girvan; and Ireland.
,, (,, ?) *Hawlei* (Barrande).
,, (,, ?) *conformis* (Angelin).

Group II.

,, (,,) *bimucronatus* (Murchison sp.).
,, (,,) *bimucronatus* var. *α*, *bimucronatus* (Salter). British only: Bala to Ludlow.
,, (,,) *bimucronatus* var. *β*, *centralis* (Salter). British only: Bala to Ludlow.
,, (,,) *bimucronatus* var. *acanthodes* (Marr and Nicholson). Stockdale Shales.
,, (,,) *insignis* (Barrande).
,, (,,) *Quenstedti* (Barrande).
,, (,,) *Quenstedti* var. *præcursor* (Frech).
,, (,,) *Beyrichi* (Barrande).
,, (,,) *brevimucronatus* (Münster). ? Ireland; Bala.
,, (,,) *obtusatus* (Corda).
,, (,, ?) *cancrurus* (Salter). British only: Bala.
,, (,, ?) *bifurcatus* (Barrande).
,, (*Crotalocephalus*) *Sternbergi* (Boeck). Middle Devonian, Lummaton.
,, (,,) *Sternbergi* var. *interrupta* (Kayser).
,, (,,) *gibbus* (Beyrich).
,, (,,) *gibbus* var. *interrupta* (Barrande).
,, (,,) *pauper* (Barrande).
,, (,,) *myops* (Roemer).
,, (,,) *articulatus* (Münster). ? British. Devonian.
,, (,,) *Lenoiri* (Bergerson).
,, (,,) *Pengellii* (Whidborne). British only. Mid. Devonian.
,, (,,) *Cordai* (Barrande).

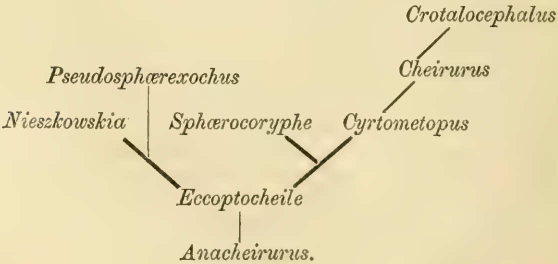
Doubtful Position.

Cheirurus fortis (Barrande).
,, *vinculum* (Barrande).
,, *radiatus* (Barrande).

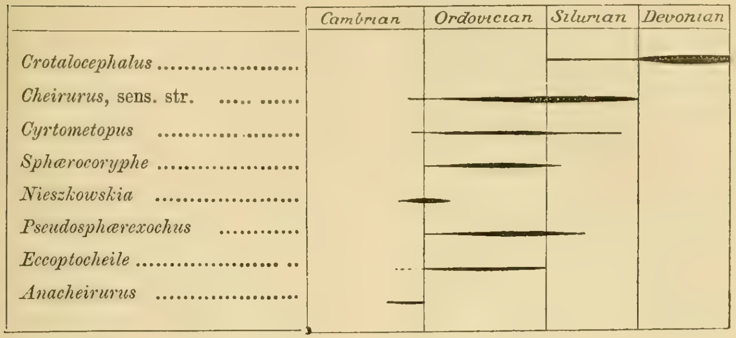
Cheirurus minutus (Barrande).
,, *dubius* (Pompecki).
,, ? *decacanthus* (Angelin).

* The description of these new species will shortly be published.

GENERAL SCHEME OF RELATIONSHIP OF SUB-GENERA OF *CHEIRURUS*.



GENERAL RANGE OF SUB-GENERA OF *CHEIRURUS* IN TIME IN EUROPE.



VI.—The Altered Clastic Rocks of the Southern Highlands, their Structure and Succession.

By Peter Macnair.

I. Introductory.

In the following paper I propose to give an account of some observations upon the structure and succession of the rocks of the Southern Highlands. By the term Southern Highlands I mean that part of the Scottish Highlands lying immediately to the north-west of the great line of fault separating the older rocks of the former area from the younger Old Red Sandstone series of the low grounds.

The more detailed stratigraphical part of the work which I have been enabled to undertake has principally been confined to the central parts of Perthshire, and the sections illustrative of the structure of the Southern Highlands will be principally drawn from that source. But it will be evident to anyone upon the inspection of a geological map that such sections will be more or less typical of the whole series, seeing that the rocks strike in such a prevalent north-east and south-west direction across the whole country.

The principal object of the paper, then, will be to give an account of the altered clastic rocks of the district, only mentioning incidentally, and where it is necessary for making the sections clear, the occurrence of igneous rocks. The nature of these clastic rocks as altered sediments has now been long known, but the more difficult points involving their structure, succession, and relationships have not been at all understood; and it is to these, then, I would more particularly draw your attention, trusting to be able to throw some light upon the somewhat obscure and difficult subject.

II. Work of Previous Observers.

Before passing to the more immediate subject of the paper, I would here briefly refer to the work of some of the previous observers upon this district, and that for a more particular reason, namely, that justice may be done to one of the most illustrious names connected with Scottish geology, I mean James Nicol, whose knowledge of the Highland rocks and abilities as a stratigrapher was far in advance of his time.

In the years 1860–1 Murchison and Geikie,[1] and also R. Harkness,[2] published papers dealing with certain traverses of the Southern and Central Highlands. These papers were naturally based on the supposed succession in the north-west of Sutherlandshire, so that their observations were no doubt to a great extent overshadowed by it, Murchison and Geikie being of course predisposed to the old theory, so that they saw nothing in these traverses but what conformed to it, and that, simply put, was that all the rocks below any limestone band were quartzose and flaggy, and represented their lower series, and all above it were micaceous and schistose, and representing their upper series; though the latter seems to have had serious doubts on the matter, not being able to make nature fit the theory, the consequences of the whole being that the true mineralogical character of the beds and their stratigraphical succession escaped them.

The paper of Harkness bears upon itself such evident misconception of the mineral characters of the Highland rocks, which had already been established by such observers as Maculloch, as to render it entirely worthless from a geological point of view. For instance, a comparison of the description of the Pass of Leny section with that given by Nicol the following year, shows clearly the difference in value of the two observers' work.

Turning now to Nicol's paper,[3] published in 1862, we find it thoroughly characteristic of the man. His reading of the sections are simple descriptions of what he saw in nature. At the outset he states the object of his paper, which was to investigate the relationships of the three great formations, the clay-slate, the mica-slate, and the gneiss; and though he seemed to be burdened with the Wernerian doctrine of their succession, yet his paper seems to me to show his masterly conception of what the unravelling of the Highland rocks meant. The manner in which he chose his sections, and the faithful description he gave of their rocks, are scarcely surpassed by those of the Geological Survey of the present day, who have adopted much the same methods in attacking the Highland problem. His method was to take a series of sections at different points from east to west across the Highlands from the verge where they abut against the Old Red Sandstone, explaining their principal mineral

[1] "Altered Rocks of the Central Highlands": Quart. Journ. Geol. Soc. 1861.
[2] "On the Rocks of Portions of the Highlands of Scotland": Quart. Journ. Geol. Soc. 1861.
[3] "Southern Grampians": Quart. Journ. Geol. Soc., vol. xix, p. 180.

and stratigraphical features. He noticed in all his sections the occurrence in regular order of clay-slates, grits, greywackes, and mica-schists. He also noticed the reversal of dip from south-east to north-west as he proceeded from west to east across the Grampian range. His final conclusion, however, as to the south-east being the normal dip, and the clay-slates consequently being the highest members of the series, while the north-westerly dip and consequent infraposition of the slates was owing to a reversal of the normal order, seems now to have been incorrect, and was probably owing to his strong Wernerian leanings. After the publication of these papers little or nothing seems to have been done in the investigation of these rocks. The great name of Murchison and the assent of such men as Harkness, Ramsay, and Geikie swayed the scientific world, and Nicol and his papers, both on the North-west and Southern Highlands, were soon forgotten. However, time and the unchanging mountains, in whose hands this great geologist had to leave his cause, eventually proved the truth of his observations and deductions. Afterwards the work of Dr. Callaway and Prof. Lapworth in the north-west re-awakened interest in the problem, the results being the final establishment of the essential principles arrived at and maintained by Prof. Nicol.

In a brief summary of the rocks of Highland Perthshire,[1] by Mr. H. Coates, F.R.S.E., and myself, published in 1891, we gave a table of the succession of the Highland rocks, which, though not so much in detail, was practically the same as that given at the end of this paper, and similar to the succession afterwards given by Sir A. Geikie as the work of the Geological Survey in his Presidential Address to the Geological Society, the great argillaceous, arenaceous, and limestone zones being then marked out as follows, in a descending order :—

6. Quartzites, grits, greywackes, and other arenaceous rocks.
5. Mica-schists, quartz-schists.
4. Calcareous mica-schist and pure limestone.
3. Mica-schist and quartz-schist in varying proportions.
2. Quartzite, grit, greywacke, and conglomerate.
1. Clay-slates, phyllites, and other argillaceous rocks.

In the explanatory note accompanying his geological map of Scotland,[2] published 1892, Sir A. Geikie gives a brief summary of these rocks, using the term Dalraidian to define them, as he had previously proposed in his Presidential Address.[3] He again refers to the occurrence of annelid tubes in the quartzites, but does not give their localities or horizons, and whether they are identical with those described by the Duke of Argyll[4] and the author[5] in 1889 I am unable to say.

[1] Transactions Perthshire Society of Natural Science, vol. i, p. 221.
[2] Explanatory Notes to Geological Map of Scotland, p. 8.
[3] Presidential Address, Quart. Journ. Geol. Soc., vol. xlvii, 1891.
[4] "Bodies of Organic Origin": Roy. Soc. of Edinburgh, 1888–9, p. 40.
[5] Trans. Perthshire Soc. of Nat. Science, vol. i, p. 116.

In the last edition of his textbook,[1] published 1893, Sir A. Geikie gives a short account of the work of the Geological Survey amongst the rocks of the Central and Southern Highlands. He there says it is deserving of remark that the rocks along the southern margin of the Highlands are for the most part so little affected as closely to resemble portions of the unaltered Silurian series of the South of Scotland, and that they dip towards the mountains, being more highly foliated and crystalline as they recede from the Lowlands. This may be practically said to be all that is at present known of the stratigraphical affinities of these rocks, a fact which was pointed out nearly fifty-one years ago by James Nicol; and from this fact, with his description of the Southern Highlands and his theory of the north-west, taken together, it will be found that, generally speaking, our knowledge of the geological structure of the Scottish Highlands has not much advanced beyond where Nicol left it. It is quite evident from his writings that he saw clearly the fallacy of Sir R. Murchison's observations and deductions as to the supposed north-west succession, and this being so it left him untrammelled in his descriptions of the other parts of the Highlands, so that we find them, as I have already said, perfect transcriptions of what he saw in nature. He states his position on this point very clearly in the conclusion of his famous paper.[2] There is no evidence, he says, to connect the great mass of crystalline schists, stretching from the north coast of Sutherland to the south of Inverness-shire, more closely with the mica-slates of Ben Hope than with the gneiss of Scourie Loch, Inver, and the Gairloch, or to justify us in throwing aside mineral characters for some assumed synchronism in the age of the original but now wholly altered deposits.

III. Lower Argillaceous Zone.

At the end of the paper I have bracketed together into zones and given in the form of a table the chief rock groups occurring in the Southern Highlands. Perhaps a word explaining the table would be of advantage here. The table is a descending one, the highest rocks being placed at the top, the lowest at the bottom. They have been grouped together into zones under their larger lithological features, which will be found to be more or less characteristic of each rock-bed. As I mentioned before, these zones have principally been determined from sections in Perthshire, but they undoubtedly range across the country from shore to shore in a succession similar to that occurring in Perthshire. The lowest member of the series (the lower argillaceous zone) given in my table is one whose lithological features are so well known as scarcely to need description. Outcropping at almost the base of the exposed rocks of the Southern Highlands, it strikes across their flanks from north-east to south-west. It does not, however, mark

[1] Textbook of Geology, 3rd edition, pp. 627, 708.
[2] "North-west Highlands": Quart. Journ. Geol. Soc., vol. xvii, 1860.

the real base of the system, that being covered by the later overlapping Old Red Sandstone series, the clay-slates often being seen to pass downwards before plunging beneath the Old Red Sandstone basal conglomerates into grits and greywackes similar to those which overlie it. These argillaceous rocks are therefore intercalated between the grits, greywackes, and conglomerates of the lower arenaceous group, and represent a period of sedimentation, during which the land-surface had reached a maximum of depression beneath the waters of the ocean.

The principal rocks of this zone are clay-slates, phyllites, black shales, and limestones, the typical rock of the whole being the clay-slate, which is simply a highly indurated mud upon which a fine fissile structure has been superinduced by metamorphism. As a rule, the cleavage of these rocks coincides with their bedding; this is shown by the manner in which these slates are intercalated between the bedding planes of the grits and conglomerates of the arenaceous zone. There is, therefore, seldom evidence of any more than the one set of divisional planes. Occasionally, however, evidences of other divisional planes cutting across the former are to be met with.

Sometimes the clay-slates pass into a fine lustrous or micaceous variety, to which the term phyllite has been applied. These phyllites seem to me to be simply further stages in the process of metamorphism, and probably link the clay-slates with such highly foliated crystalline rocks as the sericite schist of Ben Lawers. These phyllites show an occasional tendency to foliation, as seen in the beds above Loch Lubnaig.

Towards the north-east this argillaceous zone, which is thus found to form the outer edge of the Southern Grampians, dips inwards, and is seen to be overlain by the main mass of the Grampian range. On tracing this zone, however, towards the south-west, a gradual reversal of the dip towards the south-east is seen to occur. It will be evident, however, from sections to be described, that the order occurring in Perthshire and further to the north-east is the normal order, while that seen at Loch Lomond and further westwards represents a reversal of the beds. Black graphitic shales are also to be met with upon this horizon, though they do not seem to be as extensively developed as in the upper argillaceous zone, which will be noticed later on.

Limestone is also to be found on this horizon, as at the Pass of Leny, above Kilmahog old toll-house, which will be described in the Pass of Leny section. I am also led to understand that it has been seen further to the east, near Birnam.

IV. Lower Arenaceous Zone.

Underneath and immediately above the lower argillaceous zone just described we find a series of rocks, varying from a fine-grained greywacke, through quartzites and grits, to coarse conglomerates, to the whole of which, taken together, we have given the name lower arenaceous zone. As before remarked, the lower argillaceous zone is intercalated between these rocks, and is seen at some places to pass downwards into them, though they are soon covered by the later Old Red Sandstone conglomerates. Above the argillaceous zone, however, a strong and constant band of these arenaceous rocks is well developed. Along the shores of Loch Lomond they are to be seen below Rowardennan, being also well exposed near Sallachie Wood, from whence they strike northwards, being well developed along the northern shores of Loch Katrine. Still further eastwards, massive beds characteristic of this zone are seen in Ben Ledi; passing further along the line of strike, they are shown in Ben Vorlich, around St. Fillans, in Glen Leadnock, thence by Dunkeld Bridge of Cally, and onwards to the sea above Stonehaven. The rocks of this lower arenaceous group are easily recognized by their scarcely altered fragmental aspect, showing little or no evidence of the intense metamorphism which is to be found nearer the centre of the Highland area. They have, of course, been more or less indurated, but they rarely show such evidences of extreme crystallization and foliation as are to be found amongst some of the higher zones to be described. The rocks of this zone vary from exceedingly fine light or dark greywackes (which are hardly to be recognized from an igneous rock, so fine is their texture through grits, with their pebbles of quartz and felspar set in a fine matrix of comminuted felspathic matter) to massive conglomerates with pebbles, often as large as an inch and more in diameter. These fine-grained greywackes often exhibit a closely banded structure of lighter and darker shades of grey, which is undoubtedly referable to the original sediments out of which the beds have been formed.

V. Middle Arenaceous Zone.

The next zone in ascending order is that to which we have given the name middle arenaceous zone, because it is found to lie between the lower arenaceous group just described and an upper argillaceous and arenaceous zone, from both of which it is easily distinguished by its lithological features. Intercalated in this group occurs the Loch Tay limestone zone, about to be described.

The characteristic rocks of this middle arenaceous group are a series of mica-schists, quartz-schists, and grits. They are more highly foliated than the arenaceous groups below, and seem to have suffered a further degree of metamorphism. Upon the whole, they seem to present more of an arenaceous than an argillaceous affinity, they being easily distinguished, as I have already remarked, from the arenaceous band below. Geographically, they extend in a broad band across the country in a similar manner to those zones just described, occupying the region between the lower arenaceous group on the south and the upper argillaceous zone on the north. They are well exposed in the valley of the Dochert, the braes of Balquhidder, also on the hills that lie between Loch Earn and Loch Tay, stretching north-eastwards by Aberfeldy, Pitlochry, and thence onwards into the Eastern Grampians, where they seem to have been largely displaced by the later eruptive masses of granite and other igneous rocks.

The quartz-schists and mica-schists of this zone represent between their two extremes an infinite variation of their two constituent minerals—mica and quartz. The quartz-schists seldom, however, lose so much of their mica as to approach the typical quartzites of the lower zone, while the mica-schists, on the other hand, rarely become so argillaceous as to approach the finely foliated mica-schist of the upper argillaceous series. Both the micaceous and quartzose varieties are often highly charged with garnets, as in and around both Loch and Strath Tay.

The grits of this series, like the other members just described, show a more distinct tendency to foliation than those belonging to the lower series, the finer matrix in which the pebbles of quartz are imbedded becoming more or less foliated, and wrapping each individual pebble in a series of plates of mica, giving the rock somewhat of a gneissose aspect. The larger pebbles of quartz show evidence of having been drawn out along the lines of shear, and look more like veins of segregation than original quartz pebbles.

VI. The Loch Tay Limestone Zone.

The next zone which falls to be mentioned is that of the Loch Tay limestone, which, as we have already noticed, is found intercalated in our middle arenaceous group, the quartz and mica-schists of the latter being found both to underlie and overlie the band of limestone. The rocks of this zone are not always pure limestone, but often pass into a calcareous mica-schist, the whole pointing, as in the lower argillaceous zone, to the land-surface having reached a maximum of depression below the level of the sea. Below this limestone band and upon this horizon occur massive beds of sheared basic rocks, which follow the limestone in a remarkable manner; wherever it is found, in fact, they may be said to be coextensive with the limestone from the east to the west coast across the whole of the Southern Highlands. They are evidently basic igneous rocks which have been intruded into the schists and limestones at a period prior to their metamorphism, and which have subsequently undergone the same shearing process as the clastic rocks, being now structurally identical with the schists.

The Loch Tay limestone has been traced by the officers of the Geological Survey from shore to shore across the Southern Highlands, through the shires of Banff, Perth, and Argyll. In Perthshire, where I have principally been enabled to trace its outcrop, it is found to extend from Crianlarich in the east, down the north side of Glen Dochert to Killin, and thence north-eastwards by Loch Tay to Fernan, where it is abruptly cut off by a fault. It does not seem to appear again in Strath Tay, but after passing Strath Ardle it appears again at Ashintully, Kirkmichael, and Mount Blair.

VII. The Upper Argillaceous Zone.

The upper argillaceous zone, which I have given as succeeding the higher members of the middle arenaceous group, is characterized by a series of highly altered argillaceous rocks, the principal member of which is a fine sericite schist, occasionally becoming calcareous with subordinate beds of finely banded greywackes and quartzites, both of which contain traces of annelid burrows. The other member of this zone is a fine black graphitic schist, which occurs upon a horizon higher than the sericite schist, and marks the top of this group. Like the other calcareous and argillaceous zones, it seems to represent a maximum of depression beneath the waters of the ocean.

The traces of annelid tubes which have been found in this zone were discovered by the Duke of Argyll[1] and myself,[2] His Grace finding his specimens behind the castle at Inverary, my own being found on Craig Na Challeich, a mountain above Killin, Perthshire. The beds in which the Duke found his specimens are described by him thus: "The comparatively thin beds in which the annelid tubes are found at Inverary are by no means the lowest in our series. They are underlain and overlain by a great number of beds, both slaty and siliceous, but the great mass is slaty, with a highly developed micaceous character." The annelid tubes were thus found in a thin band of quartzite, intercalated in a series of highly micaceous schists, which exactly corresponds to the character of the rocks where I found my own on Craig Na Challeich—that is, in the upper argillaceous zone. Further, in his map of Scotland, published in 1892, Sir A. Geikie[3] colours the rocks in which His Grace found his specimens as the same as those occurring on Craig Na Challeich, so that I have no hesitation in believing them to be the same beds, and that these annelid tubes mark a distinct horizon in these Highland rocks.

This zone, like the others just described, is found to have a similar geographical distribution across the whole of the Southern Highlands. In Perthshire I have traced it at Tyndrum, where it is faulted against a series of quartzites. Further east, on the high ridge above Loch Tay, it is found occupying its normal position above the middle arenaceous group, stretching through the peaks of Craig Na Challeich, Ben Cruben, Ben Lawers, and thence eastwards by Killiecrankie and the Spittal of Glenshee.

(*To be continued.*)

REVIEWS.

I.—Memoirs of the Geological Survey of Scotland: Explanation of Sheet 5. By John Horne, F.R.S.E.; with the collaboration of B. N. Peach, F.R.S., and J. J. H. Teall, F.R.S. (Edinburgh: printed for Her Majesty's Stationery Office by Neill & Co., 1896. 8vo, pp. 71, with 5 illustrations. Price 1*s.* 6*d.*)

SHEET 5 of the Geological Survey Map of Scotland includes a large portion of Kirkcudbrightshire, being the country around Castle Douglas, Dalbeattie, Kirkcudbright, and Gatehouse-of-Fleet.

[1] "Bodies of Organic Origin": Roy. Soc. of Edinburgh, 1888-9, p. 40.
[2] Trans. Perthshire Soc. of Nat. Sci., vol. i, p. 116.
[3] Map of Scotland, 1892.

Geologically the area is of considerable interest: it embraces a portion of the Southern Uplands, with rocks ranging in age from Arenig to Ludlow, Old Red Sandstone, and Carboniferous, to say nothing of Glacial Drifts and more recent deposits. It includes, moreover, various interbedded and intrusive igneous rocks, notably the great granite area of Criffel, with its fringe of metamorphic strata. The map has long been published, for the area was surveyed geologically nearly twenty years ago by Messrs. John Horne, D. R. Irvine, and C. R. Campbell, and of these Horne alone remains to tell the story of the work.

The delay in the issue of the descriptive memoir was caused, as we are told by the Director-General, by the publication in 1878 of Prof. Lapworth's classic memoir on "The Moffat Series," a work which rendered it desirable to again examine the area by "the light of his researches, which had at last supplied, in the zonal distribution of the Graptolites, a clue to the unravelling of the complicated structure of the Southern Uplands." This revision has now been accomplished, partly by Mr. Horne, partly by Mr. Peach, Mr. Macconochie, and Mr. Teall, with the personal aid of the Director-General.

The explanation is of far more than local interest, although it is strictly confined to a consideration of the phenomena observed in the district. The subject of contact-metamorphism does not appear to be dealt with at all fully, the matter being reserved for a promised general Memoir.

While the elaborate work of Professor Lapworth furnished the key for the interpretation of the complicated stratigraphy of this Palæozoic region, some considerable additions to our knowledge have been made during the course of the re-examination of the district by the Geological Survey. The existence has been ascertained of lavas, tuffs, and agglomerates in the Arenig group, and also of a well-marked and persistent horizon of Radiolarian cherts and mudstones in the upper portion of this volcanic series. Although only about 60 or 70 feet thick, these cherts appear to represent the whole succession of deposits which elsewhere in Britain intervene between the Middle Arenig and uppermost Llandeilo strata.

Interesting nodules composed of oxides of iron and manganese have been found in the Arenig mudstones, and Mr. Teall infers that "the rock was originally a limestone, that it was subsequently changed to a carbonate of manganese and iron, and, finally, that the carbonate was decomposed under oxidizing conditions so as to give rise to the nodular masses of the oxides of manganese and iron."

The various strata and their fossils, up to the top of the Silurian, are duly noticed, and the igneous rocks are then described.

The Upper Old Red Sandstone, poorly developed, consists of red sandstone, red clays, and cornstones, which underlie the volcanic group that forms the commencement of the Calciferous Sandstone Series. This Carboniferous group comprises sandstones and shales with marine bands surmounted by coralline limestone.

The Glacial Drifts are well represented, and proof is given that the ice which drained from the inland country was in mass sufficient to override Criffel, and must therefore have had there a minimum thickness of 2000 feet—a fact of considerable interest in connection with the wide dispersal of boulders of Criffel granite.

Raised Beaches, Caves and Cavern Deposits, Peat and Alluvium, and Economic Products are duly mentioned.

Considerable interest naturally attaches to the large granite mass which covers upwards of seventy-five square miles of ground. The granite and its apophyses traverse strata of Llandovery, Wenlock, and Ludlow age; but the intrusion of the igneous complex must be older than the Upper Old Red Sandstone. Though mainly massive in character, yet in certain limited tracts along its margin the granite has a marked foliated character, and evidence is given to show that this foliated structure has been produced by mechanical deformation which has simultaneously affected, not only the main body of the granite, but also the basic inclusions which this rock contains, as well as the acid and even the quartz veins that traverse it. It is pointed out that the quartz and alkali-felspar, which were the last constituents of the granite to solidity, are those which have yielded most in the deforming stresses; while the fact that the foliation in the acid veins has no reference whatever to the direction which they take, is stated by Mr. Teall to be a striking proof that it cannot be due to fluxional movement during intrusion.

Dykes of porphyrite occur not only in the sedimentary rocks but also in the granitic masses. It is pointed out that the term "porphyrite" has hitherto been employed in a different sense by the Geological Survey, for certain lavas which occur in association with Palæozoic sediments, and which in reality are merely altered andesites. The present usage of the term is that adopted by Prof. J. P. Iddings for rocks of the type under consideration, which occur as sills and laccolites as well as dykes.

A detailed list is given of the rocks examined under the microscope, with their localities, and with remarks on their mineral structure.

We may add that the printing by Messrs. Neill and Co. compares so favourably with that noticed in a recent Survey Memoir printed in England, that we wonder H.M. Stationery Office does not have all its printing done in Edinburgh.

II.—Petroleum. By Boverton Redwood, F.R.S.E., assisted by Geo. T. Holloway and other contributors. Two Vols. 8vo. pp. 900. (London: Charles Griffin and Company, 1896.)

THIS comprehensive treatise is in every way creditable to both author and publisher: it has been prepared with care and skill, printed in clear and varied type, and provided with numerous illustrations. Its two volumes together comprise no fewer than 900 pages; there are 327 figures in the text; two frontispieces show respectively the distribution of petroleum throughout the world, and the appearance of the flame-caps corresponding to six different proportions of admixed pentane and air; fifteen large plates illustrate the distribution in various oil-fields, sections of typical wells, and apparatus used in the industry. Reference to the detailed work is greatly facilitated by a table of contents extending over eleven pages, and by a copious index of twenty-six.

No one could be better qualified than Mr. Redwood for the preparation of such a treatise: for a quarter of a century he has had a consulting practice in connection with the petroleum industry; he is consulting adviser to the Corporation of London under the Petroleum Acts, and chemical adviser to the Oil Trade Section of the London Chamber of Commerce; he has visited the principal oil-fields and refineries of the world; and has made a special study of the numerous methods which have been devised for testing the various commercial products. But, as Mr. Redwood points out, the task of preparing a work satisfactory to himself would have been insuperable but for the practical help given to him by many friends, more especially by Mr. George T. Holloway, to whom he expresses his great indebtedness for assistance in the preparation of the matter for the Press, and in the toilsome revision of the proofs.

In the short space to which this notice is necessarily limited, it is impossible to do sufficient justice to the labour devoted to the preparation of the treatise, or to the skill with which the vast amount of information has been classified and made readily accessible. A brief statement of the contents, however, will give a good idea of the scope of the book. The first section (31 pages) deals with the history of the petroleum industry, beginning with accounts of occurrence and modes of collection placed on record by Herodotus, the Father of History, 2300 years ago; the history of the development of the industry in each of the countries of the world is then briefly sketched. Here are mentioned facts, the records of which are as impressive as fairy tales—fountains which have yielded £11,000 worth of oil daily, or which have shot up hundreds of feet high, carrying away the machinery used in the drilling of the well. The second section is the most extensive in the book (144 pages), and treats of the geological distribution of petroleum: the three theories of the cause of the pressure—overlying strata, water, accumulated gas—are first discussed; then follow descriptions of the geological peculiarities of the various oil-fields of the world. The manuscript of this section was revised by the late Mr. William Topley, F.R.S., who had given much attention to the subject, and whose early death all geologists deplore. The third section (53 pages) gives an account of the chemical and physical characters of petroleum, and contains many valuable tables. The fourth section is very brief (13 pages), and deals with the origin of this natural product: the author points out that the theories which regard petroleum as resulting from the decomposition or distillation of animal remains are now largely accepted by chemists. The fifth section (70 pages) relates to the winning of petroleum, and gives a detailed description of the apparatus used for the purpose in different countries. Section VI is a very important one, extending to nearly 100 pages, and gives an account of the different methods which have been devised for the refining of the crude natural products. Section VII (63 pages) treats of the Shale-oil and allied industries. Section VIII (also 63 pages) describes the methods of transport, storage, and distribution: it is interesting to read, for example, that one line of pipes—the Emery (United States) Line—is 488 miles long. Section IX is another most important chapter, and one in which the experience and special knowledge of Mr. Redwood is manifest: it treats of the testing of the raw material and manufactured products. The next section (73 pages) gives an account of the uses of petroleum and its products; and the last one (86 pages) collects together the statutory, municipal, and other regulations adopted by various countries relative to the testing, storage, transport, and uses of petroleum. The work is then rounded off with 50 pages of statistics.

It is evident that Mr. Redwood's treatise will long be the standard work on this important subject.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting.—February 21st, 1896.

Dr. Henry Woodward, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library Committee for the year 1895. In the former the Council again congratulated the Fellows on the satisfactory condition of the Society's finances, and announced that the decrease in the number of Fellows, to which attention had been drawn in the three previous annual reports, had now been all but arrested.

During 1895 the number of Fellows elected was 43; of these 32 qualified before the end of the year, making, with 12 previously elected Fellows, a total accession of 44 during the twelvemonth. In the same period the losses by death, resignation, and removal amounted to 45, the decrease in the number of Fellows being 1. The total number of Fellows, Foreign Members, and Foreign Correspondents was 1318 at the end of 1895, as compared with 1321 at the end of 1894.

The balance-sheet for the year 1895 showed receipts to the amount of £3249 13*s.* 4*d.*, and an expenditure of £2398 5*s.* 11*d.*, the excess of actual income over expenditure being £492 18*s.* 4*d.* Certain of the stocks belonging to the Society and to the Wollaston, Barlow-Jameson, and Bigsby Trusts were sold out, and re-invested in equally sound securities bearing a higher rate of interest.

The completion of vol. li of the Quarterly Journal was announced, as also the publication of No. 2 of the Record of Geological Literature added to the Society's Library. The Index to the first fifty volumes of the Quarterly Journal will, it is hoped, be issued to the Fellows in the course of the present year.

The question as to the desirability of retaining the Society's Museum had formed the subject of long and earnest deliberations by the Council, and, in accordance with the report of a Special Committee, the Trustees of the British Museum had been asked whether they would undertake to house and care for the collections, keeping type-specimens and specimens illustrative of papers read before the Society distinct, defraying also the expenses of transference. To these conditions the Trustees had assented, and the matter will no doubt before long be submitted to the Fellows for their decision at a special general meeting.

The proposed introduction of the electric light and redecoration of the Society's apartments was briefly referred to; and, in conclusion, the awards of the various medals and proceeds of donation funds in the gift of the Society were announced.

The report of the Library Committee enumerated the large additions made during the past year to the Society's library, and stated that the manuscript card catalogue of the geological maps and sections was now practically completed.

In handing the Wollaston Medal to Sir John Evans, K.C.B., D.C.L., F.R.S., F.L.S., Foreign Secretary (for transmission to Eduard Suess, Ph.D., For.Memb.R.S., For.Memb.G.S., Professor of Geology in the University of Vienna), the President addressed him as follows:—Sir John Evans,—

May I request you, in your official capacity as Foreign Secretary, to receive and transmit to our esteemed Foreign Member, Prof. Eduard Suess, of the University of Vienna, this Medal, founded by that eminent man, Dr. Wollaston, in 1828, "to promote researches concerning the mineral structure of the earth, and to enable the Council of the Geological Society to reward those individuals of any country, by whom such researches may hereafter be made." Of the 27 occasions on which this Medal has been transmitted to foreigners, it has twice before been awarded to Austrian geologists, namely, in 1857, to the illustrious Barrande, and in 1882, to Franz Ritter von Hauer, Intendant of the Imperial Museum of Natural History in Vienna and Director of the Geological Survey of Austria.

In speaking of a man so well known as Prof. Suess, words of commendation on my part are hardly needful. For 39 years he has occupied the Chair of Geology in the University of Vienna, and has exercised an influence on the work of the distinguished school of geologists in that city—including such men as Neumayr, Mojsisovics, Fuchs, Waagen, Penck, and many others—which proves him to be a great master of our science. Since 1851 a steady stream of memoirs, issued by him, has proved him to be a great worker in geology; while the intellectual stimulus of his writings on foreign geologists shows him to be a great thinker. He is worthy of this award, therefore, not only for the work which he has accomplished himself, but by what he has roused others to do, not only by the originality of his own thought, but by the extent which he has influenced the mind of others.

Suess is not a specialist. He began work on Graptolites; he next laid the foundations of the modern classification of the Brachiopoda and Ammonites. Alpine problems roused his interest in dynamical and structural geology, and led to studies of the Austrian and Italian earthquakes, and to his suggestion of the connection between these and the great circle of European Tertiary volcanoes and the elevation of the Alps. Work on the complex Tertiaries of the Vienna Basin and a study of the Mediterranean littoral geology led to his researches in Faunistic Palæontology, and so prepared the way for his pupil Neumayr.

Suess's varied knowledge, penetrative insight, and suggestive originality are perhaps best exhibited in his "Antlitz der Erde," wherein he tried to show the main factors and methods that have ruled in geographical evolution.

The intimate union thus established between the problems of geology and geography cannot but be regarded as of the highest importance to the advancement of both sciences, and the world has been made wiser by the rich stores of knowledge which Prof. Suess has garnered for geologists and geographers in all countries.

Prof. Suess has been connected with this Society since 1863, in which year I made his personal acquaintance when he visited London He has now been a Foreign Member since 1876, and is one of the three oldest foreign geologists on the Society's list. His attachment to this country will be better understood when it is known that Prof. Suess was born in London on the 20th of August, 1831, his father being at that time a merchant in the City.

I am sure it will add to Prof. Suess's pleasure to be told that this Medal was awarded him by the unanimous vote of the Council, and that we send with it our warmest remembrances and good wishes for his continued health and prosperity.

Sir John Evans, in reply, said :—Mr. President,—

The recipient of this award, whose professorial duties as well as his advancing age prevent him from attending this meeting, has requested me to read the following communication from him:—"By adding my name to the list of those masters of geological science who have been honoured before me by the award of the Wollaston Medal, your illustrious Society renders me truly proud, and I can hardly find words adequate to express my feelings of gratitude.

"In addition to field-work, I have for many years laboured to obtain some approximately comprehensive view of the surface-structure of the whole of our planet, and during this endeavour not a day has passed without bringing again and again before my eyes the vastness of the British Empire, the worldwide activity of British geologists and travellers, and the enormous amount of geological work and learning recorded in the English language.

"I often and gladly remember the kindness and the instruction which during the course of my life I have received from my English masters, and above all from my repeated intercourse with Sir Charles Lyell, but I dared not think that my own modest essays would ever be deemed worthy of this distinction—the highest that English geologists can bestow.

"This, however, now comes to me at an age when the natural diminution of physical strength confines me to valley and home; hammer and belt rest on their peg, and dreams and remembrances alone still carry me along those Alpine wanderings which form the highest charms of our incomparable science, and in the lonely grandeur of which Man feels himself more than ever a child of surrounding Nature.

"In these hours of enforced inactivity, the award of your Society leads me to hope that my past exertions have not been quite in vain; and with deepest thanks I receive this Medal as a token of indulgence, of encouragement, and also of consolation."

The President then presented to Alfred Harker, Esq., M.A., F.G.S., of the Geological Survey of Scotland, and of St. John's College, Cambridge, the balance of the proceeds of the Wollaston Donation Fund, addressing him as follows:—Mr. Harker,—

The Council request your acceptance of the Wollaston Fund in recognition of the admirable work in Petrology and your studies in the Metamorphic and Igneous Rocks and in Dynamometamorphism, to which you have given such careful attention since you joined our ranks as a Fellow in 1884.

I have only to allude to your papers before this Society on the Gabbro of Carrock Fell and its Granophyres; your petrological notes on rocks from the Cross-Fell Inlier; your paper on the eruptive rocks of Sarn, Caernarvonshire; your joint papers with Mr. Marr on the Shap Granite and the associated Metamorphic Rocks,—to show the nature of the work in which you have been engaged.

Your Sedgwick Essay, on the Volcanic Rocks of Caernarvonshire, is a model of what such work should be. It has already received a well-merited encomium from your present chief, the Director-General of the Geological Survey.

In the past twelve years you have also been a frequent contributor to the pages of the Geological Magazine, in which some twenty articles of yours are to be found.

Lastly, your excellent "Petrology for Students," issued from the Cambridge University Press last year, greatly adds to your credit in this field of research.

This slight recognition from the Council may serve to assure you how highly your past work has been appreciated, and how much more good work we trust that you will live to achieve.

Mr. Harker, in reply, said:—Mr. President,—

I heartily thank the Council for the honour which they have conferred upon me, and yourself for the graceful words with which you have accompanied this award.

In the work to which you have made kind reference, I have confined myself to only one among the several lines of research recognized by this Society. I have, however, always regarded Petrology, not as a study apart, but as a branch of geological science; and whatever value may belong to my results, I owe in large measure to the fortunate circumstances which have enabled me constantly to combine work in the field with work in the laboratory.

Generous appreciation at the hands of those best qualified to judge is an incentive second only to the pleasure of the work itself. To the encouragement which I have at all times derived from the comradeship of fellow-workers, both at Cambridge and elsewhere, is now added that which must always attach to such an honour as the present one; and for the encouragement, no less than for the recognition, I tender my best thanks.

In presenting the Murchison Medal to T. Mellard Reade, Esq., C.E., F.G.S., the President said:—Mr. Mellard Reade,—

The Council of the Geological Society have awarded to you the Murchison Medal, in recognition of your work on "The Origin of Mountain Ranges," containing the records of much original and experimental research. Since you joined this Society in 1872 you have contributed to the various scientific journals, and to this and other kindred institutions, more than a hundred papers on geological subjects, treating of "the Geology and Physics of the post-Glacial Period in Lancashire and Cheshire," "the Buried Valley of the Mersey," "the Drift-beds of the North-west of England," "the Chalk-masses in the Contorted Drift of Cromer," "Tidal Action as a Geological Cause," "the Moon and the Earth," and many other kindred subjects bearing upon Dynamical Geology, to which you have devoted much careful thought and originality of observation extending over more than a quarter of a century, and have never permitted an opportunity to slip of adding to our store of geological knowledge.

This medal will serve to assure you that, although not often present at our meetings, and living at a distance from town, you are neither overlooked nor forgotten by your fellow-geologists here, nor have your labours been unappreciated.

Mr. Mellard Reade replied as follows:—Mr. President,—

It is with mingled feelings, difficult, nay impossible, to express here, that I receive the medal founded by the illustrious author of "Siluria," which the Council of this Society, in the exercise of their functions, have thought fit to award to me. If one circumstance more than another could add to the pleasure which the award affords me, it is, Dr. Woodward, that I receive it through you as President of this Society. I cannot forget that my first little geological venture was launched in the columns of the Geological Magazine, and that ever since you have proved to be a true and consistent friend.

As regards the work and researches of which you have so favourably spoken, it is for others to assess their value, and for me to rejoice that they have been considered worthy of so handsome a recognition. Like the founder of this medal, I began the study of geology in middle life, and doubtless the direction and the character of my researches have been profoundly influenced by previous professional training as well as by natural bias. The study of geology has been to me a labour of love as well as an interesting and healthful recreation. It has also been an education. Doubtless some of the work to which I have directed my attention has been of an arduous nature, but, as Shakespeare says, "The labour we delight in physics pain."

It now only remains for me to thank the Council and yourself for this much appreciated recognition of my small services to geological science, and to assure you that the addition of my name to the distinguished list of Murchison medallists is calculated to inspire and support me in any further work which in God's providence I may be permitted to carry out.

The President then presented the balance of the proceeds of the Murchison Geological Fund to Philip Lake, Esq., M.A., F.G.S., addressing him in the following words:—Mr. Lake,—

The Council of the Geological Society have awarded to you the balance of the proceeds of the Murchison Geological Fund, in recognition of your work in India, too soon interrupted by ill-health. Before you left, however, you had made a solid contribution to the history of the origin of the remarkable Laterites of that region (Mem. Geol. Surv. India, vol. xxiv, art. 3, 1890), as well as to some other Indian geological problems. You have now commenced in Wales: first, in conjunction with Mr. T. T. Groom, at Corwen (Quart. Journ. Geol. Soc. 1893, vol. xlix, p. 426); and at a later date alone, near Llangollen (*ibid.* 1895, vol. li, p. 9), you have given the Society careful and accurate contributions on the geology of these difficult regions.

Nor have you neglected palæontological studies, as your recent paper on *Acidaspis* bears testimony. It is hoped that this award may prove not only useful, but that it may serve as an incentive to continued and important geological work in the near future.

Mr. Lake, in reply, said:—Mr. President,—

I am deeply sensible of the honour which the Council have done me in making this award; for, to a labourer in the cause of science, there is no truer pleasure than the appreciation of his labours by his fellow-workers. It is an additional gratification that it should fall to my lot to receive the award at your hands, since of late I have attempted to follow in your footsteps in the field which you have made so peculiarly your own.

I feel, however, that the award is a recognition far beyond what my work has hitherto deserved; and I look upon it rather as an encouragement to persevere in the researches which I have begun.

In presenting the Lyell Medal to Arthur Smith Woodward, Esq., F.L.S., F.G.S., the President said:—Mr. Arthur Smith Woodward,—

The Council of the Geological Society have awarded you the Lyell Medal, because it appeared to them that the palæontological work to which you have so earnestly devoted your life since you commenced your career in the British Museum in 1882 would have met with the cordial approval of the distinguished geologist and writer who founded this medal.

Trained at the Owens College, Manchester, you had, besides this, an innate love of scientific work, and only needed the opportunity to develop into an accomplished palæontologist of the Vertebrata.

In dealing with the whole field of Fossil Vertebrata, you wavered at first between the varied groups to which your studies invited you; but, after a few papers on Mammalia and Reptilia, you turned with a steady resolve to the study of Fossil Fishes, from which you have scarcely ever departed. More than one hundred papers on Fossil Fishes, besides a descriptive and illustrated Catalogue of Fossil Fishes in the British Museum, of which three volumes have already appeared (1889–95), and two Memoirs on the Fossil Fishes of New South Wales, attest the settled life-line of research to which you now stand committed.

But we have to thank you also for a joint work with Mr. C. Davies Sherborn, F.G.S., of the very greatest usefulness to palæontologists, "A Catalogue of British Fossil Vertebrata," 1890—a most trustworthy and excellent compilation, critically and carefully prepared.

That in the space of fourteen years you should have accomplished so much good work, is due to the fact that you have never wavered from the object which you had set before your mind to accomplish, and even in your numerous journeys in Europe and to North America you have ever kept your ichthyological researches steadily in view.

I trust that this medal, and the good wishes which accompany it from your friends here, will encourage you to the completion of your labours on the Fossil Fishes, and that the remaining group of the Teleosteans may enjoy the same careful and critical attention and study at your hands as you have bestowed upon the other and earlier groups.

Mr. Smith Woodward, in reply, said :—Mr. President,—

I desire to express my thanks to the Council of the Geological Society for the great honour that they have done me in making this award, and to yourself, sir, for the very kind and complimentary terms in which you have presented the medal. During the last thirteen years I have merely tried to make the best use of the opportunities for research afforded by my official connection with the British Museum; and the great gratification experienced in the pursuit of duty of this kind is in itself so ample a reward for the labour involved, that a naturalist thus circumstanced scarcely looks for anything beyond it. When, however, the honourable marks of approbation officially bestowed are unexpectedly coupled with so highly esteemed a distinction as the award of the Lyell Medal by the Geological Society of London, I feel doubly encouraged to persevere and endeavour to merit the compliments that have been expressed.

I was first led to take a special interest in extinct Fishes by attending Dr. Traquair's course of Swiney Lectures on the subject in 1883. I was thus enabled to apply to this field of research the methods that I had previously learned from Prof. Boyd Dawkins when a student in the Owens College. Since that time the kindly encouragement of so many friends—yourself and the late Mr. William Davies among the foremost—has made progress easy; and the very fortunate circumstance that most of the larger private collections of Fossil Fishes in this country have now been acquired by the British Museum, has afforded me favourable opportunities for study such as never have been enjoyed by anyone previously. The biological problems suggested by these fossils seem to me to outweigh in interest the geological questions connected with them to so great a degree, that I have rarely been able to look upon them from any but a morphologist's point of view; and all the more on this account do I appreciate the high honour that is conferred upon me by the Geological Society to-day.

The President then presented one-half of the balance of the proceeds of the Lyell Geological Fund to Dr. William Fraser Hume, Assoc.R.S.M. and R.Coll.Sci., F.G.S., and addressed him as follows :—Dr. Hume,—

Although for several years you have been actively engaged as a Demonstrator in Geology in the Royal College of Science, you have not allowed any opportunities for doing original work in the field to escape you; and your essay on the Chemical and Micro-mineralogical Structure of the several zones of the Upper Cretaceous rocks of the South of England illustrates admirably how such detailed work should best be carried out.

Your papers on the "Black-earth," "the Loess," and on the Chalk of Russia, "on the Genesis of the Chalk," and on "Oceanic Deposits," indicate the bent of your researches towards the microscopic investigation of rocks—a line of study which Dr. H. C. Sorby, F.R.S., a past President of this Society, so profitably engaged in.

The Council hope, by the presentation of this award, not only to mark their appreciation of your past researches, but to encourage you to extend them to other formations with the same useful results.

Dr. Hume replied as follows :—Mr. President,—

At times a feeling of despondency has crossed my mind, when I have considered the vastness of our subject, and the smallness of the contributions which I have endeavoured to add to our knowledge of the past; it is therefore a great encouragement to receive this mark of approval from those whose opinion we most value and esteem. It would, indeed, have been strange if, with the resources of the Royal College of Science at my disposal, I had not availed myself to the utmost of such exceptional opportunities.

Two facts afford me special gratification on the present occasion: the first, that this award should be intimately connected with the great geologist whose historical and geographical methods I have been most anxious to follow to the best of my ability; the second, to receive it from you, seeing that you were the editor who piloted with friendly hand my first publication, at a time when it was especially in your power to damp or re-inspire the ardour of a young enthusiast. Therefore to you, sir, to the Council, and to the kind friends who have aided me by active counsel or friendly criticism, I hereby tender my most warm and hearty thanks.

The President then handed the other moiety of the balance of the proceeds of the Lyell Geological Fund to Charles W. Andrews, Esq., B.A., B.Sc., F.G.S., of the British Museum (Natural History), and addressed him as follows :—Mr. Andrews,—

Although your scientific career has been but a short one, you have lost no time in engaging in active and earnest studies as a comparative anatomist of the fossil and living Vertebrata, and have already done some excellent work on the remains of the extinct gigantic Birds from Madagascar and from other parts of the world. Your papers on *Keraterpeton* from the Coal-measures, and the Oxfordian genera of Plesiosauria, prove that you have already acquired an accurate knowledge of many points of detail in the anatomy of these extinct reptiles, which can only be appreciated by an equally careful study of existing forms.

In making this award, the Council desire not only to assist and encourage you in the work which you have taken in hand with so much enthusiasm, but they have a confident expectation that you will ere long contribute papers to their Proceedings, which shall do honour to their prescience and bring *κῦδος* to yourself.

Mr. Andrews, in reply, said :—Mr. President,—

I wish to express my sincere thanks to the Council for the great honour that they have done me, and to you, sir, for the altogether too kind remarks that you have made. It was always my earnest desire to study the structure of animals, but in my wildest dreams I never hoped to have such opportunities as I now enjoy at the Natural History Museum, and I feel continually a sense of responsibility and fear lest I should prove unequal to my task. Having now received this award, I am still further bound in honour to do my utmost to justify it, and to fulfil as far as possible the expectations that you have expressed.

In handing a moiety of the Barlow-Jameson Fund to Dr. G. J. Hinde, F.G.S. (for transmission to Joseph Wright, Esq., F.G.S., of Belfast), the President addressed him as follows :—Dr. Hinde,—

The Council have awarded the sum of twenty pounds from the Barlow-Jameson Fund to Mr. Joseph Wright, in recognition of the valuable services that he has rendered to the palæontology, not only of the Carboniferous rocks in the South, but of the Cretaceous and post-Tertiary deposits in the North of Ireland, and the glacial deposits there, and in Scotland.

Mr. Wright is the author of numerous papers in the Transactions of the Belfast Naturalists' Field Club, on the Irish Liassic and Cretaceous Foraminifera and other Microzoa; he has also prepared and published many lists of Foraminifera from the Scottish and Irish Boulder-clay and other post-Tertiary deposits.

He has done much good work, extending over many years, when resident in the South of Ireland, in connection with the fossils of the Carboniferous Limestone, and both as regards these, and the newer deposits of the North, his specimens have been always available to anyone engaged in writing on the fossils. To Davidson, Rupert Jones, Holl, Brady, myself, and others Joseph Wright's cabinet was ever accessible and his specimens freely lent for study.

I trust that this award will serve to express to Mr. Wright our appreciation of his services, and will act as an incentive to him to continue his useful geological work.

Dr. Hinde replied as follows :—Mr. President,—

It gives me great satisfaction to receive this award on behalf of my friend Mr. Joseph Wright. He is unfortunately unable to be present, and has sent the following letter for communication to you:—

"I desire to express my sincere thanks for the honour conferred upon me by the Council of our Society in recognition of my past work, and for their assistance in the further prosecution of my researches. Working so remote from the headquarters of the Society causes this award to be the more appreciated.

"I regret that I am prevented from being present to receive it in person, but I hope that the Council will accept this expression of my feelings regarding their approval of my work in a somewhat neglected field.

"For some years past nearly all my spare time has been spent in microscopically examining the Glacial Clays for Foraminifera. My anticipation as to the occurrence of these organisms in clays laid down under Glacial conditions has been fully confirmed both as regards our local deposits and other British clays, and I cannot avoid thinking that this fact must more or less influence our views as to the origin of these drifts."

In handing to A. Strahan, Esq., M.A., F.G.S. (for transmission to Mr. John Storrie, of Cardiff), the second moiety of the award made from the Barlow-Jameson Fund, the President addressed him as follows:—Mr. Strahan,—

The Council have accorded to Mr. Storrie the sum of twenty pounds from the Barlow-Jameson Fund, in recognition of his services for the advancement of geological science while in charge of the Cardiff Museum, and subsequently as a volunteer worker on the geology of South Wales. Mr. Storrie, I am informed, was the first to detect and describe an actual exposure of the base of the Old Red Sandstone near Rumney, and his researches have done much to elucidate the obscure plant-remains from the Silurian rocks of that locality.

In the Rhætic and Triassic strata he found and fixed the exact horizon of certain fossils new to the district, while in the latter he made an interesting discovery of grains of gold. His intimate and accurate knowledge of the Cardiff area proved of great service to geologists at the time when the British Association held its meeting in that town. Indeed, few geologists have worked in the neighbourhood of Cardiff without being indebted to him for assistance.

I have much pleasure in handing you this award for transmission to Mr. Storrie.

Mr. Strahan, in reply, said:—Mr. President,—

It will be a great pleasure to me to forward this award to Mr. Storrie. The pages of our Journal testify to the value of the aid that he has rendered to many Fellows of the Society. I have myself been indebted to him for most valuable assistance in the geological mapping of the neighbourhood of Cardiff. Mr. Storrie writes to me:—

"I regret that it will not be in my power to attend personally to thank the President and Council for the great honour that they have done me. I am afraid that up to now I have not done enough to warrant my selection, but if ever I am able in future to do anything in the way of original work I shall be very anxious to justify this choice and give my whole mind to the accomplishment of the best work possible. You will, I hope, convey in better words than I can the extreme gratitude which I feel for the award."

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last annual meeting, including the Marquis de Saporta (elected Foreign Member in 1889), J. D. Dana (elected Foreign Member in 1851), J. W. Hulke (President from 1882–4), Sir E. H. Bunbury (elected in 1837), the Rt. Hon. T. H. Huxley (elected in 1856), Valentine Ball (elected in 1874), James Carter (elected in 1877), Sven Lovén (elected Foreign Member in 1882), Ludwig Rütimeyer (elected Foreign Member in 1882), W. B. D. Mantell (elected in 1858), Charles Tyler (elected in 1863), E. A. Wünsch (elected in 1875), Hugh Miller (elected in 1874), and Francis E. Brown, late Assistant Clerk to the Geological Society.

The President congratulated the Society on its continued financial prosperity, and on the excellent scientific work carried on under its auspices. He spoke of the progress of the Geological Survey, and the new development made in maps and memoirs; and congratulated the Palæontographical Society upon attaining its 50th year of existence. He thanked the Fellows for the support that they had given to the GEOLOGICAL MAGAZINE, now in the 32nd year of its existence.

He then resumed the subject of his address of 1895, dealing this year with "The Life-history of the Crustacea in Later Palæozoic and Neozoic Times." He pointed out that the great change between Palæozoic and Neozoic life was observable in the Carboniferous period, when we reached the upward limit of the Trilobita, the Eurypterida, and the Ceratiocaridæ. But before these had disappeared, the air-breathing Scorpions had already come into being as far back as in the Upper Silurian period; the Amphipods and Isopods had also commenced, the former in the Upper Silurian and the latter in the Devonian: this formation also revealed the earliest Macruran decapod, a type still better represented in the succeeding Coal-measures. He showed that there was no sharp division in the Crustacea, but before one order died out and disappeared, other and successive groups had already come into existence, thus illustrating the same gradual evolution marked by so many other groups of organisms. At the same time, he observed that many groups were remarkably persistent, as the Ostracods and some Phyllopods, and the King-crabs (Xiphosura).

Dr. Woodward then traced briefly the development of the orders Amphipoda, Isopoda, Cumaceæ, Stomatopoda, Schizopoda, Macrura, and Brachyura in time, giving a slight sketch of the life-line of each great division and of some of the most noteworthy forms of the several orders. He concluded his address as follows:—

"Last year I invited your attention mainly to the state of our knowledge of the earlier and simpler forms of Crustacea inhabiting the Palæozoic seas, placed in the great division of the Entomostraca. I referred to the extinct Trilobita and the important advance in our knowledge of this group which we owe to American palæontologists. I spoke of the Merostomata, including therein the Eurypterida and Xiphosura—the former aquatic division being now entirely extinct, but having, no doubt, given origin, in its remote ancestry, to the terrestrial and air-breathing Scorpionidæ, which have come down from the Silurian epoch to our time, apparently but little changed in structure; whilst the latter (the living Xiphosura, 'King-crabs') have even adhered, in both their general form and their aquatic mode of respiration and life, to their Palæozoic progenitors. I discussed the Palæozoic 'giant pod-shrimps,' Phyllocarida, placed heretofore with the general group of the Phyllopoda, now claimed as the direct ancestors of the modern Malacostraca, but still represented by one living form, apparently but little changed—the genus *Nebalia*.

"Of the other divisions of the Brachiopoda I said but little, nor could I do justice to the Ostracoda and Copepoda, while as regards the Cirripedia, on which Charles Darwin laboured so long and exhaustively, I have been silent, because I found the whole subject of the Crustacea more than sufficient for two addresses.

"To-day I have attempted, in a very imperfect manner, to bring into the focus of my discourse a summary of the fossil Malacostraca, to which our modern Crustacea chiefly belong. It is true that the evidences of the existence of this division prior to the Mesozoic epoch are but few and scanty; nevertheless, even in Carboniferous times, if not in still earlier ones, we catch a gleam of the light of the living life-forms of to-day, shining clearly, though afar off, down the corridors of time, revealing ancestral forms, the prototypes of those which people so abundantly our modern seas, proving that the living present and the far distant past are indissolubly linked together, and that the stream of life has flowed, from its parent source, through all time, at first in tiny rills and murmuring streamlets, yet ever growing stronger, 'from running brooks to rivers wide,' pressing ever and for ever, onwards from the river to the sea.

"As to the minute details of the course which the evolution of Crustacean life has followed in past times, we can, in many cases, only infer, we cannot absolutely prove our proposition. Thus we have no doubt that the aquatic Eurypterida gave rise to the terrestrial Scorpionida, but we cannot show any direct evidence, because we have *Eurypterus* and *Scorpio* side by side in Upper Silurian rocks, but the earlier evolutionary history is wanting. Again, *Nebalia*-like forms are most probably in the direct line of the ancestry of the modern Malacostraca, and in the Carboniferous period we have *Cumacea*-like forms, which have probably been derived from *Ceratiocaris* and have given rise to higher Malacostraca; but Macruran and other forms of Podophthalmata and Edriophthalmata were already in existence in the Devonian, and both Cumaceæ and Nebaliæ continue to exist unchanged to the present day.

"Looked at broadly, however, the Crustacea show the same upward and onward development which marks other living forms whose geological history can be traced. The great extinct orders of Eurypterida and Trilobita have disappeared; the other Entomostracan orders have survived, but they no longer occupy the whole field; with the close of Palæozoic times the Malacostraca have developed in strength, and now occupy the stage associated with the Tracheata proper, and the King-crabs and Scorpions, which latter, like the Ostracoda and Phyllopoda, are survivals from a pre-Silurian age.

"Truly, 'The old order changeth, yielding place to new.'"

(The address was illustrated by about 100 drawings and specimens of Crustacea.)

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*Council*: H. Bauerman, Esq.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; Prof. W. Boyd Dawkins M.A., F.R.S.; H. T. Brown, Esq., F.R.S.; Sir John Evans, K.C.B., LL.D., F.R.S.,; Sir A. Geikie, D.Sc., LL.D., F.R.S. L. & E.; Prof. A. H. Green, M.A., F.R.S.; J. W. Gregory, D.Sc.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Henry Hicks, M.D., F.R.S.; Rev. Edwin Hill, M.A.; T. V. Holmes, Esq.; R. Lydekker, Esq., B.A., F.R.S.; Lieut.-General C. A. McMahon; J. E. Marr, Esq., M.A., F.R.S.; Prof. H. A. Miers, M.A.; E. T. Newton, Esq., F.R.S.; F. Rutley, Esq.; A. Strahan, Esq., M.A.; J. J. H. Teall, Esq., M.A., F.R.S.; H. Woodward, LL.D., F.R.S.

CORRESPONDENCE.

MR. JUKES-BROWNE AND THE GENITIVE.

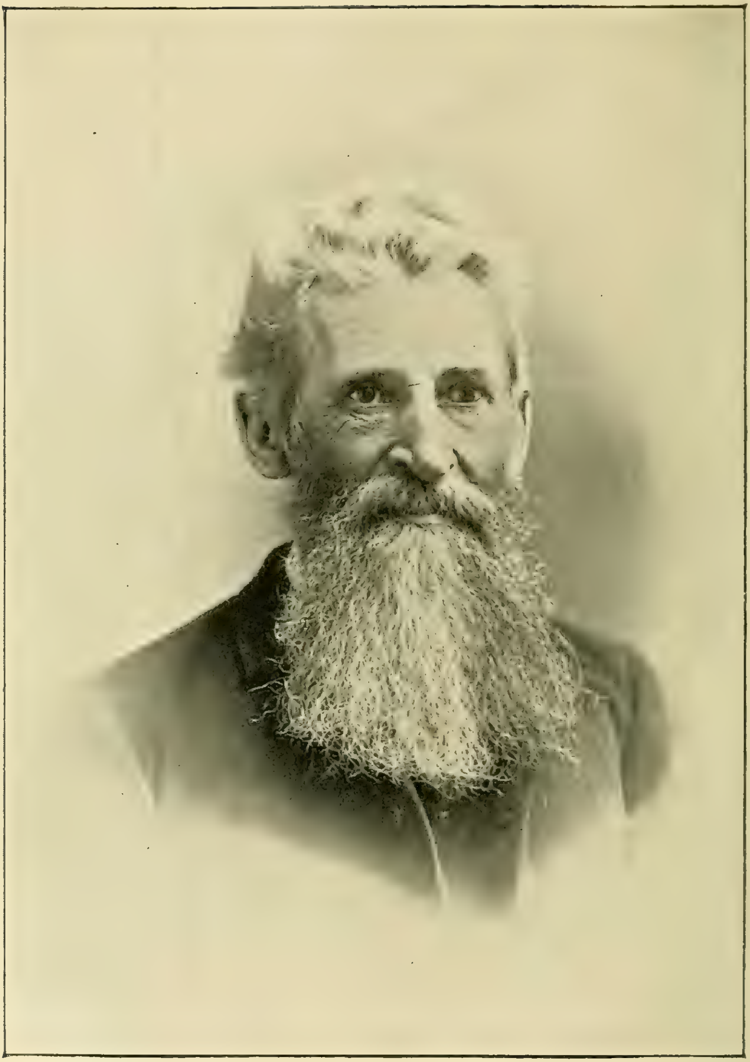
Sir,—Mr. Jukes-Browne asks whether I "made a slip in the construction of the name" *Merocrinus Salopiæ.* I answer, "No." I deliberately preferred the name to several alternatives, on the grounds of euphony and brevity. One alternative was "*Merocrinus scrobbesbyrigshirensis*": am I wrong in my preference? Mr. Jukes-Browne intimates that I am wrong; and this forces me to traverse all his assertions.

It is needless to discuss whether *salopiensis* or *salopicus* be the more correct adjectival form of *Salopia*: Mr. Jukes-Browne prefers the latter; the former is the one in universal use. I rejected both, not from considerations of correctness or incorrectness, but because I liked "*Salopiæ*" better. Mr. Jukes-Browne politely but firmly rebukes me. I apologise, indeed, for the unintentional insult to one of his lady friends; but to me, and to all good folk round the Wrekin, "*Salopia*" means primarily Shrewsbury; and, by a well-known figure of speech, we constantly extend the name to embrace the whole "*comitatus salopiensis.*" Now Mr. Jukes-Browne may dislike genitives as much as did Mistress Quickly, but that does not make them improper. Was it a slip when Tacitus wrote of "*Germaniæ gentes*" (Histor. III, xli), or "*Mœsiæ duces*" (III, liii), or "*plana Umbriæ*" (III, xlii)? If a man likes to talk about the *Merocrinus* of Salop, rather than the Salopian *Merocrinus,* what power in the world is to hinder him?

I fail to understand, I cannot conceive, on what grounds Mr. Jukes-Browne lays down the law. Apart from the usage of classical Latin writers there is nothing to guide one, except the rules and recommendations formulated by various committees of zoologists. In the first code, that of Strickland (which Mr. Jukes-Browne would call the Stricklandian), nothing is said on this point, but genitive forms are accepted as ordinary components of the appellations of species. In the last code, that adopted by the International Congresses of 1889 and 1892, I find these rules:—

"14*b*.—Names of persons to whom the species is dedicated. These names are always to be put in the genitive. This genitive is always to be formed by the addition of a simple *i* to the exact and complete name of the person to whom the dedication is made."

"19.—If the specific name demands the employment of a geographical name, this should either be put in the genitive or employed under its adjectival form, if it was known to the Romans, or if it has been Latinized by mediæval writers. Under its adjectival



CHARLES WACHSMUTH.

1829–1896.

[*See Obituary*, Geol. Mag., p. 189, *April*, 1896.]

form it is always to be written with a small initial letter: e.g. *Antillarum, Galliæ, lybicus, ægyptiacus,* etc."

It is then strange, but true, that the name *Merocrinus Salopiæ* is not only in conformity with Latin usage, but also with the rules of zoologists. As for euphony, tastes differ, especially in different countries. Mr. Jukes-Browne modestly shrinks from the Latinized genitive of "Bell"; some, however, find more pungent offence in the adjectival form of my critic's own name, even when screened by a "jukes" or similar useful prefix. Still, these objections are purely provincial; they would not be felt by a German or Japanese; they have no place in orthography or zoology. And is it not absurd of Mr. Jukes-Browne and myself to be discussing a mode of nomenclature that he has taken a vow never to employ, a vow which I hope we shall both live long to keep?

Natural History Museum, S.W.
March 4th, 1896.

F. A. Bather.

OBITUARY.

CHARLES WACHSMUTH.

Born September 13th, 1829. Died February 7th, 1896.

The Museum of Comparative Zoology at Harvard is about to publish "A Monograph of the Crinoidea Camerata of North America," in two volumes, consisting of 800 pages and 83 plates. This great work is the result of some 40 years' labour on the part of Charles Wachsmuth, of Burlington, Iowa, assisted for about half that period by Frank Springer. Those who have followed the writings of these palæontologists, and who are looking forward to this climax of their efforts, will deeply regret to hear of the death of the senior author, which has deprived him of the congratulations of his colleagues and the joy of an aspiration fulfilled.

Charles Wachsmuth was the only son of Christian Wachsmuth, an eminent lawyer of Hanover, Germany, in which city he was born and educated. He abandoned the profession of the law on account of weak health, and early turned his attention to commerce.

In 1852 Charles Wachsmuth went to New York as an agent for a Hamburg shipping house in the interest of German emigration. Here he remained for two years, but as the climate did not agree with him, he removed to Burlington, Iowa, where he finally settled, having married, in 1856, Miss Bernandina Lorenz. Up to this time Wachsmuth had paid no attention to science, but being still of weak health, he was advised by his physician to spend as much time as possible in the open air, and to take to fossil-collecting. The magnificent remains contained in the Burlington Limestone, especially the fossil crinoids, soon aroused in him the enthusiasm that ceased only with death. In less than three years he had made a collection whose fame extended into other States. Excited by the report of Jules Marcou, in 1864 Louis Agassiz visited Burlington, and struck by the intelligence of Wachsmuth invited him to Cambridge. Thither he went, in 1865, on his way to Europe. This journey was used by him to good purpose in collecting European fossils, and in studying the crinoids in the principal museums. Finally he visited the British Museum, with one of his magnificent Burlington specimens in either pocket; these were promptly purchased. Fired by what he had seen, Wachsmuth, on his return to Burlington, determined to devote the rest of his life to the study of the crinoids. His want of scientific training was not altogether a disadvantage, since he came to the subject unhampered by the preposterous notions of crinoid, or at least fossil crinoid, morphology that obtained among the older writers. W. H. Niles, a student of Agassiz, had been led to believe, from the published observations of Dr. C. A. White, and from notes given him by Wachsmuth, that a careful study of the distribution of the crinoidal remains at Burlington would be rewarded with interesting results. He came to Burlington and, as he says, "found Mr. Wachsmuth acquainted with many important facts in this connection which could be reached only by a long experience in collecting these fossils, by an intimate acquaintance with the species, and a series of most careful observations." The result of his visit was the joint paper published in the American Journal of Science in 1866, proposing a division of the Burlington Limestone into two horizons, based on the restriction of the various species of Crinoids to one or other of these two. The paper was also of importance as pointing out the gradual progression of crinoidal life and structure from the Lower Burlington to the Keokuk Limestone, an idea afterwards elaborated by Wachsmuth and Springer in their remarkable paper on "Transition Forms in Crinoids," 1878. F. B. Meek, who was preparing the fifth volume of the Illinois Survey, also came to study Wachsmuth's collection, and in that volume are several remarkable notes on the structure and habits of Palæozoic Crinoidea, based upon "some unique and exceedingly interesting specimens" in the collection of Wachsmuth. The authors, Meek and Worthen, remark: "We express our thanks to Mr. Wachsmuth for the zeal, industry, skill, and intelligence he has brought to bear, in collecting and preparing for study, such an unrivalled series of the beautiful fossil Crinoidea of this wonderfully rich locality. Some idea of the extent of his collection . . . . may be formed, when we state that of the single family Actinocrinidæ alone, after making due allowance for probable synonyms, he must have specimens of near 150 species, or perhaps more, and many of them showing the body, arms, and column. It is also due to Mr. Wachsmuth that we should state here that he is not a mere collector only, but that he understands what he collects, and knows just what to collect, as well as how to collect."

Later on Agassiz paid a second visit to Burlington, and for the sum of 6000 dollars induced Wachsmuth to part with his magnificent collection, and also to come to Cambridge to arrange the specimens for exhibition, and to study them and publish the results. After this Wachsmuth made a second collection, by no means so extensive as the first, but still containing many splendid specimens, which he brought with him on his second visit to Europe in 1874, and sold to the British Museum for £80. The 203 specimens thus obtained, together with 75 specimens received through exchange in 1888, contain many of the finest examples in the Museum, and some which are in their way unique, notably the splendid calyx of *Megistocrinus Evansi*, measuring 8 cm. ($3\frac{3}{16}$ inches) in diameter.

Again Wachsmuth settled down in Burlington, eager to make a fresh collection and continue his studies. He was so fortunate as to fall in with Mr. Frank Springer, then a young lawyer at Burlington, with whose assistance he again gathered together one of the finest collections of crinoids in the world, to receive which he built a special fire-proof museum at the back of his home in Marietta Street. From this time onwards there have appeared a series of important papers, which, with the exception of "Notes on the Internal and External Structure of Palæozoic Crinoids" (American Journal of Science, 1877) have been written by the two friends. Next to the paper just mentioned, which was an epoch-making one in this branch of science, the most valuable is the "Revision of the Palæocrinoidea," published by the Philadelphia Academy. To deal in detail with the differences in our knowledge of these animals that have been due to Wachsmuth and Springer, is impossible on the present occasion, and readers may be referred to the Geological Magazine, Decade III, Vol. VIII, pp. 219–224, for one of the very few accounts of their work that have appeared in this country. We may, however, again point out that these authors were very different from the usual race of species-mongering collectors that flourish too plentifully in similar rich localities. Their aim was not so much to add to the already overladen lists of species as, on the one hand, to sift, summarize, and correct the work of their predecessors, and, on the other hand, to throw what light they could upon the structure and classification of the Crinoidea. It is not the least praise that can be accorded them to say that many of the suggestive views which they have at various times put forward they have at other times overthrown by their own more careful, more extended observations. There are those who jeer at the inconsistencies of science, forgetful of the wise saying that it is only fools who never make mistakes. In searching out his knowledge Wachsmuth was possessed of indefatigable patience; and in maintaining what he held to be the truth, he displayed a vigorous enthusiasm. At the same time he was always ready to discuss objections, and to yield with open mind to more powerful arguments. His generosity to his fellow-workers, and especially to those in England, must not pass unnoticed here. I could speak myself of his kindness, both in correspondence and in person, when I had the pleasure of staying with him and examining his marvellous collection at Burlington; but it is perhaps more fitting that I should quote from Etheridge and Carpenter's preface to their "Catalogue of the Blastoidea in the British Museum," when they say—"Our chief difficulty, the want of adequate material, was soon and simply solved; for Mr. Charles Wachsmuth generously offered to place at our disposal a selected series from his fine collection of American Blastoids. Though it was originally lent for six months only, the owner's liberality has enabled it to remain in our hands for over five years. Nothing that we can say can express better than this statement the extent of our indebtedness to Mr. Wachsmuth's generosity, which prompted him to expose a valuable collection to a double journey across the Atlantic and a prolonged detention in this country, in the hope of promoting scientific knowledge. Besides providing us with material, Mr. Wachsmuth has also been kind enough to keep us informed from time to time of the progress of his own researches. We tender him our most sincere thanks for the very free use which he has allowed us to make of his unpublished observations." F. A. B.

MISCELLANEOUS.

Palæontographical Society.

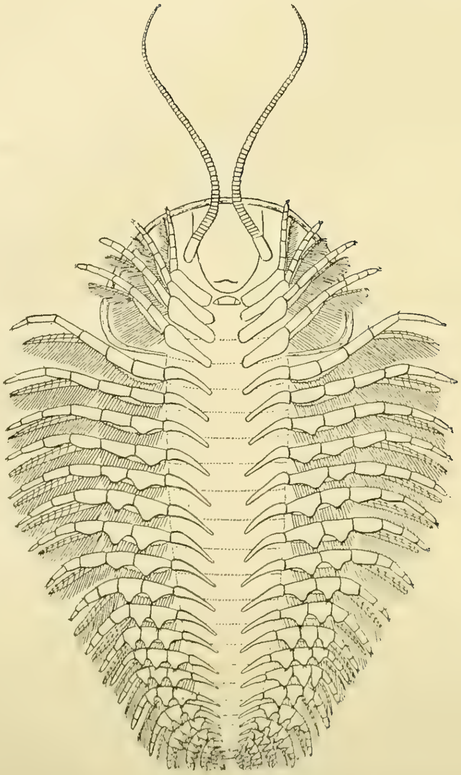
THIS Society, which was established in the year 1847 for the purpose of figuring and describing the fossils of the British Isles, issued last year its 49th volume, and the 50th volume may be expected early this year. The monographs in course of publication include those of the Gasteropoda of the Inferior Oolite, by Mr. Hudleston; the Ammonites of the same formation, by Mr. S. S. Buckman; certain Lamellibranchs of the Coal-measures, by Dr. Wheelton Hind; the Devonian Fauna of the South of England, by the Rev. G. F. Whidborne; the Crag Foraminifera, by Prof. T. Rupert Jones; and the Fossil Sponges, by Dr. G. J. Hinde.

Although so much has been accomplished, there yet remains a very large amount of work to be done. Of this future work the more important will be the description and illustration of the Jurassic and Cretaceous Fishes (certain Ganoids excepted); the Jurassic and Cretaceous Lamellibranchs (with the exception of those of the Great Oolite and the *Trigoniæ*); the Gasteropods of the Lias, Middle and Upper Oolites, and Cretaceous Rocks; the Lower Carboniferous, Silurian, and older Mollusca; the Polyzoa of all formations (except the Crag); the Mesozoic Crustacea; the Palæozoic Echinoderms (except the Devonian); and the Insects of all formations.

Unfortunately, Palæontology is not an exact science, and with the multiplication of species nowadays it is difficult to foretell the time when the Palæontographical Society will have terminated its valuable labours.

It has now reached the point of preparing to issue its fiftieth annual volume, and it seems highly desirable that public attention should be drawn to the important work carried on by this Society, in order to attract new members. We can imagine no better way to effect this object than by sending out a circular announcing the *Jubilee* of the Society this year, and inviting all members to celebrate the occasion by a public meeting and dinner, at which all old "pals" should meet once more. The custom was to hold an annual dinner on the anniversary day, and we hope this excellent and time-honoured practice of the Palæontographical Society will now be revived.

2.



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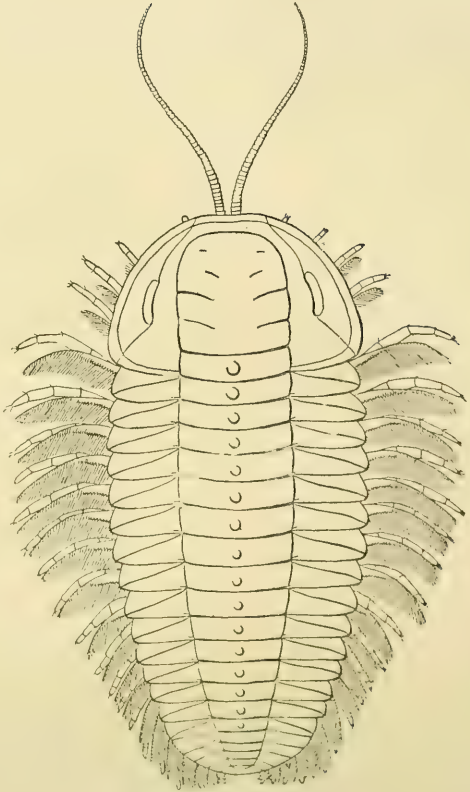

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ORIGINAL ARTICLES.

I.—The Morphology of *Triarthrus*.[1]

By C. E. Beecher,

Of Yale Museum, New Haven, Conn., U.S.A.

(PLATE IX.)

MOST of the recent advances in the knowledge of trilobite-structure have come from the study of *Triarthrus*. Since Valiant's discovery of the antennæ, and its announcement by Matthew in 1893, the writer has published a series of papers on the detailed structure of this trilobite. Much time has also been spent in carefully working out the numerous specimens from the abundant material in the Yale Museum. Altogether upwards of five hundred individuals with appendages more or less complete have been investigated; and at the present time, it may safely be said that the important exoskeletal features have been seen and described.[2]

Notwithstanding the amount of information regarding the details of the various organs, very little has been shown illustrating the general appearance of the animal with the appendages in a natural and lifelike position, and it is one object of the present article to supply this deficiency.

Several specimens have been lately developed which preserve not only the appendages in great perfection, but also show them extended and disposed in a very lifelike manner. No new structural points are here brought out, yet the representation of the complete animal serves as a summary of present knowledge, and also gives a definite picture of great assistance in forming a conception of general trilobite morphology.

The dorsal view represented on Plate IX is from a camera drawing based upon three specimens of about the same size. One gives the entire series of legs down to the ninth free segment, with the exception of the exopodites of the head, which are supplied from a second individual. In the third specimen, the anterior appendages are bent and irregularly arranged, while from the ninth backward to the end of the pygidium they are complete and uniformly extended. The figure is, therefore, a restoration only in so far as representing the best portions of three individuals.

[1] Reprinted from the American Journal of Science, 4th series, vol. i, No. 4, April 1896, pp. 251–256.

[2] The more important literature relating to the structure of the genus *Triarthrus* is given at the end of the present article; numbers in the text refer to this.

The ventral view, Plate IX, is based mainly upon two very excellent specimens. One was figured on plate iv, vol. xv, of the *American Geologist*, and another, since found, nearly completes the ventral aspect. The under side of the head and pygidium was carefully compared with all the available material, and no attempt was made to supply any characters except as to the exact number of joints in the endopodial cephalic elements and the precise form of the cephalic exopodites, which from every character observed, and from analogy with similar structures elsewhere, were as represented.

So many specimens preserve the appendages in the position shown in the figures, that this must be recognized as natural and one likely to have been assumed by the living animal when extended. Few, however, show the details of the limbs with sufficient clearness to enable one to make out all their joints, and more minute characters.

In comparison with what is now known of the appendages of several other genera of trilobites, especially *Trinucleus*,[1] those of *Triarthrus* seem to have been exceptionally long. On this point Bernard, in a letter to the writer, suggests that "*Triarthrus* must have been a sort of 'Daddy longlegs' among the Trilobites, as *Scutigera* is among the Myriapoda." The entire length of a thoracic leg, including the coxal joint, is nearly equal to the width of the body at that point, and about half the length projects beyond the pleura.

The limbs of the head diminish in length forwards until the anterior pair scarcely extends beyond the border of the cephalon. The anterior thoracic legs are the longest, and there is a gradual shortening backward in the series, especially noticeable after passing the fifth, those at the extremity of the pygidium being about one-ninth the length of the first thoracic leg. Their position is also of interest. At the posterior extremity they point almost directly backwards, while those on the head are directed more or less forwards. Between these two extremes, all the intermediate positions occur in regular order.

The gnathobases, or coxopodites, become more and more specialized anteriorly, growing broader and having their inner edge denticulate, until on the head they function as true manducatory organs. The second pair, however, corresponding to the mandibles of higher crustacea, has not become clearly differentiated from the rest of the series, and apparently has not lost the exo- and endopodial branches.

Few changes of importance can be traced in the exopodites, though the latter are considerably reduced in size on the cephalon. Over the anterior half of the thorax, they functioned as vigorous paddles; and on the pygidium their length and compact arrangement made them overlap each other, thus producing two broad flaps, or fin-like organs. The conclusion cannot be avoided that *Triarthrus* must have been an active creature, and with its rows of endopodites and exopodites it was as fully equipped as the bireme in classic

[1] "Structure and Appendages of *Trinucleus*," C. E. Beecher: Amer. Journ. Science, vol. xlix, April 1895.

navigation. The form of the animal and the multiplicity of locomotor organs were well adapted for rapid motion either along the sea-bottom or through the water.

The youngest and most immature limbs are on the pygidium, and in a young trilobite they are very much like those in the larval *Apus* (4) and are typically phyllopodiform. According to the law of morphogenesis, these limbs may be taken as of phylogenetic value and indicative of the primitive type of limb structure.

The whole series of endopodites anterior to the last two or three show modifications from the phyllopodous type, the change involving progressively from one to all of the endites. The endopodites of the pygidium have a true phyllopodiform structure, and are composed of broad leaf-like joints, wider than long. This character is gradually lost in passing anteriorly, the distal endites being the ones first affected. By the time the anterior pygidial limb is reached, the three distal joints are longitudinally cylindrical. The ninth thoracic endopodite shows a fourth endite becoming cylindrical, and on the first and second thoracic legs even the proximal ones are thus modified, making all the endites of these limbs slender in form.

This gradual modification of a phyllopodiform swimming member into a long, jointed, cylindrical crawling leg deserves more than passing notice, for here, probably, better than in any known recent form, can the process and its significance be studied. No living type of crustacean more nearly conforms to the theoretical archetype of the class than do the trilobites; and as *Triarthrus* belongs to an ancient Cambrian family, it may be expected to retain very primitive characters.

In this genus several causes evidently influenced the modification of the appendages. First may be mentioned the specialization into oral organs of the gnathobases of the head, which would tend toward a reduction of the other portions of the limbs. Next, the assumption of a walking habit would gradually lead to a corresponding adaptation of the anterior thoracic endopodites, this region of the body being naturally the place where they would be most operative. Lastly, any tendency to change the form of the anterior limbs would be accelerated through the greater number of moults they undergo as compared with the abdominal appendages.

Since the anal segment of crustacea contains the formative elements out of which all the trunk segments are successively developed, it may be considered as the same segment in all crustacea, no matter how many nor what kinds of segments may intervene between it and the head. The youngest segment, therefore, is always in the budding zone, just in front of the telson, or terminal somite, and those further anterior and more differentiated are older. This sequential order in the age of the segments and appendages may be greatly obscured in higher forms, so that, as in the Thoracostraca, the last pair of pleopods, forming with the telson the caudal fin, appears at an early stage of the ontogeny. In such cases, as Lang says, "the grade of development and physiological importance of a section of the body or of a pair of limbs in the adult animal may be recognized by the earlier or later appearance of their rudiments."[1]

In *Triarthrus*, these disturbing factors are hardly to be recognized, for no pair of limbs had an excessive physiological importance over any other pair or series of pairs, and increase progressed regularly by the addition of new members in front of the anal segment. The pygidium, being formed of fused segments, accommodated itself to this kind of growth by pushing forward the series of limbs and by the formation of a new free segment at the posterior end of the thorax. This process of metameric growth continued from the protaspis stage with no free thoracic segments, and successively added segment after segment with corresponding moults, until the full complement was reached, after which the moulting resulted mainly in increase in size. The repetition of moults afforded the chief means by which modifications in the appendages could be brought about.

The earliest protaspis stage shows, from the segmentation of the axis, that there were present five pairs of appendages on the head and two on the pygidium (6). The adult animal has thirteen or fourteen free thoracic segments and six pygidial.[2] Now, so far as is known of trilobite ontogeny, there was never more than one segment added at a single moult, though there is no evidence that there may not have been more moults than segments between the protaspis stage and the finished segmentation. In *Triarthrus*, the average full number of segments was attained by the time the animal reached a length of about 7 mm.: so that the limbs of the anterior thoracic segment in an individual 7 mm. in length, and containing the full complement of fourteen free and six pygidial segments, must have undergone at least seventeen moults. The second thoracic segment, therefore, at this stage of growth would have been moulted sixteen times, the fifth thirteen times, the tenth eight times, and the fourteenth four times. The length of full-grown individuals is from 25 to 40 mm., and to have reached this size a considerable number of additional moults must have occurred, in which all the segments participated alike.

Some mention should be made of the probable method of respiration of *Triarthrus*. No traces of any special organs for this purpose have been found in this genus, and their former existence is very doubtful, especially in view of the perfection of details preserved in various parts of the animal.

The delicacy of the appendages and ventral membrane of trilobites and their rarity of preservation are sufficient demonstration that these portions of the outer integument were of extreme thinness, and therefore perfectly capable of performing the function of respiration. Similar conditions occur in most of the Ostracoda and Copepoda, and also in many of the Cladocera and Cirrepedia, where no special respiratory organs are developed.

[1] "Textbook of Comparative Anatomy," English edition (Bernard), p. 410.

[2] A few individuals of this species (*T. Becki*) have been observed with one or two additional thoracic segments.—Walcott (11).

The fringes on the exopodites in *Triarthrus* and *Trinucleus* are made up of narrow, oblique, lamellar elements becoming filiform at the ends. Thus, they presented a large surface to the external medium, and partook of the nature of gills. But, as Gegenbaur says, "the functions of respiration and of locomotion are often so closely united that it is difficult to say whether certain forms of these appendages should be regarded as gills, or feet, or both combined."[1] For purposes of locomotion, the limbs of the cephalon and pygidium were of feeble assistance compared with those on the thorax; and in the higher crustacea, these two regions are the ones where the greatest branchial specialization takes place.

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Explanation of Plate.

Fig. 1.—*Triarthrus Becki*, Green: dorsal view; showing character and extent of antennules and limbs beyond the carapace. × 2½.

Fig. 2.—*Triarthrus Becki*, Green: ventral view; showing entire series of appendages, together with hypostoma, metastoma, and anal opening. × 2½.

Formation and locality.—Utica Slates, Ordovician: near Rome, New York, U.S.A.

[1] "Elements of Comparative Anatomy," Eng. edit. (Bell and Lankester), p. 211.

II.—On the Identification of the *Acanthoceras mammillatum* and *Hoplites interruptus* Zones at Okeford Fitzpaine, Dorsetshire.

By R. Bullen Newton, F.G.S.

SOME molluscan and other remains obtained by Miss Forbes and Miss Lowndes from a brick-pit exposure at Okeford Fitzpaine, near Shillingstone station, Dorsetshire, have recently been submitted to me for determination. They comprise two series of specimens indicative of the well-known Cretaceous zones of *Acanthoceras mammillatum* and *Hoplites interruptus*. Those from the former or earlier horizon were collected about nine years ago, whereas the others were obtained within the last few weeks. It will be convenient to name the species identified from the *Acanthoceras mammillatum* zone first, then to describe the beds constituting the whole of the section, and lastly to give a list of the fauna from the *Hoplites interruptus* zone.

(A) The *Acanthoceras mammillatum* Zone.

Acanthoceras mammillatum,[1] Schlotheim, sp.
Hoplites Benettianus, J. de C. Sowerby, sp.
Pleuromya plicata, J. de C. Sowerby, sp.
Cucullæa carinata, J. Sowerby, sp.
Ostrea Leymeriei (Deshayes MS.), Leymerie.
Exogyra sinuata,[2] J. Sowerby.

The matrix surrounding these shells is mostly of an argillaceous sandy character, slightly micaceous, and of a brown, grey, or yellowish colour. That associated more particularly with the specimens of *Ostrea* and *Exogyra* exhibits an oolitic structure, the grains of which are heavily charged with hydrated oxide of iron. This fossiliferous bed, containing also some small siliceous pebbles, has a thickness of five feet, and lies about twenty-eight feet from the surface; beneath is a deposit of pure sand, having a depth of three feet, which reposes on a stiff blue clay of, probably, Kimeridge age; at the base of this occurs a sandy rock-formation which possibly belongs to the Corallian period. Immediately above the deposit containing the shells is a seam of brown sandy rock, four feet in depth, succeeded by fifteen feet of a grey-coloured sandy clay (of a bluish tint when damp), with phosphatic nodules interspersed (a section of one showing veins of calcite); both these bear a Lower Gault fauna, characterized by *Hoplites interruptus*, etc. Then follow two unfossiliferous bands—one of brown clay, five feet thick, the other of yellow clay with angular fragments of chert, three feet thick; a foot of subsoil occurring above this completes the section.

[1] This name has been incorrectly written *mammillaris* by many authors, though its original rendering was [*Ammonites*] *mammillatus*.

[2] *E. sinuata* (synonymous with *E. aquila* of Continental authors) is not to be confounded with *E. Couloni*, Defrance (= *subsinuata*, Leymerie), the latter differing not only in specific details, but characterizing a lower horizon, viz. the Hauterivien stage, or the upper part of the Neocomian strata.

In tabular order the beds[1] may be thus arranged:—

		Feet.
	Subsoil	1
	Yellow clay with chert	3
	Brown clay without chert	5
Hoplites interruptus Zone.	Dark-grey coloured, micaceous, and sandy clay with phosphatic nodules; fossiliferous in the lower 4 feet	15
	Brown sandy rock, with fossils in the upper part	4
Acanthoceras mammillatum Zone.	Argillaceous sandy beds, micaceous, and of a brown, grey, or yellowish colour; ferruginous and oolitic; siliceous pebbles interspersed; fossiliferous	5
? Aptian.	Pure sand	3
Kimeridgian.	Stiff blue clay	8 or 10
? Corallian.	Sandy rock.	

Among the great group of the Ammonites characterizing the Cretaceous formation, none is perhaps of more importance than that of *Acanthoceras mammillatum*. As a zonal species it is of the highest value to the geologist, being restricted in its distribution to the topmost stratum of the Folkestone beds, and never occurring either above or below this position in the series.[2] The present discovery, therefore, of the *Acanthoceras mammillatum* zone in Dorsetshire is of interest as establishing its extension more westerly than hitherto recognized. A few years ago Mr. Jukes-Browne called attention (Geological Magazine, 1891, p. 456) to the occurrence of some clays and sands beneath the Gault in Dorsetshire, which were traced for a distance of four or five miles between Twyford and Childe Okeford, and determined as of Lower Greensand or "Vectian" age. The stratigraphical particulars given of these beds appear to correspond so closely with those observed at Okeford Fitzpaine that it is highly probable they refer to the same series of deposits, though, as no palæontological evidence was referred to by Mr. Jukes-Browne, it must remain a little doubtful until a future comparison can take place on the spot. There is, of course, no reason why the beds on the eastern side of the Stour valley should not be continued across the river in a south-westerly direction to Okeford Fitzpaine, and even to other localities further on that are situated near the junction line of the Kimeridge with the Cretaceous rocks (see Geological Survey map of this district, No. xviii).

Opinions were long divided as to whether the *Ac. mammillatum* zone represented the top of the Lower Greensand (Aptian) or the base of the Gault (Albian). The latter view is that generally adopted now, on account of so many species passing up into the true Gault series. The present fossils contain only two forms which

[1] I am greatly indebted to Miss Forbes and Miss Lowndes for supplying me with the details of this section. Unfortunately, only the *Hoplites interruptus* beds are now exposed, the lower part of the section having been filled in.

[2] In Reid and Strahan's "Geology of the Isle of Wight" (Mem. Geol. Survey, 1889, p. 279), *Ac. mammillatum* is stated to have been found in the Chloritic Marl of Mottistone Down, which is probably either a misdetermination or some error has crept in as to the horizon.

survived to later times, viz. *Pleuromya plicata* and *Cucullœa carinata*; the other species are not known in a higher horizon than this zone. *Hoplites Benettianus* appears to be confined to it; whereas *Ostrea Leymeriei* and *Exogyra sinuata*, having been found at Atherfield and in the upper part of the Speeton Cliff, etc., would date their existence from the Rhodanien stage of the Urgonian (or Barremian) epoch. The examples of *Ostrea Leymeriei* are of great size, one of them measuring 221·5 by 180 millimetres, being in excess of the largest known specimen figured by Coquand in his work on the "Ostrea," 1869, pl. lxxi, fig. 6, which measures 180 by 175 mm.

(B) The *Hoplites interruptus* Zone.

The matrix of this zone, as represented at Okeford Fitzpaine, is more sandy than argillaceous, and full of minute specks of mica; in these characters, as well as in its dark-grey colour, it bears a strong resemblance to what obtains in the Lower Gault beds at Black Ven, near Lyme Regis—and *Lima parallela* appears to be equally abundant at both localities.

As this is the first record of Gault fossils from this part of Dorsetshire, the following list of species recently collected by Miss Forbes and Miss Lowndes will, it is hoped, be of special interest:—

PISCES.

Lamma appendiculata, Agassiz, sp.
Synechodus, sp.

CEPHALOPODA.

Hamites, sp.
Hoplites interruptus, Bruguière, sp.
Hoplites splendens, J. Sowerby, sp.
Nautilus Clementinus, Orbigny.

GASTEROPODA.

Actæon Dupiniana, Orbigny (allied to).
Anchura carinata, Mantell, sp.
Avellana inflata, J. de C. Sowerby.
Natica Gaultina, Orbigny.
Scala Dupiniana, Orbigny.
Solarium ornatum, J. de C. Sowerby.

LAMELLIBRANCHIATA.

Cucullœa carinata, J. Sowerby, sp.
Entolium orbiculare, J. Sowerby, sp.
Gervillia solenoides, Defrance.
Inoceramus concentricus, Parkinson.
Lima parallela, J. Sowerby, sp.
Mytilus subsimplex, Orbigny (allied to).
Nucula pectinata, J. Sowerby.
Ostrea canaliculata, J. Sowerby, sp.
Pecten, sp.
Pleuromya plicata, J. de C. Sowerby.
Solen Dupinianus, Orbigny.
Thracia simplex, Orbigny, sp.
Trigonia alæformis, Parkinson.
Trigonia Archiaciana, Orbigny.
Trigonia Fittoni (Deshayes), Leymerie.

ANNELIDA.

Serpula antiquata, J. de C. Sowerby.

PLANTÆ.

Coniferous wood.

In conclusion, the author desires to thank Mr. G. C. Crick, F.G.S., for his assistance in determining the Cephalopods referred to in this paper. Mention should also be made of the fact that the fossils enumerated from these Cretaceous zones are the property of Miss Lowndes, but she has generously consented to give a selection of them to the Geological Department of the British Museum (Natural History), Cromwell Road.

III.—Notes on the "Pleistocene Beds" of the Maltese Islands.

By John H. Cooke, F.G.S., F.L.S.

In August, 1891, I published in the Geological Magazine the results of my work on the Pleistocene beds of Gozo.[1] Since then I have made a careful and systematic survey of the islands, and have discovered and traced out several important beds that had escaped the notice of those who had preceded me in working out the islands' geology. In the following "notes" I have briefly summarized the results in the hope that they may be of use, not only to other students of the geology of the district, but also to the agriculturist, who, by drawing on the resources that they offer, may bring into cultivation much of that portion of the western parts of the islands which from its supposed dearth of soil has hitherto been looked upon as uncultivable. I have elsewhere described this district and its capabilities; there is, therefore, no need for me to enlarge upon that part of the subject here.[2]

St. Paul's Bay Deposits.—The valley at the head of St. Paul's Bay known as Uied tal Puales, as well as the slopes that bound the bay itself, are covered with superficial deposits of varying ages and characters. They comprise calcareous loams, alluvial soils, imperfectly formed limestones, and accumulations of limestone-agglomerates and breccias. St. Paul's Bay owes its origin to a depression between two sets of parallel faults, the faces and faults of which are furrowed with small valleys and gullies. The flood waters from these tributaries have largely assisted in filling up the inequalities of the depressed area with the detrital products of the surrounding plateaux; and the alluvium which has been thus spread over has, in many parts, a thickness of from 15 to 20 feet. Besides these accumulations of residual materials the slopes of the valley sides are, in places, lined with alternating deposits of loam and rock-fragments capped with a compact layer of limestone of a greyish colour.

[1] "Notes on the Pleistocene Beds of Gozo": Geol. Mag., Aug. 1891, p. 348.

[2] J. H. Cooke, "On the Cultivation of *Agava rigida* in Malta": Med. Nat., Nos. 26 and 27, 1894.

The loams are similar to those which occur in most of the plateau valleys of the islands. They are very homogeneous in texture, and are somewhat incoherent. They exhibit no signs of stratification, but lines of bedding are strongly marked. Both these, and the underlying layer of compact rock, contain considerable quantities of land-shells, comprising *Helix aspersa*, *H. Melitensis*, *H. vermicularis*, *Clausilia bidens*, *Rumina decollata*, *Cyclostoma Melitensis*, and *Clausilia sulcatum*; but no mammalian or other remains are present. On the southern slopes, near the head of the bay and in the valley which debouches on Ghain tal Razul, numerous interesting sections are to be seen. On the south-eastern shore, between the main road and the old church, there is an extensive bed of grey, calcareous loam, capped with a layer of fine sand and grit. Like the valley deposits it contains enormous quantities of land-shells, but all of them are broken and beyond identification.

The deposit is distinctly stratified, and it averages five feet in thickness. The most interesting of the beds that occur in this locality are the limestone agglomerates which fringe the shore-line.[1] These agglomerates admit of being divided into two classes, one of which is more ancient than the other; the older of the two is to be seen along the shore, extending from the tower to the cliffs below Selmone Castle. Along the southern shore of the bay it lies unconformably on a considerable area of Upper Coralline Limestone, which has been depressed beneath the sea-level by a secondary fault. This depressed area extends from Cala tal G-gazenin to Ghain tal Razul; and the agglomerates cover it for a distance of about two hundred yards, and fill all of its fissures and surface extravasations. The creek of G-gazenin is bounded on the south-west by a narrow promontory which disappears beneath the waters of the sea in an easterly direction, and reappears at a distance of twenty yards as two small outliers. Both the surfaces of the promontory and of the outliers are covered with the agglomerates. The rock upon which these beds now rest had been much eroded into fissures and pot-holes, prior to the deposition of the agglomerates, but all of these irregularities are now filled with the Pleistocene materials. In places a layer of stalagmite of from one to two inches in thickness serves as a line of demarcation between the beds. The agglomerates consist of a mass of angular, subangular, and rounded rock-fragments, all of which have apparently been derived from the Upper Coralline formation. They are promiscuously intermingled, and are embedded in an exceedingly compact, calcareous and ferruginous earth of a deep red colour. Small veins of calcite traverse the rock in all directions, and the sections are pitted with minute borings the interiors of which are lined with crystals of calcite.

The bedding planes are distinctly marked, but evidences of stratification are not so apparent. The bed is so compact that it is only with difficulty that specimens can be detached from it. Some idea of its compactness and durability may be obtained from the fact

[1] Photographs of these, and of most of the other beds that are referred to in these notes, may be seen in the Library of the Geological Society of London.

that it is at all times being battered by the Mediterranean waters, but though blocks of the underlying limestone have been broken off and hurled by the storm-waves to considerable distances, the agglomerates have been but little affected. The thickness of the deposit averages about four feet. I have made many careful examinations of the bed, but the only trace of organic remains that I could find was a portion of a bone of some mammal which I detached from a mass of the agglomerate which lay on the shore-line immediately below the Scicluna Palace. Similar deposits are to be seen at the head of the bay and on the shore-line of the Melleha road. Below Ghain tal Razul there is another and more recent accumulation of a similar character which averages about 16 feet in thickness. It lies on the shore-line at the mouth of the Razul valley, and unconformably on the Globigerina Limestone. Unlike its more ancient prototype it consists of several distinct beds.

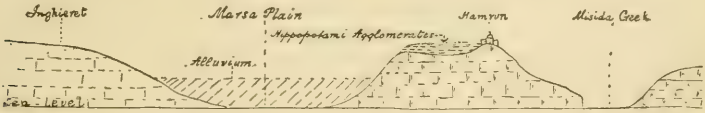
a. The base is composed of silt and fine gravel, intermixed with a few pebbles of Globigerina Limestone of varying sizes and shapes.

b. Above this is a layer of about 15 feet in thickness, consisting of subangular and rounded masses of the Upper Coralline Limestone and of the Globigerina Limestone indiscriminately heaped together and embedded in a loose red earth.

The deposit is roughly stratified, and it is quite unfossiliferous. On the old Melleha road the plateau slopes are covered with considerable quantities of the brecciated loams.

The Hamrun Beds.—These deposits lie on the summit and along the sides of an elevated ridge of the Globigerina Limestone, which lies between the Marsa plain and the Marsamuscetto harbour. The ridge forms the eastern boundary of the Marsa plain, and rises from it with a gradual ascent. It lies immediately opposite to the mouth of the gorge, Uied Kbir, and in a line with Uied Curmi. These two gorges form the main drainage channels of the most extensive catchment basin in Malta.

The height of the summit of the ridge above the Marsa plain varies, the outline being undulatory, and it has a gradual decline toward the head of the Grand Harbour; but the average of the highest points is about forty feet.



A few years ago the whole of the summit of the ridge was laid out in fields, but latterly house-building has progressed so rapidly that the area has now been converted into a densely populated suburb of Valletta. It was whilst the drainage system of the neighbourhood was in process of construction, and the new streets were being laid out, that my attention was first called to the occurrence of these agglomerates, with the molars of *Hippopotami*

Pentlandi embedded in them. The section which was exposed when trenching for the laying of water-pipes in Strada St. Giuseppe is of a very interesting character. The following is the order in which the layers occurred:—

a. Alluvial soil. One foot in thickness.

b. A whitish, highly calcareous loam; very homogeneous, and apparently structureless; plastic and tenacious when wet, but incoherent when dry. It contains a few small fragments of decomposing limestone and numerous land-shells in a good state of preservation. Two feet in thickness.

c. A rich alluvial soil of a reddish colour. It is similar in its general characters to layer *b*, into which it merges by almost imperceptible gradations. One specimen of *Helix pisana* was found. The bed is about two feet in thickness.

d. A layer of angular fragments of Lower Coralline Limestone, together with some decomposing fragments of Globigerina Limestone. The matrix consists of a reddish clay nine inches in thickness.

e. Layer *d* gradually changes in its character towards its base until it passes into a typical conglomerate consisting of rounded pebbles and fragments of bones and molars of *Hippopotami Pentlandi*. The bed was so compact that it was only with the greatest difficulty that the workmen were able to cut through it.

I was not able to ascertain the acreage over which the bed extended, as the trench was but 2½ feet wide. It extended throughout the length of the trench, a distance of 210 feet, and the average thickness was 7¾ feet.

The layer of conglomerate was lenticular in shape, thinning out in a south-east and a north-west direction. Its longer axis was at right angles to the mouth of the Kbir gorge, from which it seemed evident that the materials had been laid down at one extremity of the "cone of dispersion" which had been formed on the plain by the drainage waters of the gorge.

The width of the bed is not, however, very great, as in many of the sections which were exposed in the cess-pit and well-cuttings in the vicinity no trace of the conglomerate could be found.

The overlying beds extend for a considerable distance in all directions. The thickness of these layers varies considerably. They often assume a lenticular shape, and have their thin ends dovetailed the one into the other.

In a cutting which was made about fifteen yards to the north of the tower in Strada St. Giuseppe the following beds were exposed:—

a. Alluvial soil. One foot in thickness.

b. An orange-coloured loam, unstratified, and containing an abundance of fossil land-shells. One foot six inches in thickness.

c. An evenly bedded, slightly indurated limestone, which thinned out in a north-westerly direction. It was one foot six inches in thickness, and passed imperceptibly into *d.* A light-grey loamy earth, structureless and slightly indurated. It contained a few decomposed fragments of limestone, and two specimens of *Helix pisana.* Three feet in thickness.

e. A layer of subangular fragments of the Lower Limestone, decomposing fragments of Globigerina Limestone, and a few pieces of flint. All of the fragments lay with their flattened sides in a horizontal direction. Eight inches thick.

Layers *b* and *d* are very calcareous, and slightly plastic. They are known among the native workmen by the name of "torba," a kind of clayey earth which is used for making the roofs of houses damp-proof.

All of the layers are very homogeneous, and with the exception of *c*, and *e*, none of them present any evidences of structure. Land-shells (*Helix pisana*) in an entire and a broken condition occur at intervals; but besides these no other organic remains were met with.

Layers *b*, *c*, and *d*, passed imperceptibly the one into the other; but the surface of layer *b*, was eroded into "pipes," all of which were filled up with the alluvium of the layer *a*. Between layer *e*, and the underlying rock the line of demarcation, though perceptible, was not strongly marked owing to the decomposition which the surface had undergone.

Numerous other sections in the neighbourhood were also examined, but the only differences consisted in the varying thicknesses of the layers, and in the total absence of the ossiferous conglomerates.

In none of the beds can it be said that the lines of stratification were of a very pronounced character. In this respect the "torba" layers were puzzling; but when small cubes of these layers were cut out they readily split along their bedding planes. From the character and situation of these deposits, it seems probable that they must have owed their origin to the flood waters which poured down the gorges to which I have already referred.

The traces of lamination which the "torba" beds exhibit show that the periods of deposition had quiet and tranquil phases, just as the coarser materials and the huge pot-hole on the opposite side of the hill, in the garden of Villa Frere, demonstrate that they had tumultuous ones.

The Malak Agglomerates.—The surfaces of the fault terraces at Malak are enveloped with extensive accumulations of angular and subangular boulders firmly embedded in a reddish-yellow loam. These accumulations have been referred to by Dr. Leith Adams, but no attempt was made to classify them. They admit of a tripartite division.

A. Yellowish clays containing small subangular fragments of rock, but without any evidences of organic remains. These lie at the base of the sea-cliffs at the sea-level, and they may be traced from Ras-el-Hamra to Ras-el-Scuda. They lie unconformably on the Upper Coralline Limestone, which in this part of the island has been depressed about 500 feet by the Malak faults.

B. A talus of from six to ten feet in thickness, consisting of angular and subangular boulders of the Lower Coralline Limestone. It inclines at a high angle, and extends down the slopes, overlapping A, to the water's edge. This division is only found between Ras-el-Hamra and Uied-el-Mirhla. Adams[1] found the greater portion of a skull of *Elephas Falconeri.* I have found no organic remains here, but in the deposits at the same horizon which lie to the left of the mouth of Uied-el-Mirhla I obtained several limb-bones, including a portion of a humerus of *Elephas Mnaidra.*

C. Higher up the slopes there occurs a layer of angular rock-fragments embedded in an extremely compact calcareous cement. It is persistent all along the fault terrace, and averages about two feet in thickness. In places it overlaps division B, and it is therefore more recent than either of the other layers. The character of the rock-fragments, which are similar to those contained in divisions A and B, as well as the great compactness of the deposit, prove that it must be of considerable antiquity. Land-shells, chiefly *Helices,* in a broken condition were abundant; but mammalian remains appeared to be absent.

Kammieh and Melleha.—The Pleistocene beds at Kammieh and Melleha may be separated into two well-marked divisions, the lower of which differs but little from the loam-breccias that line the bottoms of the slopes of the valleys in other parts of the islands, while the upper one, though possessing certain distinctive characters of its own, is similar in many respects to the beds at Forn-ir-Rieh and Hammar. The sections which are exposed between Redum ta Kassisu and Redum tal Imgharka on the north-western side of Melleha Bay, along the coast of Ramla ta Chumnia, and Ghain Zeituna on the south-eastern shore, and along the shore-line of Il Ponta tal Circheuna and of L'iscol tal Marfa in the Kammieh peninsula, show that all of the deposits in these regions are identical in character. The deposit at L'iscol tal Marfa is typical. It exhibited the following sequence:—

a. A series of layers of red and yellow, compact gritty limestones, resting unconformably one on the other. The materials vary in character, being sometimes coarse and sometimes fine. They abound with land-shells, principally *Helices,* and also with a stunted brackish-water form of *Cerithium.* As a rule the layers exhibit few traces of structure, but where the materials are the coarsest, evidences of irregular bedding and of stratification are apparent.

b. Beneath these layers and passing abruptly but conformably into them is a seam of subangular and of rounded pebbles, of about two inches in thickness. None of the pebbles exceed the size of a walnut, and the majority are no larger than

[1] A. L. Adams, "The Nile Valley and Malta," p. 174. Edinburgh.

a small nut. The rock-fragments lie with their longer axes parallel to the bedding planes of the deposit, and the shells are intact, thus presenting every appearance of having been formed under comparatively quiet conditions.

It is not, however, persistent throughout all of the deposits in the neighbourhood, but occurs only in those localities where the angle of the slopes, whence the materials were derived, was a moderate one. The rock-fragments have been derived from the Upper Coralline Limestones in the vicinity. Beneath this seam lies another bed of gritty limestone, which is similar in its lithological aspects to the upper members of the series. The materials of which it is composed are rounded, and they are so compactly bound together that freshly fractured surfaces present a homogeneous appearance. This portion of the bed averages three feet in thickness, and it extends along the shore for about a mile. *Helices* and a minute *Cerithium* are extremely abundant. Spratt has noted the occurrence of the tests and spines of echinoderms in similar deposits at the head of the bay, but it was not my fortune to meet with any. This series, which I shall call the Upper series, averages about ten feet in thickness.

Beneath this is the lower portion, which lies unconformably on a bed of brecciated loam, consisting of a heterogeneous assortment of pebbles and angular fragments of limestone disseminated throughout the mass. The loamy matrix is made up of finely comminuted clayey particles intermixed with a large percentage of calcareous rock powder, and an appreciable quantity of ferric oxide. Both in its composition and in its general characters the bed agrees closely with the loam-breccias, to which reference has already been made. It averages about three feet in thickness, and, as it forms the basement of the limestone grits, the rapid degradation that it is undergoing is causing the equally rapid destruction of the beds that overlie it. The shore-line is therefore strewn with huge masses of "grit," which have broken away from the main upper bed in consequence of the wearing away of these loamy foundations. The bed contains an abundance of land-shells, but they are not so well preserved as in the upper stratum.

Besides these shore deposits, there are in the bottom of the depression between Kammieh and Melleha, to the west of Torre Hamra, and along the summit of the peninsula of l'Arasc, considerable accumulations of loose "grit," the products of the degradation of the Pleistocene beds which formerly served as a capping to the Upper Coralline Limestone of the district. Large quantities of it have been scattered by wind action over the Kammieh isthmus; and in places, where the surroundings have been favourable, it has been carried down the slopes on the northern side of the isthmus, and has been formed into terraced beds which are very similar in character to the "grits" around the shores of the bay.

The adjoining fault terrace in Uied-tal-Mistra is likewise covered with some interesting deposits of Pleistocene age. Throughout its length it is cloaked with indurated loams and agglomerates, which towards the centre extend across the valley and form a broad flat plain between the slopes. In several places on the northern side these accumulations attain a thickness of from 10 to 15 feet, but the average depth is four feet. The beds are analagous in character to the loams in the Dueira, Il Kala, and other elevated districts of the islands, but owing to the difficulties in the way of properly irrigating the district these beds have not been much disturbed by the agriculturist. Near Mizieb-ir-Rih the deposits attain a considerable thickness, and where they have been broken up they have formed a rich, red, fertile soil. They consist of a heterogeneous assemblage of rock-fragments and loam, all of which have been derived from the Miocene beds in the vicinity. In parts, the breccia that has thus been formed is so indurated that it has been cut out in blocks and utilized by the husbandmen for the building of walls and cattle-sheds. The beds attain their greatest thickness in the bottom of the valley near Mizieb-ir-Rih and Hofriet-migdun, but as the slope rises they thin out and disappear. Land-shells, fragmentary and entire, abound, and several fragments of mammalian bones were found, probably *Cervus*. Southward equally interesting sections are to be seen. No part of either Malta or Gozo exhibits so many evidences of stratal disturbance as does that which lies between Karraba and Kammieh. The cliffs are fissured in all directions, and considerable faults have been formed. In the centre of this disturbed region is a talus of red loam and angular and subangular débris of Upper Coralline Limestone origin, which extends from the summit of the cliffs to the sea-shore, a distance of between 250 and 300 feet. It bears a striking resemblance to the elephant beds at Malak, but the only remains that I could discover after many diligent searches were comminuted fragments of *Helices* and other land-shells. All of the plateau valleys exhibit evidences of the presence of similar beds. It will therefore be sufficient if I draw attention to one which, besides being noteworthy in many details, is also easy of access.

The slopes of the Imtarfa plateaux are marked by deposits which are very typical of the superficial beds of the plateau region. They exhibit the following sequence:—

	in.
a. Alluvial soil.	18
b. A slightly indurated red loam, intermixed with subangular boulders	24
c. Friable loam and fine gravel, with remains of broken land-shells.	24

Besides the preceding deposits, which I have described as being the most noteworthy and as being typical, there are numerous other localities in which I have noted patches of Pleistocene beds. All of the bays on the eastern and south-eastern coasts of the island have stratified accumulations of loam and rock-fragments lining their slopes and higher reaches. To the north of Cala di St. Tommaso, a patch extending over an area of one and a half square miles offers some excellent sections; and between Marsa Scirocco and Delimara Fort there are extensive beds of alluvial material lining the shores and attaining thicknesses of from six to ten feet.

The elephant bed in the Benhisa gap has been described in detail by Dr. Leith Adams, and therefore needs no further remark from me. On the north-eastern shore-line there are several interesting patches deserving of notice.

The valley of St. Julians, St. George's creek, and the cliffs at Sliema and Ghar-id-dud are lined with accumulations of roughly bedded loams and angular débris. At Sliema these accumulations assume the character of a friable ferruginous loam with hard, calcareous, concretionary masses interspersed throughout; or as masses of agglomerate made up of rock-fragments bound together with a compact ferruginous cement and interstratified with stalagmitic layers that often attain a foot in thickness.

I will now briefly summarize the preceding details. The beds may be grouped in three classes—

I. The valley loams and breccias.
II. The agglomerates which are found along the coast-lines and fault-terraces.
III. The ossiferous deposits in the caves and fissures.

The cave deposits have already been described in detail by the late Dr. Leith Adams and myself.[1] I need not, therefore, make any further reference to them here. The valley deposits may be subdivided into the residual and the alluvial beds, which are found on the higher slopes of the plains and plateaux, and the diluvial deposits, which cover the sides and beds of the gorges and valleys. Of the former of these subdivisions, the beds at Dueira, Giurdan, Gebel Ciantar, Imtarfa, Nadur, Tal Mistra, and Tal Asiri are prominent examples. The structural facies of these beds may be thus summed up:—

1. A capping of indurated limestone made up of the finer residual products of the underlying layer.
2. Unstratified layers of angular and subangular rock-fragments. The rock-fragments have always been derived from the Miocene formations in the neighbourhood.
3. Thin interstratified layers of loam and stalagmite. The loams often present evidences of oblique lamination.

In the districts where the angle of the slope is not a high one, as at Imtarfa and Tal Mistra, the basement layer consists of a homogeneous, highly calcareous loam; but where the angle of the slope is a high one the loam is intermixed with angular fragments of rocks, and it assumes a roughly stratified appearance. Where the

[1] Adams, Leith A. L., "Maltese Bone Caves": Geol. Mag., Vol. I, p. 140.
idem. "Fossil Elephants of Malta": Geol. Mag., Vol. II, p. 448.
idem. "Maltese Fossiliferous Caves": Rep. Brit. Assoc. 1886.
idem. "Nile Valley and Malta." Edinburgh, 1870.
Cooke, J. H., "The Har Dalam Cavern, Malta": Proc. Royal Soc., vol. liv, 1893.

intermixture has taken place in about equal proportions more or less distinct traces of bedding are perceptible, but where the rock-fragments or the loam respectively predominate the bed exhibits no definite structure. The alluvial beds are found in the valleys that have long, gentle slopes. These deposits are very uniform in their nature and composition. The rock-fragments that enter so largely into their composition are small in size, and of local origin. They are most numerous in the middle portions of the deposits, and are generally very freely distributed in the divisions that are situated above the middle line. These beds have as their homologues the alluvial calcareous earths which are at present being slowly formed along the valley terraces by the action of rain-wash. Both are similar in composition, and both are devoid of structure. The fossils found in these beds consist of land-shells in a very comminuted condition.

At Dueira, Tal Asiri, Redum Ahmar, Tal Mistra, and San Giorgio, fragments of the limb-bones of ruminants and of horn-cores of a species of *Cervus* were found in comparative abundance. It is a noticeable fact that no plant-remains have been found either in these or in any of the other superficial beds of the islands. But this is to be expected when the broken condition in which the shells and the mammalian remains were found is taken into consideration. The maceration and the rough usage which the plant-remains must have undergone, would have effectually destroyed them long before they could have been deposited with the other materials. And even if the deposition had been accomplished, the loose, porous nature of the beds is such as to have been highly favourable to their rapid decomposition. At the debouchures of all of the larger gorges plains of considerable area occur consisting of stratified deposits of alluvial material. These have been spread out in a fan-shaped form, the apex of the cone of dispersion being the mouth of the gorge. In none of these alluvial tracts have any appreciable changes been effected by the storm rainfall of modern times.

Proceeding now to a consideration of the agglomerates, we see that they possess many features that differentiate them from the foregoing beds. They are always found lying either at the foot of fault-terraces or along the lower slopes of other depressed areas. And they are either submerged or lie immediately at the water-line. In no instance have any of them been found in the plateaux. They are very similar in composition and arrangement in every part of the islands. The materials are of local origin, and consist of rounded and subangular boulders, pebbles, and grit. Land-shells are abundant, and at Benhisa and Malak numerous remains of *Elephas Falconeri*, *E. Mnaidra*, and *Hippopotamus Pentlandi* were found. At Dueira and Tal Asiri the bones and horn-cores of *Cervus* sp.? were abundant, and at Hamrun the teeth and bones of *Hippopotamus Pentlandi* were very numerous.

IV.—The Altered Clastic Rocks of the Southern Highlands, their Structure and Succession.

By Peter Macnair.

(*Continued from the April Number, page* 174.)

VIII. The Upper Arenaceous Zone.

I HAVE not been able to trace the exact relationships of this zone, with its bands of limestone, to those already given, as underlying it. Certain grits and quartzites occurring on the top of the Ben Lawers ridge may possibly belong to it, and it is certain that many of the quartzites and grits of Glenlyon, Blair Athole, and Ben Y Ghloe belong to a horizon higher than the upper argillaceous series just described. Leaving the matter thus in the meantime, until further research shall explain their true relationship, it is certain that an arenaceous band of grits and quartzites succeeds the sericite and graphite schists of the upper argillaceous zone, thus completing the whole cycle of deposits, though no evidence has yet been forthcoming to show what or where the top of this series may be.

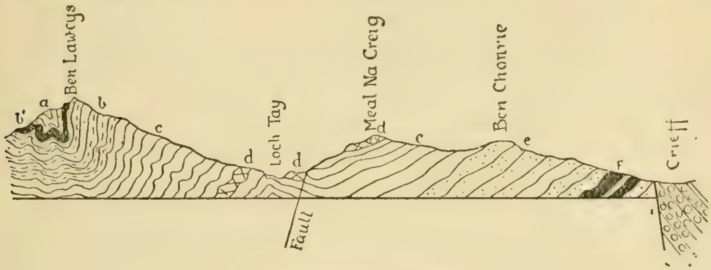


Fig. 1.—Section across Ben Lawers to Crieff.

a. Upper Arenaceous Zone.
b. Upper Argillaceous Zone.
b′. Band of Graphite Schist.
c. Middle Arenaceous Zone.
d. Loch Tay Limestone Zone.
e. Lower Arenaceous Zone.
f. Lower Argillaceous Zone.

IX. Section across Ben Lawers to Crieff.

Passing now to a consideration of these sections seen in Highland Perthshire, from which we have principally been enabled to determine the general succession and character of the rocks forming the Southern Highlands, the first section we propose to describe is that from the top of Ben Lawers, across Loch Tay, through Meal Na Creig, and down Glen Turret, as given above. This section shows in descending order the whole of the zones described. On the north-west side of Ben Lawers, and beside the footpath which leads over from Loch Tay to Glenlyon, a quarry has been opened in the graphitic schist beds that form the uppermost member of our upper argillaceous zone. The graphitic schist is here highly carbonaceous and finely foliated, having evidently undergone an extreme amount of alteration, and lying at high angles, with a dip towards the north-west. This bed is shown in the section at the top of the upper argillaceous series marked *b*. In the section accompanying his map of Scotland, Sir A. Geikie shows the upper arenaceous series as also being seen on the sharp folds of the upper Ben Lawers strata, but this I have not been able to satisfactorily determine. Passing now to the south-east over the crest of the mountain, we come upon the sericite schist with its bands of quartzite, the lower member of our upper argillaceous series. This rock I have already described. It forms the whole of the top of Ben Lawers, where some very fine sections showing its extreme corrugation may be seen, the precipice on the south-west front being specially worthy of notice. It will be seen from the section that the whole of these beds dip to the north-west at greatly varying angles. Proceeding down the south side of the hill, this rock may be traced for a considerable distance, when it passes into the mica-schists and quartz-schists of the middle arenaceous group. At its base, and intercalated amongst the latter rocks, we come upon the Loch Tay limestone zone, which passes underneath the mountain with a north-west dip. Traced eastwards, it is seen to be cut off by a powerful fault at Fernan; and westwards it is found to enter Glen Dochert at Killin. The limestone here is similar to what we have already described, the two principal kinds being the pure limestone and its argillaceous or micaceous variety. Crossing the loch, the bottom of the latter is seen to be formed by the members of the middle arenaceous zone, underlying the Loch Tay limestone. On crossing to the south side of the loch, the structure and succession of the rocks is here made somewhat complex by the presence of the powerful fault already mentioned, which has been carefully traced by the officers of the Geological Survey. The fault enters the loch to the east of Ardeonaig, crossing and emerging again on the north side at Fernan. In the Ardeonaig limestone quarry, near Dall, the limestone is again met with at a slight level above the loch. This is shown on the section immediately to the north of the fault. From this point the limestone runs westwards to the head of Glen Ogle, and southwards down Glen Beich towards Loch Earn. The downthrow side of the fault is to the north-west, so that in following the section further south, an outlier of the Loch Tay limestone zone is met with on Meal Na Creig. Capping that mountain, and occupying the position as shown on the section, passing over the crest of the mountain and descending its southern side, we again cross the lower members of the middle arenaceous zone, with their characteristic mica and quartz schists. Still further to the south of the section, the latter rocks are seen to merge downwards in Glen Turret into the pebbly grits, greywackes, and quartzites of the lower arenaceous zone, which in turn are succeeded by a narrow band of clay-slates belonging to the lower argillaceous zone.

X. Section across Craig Na Challeich to Loch Earn.

Passing now to another section, about eight miles to the west of that already given, and extending from Craig Na Challeich above Killin to the south side of Loch Earn, we find in it a similar succession, though somewhat different in structure from that in the Ben Lawers section. The sericite schist of the upper argillaceous zone is the highest bed seen on this mountain, being very well exposed in the bold escarpment of rock forming its summit. This section of the upper argillaceous series is an exceedingly interesting one: besides being well seen in the escarpment of the hill, it is also finely exposed in the beds of two streams that descend from the broken ridge of the corrie. From the summit, which is 2,999 feet above sea-level, down to about the 2,000 ft. contour-line, the mountain is almost entirely composed of a great series of beds of finely foliated sericite schist with intercalated beds of quartzite and greywacke. The sericite schist of this zone I have already described; the quartzites and greywackes may be further noticed.

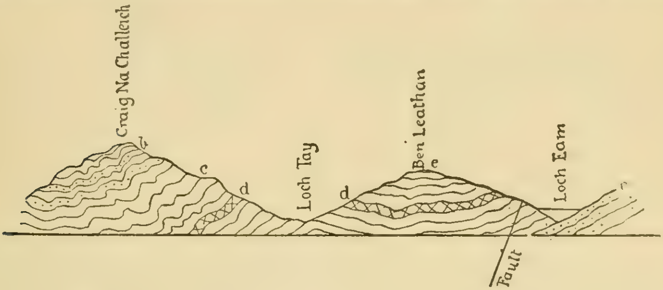


Fig. 2.—Section across Craig Na Challeich to Loch Earn.

b. Upper Argillaceous Zone.
c. Middle Arenaceous Zone.
d. Loch Tay Limestone Zone.
e. Lower Arenaceous Zone.

The quartzites are of an exceedingly fine texture, having been highly indurated, and are plentifully charged with iron pyrites. The greywackes are also of an exceedingly fine character, and show some beautiful examples of lamination. The usual colour is a dark greyish hue, the laminæ or banding being of a lighter shade of the same colour. It is in these bands of greywackes the author found traces of annelid tubes already cited. These annelid tubes have undoubtedly originally been of the ordinary type, being simply cylindrical tubes of sand differentiated out from the surrounding matrix, and passed through the body of the worm. But now, owing to the shearing and metamorphism of the rock, they have been deformed into ovates, the substance of which is generally lighter in colour than the surrounding rock. On weathered surfaces these ovates present all the characteristics of the annelid tubes of the north-west of Sutherlandshire, at times the material composing the ovates being weathered out, and showing on the surface of the beds a series of cylindrical holes similar in every respect to the mouth of an unaltered burrow; at other times, the matter composing the ovate being of a harder texture than the surrounding rock, they stand up in buttons like the nails in a workman's boot. Seen in section these burrows have all been more or less deformed from their original cylindrical form, the whole of them having been drawn out into ovates, and in the case of extreme shearing have been reduced to a mere line or streak. Seen under the microscope, these greywackes present a finely fragmental structure with occasional crystals of felspar disseminated through the mass. Passing down the mountain-side, we cross the middle arenaceous group, which as usual is composed of massive beds of quartz-schist, often becoming highly garnetiferous. Near the level of the road which passes along the north side of Loch Tay, we come upon the Loch Tay limestone zone, with its massive beds of limestone and calcareous mica-schist; followed eastwards it is found to pass under the base of the Ben Lawers group; westwards it skirts the base of Sron Clachan in a bold escarpment, and thence stretches to the west through Glen Dochert. The sill of altered basic rocks upon which the limestone rests may be well seen on the road leading to Killin Pier. Here the limestone is shown resting immediately upon the sheared basic rock, and evidence of the extreme alteration of the limestone is to be found in the hardened bands of that rock found running along the lines of contact. It is not our intention here, however, to enter into a detailed description of these associated igneous rocks, but merely to mention their occurrence in connection with the clastic series.

Following the line of section and crossing the head of Loch Tay, the lower members of the middle arenaceous group are exposed, lying below the limestone zone, and folded over in an anticlinal axis. They are well seen at the falls of Dochert near the head of the village of Killin, where they are still found dipping to the north-west. Passing up the burn at the back of Auchmore House, the quartz-schists are found to become flatter and flatter till they roll over and dip to the south-east. Near the base of Ben Leathan and at the head of the burn, we again come upon the Loch Tay limestone zone, now dipping to the south-east at a very gentle angle, and capped to the top of Ben Leathan with the upper members of the middle arenaceous group. A transverse section of the latter mountain is well exposed in the deep pass of Glen Ogle; all the beds seen on the higher sides of that glen to the top of Ben Leathan belong to the upper members of the middle arenaceous zone, and are mainly, as usual, composed of massive beds of quartz-schists, with occasional bands of grit and conglomerate. From the head of the Auchmore burn to the old Killin junction at the head of Glen Ogle, the Loch Tay limestone skirts the base of Ben Leathan; down Glen Ogle the quartz-schists and limestone are seen to undulate gently to the south-east, the latter being well exposed in the quarry at Dalveich on the northern shore of Loch Earn. In Glen Ogle several very fine sections of the limestone resting upon the sheared basic rocks are to be seen; one, in particular, about a quarter of a mile north of the Glen Ogle toll-house, exhibits all the phenomena before described as seen on Loch Tay at Killin Pier. On the south side of Loch Earn, the massive beds of grit and conglomerate belonging to the lower arenaceous group are well seen on the sides of Ben Vorlich, where our section is supposed to terminate.

XI. Section across the Pass of Leny.

The next section we propose to describe is one through the Pass of Leny to the north of Callander, which is a particularly favourable one for the study of the lower argillaceous and lower arenaceous zones. The lowest rock seen in this section is our lower argillaceous zone, which runs up immediately to the north of the Old Red

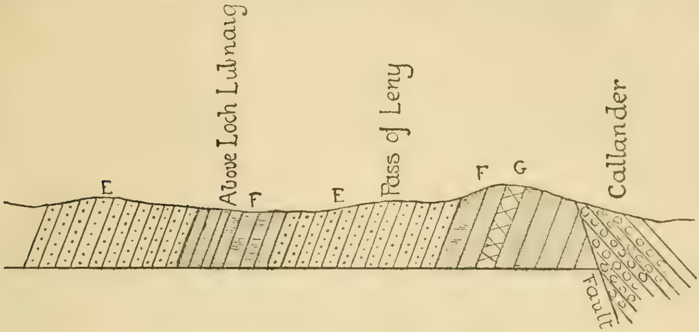


Fig. 3.—Section across the Pass of Leny.
e. Lower Arenaceous Zone.
f. Lower Argillaceous Zone.
g. Leny Limestone.

Sandstone with an average dip of about 50° to the north-west. It is mainly composed of fine greywackes, with beds of clay-slates, and black graphitic schists, and is well seen in the lower gorge of the Pass of Leny, both in the bed of the river and in cuttings along the road. One of the most interesting sections of this series is to be seen in the old limestone quarry. On the hills above the old Kilmahog toll-house here, the limestone is exposed dipping to the north-west at an angle of 50°; the limestone is underlain by a series of beds of black graphitic shales, while above it appears another series of reddish slates, intruded into which we find a vein of quartz felsite strings, and smaller beds of limestone are seen disseminated through the slates. Upon the whole, these lower argillaceous beds remind us wonderfully of the upper argillaceous series found on the Ben Lawers and Craig Na Challeich ridge. The component rocks are exactly the same in both. We find limestones, graphite slates, and such fine argillaceous rocks as clay-slates and greywackes. The rocks of the upper zone, as before observed, show evidence of more extreme metamorphism than the lower, this probably being accounted for by their higher position in the mountain mass, they being consequently more liable to contortion and shearing than the lower members, which would be simply pressed out or indurated. The evidence on this point is not, however, very strong, and will require further and more detailed investigation. Passing from the lower and more argillaceous beds, and further north on the line of section, the latter are seen to pass upwards into a more arenaceous group marked by massive beds of grit, greywacke, and conglomerate.

These are well exposed in the upper gorge of the Pass of Leny, and at the foot of Loch Lubnaig. At the upper part of the Pass, and near the foot of Loch Lubnaig, the greywackes become highly gritty and conglomeratic, the pebbles being composed of quartz and felspar set in a matrix of fine argillaceous material. Along the eastern shores of Loch Lubnaig these greywackes are followed by zones of slates, approaching more closely to a phyllite than any we have seen in this group. They are well exposed in the quarries on the side of the hill, and are shown still dipping, with an average dip of about 50° to the north-west. Passing northwards, they are seen to plunge under the massive beds of grit and conglomerate shown on the south side of Loch Earn and in Ben Vorlich, the position of which to the middle arenaceous zone is shown in the section from Craig Na Challeich to Loch Earn (Fig. 2).

XII. Conclusion.

It now remains for us, in conclusion, to make some general remarks upon the structure, succession, and age of these rocks along the margin of the Highlands. The sections we have described from Perthshire have their beds dipping at such low and gentle angles that little doubt can exist as to their exhibiting the true succession of the beds. Sir A. Geikie notes this fact thus: "Over many square miles the angles of inclination are low, and the successive bands may be traced from hill to hill across strath and glen, forming escarpments along the slopes and outliers on the summits precisely as gently undulating beds of sandstone and limestone may be seen to do in the dales of Yorkshire."[1] In Perthshire and to the north-east, in the counties of Forfar and Kincardine, along the Highland border, the order of succession we have just given seems to hold good so far as we have had opportunities of observing; while on the other hand, to the south-west of Perthshire and in the counties of Argyll and Dumbarton, the rocks of the southern margin of the Highlands have been plicated into a deep and acute synclinal fold with a reversal of dip; this reversal being well shown in the Ben Lomond section, where from the clay-slates on the margin of the Highlands, and inward towards Ben Lomond, the whole series of grits, slates, and greywackes are seen to dip to the south-east. Thus our conclusion as to the true succession of these rocks is exactly the opposite to that arrived at by Prof. Nicol.

Turning now to the difficult subject as to the age of these rocks, little can yet be said as regards their true position in the geological scale. The discovery of radiolarian cherts associated with the graphitic schists of our upper argillaceous zone, according to Sir A. Geikie, seems to point to the identity of these higher rocks with the Ordovician of the southern uplands; while our annelid tubes occurring near the base of that zone might point to the similarity of it to the Cambrian quartzites of the north-west of Sutherlandshire—thus

[1] Quart. Journ. Geol. Soc., Presidential Address, vol. xlvii, p. 73.

making these upper rocks represent a succession from Cambrian through a Lower Silurian series, while the lower members represent a still older group of rocks, some of which may be the deep-sea equivalents of the pre-Cambrian conglomerates of Loch Torridon and other parts of the west coast, an idea which I pointed out some years ago.

Table of the Altered Clastic Rocks of the Southern Highlands of Scotland.

ZONE.	ROCKS.	LOCALITIES.
Upper Arenaceous Zone.	Limestones. Quartzites.	Glen Tilt, Blair Athole. Glenlyon, Schiehallion, Ben Y Ghloe.
Upper Argillaceous Zone.	Graphite Schist. Sericite Schist. Quartzites and Greywackes, with Annelid Tubes.	Ben Lawers, Glenshee. Loch Fyne, Ridge north of Loch Tay. Craig Na Challeich, Ben Lawers, Killin.
Middle Arenaceous Zone.	Garnetiferous Quartz-schists and Mica-schists, with bands of Grit and Conglomerate.	Loch Tay, Loch Earn, Glen Dochert, Balquhidder.
Loch Tay Limestone Zone.	Pure Limestone and Micaceous Limestone.	Loch Tay, Loch Earn, Glen Dochert, Ashintully.
Middle Arenaceous Zone.	Garnetiferous Quartz-schists and Mica-schists, with bands of Grit and Conglomerate.	Loch Tay, Loch Earn, Glen Dochert, Balquhidder.
Lower Arenaceous Zone.	Massive Grits and Conglomerates. Grits, Greywackes, and Quartzites.	Ben Ledi, Ben Vorlich. Pass of Leny, Glen Leadnock, Forneth.
Lower Argillaceous Zone.	Clay-slates and Phyllites. Limestone. Graphite Shale, Red and Purple Shale.	Aberfoil, Loch Lubnaig, Pass of Leny. Kilmahog, Pass of Leny. Kilmahog, Pass of Leny.

V.—Palæontological Considerations on the Old Red Sandstone of Scotland.

By Peter Macnair and James Reid.

The Ganoidian Fishes of the Old Red Sandstone.

HOWEVER paradoxical it may appear, we have reason to believe that the occurrence of so-called ganoidian fishes—of a fresh-water type—in the Old Red Sandstone affords the strongest evidence in favour of its marine origin. That recent representatives of the ganoids of the Old Red Sandstone inhabit rivers and lakes of the globe, is by no means a proof of the fresh-water origin of the latter fishes. The immense interval of time implied by the comparison renders its value somewhat problematical. Sir A. Geikie, in referring to the fishes of the Old Red Sandstone, says: "That some of the fishes found their way to the sea, as our modern salmon does, is indicated by the occasional occurrence of their remains among those of the truly marine fauna of the Devonian rocks."[1]

The life history, however, of the salmon presents evidence of a somewhat different kind; for we find that the Salmonidæ made their appearance for the first time in the *Chalk* of the Cretaceous system,[2] which would rather indicate a migration *from* the sea. In like manner, the life history of these obscure representatives of the ganoids of the Old Red Sandstone would probably show that they preserved their existence "in the struggle for life" by a successful adaptation to new surroundings—namely, fresh-water conditions—while their less-favoured contemporaries succumbed.

The large numbers of fish-remains entombed in the Caithness flags indicate a widespread and sudden destruction of life. Earthquake shocks, the discharge of mephitic gases, and heated waters have been respectively suggested as the cause of the catastrophe. But whatever the agent of destruction may have been, it apparently came in from an outside area, sweeping before it the fishes of the Old Red Sandstone of Caithness inward towards the shallow shores, where they perished. In referring to the flagstone quarry of Achanarras and its contained fish-remains, Dr. R. H. Traquair states that in the lower bed, two and a half feet in thickness, "there all the species in the list occur almost indiscriminately."[3] It is impossible to conceive the manner in which dead fishes could be preserved entire, during the formation of sandstones and shales of several feet in thickness, in a *tideless fresh-water lake.* But a shallow seashore, presenting broad stretches of sandbanks and mud-flats, would afford a more adequate medium for this purpose. The diurnal tides, on the one hand, laden with sand and mud in their ebb and flow, would undoubtedly cover up immense numbers of the fishes in question; while, on the other, the antiseptic properties of salt water would tend to their preservation, even for some time afterwards.[4]

The Introduction and Geographical Distribution of the Old Red Sandstone Fishes.

With regard to the introduction and geographical distribution of the fishes of the Old Red Sandstone, the case of the "Lake theory" displays conspicuous weakness. The Eurypterids and Cephalaspidians of the Upper Silurian are in evidence; but of the genera *Osteolepis, Dipterus, Glyptolepis,* and other fishes of the Old Red Sandstone, no undoubted plates or scales occur in the preceding formation. The question therefore arises, whence came these highly organized

[1] "Classbook of Geology," 1890, p. 262.
[2] Günther, "Study of Fishes," 1880, p. 631.
[3] Proc. Roy. Phys. Soc. Edinburgh, vol. xii, p. 283.
[4] Proc. Perthshire Soc. Nat. Sci. 1893–4.

fishes of the Old Red Sandstone? More especially, from what fresh-water region did they migrate? Not only so, but as the same genera of fishes occur in the Devonian of North America and the St. Lawrence basin, we have an equal right to know by what fresh-water pathway of distribution they were enabled to migrate some 3000 miles between one point and another.[1]

But so far as these questions are concerned, the advocates of the "Lake theory" have maintained an ominous silence. Some eminent palæobotanists have advocated the view of an Arctic origin and southward migration of the flora of the globe; while Dr. A. Wallace also believes "in the northern origin of both the fauna and the flora of the world."[2] The simultaneous occurrence of ganoidian fishes of the same genera and species in the formations of North America and Britain, and in the Devonian of Russia and Central Europe, seems also to indicate a boreal origin and southward migration of the fishes of the Old Red Sandstone. In this connection the genus *Acanthaspis* (Newberry), of the Devonian of Ohio, is of especial interest. A specimen of this fish from the Lower Devonian of Spitzbergen is figured and described by Mr. Smith Woodward,[3] while Dr. R. H. Traquair mentions its occurrence in the Lower Devonian of Prüm in the Eifel.[4] These discoveries thus show an extremely wide range for this Placoderm of the Devonian.

Stratigraphical and Biological Comparisons.

We find Sir A. Geikie stating that no unequivocally marine fossil remains occur in the Old Red Sandstone.[5] We believe we are correct in assuming that our author refers to the fishes and crustaceans alike as equivocally marine remains. We have, however, seen no reason assigned why Eurypterids and Placoderms of the same genera, which are marine in the later Upper Silurian, and fishes of the same genera and species, which are equally marine in the Devonian of Russia and Central Europe, as well as in the Devonian of North America, should be termed equivocally marine in the Old Red Sandstone. But further, Sir A. Geikie refers to the occurrence, in the heart of the Old Red Sandstone of Lanarkshire, of a band of rock about 5000 feet above the base of the system, containing true Silurian fossil remains, whose occurrence he attributes to an irruption of an outside sea of Silurian character.[6]

The Evidence derived from Fossil Plant-Remains.

It has been frequently assumed that the presence of land plants in the Old Red Sandstone is a proof of its fresh-water origin. But from an *a priori* point of view, no good reason can be assigned against the occurrence of land plants in either the sea, on the one hand, or in inland lakes, on the other. As a matter of fact, plant-remains occur indifferently in the Old Red Sandstone and Devonian.

[1] Proc. Perthshire Soc. Nat. Sci. 1893–4.
[2] Brit. Assoc. Address by Sir J. D. Hooker, 1881.
[3] Nat. Science, vol. i, No. 8, p. 602.
[4] Ann. and Mag. Nat. Hist., sec. 6, vol. xiv, p. 370.
[5] "Textbook of Geology," 1882, p. 706.
[6] *Ibid.*, p. 714.

Land plants of the same genera and species are met with in the Old Red Sandstone and Devonian of Europe and North America. In littoral deposits they occur abundantly, but in deep-water deposits they are more sparingly met with. On the other hand, traces of seaweeds undoubtedly occur in the Old Red Sandstone. In the sandstones of Gaspé, *Nematophyton* (with which *Pachytheca* is closely associated) is prevalent. This plant has been referred by Penhallow and Carruthers to the Algæ. *Pachytheca* is met with in the sandstones of Murthly[1] and in the flags of Forfarshire, while in a late edition of Page's Geology an undoubted fucoid is figured from the Old Red Sandstone of Roxburghshire. Nicholson also says: "The Old Red Sandstone of Scotland contains a good many fragments supposed to belong to seaweeds."[2]

The Key to the Devonian Question.

Perhaps in the Middle Devonian of the Russian formation we find the strongest evidence in favour of the marine origin of the Old Red Sandstone. From the northern to the southern boundary of Russia the Devonian deposits have remained comparatively undisturbed to the present day. In the Russian formation "the Devonian and Old Red Sandstone types appear to be united, the limestones and marine organisms of the one being interstratified with the fish-bearing sandstones and shales of the other."[3] "Indeed, cases occur where in the same band of rock Devonian shells and Old Red Sandstone fishes lie commingled."[4] The lower division of the Devonian being absent in the Russian formation, no crustaceans or cephalaspidian fishes occur; but in the lower part of the system (Middle Devonian) we find the remains of the genera of *Osteolepis*, *Dipterus*, etc., "which are specifically identical with those of the Old Red Sandstone of Scotland."[5] The characteristic *Holoptychius nobilissimus* and *Bothriolepis* and other fishes of the Old Red Sandstone of Scotland are met with in the upper division of the Russian Devonian, as well as in the Devonian of North America. In the fish-bearing sandstones of the Devonian of Russia no marine shells occur. This may be generally said of the red sandstones and shales of the Old Red Sandstone of Britain, though in the Welsh area *Conularia* (whose recent representative is a denizen of the deep sea) is met with. *Orthoceras dimidiatum* and other marine remains occur in the Old Red Sandstone of Lanarkshire. It is in the St. Lawrence basin, however, where marine shells are more numerously met with. Sir Wm. Dawson says of the marine shells of the Nova Scotian beds: "With respect to the fossils, I may remark that they are all marine; that they belong to numerous genera and species."[6] "Some of the fine beds (of Gaspé) hold shells of *Lingula* and *Modiomorpha* of

[1] See *Nature*, 10th April, 1890.

[2] "Manual of Palæontology," 1872, p. 521; also Annals of Botany, vol. v, No. xviii, p. 158.

[3] "Textbook of Geology," A. Geikie, 1882, p. 703.

[4] *Ibid.*, p. 704.

[5] *Ibid.*, p. 704.

[6] "Acadian Geology," 1855, p. 315.

Hall."[1] It is interesting to note that "a large lamellibranch, closely resembling the Irish *Anodonta*,"[2] is met with in the Devonian of New York.

Conclusion.

We freely admit that the geological opinion of the present day is largely in favour of the fresh-water origin of the Old Red Sandstone. The unique character of the strata, the presence of well-defined lake boundaries, and the absence of marine fossil remains have been freely assumed, whilst supporting evidence is conspicuous by its absence. In the Cambrian formation of Wales we find large zones of red sandstones and conglomerates, rivalling, if not exceeding, in extent similar deposits which characterize the Old Red Sandstone of Scotland. The so-called boundaries of lake basins of the Old Red Sandstone would be somewhat difficult to find, for (if we may use the term) they appear to be "of a one-sided order." In the Welsh area, the South of Ireland, and the North of Scotland, the Old Red Sandstone runs out to sea; while in Midland Scotland, if the Old Red Sandstone thrown down by the great fault which stretches across the country from Ayrshire to Midlothian were raised to its original position it would show a south-eastward trend, towering some 12,000 feet over the highest peak of the Southern Uplands. The marine denudation of the Silurian rocks of the Highlands of Scotland is not in dispute, but Ramsay and Geikie have assumed a subsequent lake or fresh-water denudation. The conformable deposition, however, of the Old Red Sandstone upon the preceding Upper Silurian deposits in the counties of Edinburgh and Lanark, the Welsh area, and in the St. Lawrence basin, precludes any such idea; for from the base of the Upper Silurian to the top of the Lower Old Red Sandstone the sequence of these deposits is unbroken. It therefore follows that the denudation of the rocks of the Highland area being marine, the equivalent deposits occurring in the Upper Silurian and Lower Old Red Sandstone are equally marine. We find in the Moray Firth area a large stratum of yellow *saliferous* sandstone, interbedded with shales containing remains of Old Red Sandstone fishes.[3] This stratum of *saliferous* sandstone is well exposed in the precipice of the Burn of Eathie, near Cromarty, and we think but one conclusion alone can be drawn therefrom—that the formation and its contained fish-remains were marine. The widespread occurrence of so-called fresh-water fishes in the Devonian of Russia, Central Europe, Britain, and North America, renders the "Lake theory" view of the fresh-water origin of these fishes utterly untenable. Finally, we feel justified upon both physical and palæontological grounds in concluding that the Old Red Sandstone and Devonian, in their respective littoral, shallow-water, and deep-sea deposits, represent the one Devonian system, ***which is marine.***

[1] Report Geol. Surv. Canada, 1871, p. 4.
[2] "Textbook of Geology," A. Geikie, 1882, p. 706.
[3] "The Old Red Sandstone," 4th ed., 1850, p. 285.

VI.—On the Old Red Sandstone and Carboniferous Rocks of the North-east of the Island of Arran.

By James Neilson,
Vice-President of the Glasgow Geological Society.

(*Continued from the April Number*, p. 161.)

In the Transactions of the Edinburgh Geological Society (vol. v, p. 316) will be found a notice of a section at Lochrim Burn, a quarter of a mile south of Corrie, where is exposed a bed of red sandy shale containing marine fossils. The catalogue contains fifteen species (certified by Mr. John Young, LL.D.), and every one of these is common in the Carboniferous Limestone series of the West of Scotland. This bed is overlain by another bed containing abundant plant-remains, of which a list of seven species is given. The Rev. D. Landsborough, of Kilmarnock, found here another, viz. *Carpolithes sulcatus*, L. and H. ("Fossil Flora," pl. ccxx), which Mr. Kidston considers to be characteristic of the Calciferous Sandstone series. It seems to me, however, that the evidence is rather in favour of these beds belonging to the Limestone series. Then, as already noted, there are the fireclays, of which I have observed several distinct beds along the Corrie shore. There is also a bed of fireclay in the old quarry behind Corrie Hotel (within 100 feet of the *Productus giganteus* limestone); this overlies a bed of fine white sandstone. Fireclays also occur in the gap between the northern and the great eastern cliff.

So far as I am aware, fireclays have not hitherto been recorded from Arran, but they have an important bearing on the question presently at issue. Let us again quote Geikie (pp. 806–814): "Fireclay or shale, through which rootlets branch freely in all directions. . . . . . They appear to be the soil in which the coal grew."

These Arran fireclays differ in no respect, except that some of them are redder or whiter than those I am so familiar with near Glasgow, being crowded with rootlets, while here and there the usual *Stigmaria ficoides* is to be seen. Some of these fireclays show the peculiar slicken-sides so well known.

These Red Sandstone strata not only contain fireclays, but also ironstone, which occurs as nodules (in the fireclays and shales) varying in size from half that of pin-heads upwards to about a foot in greatest diameter. There are also regular bands of ironstone, which may be seen at Corrie, both on the shore and in the old quarries already referred to, and also on Maoldon and the mill burn at Brodick. The ironstone is nearly all in the state of peroxide (hematite iron ore), which is doubtless the colouring material of all the red rocks of Arran; in fact, we have concluded that the nodules and possibly the seams of hematite are simply segregated out from the abundance of this material; one very striking instance being that of a nodular band about one inch thick which has apparently entirely exhausted the red matter from the clay in which it lies, leaving the clay of a creamy white colour.

Returning now to the question of marine limestones—If they belonged to the Old Red Sandstone age, one would have expected the fauna to be of Devonian rather than of Carboniferous type; and it would indeed be strange if there should exist at the same time in the sea, in what is now Devonshire and Arran, two faunas so dissimilar as are the Devonian and Carboniferous, and that changes should occur involving the annihilation of the entire Old Red Sandstone and Devonian fauna, and yet leave these Carboniferous fossils unchanged throughout all the long period represented by the Upper members of the Old Red Sandstone,[1] and the whole of the Calciferous Sandstone period to be again introduced unaltered into the British area at the beginning of the Carboniferous Limestone period. It may be so, but I cannot accept it without proof. On the contrary, the fossils show undoubtedly that these are the true Carboniferous Limestone strata themselves. Dr. Bryce (p. 224) records some 36 species of marine fossils from these beds, all of which are found elsewhere in the Carboniferous series of the West of Scotland. The thing that strikes one most in the limestones at Corrie, Laggan, and Maoldon, is the enormous number of *Productus giganteus* to be seen.[2]

Now, it will be generally conceded that species, like individuals, have first a period of infancy, and then a full development, from which they dwindle and gradually die. *Productus giganteus* is no exception to this rule, and its period of overwhelming development is well known in the West of Scotland near the bottom of the Limestone series, where some of the beds are known as *Productus giganteus* limestone.

This series of beds is the thickest of the lowest limestones, and is generally called the main limestone; they have been extensively worked at Beith, Dalry, Busby, Hurlet, Campsie, Carluke, etc., and I have no hesitation in setting down the Corrie limestones as the equivalents of this series of beds, to whose position they correspond stratigraphically. It was my intention to re-examine the shore south of Brodick Bay, in order to have worked out the evidence in that direction, but the broken state of the weather prevented me from completing this part. I may, however, say that the evidence here is not so complete, nor so continuous; while the greater part, if not the whole, of the strata between those already described and the

[1] [The author should bear in mind that many authorities are inclined to group Upper Old Red Sandstone in the Carboniferous system. The "Upper Old Red" of North Wales and the so-called "Old Red" of the Lake District are now grouped as Basement Carboniferous. The uppermost Devonian beds have a Carboniferous fauna. With regard to the Arran limestones, however, Sir A. Geikie has himself corrected the error. See sequel to this paper, p. 227.—EDIT. GEOL. MAG.]

[2] I measured a square yard in the roof of one of the mines, and counted in it 48 shells of this species. I also counted in the face of the quarry 21 layers of these shells. These figures show that each layer contained (48×4840) over 232,000 shells per acre, and this, multiplied by the number of layers, gives nearly 5,000,000 shells per acre; a number which, however gigantic, is, I am persuaded, under rather than over the actual fact.

thick sandstones which overlie the upper limestones near the Cock of Arran, appears to be wanting.

I will, therefore, take up the strata on the north coast, at the point half a mile north of the shepherd's house at Laggan. This part is generally called Salt Pans. These consist of sandstones and shales, with two or three seams of coal, which have been wrought down to the level of the sea; also several ironstones, three bands of which, exposed in a little bay, have long been noted for their beautifully tessellated structure.[1]

No marine remains have been recorded, nor observed by me from these strata, the beds presenting the appearance of having been deposited in fresh water. They contain numerous plant-remains, mostly indecipherable, although *Stigmaria* is common, and I found a small frond of *Sphenopteris*. Dr. Bryce says (p. 128) that "the shale and coal tract is bounded by a black limestone below and a red limestone above, 1400 yards apart." These lie between the Lower and the Upper Limestone series, and I believe they are the representatives of what are denominated in the West of Scotland "the Middle Coal and Ironstone series." These are represented in the neighbourhood of Glasgow by the Possil and Govan Coals and Ironstones, with which they correspond in geological position, mineral character, and economic products of coal and ironstone, although we have not observed the *Lingula*, which is so characteristic of this division.

Proceeding still north-west along the shore, we find overlying the last group another series of red rocks, even redder than before. These consist of sandstones, shales, and several limestones. The limestones are charged with marine fossils; one bed (the lowest) being covered with shells of *Productus latissimus*,[2] while another abounds with large stems of encrinites, and a third with various shells. Not only these beds, but the fossils they contain are as red as any Old Red Sandstone rock in Scotland. These beds exhibit a decided change from the last group, viz. a change from fresh-water to marine conditions.

I consider these beds to belong to the Upper Limestone series, to which they correspond in stratigraphical position. *Productus latissimus* attains its greatest development at a certain horizon known in the West of Scotland as the *Productus latissimus* limestone, also as the Index or Cowglen limestone, which is the lowest limestone in the Upper Limestone series; and I am inclined to consider the Arran bed charged with *Productus latissimus* to be the Index Limestone itself.

Overlying these rocks at the Cock of Arran are thick beds of sandstone, then breccias, then sandstones again, till the whole are cut off by a great fault and by the slates coming down to the shore. It will be observed that these sandstones occupy the natural position of the Millstone Grit, and as no unconformity or break in the

[1] This bed is referred to by Mr. E. A. Wünsch in a paper, "On a Coast Section at Arran," read before the Geological Society of Glasgow, March 2nd, 1871: GEOL. MAG. 1871, Vol. VIII, p. 226.

[2] See Mr. E. A. Wünsch's paper already referred to.

sequence has been recorded or observed, I am inclined to relegate them to that position. These sandstones, etc., were described by Sedgwick, Murchison, and Ramsay, as belonging to the New Red Sandstone formation, while Bryce sets them down as belonging to the Upper Carboniferous series (we presume the equivalents of the Bothwell red sandstones, which overlie the highest of the Lanarkshire coal-seams).

In Sir Archibald Geikie's Geological Map of Scotland, published 1892, these rocks are set down as Upper Old Red Sandstone; but they clearly overlie, probably, one thousand fathoms of strata containing Carboniferous fossils; and, more astonishing still, the pebbles of the breccias in these red sandstones contain fossils of Carboniferous age, originally discovered by Mr. James Thomson, F.G.S., a fact well known to the members of this Society many years ago.

These rocks, then, may be considered as the highest rocks in this part of Arran, and it is evident that the Upper Coal-measures are absent.

I have already stated that the ring of slates or schists completely encircles the granite, but Sir A. Geikie's map shows, on the east, the granite in contact with the Old Red Sandstone for a distance of about three miles. This is not so in the White Water (described in all the Handbooks), nor in the Punch Bowl, or Coich-na-Oich junction, where the granite and slate can be seen in contact. The rocks here are coloured as Lower Old Red Sandstone, while I am inclined to regard them as Upper Old Red Sandstone.

For comparison with the Arran rocks I append Sir Archibald Geikie's Synopsis of the Carboniferous Limestone Series of Scotland.[1]

Carboniferous Limestone Series.	Group of sandstones and shales, with three or more seams of limestone (Castlecary, Calmy or Arden, and *Index limestones*).
	Sandstones, shales, coals, and ironstones, but *with no limestone bands*.
	Sandstones, shales, fireclays, corals, and ironstones, with several thin limestones (Hosie's) towards the top, and the *thick main or Hurlet Limestone* at the bottom.

This, it will be seen, agrees with the Arran section.

And now, in conclusion, I cannot help asking the question—Is there any way of accounting for the redness of the Arran rocks, so different in many cases from their equivalents elsewhere?

The ironstones appear to have been deposited in a manner exactly similar to the Clay-bands of the mainland, and I am strongly of opinion that originally they were similar, and that the alteration to peroxide took place subsequently to their deposition and segregation, and was due to some change which did not apply to the West of Scotland generally.

I am inclined to attribute this change to heat. The red rocks of Arran are situated round, and at no great distance from, a granite nucleus, upheaved to its present position subsequent to the deposition of the stratified rocks, and it is just possible that to the long-continued

[1] Explanatory Notes accompanying a new Geological Map of Scotland. 1892

and gentle baking, to which they must have been subjected, is due the alteration to red oxide, both in the ironstones and sandstones. That bricks assume their red colour by firing is common knowledge; and, although a heat sufficient to burn a brick might destroy a fossil in the limestone or shale, yet the heat required to effect the change in colour may not be so great after all—as one sees in the case of the lobster that is affected by the heat of boiling water.

I throw out this suggestion with considerable diffidence, knowing it to be open to many and serious objections; but it is the only hypothesis I can suggest, and even should it prove to be erroneous, it may evoke a better and truer solution.

Since the above remarks were penned a curious circumstance has come under my notice, which has a bearing on this point. Some time ago, during excavations for a gas-holder tank at Thornhibank works, the excavated material was carted away and thrown down at Arden old quarry. It proved to be a fossiliferous shale, containing a large number of ironstone nodules. After lying some time it took fire, owing probably to spontaneous combustion, and has been smouldering away for the last month or two. The heat in the deeper parts was probably great, but on the surface was not very high—perhaps from 120° to 150° Fahr.; yet this heat has been sufficient to alter the colour of the ironstone nodules from dark-brown or blackish to red, as shown in specimens obtained by me, some of which contain fossils which have been altered but not destroyed.

Another point is the condition of the fireclay and shales charged with plant-remains. The presence of the carbonized plant-remains turns the shales and fireclays in which they occur, black, and I believe this to be the invariable rule, and feel pretty safe in saying that any which are not black have been subjected to alteration.

The effect of heat is to drive off the carbon and leave the shale white, or, if it contains iron, reddish—a fact familiar to every housewife in the country who buys stones along with her coals. Then there is the fact patent to all, that bricks, whether made from fireclay or dark carbonaceous shales, are white.

Now, none of the shales or fireclays among the red rocks of Arran are black; they are either of a creamy white or reddish colour. That alteration, as we have shown, could have been produced (and I am inclined to think has been produced) by heat.

Proceeding from observation to experiment, I took some specimens of fireclay filled with small ironstone nodules of a dirty black colour (which had been discovered by Mr. J. B. Wyse at Blochaim, north-east of Glasgow) and put a piece into the parlour fire, heaping coals over it. After about two hours roasting it was found that the black colour was gone, the matrix was changed to a white colour, and the ironstone nodules had been altered to a blue colour. As, however, I was under the impression that too much heat had been applied, another specimen was put into the fire before retiring for the night, and in the morning the result was more satisfactory. The matrix was white, and the iron in the condition of red oxide.

It may be explained that these specimens were selected from their resemblance (in all but colour) to a very remarkable and interesting bed found in Maoldon, Arran, and that after the experiments the specimens might very well have been mistaken for Arran ones.

NOTE.—After the reading of the paper on October 17, 1895, the Secretary of the Glasgow Geological Society was requested by Sir A. Geikie to mention the fact that the statement as to the Arran Limestone had already been corrected by him in his Annual Report to the Science and Art Department for 1894, which was sent, soon after publication, to the Mitchell Library, Glasgow, on Sept. 5, 1895.

The author desires to add that he was entirely unaware that Sir A. Geikie had published any statement on the subject, otherwise he would have embodied it in his paper. He now adds the following extract from Sir A. Geikie's Report referred to above :—

"PERMIAN (p. 284).—The age of the red sandstones which extend along the shore from Corrie to Brodick and thence across the southern half of the island, underneath the various sheets of eruptive rocks, has been much discussed.

"By Sedgwick and Murchison these strata were classed as New Red Sandstone, a view which was subsequently adopted also by Ramsay. Afterwards, however, Bryce and other writers placed them in the Carboniferous system and correlated them with the red sandstones of the north of Ayrshire and Renfrewshire. A re-examination of the ground was made by me last spring, in company with Mr. Peach and Mr. Gunn. We found that pebbles of the Carboniferous Limestone and its characteristic fossils actually occur in the breccias at the base of these red sandstones between Corrie and the north end of Arran, as was first observed some years ago by Mr. James Thomson. Closer inspection of the coast-sections and of the interior showed us that, besides this evidence of a decided stratigraphical break, the red sandstone, conglomerates, and breccias lie unconformably on the Carboniferous formations, though at the actual junctions the two series seem almost conformable.

"It was thus manifest that these red sandstones could not be Lower Carboniferous as was supposed, but must be later than the Carboniferous Limestone series. North of Corrie they rest on the uppermost members of the Limestone series or the base of the Millstone Grit. In the interior, at the head of Benlister Glen, they lie on the Corrie Limestone hundreds of feet lower down in the Carboniferous system, while on the west coast, at the mouth of the Machrie Water, they appear to come directly down upon the Old Red Sandstone, the whole of the Carboniferous formations having there disappeared. These upper unconformable, and overlapping red strata may be divided into two fairly well-marked sections—a lower group consisting of massive false-bedded sandstones varying from a bright brick-red colour to tints of yellow or grey; and an upper group of red marls, and shales, containing thin sandstones and occasional thin seams of nodular limestone . . . . . That they are probably Permian, may be inferred . . . . ."

REVIEWS.

I.—Ice-Work. Present and Past. By T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S., etc. 8vo, pp. 295, with 24 maps and diagrams, and frontispiece from a photograph. (London: Kegan Paul and Co., 1896.)

THE value of hypotheses or of well-considered inferences from known facts must depend, partly, on the personality of the thinker, on his usual habit of thinking and lines of thought; and partly whether the basis of his inferences rests on direct observation or on statements of facts by others. "Gather facts for yourself and then submit them to inductive reasoning," has been Dr. Bonney's advice to students; and certainly he has acted on it himself.

First, he sketches the general and special features of some Alpine regions which offer available evidence of ice-action in various ways, and which he has personally examined (pp. 3–37). Secondly, he reproduces the statements of good observers relative to the Arctic and Antarctic ice-sheets (pp. 38–75). The features and conditions of the Great Aletsch Glacier and its tributaries are described by the author from personal observation. The origin of the ice-river in the fields of dry snow and "frozen snow" of the heights is followed by its slow downward progress, with débris from the mountains, scattered or trailing on its surface. This often falls into the body of the ice by fissures; but chiefly it forms the moraines along the edges, which ultimately unite at junctions, and altogether become exposed at the melting of the glacier. Both perched blocks and great moraines result. The ice itself is allowed to have some abrading power (p. 10). The débris imbedded in its mass aids it; but more especially the blocks, stones, grit, and sand are ground, and grind the rocks at the bottom of the ice; and here also, together with mud, they form a "ground-moraine," which is as variable as the dimensions and conditions of the glacier and its imbedded rock-material. Superficial snow and ice melting in sunshine give water, which furrows the surface until lost in crevasses; and locally waters from the valley-sides plunge beneath the glacier. These all help to augment the ground-moraine, or maintain the chief line of the sub-glacial drainage. Here the pot-holes are made by gurgitation of stones and water, besides the rounded hummocks of the striated, smooth, and more or less polished floor.

Hence, though local appearances, due to other causes, may be mistaken for some of them, such conditions and phenomena as those mentioned above may be taken to indicate the path of a vanished glacier. This, though nowadays a commonplace statement, is offered by the author in a detailed form from personal observation, as a basis for his inductions.

Continuing his observations in the valleys below the ends of the glaciers, although the features vary in some degree from place to place, it is evident that far above the bed of the valley the rocks are rounded, smoothed, and striated; and perched blocks and scattered débris indicate that the bulk and sides of a glacier reached to these heights. V-shaped valleys, cut and hollowed out by water, have thus been filled with ice, now gone, leaving smooth and often bare surfaces; and their moraines, consisting of rocks other than those of the neighbourhood, tell of their former existence and work. The moraines, however, and the generally turbid stream issuing from below the end of the glacier, represent really the talus from the frost-bitten mountain-sides, and relatively but little material removed from the floor or sides of the glacier. The destructive work of mountain-torrents, though spasmodic, is found to be much more important than that of glaciers (p. 22). Thus, it is found (1) that in glaciers of moderate size, such as those of the Alps, the "ground-moraine" is absolutely small; (2) that the ice may *abrade*, but cannot *excavate*; (3) that its movements resemble those of an imperfect fluid.

The external and internal differences between recent and old moraines are noted; those near Lake Zurich being examples that the ancient and great glaciers of the Alps advanced and retreated, probably more than once, during the prevalence of an extensive ice-sheet, which reached down over almost the whole of the Swiss low-land, and rose up against the Jura for 3000 feet above Neuchatel lake, and extended northwards to near Soleure. This is indicated on a sketch-map of the glacial movements in France, Switzerland, and part of Germany. The ancient Rhône Glacier had an estimated length of at least 245 miles.

The glaciers on the southern side of the Alps are the dwindled representatives of gigantic predecessors, which, scarcely less extensive than those on the northern side, descended in the old valleys, passed over the sites of the Italian lakes, on to the plains of Piedmont and Lombardy, as shown by their moraines.

Land-ice has left its marks on the Alpine region, but in Greenland it is still in possession, representing a Glacial Period there. Records of the temperature and precipitation in Greenland, its configuration, ice-field, and glaciers, are then dealt with. Having collected the evidences of ice-action and its results in Switzerland and Greenland, Dr. Bonney proceeds to a still wider view of glacial phenomena.

With regard to Arctic and Antarctic ice-sheets, the facts collected by explorers, and summarized by the author, give him such a general idea of the conditions prevailing, and the processes at work during a Glacial Epoch, as follows:—(1) There must have been a mean annual temperature not exceeding 32° F. (2) A fair amount of precipitation, chiefly as snow. (3) An expanse of hilly upland; huge rolling fells being more favourable than lofty peaks and deep valleys; the latter would be a region of gigantic glaciers, becoming confluent outside the hill-region. (4) A general gradual slope, for the extension of the ice. (5) Proximity of the sea, although favouring precipitation, would restrict the advance of the ice.

There is heavier precipitation on the Antarctic coasts, and steeper and more uniform surface-slopes; hence their valley-glaciers are far greater than those of Greenland, and every slope becomes an ice-field moving outwards and downwards to the bed of the sea (p. 68).

The Alaska glaciers furnish many interesting facts. At the end of the great Malaspina glacier portions of the old submarine morainic material (at least 4000 feet thick) have been faulted up along eight to ten miles into hills at least 3000 feet high, within the recent period. Part of the glacier is covered by moraine with forests. The glacier itself is seen, in natural sections, to lie on unconsolidated gravel and clay; and the surface-waters, forming tunnels in the ice, carry much coarse débris into the subglacial drainage, and help to form ridges of gravel and sand not unlike "kames" and "eskers" (p. 74).

The relation of glaciers to "lake-basins" is then taken in hand (pp. 79–94). An *abrading*, but not any appreciable *excavating*, power is allowed to glaciers. Although the occurrence of lake-basins frequently coincides with glaciated regions, yet many such lakes occur where no glaciers have been, and none occur at some places which glaciers have traversed; and "the direct evidence generally is adverse to the excavatory action of ice, except under very special circumstances." Differential earth-movements are real causes for such sunken basins.

The origin of the "Parallel Roads of Glen Roy" coming within the range of glacial possibilities, is here discussed (pp. 94–107), after a brief description, with a careful exposition of views hitherto held —chiefly those advanced by Jamieson and Prestwich. The objections to a marine origin for these "roads" are regarded as insuperable. It is difficult to account for a local glacier huge and solid enough to dam up so large a sheet of fresh water as would be required to form these marginal terraces, at the time when Glen Roy itself and parts of neighbouring valleys were free from ice; so the subject is left open for further elucidation.

The origin of the isolated mounds of gravel and sand known as "kames" and "eskers" is also found to be too difficult for definite explanation, even by one so experienced in ice as the author. He gives the views of several writers; and, indicating the weak points, he cautiously concludes that, possibly, if these ridges be the leavings of ice-sheets, the hypothesis of subglacial rivers offers fewest difficulties; but more probably they may be relics of beds of rivers of melting ice and snow in the later part of the Glacial Epoch. "Drumlins" are also treated of; described by others as large longitudinal mounds of clay and stones. They are probably of subglacial origin (that is, *under glaciers*).

Both the merely local and the more continuous evidences of ice-action in Britain are succinctly noticed (pp. 120–192), including the Boulder-clay, lower and upper, and the intermediate Glacial Sands and Gravels, especially of Norfolk, Yorkshire, the Midlands, Cheshire, and Moel Tryfaen—also of Suffolk, Essex, and Middlesex. The distribution of boulders from four main centres of dispersion is carefully detailed. The proofs of glaciation in Scotland and Ireland are considered (pp. 192–205), like those in England and Wales, with reference to their probable causes, in the light of what is known (and brought forward as facts in the foregoing chapters of the book) of the conditions under which ice covers and acts on mountains, plains, and valleys in other parts of the world.

Based on the inferences drawn from facts, two kinds of explanation have been offered; one referring to *Land-ice* on the large scale, the other to *Submergence* and Floating ice. The value of and objections to each hypothesis are carefully and conscientiously stated. The objections to the extreme *Land-ice* hypothesis are apparently the less easy of removal.

Ice-work in Europe and other parts of the world; the possible causes of a Glacial Epoch (its low temperature has not yet been satisfactorily accounted for); the number of Glacial Epochs that may have occurred (the author thinks it probable that only once before the Pleistocene, that is in Carbo-Permian times, such a prevalence of Glacial conditions occurred) — also receive due attention.

The last chapter (pp. 270–284) reviews the main facts concerning ice and glacial deposits, and the general principles of interpretation; and would be well worth reproducing here, but much of it is represented in what goes before. Dr. Bonney wisely concludes that more information is still required, and especially of the effects, habits, and physical properties of large masses of *Polar* ice; but he believes "that enough has been already ascertained to enable the student to distinguish how far an hypothesis is an *induction from facts*, and how far it is an offspring of the imagination."

II.—The Geology and Scenery of Sutherland. By H. M. Cadell, of Grange, B.Sc., F.R.S.E., F.G.S., etc. Second Edition. 8vo, pp. 108, with 8 full-page and 13 smaller illustrations, and 2 maps. (Edinburgh: D. Douglas, 1896.)

THE first edition of this book came out in 1886; since that time new and interesting discoveries have been made by geologists in the North-west Highlands, allowing this new edition to be prepared on a wider basis and with more detail. How greatly the knowledge of the geological structure of a country can benefit the traveller, tourist, and others wandering over hill and dale, for pleasure or duty, has been talked of and written about ever since geology was first really studied. Even now the eyes of many, though educated to recognize the lights and shades, the tints and colours of earth and sky, are blind to the striking evidence *why* the earth presents such various features of heights and flats, of steep cliffs, jagged ridges, and soft slopes, which reflect the phenomena sought for by the artist, but apathetically seen by the multitude.

Scotland is not only a "meet nurse for the poetic child," but has been, and yet will be, the real parent of many geological men and women, who can find pleasure in an intelligent view of her scenery, and enable others to benefit by similar knowledge, both in its æsthetic and more practical advantages. A list of selected books and memoirs concerning this matter, with reference to Sutherland, is given by Mr. Cadell at pages 15 and 16.

The geology and scenery of North-western Scotland are then described in some detail, with the latest information, and in commonplace language, as far as the subject will allow, the author attempting, more or less successfully, to make it light literature. The foundation-rock or basement is the "old gneiss," composed of crumpled sheets of mineral matter, penetrated throughout by veins of other kinds of rock, relatively harder or softer, that have either filled its cracks or made their way into it.

The history of the "Gneiss" seems to us to be romantic. As with mythic heroes, its origin or parentage is doubtful or unknown. Its record begins with the evidence of the troubles it underwent, overcoming difficulties by giving way to them, and becoming self-consistent and harder (fig. opposite p. 36). So it presented a tough and jagged surface, which the envious ocean smothered with sand and pebbles (fig. 1, p. 46). Then, Titan-like, it forced its way upwards with the superincumbent burden (fig. 2, p. 47); to be cut down to a level by long wear and tear of the water-world, and again entombed by inimical agencies (fig. 3). At last, within the "to-day" of some millions of our years, it has once more regained its land-level; and now exhibits (in Scrishven, Quinag, Canisp, Suilven, and Coulmore; and along the region from Durness and Eriboll on the north, to Ullapool on the south) evidences of the victory of its persistent upward movement, bearing a load of trophies from its primeval entombments. Fig. 4, p. 48, shows these results of "latest upheaval, tilting, and denudation." The same kind of natural forces which originally folded and crumpled the gneiss, still squeezing both the underlying and the overlying rocks and strata, elevated this region, as also other parts of the earth's crust, by causing undulations and foldings to rise above the general level; and gave them side-movements and lateral thrusts, which broke them into sloping segments and pushed them one over another for a distance of even ten miles. The pressure of the displaced rock-masses one on another, along the planes of the thrusts, has ground down their surfaces into material differing from the original—now fragmentary and granular, and yet not due to any deposition in water.

These violent changes in position and substance of the rocks confused the early observers, and were very gradually realized, and only of late elucidated, by many enthusiastic geologists giving time and labour, for pleasure or duty, among the wild highlands of Sutherland.

An interesting chapter (pp. 68–76) details the circumstances under which the author carried on some experiments, with alternating layers of stucco-powder or foundry-loam and of damp sand, squeezed horizontally in a suitable press-box. A succession of obliquely faulted segments of one band, riding one over another at the *point d'appui* in the box, agreeably represented the structure of Arkle or Creag Dionard. Another series of such thrusts on a small scale, sliding along the base band, itself traversed by long oblique faults, represented Glasven in miniature. In other experiments the mass of faulted bands tended to curve forwards and downwards on and beyond the faulted basement, thus giving "an elementary model of parts of Ben More, Brebag, Ben Thuarain, and other mountains" (p. 74). The probable behaviour of the earth's internal mass under the regions of such faults and thrusts is considered, with reference to another experiment (fig. 11).

The schists, eruptive rocks, and Old Red Sandstone of the rest of Sutherland, also the remaining evidences of the Great Ice Age, and the relics of Jurassic strata and coal at Brora, are succinctly treated. The interesting but not very productive gold-field of Sutherland has a short chapter (pp. 95–103).

The excellent illustrations of the local "bens" and glens, and the two good maps, add much value to the book. One map gives the relative height of the land; and the other deals with the geological structure. It has a careful diagrammatic section of the strata from Cape Wrath to the border of Caithness; and a useful diagram showing the successive stages of rocks and strata, with their unconformities, displacements, and intrusions.

The information given in this little book on Sutherlandshire, brought together by a well-informed, enthusiastic, and trustworthy geologist, and not easily accessible otherwise, will be very useful to geologists at home or in the field; and ought to be in the hands of tourists, whether artist, sportsman, yachtsman, or idler.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 26th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Structure of the Plesiosaurian Skull." By Charles W. Andrews, Esq., B.Sc., F.G.S.

Owing to the imperfection of the specimens described, various previous accounts of the Plesiosaurian skull are incomplete, and differ from one another in important particulars. There is in the National Collection a fine skull of *Plesiosaurus macrocephalus* which has lately been cleared from the matrix, with a description of which the present communication is mainly occupied, though other specimens, which are of assistance in clearing up some difficulties, are also noticed. The author particularly considers the structure of the palate, and only such points in the structure of the rest of the skull as add to or are at variance with previous descriptions are considered.

The author's observations indicate that a general similarity of palatal structure among reptiles does not necessarily imply any close relationship; but the very great resemblances existing between the Plesiosaurian and Rhynchocephalian palates, reinforced by numerous other points of resemblance in these skeletons noted by Baur, lead to the conclusion that the Plesiosauria are descended from a primitive Rhynchocephalian reptile, as already opined by Baur, Boulenger, and others.

2. "On certain Granophyres, modified by the Incorporation of Gabbro Fragments, in Strath (Skye)." By Alfred Harker, Esq., M.A., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The rocks described form a group of irregular intrusions, the largest less than a mile in length, situated in the tract of volcanic agglomerate north and west of Loch Kilchrist. They differ from the normal granophyres, abundantly developed in the neighbourhood, in being darker, denser, and manifestly richer in the iron-bearing minerals, while in places are seen numerous small rock-fragments evidently of extraneous origin.

The fragments are mainly of gabbro. Closer examination shows that they have been abundantly distributed through the granophyre, but most of them have been more or less completely dissolved. The clearest evidence of this is afforded by the augite of the gabbro, which has been less readily attacked by the magma than the other minerals, and is seen in isolated crystals in various stages of conversion to hornblende. The material dissolved has rendered the acid magma less acid, and has influenced accordingly the products of final consolidation. The granophyre is roughly estimated to have taken up about one-fourth of its mass of gabbro, and this material has been derived, not from the rocks seen in contact with the intrusions, but from some subterranean source.

3. "Observations on the Geology of the Nile Valley, and on the Evidence of the greater Volume of that River at a former Period." By Prof. E. Hull, M.A., LL.D., F.R.S., F.G.S.

The author draws attention to the two great periods of erosion of the Nile Valley—the first during the Miocene period, after the elevation of the Libyan region at the close of Eocene times, and the second during a "pluvial" period extending from late Pliocene times into and including the Pleistocene. He notes the course of the river through escarpments of the granitic and schistose rocks of Assuan, the Nubian Sandstone, the Cretaceous limestone, and the Eocene limestone; and observes that in places the line of erosion of the primeval Nile was directed by dislocations of the strata. Evidence of the unconformity of the Nubian Sandstone upon the granites and schists of Assuan is given, and some observations made upon the age of the different parts of the Nubian Sandstone.

In the second part of the paper the terraces of the Nile Valley are described, and full details given of the characters of a second terrace, at a height varying from 50 to 100 feet above the lower one, which is flooded at the present day. The second terrace is devoid of vegetation, and its deposits have frequently furnished river-shells such as *Cyrena fluminalis*, *Ætheria seminulata*, *Unio*, *Paludina*, etc. The second terrace is traceable at intervals for a distance of between 600 and 700 miles above Cairo. Two old river-channels are also described—one at Koru Ombo, and the other at Assuan itself. The author discusses the mode of origin of the second terrace and the old river-valleys, and believes them to be due to the former greater volume of the river, and not to subsequent erosion of the valley. He gives further evidence of the existence of meteorological conditions sufficient to give rise to a "pluvial" period, and points out that other authors have also considered that the volume of the Nile has been greater in former times.

4. "The Fauna of the Keisley Limestone.—Part I." By F. R. Cowper Reed, Esq., M.A., F.G.S.

The author has examined a very full series of fossils from the Keisley Limestone of Westmoreland, and proposes to describe the fauna of the limestone. In this (first) part of the paper a description of the trilobites is given. He recognizes about forty species, belonging to ten families. Several of the forms are new, whilst others have previously been described, and many of them occur in the limestone of the Chair of Kildare and the *Leptæna*-limestone of Dalecarlia.

II.—March 11th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that, in connection with the Hungarian Millennial Exhibition, a Congress of Mining and Geology would be held at Budapest on September 25th and 26th, 1896.

The following communications were read:—

1. "On an Alpine Nickel-bearing Serpentine with Fulgurites." By Miss E. Aston, B.Sc. With Petrographical Notes by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The specimens described were collected on the summit of the Riffelhorn (near Zermatt) by Prof. W. Ramsay, F.R.S., and J. Eccles, Esq., F.G.S. As they showed some very well-marked "lightning-tubes," the former thought that possibly analyses might prove interesting. These were undertaken by Miss Aston at University College, London. The rock is a serpentine, somewhat schistose from pressure, which has been formed by the alteration of a rock chiefly composed of olivine and augite. One of the analyses gives 4·92 per cent. of nickel oxide and hardly any lime. Prof. Bonney detected some awaruite under the microscope, but not nearly enough to account for the analysis. Reasons are given to show that the nickel oxide probably replaced lime in the pyroxenic constituent of the rock.

The tubes, about $\frac{1}{10}$ inch in diameter, are round in section, cleanly drilled, and lined with a very thin film of dark-brown or black glass. The microscopic structure of this is described, as well as that of glass made by melting the rock with a blow-pipe (using oxygen). Some fulgurite-glass from the Hörnli has also been examined (much resembling that described by Mr. Rutley from Monte Viso), and an analysis of this rock is given.

2. "The Pliocene Glaciation, Pre-Glacial Valleys, and Lake-Basins of Subalpine Switzerland; with a Note on the Microscopic

Structure of Tavayanaz Diabasic Tufa." By C. S. Du Riche Preller, M.A., Ph.D., F.G.S., F.C.S., A.I.M.I.E., M.I.E.E.

(1) The main object of this paper, which is the sequel to one read last session, was to solve the problem whether the Pliocene glacio-fluviatile conglomerates of the Swiss lowlands were deposited on a plateau or in already existing valleys. For the purpose of this inquiry, the author examined last summer a large additional number of glacial high- and low-level deposits throughout the Zürich Valley, over an area more than 40 miles in length; and his investigations further led him to important conclusions with respect to the combination of causes which determined the formation of the lake-basins lying in the same zone at the foot of the Alps.

(2) The author established the true characteristics of the Pliocene nagelfluh as distinguished from Miocene—purely fluviatile conglomerate on the one hand, and from glacio-fluviatile Pleistocene gravels on the other. With respect to the origin of the Pliocene conglomerate, he contended that the material composing the same was not transported from a great distance, but was, in the main, derived from the enormous accumulations of Miocene nagelfluh at the foot of the Alps. Specimens of Miocene nagelfluh-pebbles were exhibited, including the so-called "Tavayanaz Sandstone," which the author, in an appendix to the paper, showed to be diabasic tufa.

(3) The author described in detail a variety of glacial exposures, and showed that Pliocene nagelfluh *in situ*, of which he exhibited numerous specimens, occurred not only on the ridges of the hills, but, at a gradually ascending level, also at and near the floor of the Zürich Valley.

Hence he contended that at the advent of the first glaciation the Zürich Valley was already eroded, and that, consequently, the term "Dechenschotter," or plateau-gravel, was not strictly applicable to the Pliocene glacio-fluviatile deposits of the Swiss lowlands. In his view, the isolated high-level deposits were formed during the intermittent shrinkage of the Upper Pliocene ice-sheet, while the low-level deposits were formed during the subsequent recession of individual glaciers left in the several valleys.

(4) The author reconstructed the pre-Glacial floor of the Zürich Valley upon the evidence of the solid rock and of the low-level Pliocene nagelfluh deposits, with the result that the depth of the lower part of the Valley was approximately that of the present day, while the floor of the upper part was at a higher level (maximum, 300 feet above present lake-level), and was subsequently lowered by earth-movements. He further adduced evidence that the Subalpine valleys of the Reuss, Aare, and Rhine were likewise excavated before the first glaciation. By calculation, he arrived at an estimate of the time required for the excavation of the Zürich Valley, and contrasted the erosive energy of the river with the impotence, on mechanical grounds, of a glacier 7000 times larger in volume.

(5) The author showed that the Lake of Zürich owes its origin, in the first instance, to a zonal subsidence (probably between the first and second glaciation) of about 1000 feet, as evidenced by the

reversed dip of the disturbed molasse-strata between the lakes of Zürich and Zug. During the second and third Ice-periods, the original lake-basin was gradually filled with glacial and fluviatile deposits at both ends, and was finally restricted to its present dimensions by a post-Glacial bar deposited at its lower end by a tributary river. In the author's view, the other Subalpine lakes, extending from the Lake of Constance to Lac Bourget in Savoy, owe their origin and present limits, in the main, to the operation of similar causes.

(6) With regard to the main question, the author averred that the Lower and Middle Pliocene period was, in Switzerland, entirely one of erosion and denudation on a prodigious scale. Irrespective of the evidence he had adduced, he was therefore driven to the conclusion that at the advent of the first Ice-period in Upper Pliocene times, the principal Subalpine valleys must have been already excavated approximately to their present depth; and that ever since then the action of the great Alpine and Subalpine rivers has been, as it is still in our own day, mainly directed to regaining the old valley-floors by removing those enormous accumulations of glacial and glacio-fluviatile material, which are respectively the direct and indirect products of three successive and general glaciations.

3. "Notes concerning certain Linear Marks in a Sedimentary Rock." By Prof. J. E. Talmage, D.Sc., F.G.S.

The marks described in the paper occur in a fine-grained argillaceous sandstone referred by the U.S. Geological Survey to the Triassic or Jura-Trias period, which is found on a low tableland within two miles of the bluffs overlooking Glen Canyon. The marks commonly appear as straight lines intersecting at right angles, but some have a pinnate distribution, suggesting engravings of frost-flowers. A description of the markings is given; and various experiments made in the laboratory to illustrate the effects of formation of crystals formed over sediment are described.

III.—March 25th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Submerged Land-surfaces at Barry, Glamorganshire." By A. Strahan, Esq., M.A., F.G.S. With Notes on the Fauna and Flora by Clement Reid, Esq., F.L.S., F.G.S., and an Appendix on the Microzoa by Prof. T. Rupert Jones, F.R.S., F.G.S., and F. Chapman, Esq., F.R.M.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

Excavations for a new dock at Barry have disclosed a series of fresh-water or slightly estuarine silts with intercalated peats, below sea-level on the north-eastern side of the island. The site of the excavation was overflowed by the tide until the year 1884, when the docks were commenced. The newest deposits seen are therefore Blown Sand, *Scrobicularia*-clay, and sand or shingle with recent marine shells.

These rest on an eroded surface of blue silt, with sedges in position of growth. Four peat-beds occur in this silt, at 4, 11, 20, and 35 feet below Ordnance datum respectively. The uppermost peat contains a seam of shell-marl, partly composed of the shells of ostracoda and partly of *Bythinia*, *Limnæa*, etc. The second is a mass of matted sedges. The third is a land-surface, and in places consists almost wholly of timber with the stools and roots *in situ*. The fourth is also an old land-surface, as is proved not only by the presence of roots in place beneath it, but by numerous land-shells. A fragment of a polished flint-celt was found by Mr. Storrie imbedded in the lower part of the uppermost peat.

By a comparison with the existing maritime marshes of the neighbourhood, it is shown that the fourth peat indicates a subsidence of not less than 55 feet.

The sea encroached upon the area in consequence of this subsidence. It entered by the lowest of three low cols in the southern water-parting of the Cadoxton river, thus isolating the portion of land now known as Barry Island. A slight further movement would have converted the water-parting into a chain of islands.

2. "On a Phosphatic Chalk with *Holaster planus* at Lewes." By A. Strahan, Esq., M.A., F.G.S. With an Appendix on the Ostracoda and Foraminifera by F. Chapman, Esq., F.R.M.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

This rock, which occurs at the base of the Upper Chalk, at the horizon of the Chalk Rock, does not exceed 1½ foot in thickness, and persists for a few yards only. In composition and microscopic character it presents a close analogy to the Taplow phosphatic deposit, which, however, occurs at the top of the Upper Chalk. Like it, it consists of brown phosphatic grains imbedded in a white chalky matrix. The grains include a large number of pellets, attributable to small fish, phosphatized foraminifera, chips of bone, etc. Fish-teeth also occur in abundance.

To complete the resemblance, the Lewes deposit rests on a floor of hard nodular chalk, beneath which is a white chalk traversed by irregular branching pipes filled with the brown variety. Such "floors" are attributed to concretionary action ensuing upon a pause in the sedimentation. The piped chalk is compared with the structure known as *Spongia paradoxica*.

It is concluded that phosphatized deposits may occur at any horizon in the Chalk; that the phosphatization is due to small fishes, attracted by an unusual abundance of food; that they are shallow-water deposits, and associated with a pause or change in the sedimentation.

Mr. Chapman furnishes a list of 42 species and varieties of Foraminifera and 6 species of Ostracoda. The former indicate a deeper water origin than do those of the Taplow Chalk. He notes the occurrence for the first time in this country of *Gypsina Coetæ*, Marrson.

3. "On the Classification of the Strata between the Kimeridgian and the Aptian." By Dr. A. P. Pavlow, Professor of Geology in the University of Moscow, For. Corr. G.S.

In this paper the author discusses the new evidence respecting the palæontology of the Lower Cretaceous and Upper Jurassic deposits of Russia which has come to light since the publication by himself and Mr. Lamplugh of "Les Argiles de Speeton et leurs Équivalents" (Moscow, 1892). He is now enabled to fix with certainty the zones of *Hoplites Riasensis* and *Olcostephanus hoplitoides* of the provinces of Riasan and Simbirsk, and is thus in a position to correct and complete his former classification of the Upper Jurassic and Lower Cretaceous rocks of Russia, and to define more strictly their relationship to the equivalent strata of other countries.

The whole of the Petchorian Series—that is, the zones of *Ammonites stenomphalus* and *Amm. Keyserlingi*—is now regarded as Lower Neocomian of a hitherto unknown boreal type, notwithstanding the affinity of its fauna with that of the underlying Jurassic (Aquilonian) strata. The author is thus led to carry up into the Cretaceous the corresponding stages in Western Europe, including the upper part of the zone of *Belemnites lateralis* of Speeton and Lincolnshire, the Upper Berriasian of South-eastern France, and probably the Hils Beds of Germany, instead of classing these with the Jurassic as he had previously done.

A table is given in which the detailed correlation of the rocks between the Kimeridgian and the Aptian of the various regions is attempted.

The comparison of the beds of England and Germany with those of Russia is supported by some new evidence based on the *Aucellæ*, four species of which are described as occurring in the Claxby Ironstone and Spilsby Sandstone of Lincolnshire.

In conclusion, the author shows that in the period under consideration the shore-lines of Europe have been shifted by slow progressive movements passing latitudinally through the region, and that these movements did not affect the whole area simultaneously. Hence many complicated interchanges of fauna were brought about, which can only be unravelled by studying the whole course of events over wide areas.

OBITUARY.

HON. WALTER BALDOCK D. MANTELL, F.G.S.

Born in 1820. Died Sept. 7th, 1895.

The Hon. Walter Baldock Durrant Mantell, F.G.S., was the eldest son of Dr. Gideon Mantell, F.R.S., F.G.S., the well-known Sussex geologist and discoverer of the Iguanodon. He was born in 1820, and left England for New Zealand about 1840, where he became a man of great public importance, holding the posts of Minister for Native Affairs, Postmaster-General, and Secretary for Crown Lands. He was ever mindful of the interests of the Maoris, and sought to serve them to the utmost of his power.

In 1847 Mr. Mantell sent home the first remains of *Notornis*. These were described by Owen as belonging to an extinct form; but two years later, in 1849, Mantell obtained from some sealers on the south coast of Middle Island (now called the South Island, where he was Government Commissioner for the Settlement of Native Claims) a skin, together with the skull and some limb-bones, of a *Notornis* recently hunted down with dogs, and killed and eaten by these men. Not long afterwards another smaller skin was obtained. Both these specimens are preserved in the Natural History Museum.

The bird was apparently unknown to the Maoris, but there are traditions of a "Swamp-Hen," called on the North Island *Moho,* and in the South *Takahé,* which may have been the *Notornis.*

In 1868 Mantell read a paper before the New Zealand Institute[1] "On the Moa," in which he insisted that these birds were contemporaries of man, their remains being found charred and broken in the Maori ovens, together with stone implements. He also discussed the cause of the extinction of the Moa, and ascribed it chiefly to the agency of man, a view now generally accepted.

In a later paper read before the Wellington Philosophical Society, 1872, he discusses statements that had been made, that Moa-bones had been found beneath marine deposits with extinct shells; and states that this idea arose from a misapprehension of some information supplied by him to his father, who employed it in his paper before the Geological Society.[2] He also gave an account of some new localities in which Moa-remains had been found, including Waikonaiti and Te-Rangatapu. In the latter he obtained a large number of fragments of Moa eggs, several of which he succeeded in restoring. Some of these specimens are now in the Natural History Museum.[3]

Mr. Mantell was elected a Fellow of the Geological Society in 1858. He died on September 7th, 1895, at the age of 75 years. He was in correspondence with Sir William Flower at the time of his death, as to a further donation of his remaining private collection of Moa-remains to the British Museum, which it is hoped may still be made by his representatives at Wellington, New Zealand.

MISCELLANEOUS.

Geological Survey.—We learn that Mr. J. R. Dakyns, M.A., who joined the Geological Survey in 1862, has just retired from the Service. Mr. A. Strahan, M.A., has been promoted to the rank of Geologist on the English branch of the Survey, and Mr. C. T. Clough, M.A., is similarly promoted on the Scottish branch (in the room of the late Hugh Miller). The two vacancies on the Staff of Assistant Geologists are filled by the appointment of Mr. T. Crosbee Cantrill, B.Sc., in England, and of Mr. E. H. Cunningham-Craig in Scotland.

[1] Trans. New Zealand Institute, vol. i, 1868.

[2] See Quart. Journ. Geol. Soc., Feb. 2nd and 22nd, 1848, vol. iv, pp. 225–241. [The woodcut which gave rise to the misapprehension is probably that on p. 240.]

[3] See Notice of the Remains of *Dinornis* and other Birds, and of Fossils and Rock-specimens, recently collected by Mr. Walter Mantell in the Middle Island of New Zealand. By G. A. Mantell. With Notes by E. Forbes, and Sketch-map and Notes by Walter Mantell. Quart. Journ. Geol. Soc., vi (1850), p. 319.

Skeleton of *Aptornis defossor* (Owen), New Zealand.

From a photograph by A. Gepp, Esq.

The original specimen is preserved in the British Museum (Natural History), S.W.

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ORIGINAL ARTICLES.

I.—Note on a nearly complete Skeleton of *Aptornis defossor* (Owen).

By C. W. Andrews, B.Sc., F.G.S., of the British Museum (Natural History).

(PLATE X.)

IN a collection of bird-remains sent to Dean Buckland from North Island, New Zealand, in 1842, Professor Owen noticed a tibia which he regarded as belonging to a very small species of Dinornis, to which he gave the name *Dinornis otidiformis*. A few years afterwards further material showed that this bird was not Dinornithine at all, but was probably a gigantic flightless rail, and it was therefore referred to a new genus, *Aptornis*. Subsequently, on the evidence of a nearly perfect skull, considerably larger than that of *A. otidiformis*, a second species, *A. defossor*, was described, and it is to this larger form that the fine skeleton figured on Plate X belongs. The bones from which this specimen was reconstructed were found in 1889, by Mr. W. S. Mitchell, in a chasm in the Limestone at Castle Rocks, Southland, New Zealand; together with them occurred more or less complete skeletons of *Harpagornis* (both species), *Notornis*, a large species of *Fulica*, allied to that recently discovered by Dr. H. O. Forbes in the Chatham Islands, a small *Ocydromus*, *Stringops*, *Anas*, *Apteryx*, and also *Anomalopteryx didina* and *A. didiformis*. A very interesting account of the mode of occurrence of these remains has been given by Mr. A. Hamilton, to whose papers[1] those interested may be referred for further information on this point. The same writer has also given a brief description,[2] with numerous measurements, of the bones of the species with which we are now concerned. It appears that the more or less perfect skeletons of several individuals were found mingled with one another; and, although the greater number of the bones constituting the present specimen no doubt belonged to

[1] "On the Fissures and Caves at the Castle Rocks, Southland; with a Description of the Remains of the Existing and Extinct Birds found in them": Trans. New Zealand Institute, vol. xxv (1892), p. 88. Also, *op. cit.*, "Result of further Exploration of the Bone-fissure at the Castle Rocks": vol. xxvi (1893), p. 226

[2] "On the Genus *Aptornis*, with more especial reference to *Aptornis defossor* (Owen)": *op. cit.*, vol. xxiv (1891), p. 175.

a single bird, the missing ones have been replaced by portions of the other skeletons.

A figure of the restored skeleton of this species was published by Owen, but it was largely conjectural, and as far as the vertebral column is concerned, is merely a magnified *Ocydromus*, differing in many respects from the present specimen, notably in the larger number of vertebræ bearing free ribs. It is of course possible that some may have been omitted, but examination of the column as a whole does not bear out this supposition, the various processes undergoing quite gradual modification in form and size when followed from one region to another. In the cervical region the most remarkable character is the great size of the anterior vertebræ, resulting from the enormous development of the various ridges and processes. The peculiar long, slender coracoids are anchylosed with the much reduced sternum; by Owen, Fürbringer, and others, these bones were referred to *Cnemiornis*, but their true nature has been pointed out by Forbes and Lydekker. The figure shows the probable position of the scapula in relation to the coracoid, the coraco-scapular angle being very obtuse, as in most flightless birds; the humerus is proportionately small, and its pectoral crest is reduced to a mere tubercle.

The large pelvis and powerful hind-limb indicate a bird well adapted for "cursorial," and probably, as Owen suggested, for "rasorial" habits.

On a future occasion it is proposed to give a detailed account of the more important characters of this skeleton.

II.—On Enclosures of Glass in a Basalt near Bertrich, in the Eifel.

By Mary C. Foley, B.Sc.

During a short holiday spent last summer in the Eifel, I was much struck with the occurrence of an extremely vesicular, dark-green glass in the lava at Bertrich, the most southerly point of the district at which traces of volcanic action are to be met with. It lies in the valley of the Uessbach, a little stream that flows into the Alf, a tributary of the Moselle. In all probability the ground on which Bertrich now stands was at one time covered with lava, and if the course of the Uessbach be followed for about a mile and a half above the town, thick patches of it may be clearly seen on either side of the present bed of the stream, all traces of it ceasing higher up the valley. It is well exposed in a quarry known as the Mühlrech, on the left bank of the Uessbach immediately below the high road to Kenfus, and about a mile above Bertrich. Here the lava exhibits a fine section about 90 feet high, but it is being rapidly cleared away for road metal. The quarry lies immediately at the mouth of a side-valley called the Müllischwiese, which commences near the foot of the Falkenlei, one of the three craters that overshadow Bertrich, and gently slopes down for a distance of about three-quarters of a mile into the valley of the Uessbach. The lava which can be thus so easily traced down to Bertrich is part of a great stream which in all probability commenced at some point in the Müllischwiese, and followed the course of the Uessbach, filling its channel to a considerable height. On its way it forms the well-known "Cheese Grotto," about half-a-mile above Bertrich. It is difficult to determine the exact spot in the Müllischwiese at which the flow commenced, for the valley is now all under cultivation and much overgrown in places, and no traces of the flow can be seen except at the quarry to which I have referred, which is at the junction of the two valleys. Excavations have now been commenced immediately above the quarry by the side of the high-road; and the lava which is there being exposed is exactly similar to that seen below in the large quarry, only it is not so hard and compact, and presents a somewhat slaggy appearance.

It was in the Mühlrech quarry that I found many specimens of the dark-green glass to which I have alluded. It occurs in irregularly-shaped patches, and apparently forms a thin lining to cavities in the lava. The latter is a hard, dark-coloured rock of basic composition, and consists mainly of crystals of augite and olivine imbedded in a dark-brown, glassy ground-mass, which is rich in magnetite. I have found no traces of felspar, leucite, or nepheline. Zirkel[1] thinks that the last may occasionally be present, although its outlines are indistinct, and also sanidine.

As far as I am aware, but little attention has been drawn to this curious feature of the Bertrich lava. Roth[2] attributes the origin of the green vesicular glass found in the scoriæ and lavas of Bertrich, the Falkenlei, and Hüstchen, another of the three craters to which I have already referred, to the melting down of the augite present in the lavas. "An alteration," he says, "of the olivine is nowhere to be observed, a result of the difficulty with which it fuses." Von Dechen[3] thinks that Roth's explanation is unsatisfactory; for were it correct, the glass would undoubtedly be found in lavas and scoriæ from other parts of the Eifel, since augite occurs so abundantly in them all. "Probably," he adds, "the melted augites would not lie next to the unaltered ones, and, moreover, would not have preserved the granular form of the latter while enclosed in the thick lava, whereas in reality longitudinal sections of lenticular bodies are to be found there."[4]

At first sight the colour and lustre of the glass led me to suppose that it was melted olivine; and no satisfactory proof having

[1] "Basaltgesteine," p. 180. Bonn (1870).

[2] E. Mitscherlich, "Ueber die vulkanischen Erscheinungen in der Eifel und über die Metamorphie der Gesteine durch erhöhte Temperatur": Im Auftrage der Königl. Akademie der Wissenschaften zu Berlin herausgegeben von J. Roth, 1865, p. 29.

[3] "Geognostischer Führer zu der Vulkanreihe der Vorder-Eifel," p. 26. Bonn (1886).

[4] Possibly he refers to the streak-like form sometimes taken by the glass; but his meaning is not clear to me. His words are: "Wahrscheinlich würden die geschmolzenen Augite nicht neben den unveranderten liegen und deren Körnerform in der dichten Lava eingeschlossen bewahrt haben, sich längliche Durchschnitte linsenförmiger Körper darstellen."

apparently been given by Roth as to whether it were really melted augite, I commenced a microscopic examination, which brought to light some curious features. The glass in thin sections is of a pale olive-green colour, containing many delicate colourless trichites, and it gives, as one would expect, total extinction. Its junction with the ground-mass of the rock is very thickly fringed with dense masses of microliths of all sizes, for the most part of prismatic shape, their edges in some cases ragged and incomplete, and most of them colourless, with dark inclusions, probably of iron-oxide. They react very markedly on polarized light, showing brilliant colours with crossed nicols. The shape of the prisms, the total absence of pleochroism, and their high extinction angle (ranging up to 43°), prove that they are some form of augite. Here and there they are arranged in rings, and little nests of them lie dotted about in the slide: the majority, however, seem to cling to the edge of the ground-mass. Lying in the latter and all but touching the glass are crystals of augite and olivine, which do not appear at all altered, but have preserved their usual shape and appearance; while in the glass itself, near the ground-mass, are one or two small crystals of augite which appear to be a good deal altered, the edges being very ragged, with tiny microliths clinging to them and, as it were, eating their way into the crystal. In some places the glass appears slightly stained with the dark-brown colour of the ground-mass, but on the whole the latter is separated from the glass by a distinct border.

Being still unwilling to relinquish my original idea that I was dealing with melted olivine—possibly a lime-bearing variety, which in cooling might have developed partially into some form of augite —I proceeded, at Prof. Bonney's suggestion, to fuse in the oxygen flame pieces of augite and of olivine taken from the rock itself, the fragments being held in each case in platinum forceps.[1] The augite (of the common dark-brown type) fused fairly easily, and turned into a dark glassy-looking bead with a somewhat resinous lustre. This was powdered, mounted, and examined under the microscope. The fused part was then seen to be a pale yellowish-green glass, very similar in colour to that in the Bertrich lava. The olivine, however, did not fuse so easily, although the fragment was held in the flame for about two minutes longer than the augite.[2] It turned into a black bead and adhered very firmly to the forceps; but on mounting the fragments, microscopic examination showed that a mere outer film had been melted, and the particles fused had turned into an extremely black opaque glass, totally unlike that in the Bertrich lava. The bit of olivine which I had tried to fuse was fairly pure, but contained a few granules of iron. A small chip of the rock itself was treated similarly to the olivine and augite, and it was melted down almost immediately into a rich brown glass.

[1] I am greatly indebted to Miss Aston, B.Sc., for assisting me with these experiments, which were carried out in the Chemical Laboratory of University College.

[2] Still, Prof. Daubrée states that he fused olivine without much difficulty; this, however, was done under the influence of prolonged heat in a furnace.—"Géologie expérimentale," vol. ii. Paris (1879), pp. 517-523.

The results afforded by fusion certainly go to prove that Roth was correct in his statement that the Bertrich glass is melted augite and not olivine, although in the hand-specimens appearances are strongly in favour of its being the latter. That the glass owes its origin to any secondary heating, is very improbable; for it is difficult to conceive of any causes in a lava-flow that would bring about a local rise of temperature, without affecting the ground-mass of the rock and the minerals enclosed in it, especially as the rock itself fuses so quickly and thoroughly. Neither do I think that the formation of the glass can be due to the rapid cooling, under little or no pressure, of melted augites, which were carried along on the surface of the lava stream. In that case it would be impossible to explain the occurrence of totally unaltered augites lying side by side with this glass. I found the latter in hard and compact lava, not at all slaggy in appearance, with distinct signs of columnar structure set up in it; hence the cooling down must have taken place slowly. Prof. Bonney has suggested that the pieces of glass are fragments of some deep-seated magma almost agreeing in composition with pyroxene, which, indeed, occurs as a rock.[1] These were carried up to the surface in the liquid lava from some subterranean reservoir, and cooled at first very rapidly and in a different manner to the augites in the current. Partial devitrification may possibly have taken place owing to changes of temperature at some stage before the final solidification of the mass, but I think it is more probable that the enclosed microliths may have formed, owing to local circumstances, when the glass actually became solid. The pieces of augite in the glass with ragged edges and altered appearance were doubtless entangled in it while it was still in a liquid condition. The little rings in the glass formed by the microliths are probably due to the latter collecting round some of the numerous vesicles, for, as I have already stated, the glass is very vesicular. I think it is thus possible to explain the occurrence of unaltered augites and olivines lying immediately next to the glass in the ground-mass of the rock, and the non-intermingling of the latter with the glass.[2] Von Dechen's objection, viz. the non-occurrence of the glass in other Eifel lavas, does not seem to me to carry much weight, as one would not necessarily expect to find fragments of a deep-seated magma (and this one of rather exceptional composition) in every flow. He apparently found melted and unmelted augites lying side by side in the lava. This has not been my experience, but as he concludes his description of the rock by saying that microscopic examination would probably lead to the further clearing up of difficulties,[3] it is reasonable to suppose that he did not carry out such an examination, which would doubtless have considerably influenced his opinion.

I cannot conclude this brief communication without acknowledging my indebtedness to Prof. Bonney for his kindness in examining my hand-specimens and slides, and for his valuable advice.

[1] Viz. pyroxenite and hornblendite.
[2] Miss C. A. Raisin, B.Sc., has kindly shown me a piece of tachylitic glass occurring in a dark leucitic lava of unknown locality.
[3] *Loc. cit.*, p. 26.

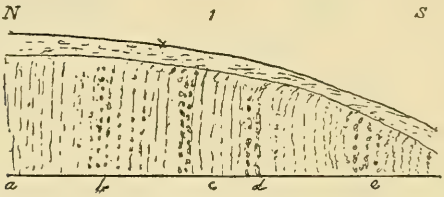
III.—Vertical Tertiaries at Bincombe, Dorset.

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

I HAVE just read the abstract of Mr. Clement Reid's paper to the Geological Society (April 29, 1896) upon the Eocene deposits of Dorset. Many years ago I paid a good deal of attention to these beds, and have many notes upon what I saw. The section which I now send is reduced from my notebook, a section which in my belief has never been seen by any geologist except myself. It was taken when a large pit was open, and the section clear and unmistakable. I copy the words I wrote on the spot. "December 24, 1855. Examined the large gravel-pit recently opened in the Tertiary Eocene beds at Bincombe. A section is given on the last leaf [of the notebook]. The deep cuttings lately made show the

Sections of Eocene beds at Bincombe, Dorset, exposed in 1855. Depth of section about 24 feet.

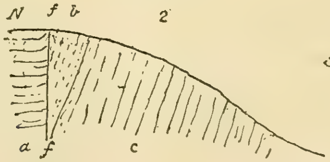
Fig. 1.



(*a*) Sand and coarse pipeclay.
(*b*) Round gravel of flint pebbles, black inside.
(*c*) Sand and clay.
(*d*) Blocks of cherty grey flint, with numerous casts of fossils.
(*e*) Subangular flint gravel, not ochreous, used for road metal.

beds to be vertical, following the dip of the chalk. The beds have much the character of those at Bournemouth, except that they are much coarser. The place of the large flints with fossils is shown in the section.[1] The manner in which the ends of the vertical beds

Fig. 2.



(*a*) Horizontal chalk.
(*f, f*) Fault.
(*b*) Eocene beds.
(*c*) Nearly vertical chalk.

[1] These casts were frequently collected by the Rev. W. Barnes, the Dorsetshire Poet. There were formerly some in the Dorchester Museum. Similar casts occur at Haldon Hill, near Exeter, and also in the neighbourhood of Evershot.

are bent over, and dragged down the slope of the hill, is particularly well shown."

Perhaps, if Mr. Strahan had seen this section open as I did, he might not have said in the discussion that "in drawing a section through Bincombe he found there was not room for the whole of the chalk below the Tertiary outlier"—for it is not an "outlier" in the usual sense of the word. The chalk and these Tertiaries are, in fact, both tilted together. The chalk at the mouth of the tunnel, about a quarter of a mile to the west, is distinctly vertical. I watched the construction of the tunnel, and am certain of this. I think, therefore, that the Tertiaries above Bincombe are a V-shaped mass, let in along a fault where nearly vertical beds abut on nearly horizontal chalk, as is the case at Ballard Head; although at that place there are no Tertiaries, only vertical chalk abuts on horizontal chalk. But there are localities in the same run of country where vertical chalk is backed by Tertiaries; for instance, at Arisk Mell, and at West Lulworth. Section No. 2 of Sheet 22 of Horizontal Sections of the Geological Survey shows a small patch of Tertiaries, caught in between the vertical chalk of Bindon Hill and horizontal chalk north of it. At all these places I suspect the structure to be as at Bincombe, and much as is indicated in Diagram No. 2.

If my theory be correct, then the coarse subangular gravel at the south end of the section is the lower, and the sandy pipeclay to the north the higher, part of the series which was exposed.

IV.—Note on some Cretaceous Fossils from the Drift of Moreseat, Aberdeen.

By G. Sharman and E. T. Newton.

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In the year 1856 Mr. J. W. Salter and Mr. W. Ferguson described before the Geological Society (Q.J.G.S., vol. xiii, p. 83, 1857) a series of fossils which had been collected from Drift material at Moreseat and other localities near Aberdeen, and seemed to indicate the occurrence of Cretaceous rocks *in situ* at no great distance from this locality.

These fossils were divided into two sets—a series contained in flint, which was referred to the Chalk, and a series preserved in fine sandstone, which was regarded as Upper Greensand.

The genera and species recognized in the flints doubtless included both Lower and Upper Chalk forms; and those recorded from the sandstone, fairly indicated an Upper Greensand facies; but it will be seen from the additional specimens lately collected, that beds of Lower Greensand age are likewise represented.

Mr. D. J. Mitchell, of Black Hills, Aberdeen, and Mr. A. M. Insch, have recently collected fossils from the same locality of Moreseat, Cruden, Aberdeenshire; and these, through the kind offices of Prof. J. W. Judd, have been forwarded to the Geological Survey for identification, and present points of interest which at the first were not apparent.

The specimens sent, which number between two and three hundred, are all in the condition of internal and external moulds, in a light-coloured, fine-grained sandstone; and although slight differences may be noticed in different pieces of the rock, they are all so similar that one can scarcely question their having been originally derived from the same bed. Notwithstanding this the fossils clearly indicate more than one horizon.

Most of Salter's type specimens are preserved in the Museum of Practical Geology, having been presented by Mr. Ferguson; and the matrix of those referred to the Upper Greensand is like that of the specimens which form the subject of this note.

Several forms, in addition to those mentioned by Salter, have been identified; and as some indicate lower horizons than the Upper Greensand, some remarks upon certain of the species are called for. These specimens being, as above stated, in the condition of moulds, it has been necessary to take impressions of the cavities; and these give the external forms of the shells, some of which are thus reproduced in a beautifully perfect manner; this was especially the case with the *Trochus pulcherrimus* and *Echinocyphus.* At first we were prepared to find these fossils to be of Upper Greensand age, as stated by Salter; and when we became aware that several of the forms were of a Lower Greensand or Speeton Clay type, we consulted with our friend and colleague, Mr. Lamplugh, who for years has been familiar with the Speeton fossils, and he at once recognized in the Ammonites and some other forms a distinctly Speeton facies. We are much indebted to him, not only for valuable suggestions, but also for the opportunity of comparing our specimens with his large series of Speeton fossils.

Cephalopoda.

Ammonitidæ.—Three Ammonites were recognized by Salter, but only one specific name was given in the list, namely, *Ammonites Selliguinus*, Brong.? and this with doubt. We have seen nothing that could be referred to Brongniart's species.

Ammonites (*Olcostephanus*) *Speetonensis*, compressed variety.—The two forms figured by Salter, but not named, we have recognized. One of these (Salter, pl. ii, fig. 10) was said to be allied to *Ammonites Jeannotii* (D'Orb., Terr. Cret., pl. lvi); but we recognize a closer relationship to *Ammonites Speetonensis*, and it seems to us to come nearest to the form called by Pavlow *Olcostephanus* (*Simberskites*) *Payeri* (Bull. Imp. Soc. Moscow, 1891, pl. xviii, fig. 1); but although flatter forms than that figured by Pavlow occur at Speeton, none are so much compressed as some we have from Moreseat; this, however, may be due to pressure in the rock. The obliquity of the ribs varies in different specimens. We regard this Ammonite as a flattened variety of *A. Speetonensis.* The *Olcostephanus Phillipsii* (Neumayer, Palæont., vol. xxvii, pl. xv, fig. 7) from the Hilsbildungen, is another closely allied form.

The second specimen figured by Salter (pl. ii, fig. 9) is related to the flattened variety of *Speetonensis*, and this we have also recognized, but only by fragments which prevent a definite determination. Our specimens do not allow us to see so near an alliance with *Ammonites Pailletteanus*, as Salter and Baily seemed to recognize (Q.J.G.S., vol. xiii, p. 87).

Ammonites (*Hoplites*) *Mortilleti*, Pictet and De Loriol.[1]—Several fragments, and one or two more perfect specimens, indicating Ammonites of from one to two inches diameter, we refer to this species. At first we thought they were *A. noricus*; but the ribs upon the back do not tend to meet at an angle as they do in that species. The specimens all seem to show that the shell was compressed to about the same extent as, or even more than, in *A. noricus*; that the umbilicus was very open, there being scarcely any overlap of the whorls; the outer ones doing little more than touch the inner ones. Around the umbilicus the ribs are nodular, and upon the sides they quickly divide into two or three ribs which pass to the back with a slight sigmoid curve; the curve is probably more marked in larger shells. On each rib, where it bends over to the back of the Ammonite, there is a small but distinct tubercle. The ribs extend a short way towards the middle of the back, and at right angles to it, but a smooth space is left along the middle line. There is no evidence of the ribs upon the back being angulated as they are in *Ammonites noricus*. This Moreseat Ammonite has some resemblance to *Ammonites splendens*, but in that species the back is more definitely flattened, the tubercles are really swollen terminations of the ribs, and the umbilicus is very small.

There is one specimen in Mr. Lamplugh's collection from the upper part of the *Noricus* beds at Speeton, about one inch in diameter, which we believe to be specifically identical with the form now being considered; and there is a second which M. Pavlow has referred to *A.* (*H.*) *Mortilleti*. It seems very probable that the two Speeton forms are the same species; but the one seen by M. Pavlow, which is nearly 1½ inches in diameter, has the tubercles, upon the outer part of the last whorl, placed at irregular intervals.

Crioceras Duvalii ?—Several fragments, some indicating whorls 1½ inches wide, and others much smaller, are doubtless referable to this genus: the large transverse ribs, with several smaller ribs in between them, and the presence on some of the larger ribs of spines, irregularly placed, give to these specimens a strong resemblance to *Crioceras Duvalii*; but the evidence is not sufficient for definite determination.

Belemnites.—Several pieces of *Belemnites* have been detected, but they are too small and fragmentary for determination; one may, perhaps, be *Belemnites minimus*. Mr. Lamplugh, comparing these with Speeton forms, detects nothing that could be referred to *Belemnites lateralis*, but thinks it just possible one or two may be portions of *B. jaculum*.

[1] Paléont. Suisse, Neocomien des Voirons, 1858, p. 21, pl. iv, fig. 2.

Gasteropoda.

Trochus pulcherrimus, Phil.—Several specimens, about one-third of an inch in length, referable to this species, have been recognized; Phillips' figure of a specimen from the Speeton Clay is scarcely sufficient to allow of identification; but examples in the Museum of Practical Geology and in Mr. Lamplugh's collection seem to be identical with the Moreseat specimens. There is some slight variation to be traced among the specimens from each locality; but all seem to be characterized by two keels, more or less crenulated, one at the lower part and another at the upper part of each whorl, between which there is a broad, concave area, marked by numerous fine, oblique threads, running in the direction of the lines of growth, and crossed by a few longitudinal threads. The flattened base is similarly marked by two sets of lines, which, being much coarser, give a more cancellated appearance to this part of the shell. There is no umbilicus, and the mouth is nearly round.

Trochus, sp.—Another form, about half an inch in length, which we refer to this genus, is likewise represented in the Speeton Clay; its sides are flat, and the sutures are not depressed, so that it forms an almost complete cone with flattened sides. At the top and bottom of each whorl there is a slightly crenulated ridge, and between these there appear to have been fine, oblique lines of growth.

Actæon, sp.—Two or three specimens referable to this genus have been noticed: the body-whorl is inflated and marked by a few (four or five) impressed lines; the spire is little more than half the height of the body-whorl.

Cerithium aculeatum, Forbes MS., var.—There is one mould of a *Cerithium* very well preserved, which agrees so closely with the specimens from Speeton, to which Prof. Forbes attached the above name, that we feel assured it is the same species, or, at most, a variety of it; and we gladly adopt the name, although no description of the species has yet been published. The Moreseat specimen is $\frac{7}{16}$ths of an inch long and $\frac{1}{8}$th of an inch wide at the largest part; and one may count 13 or 14 whorls. Each whorl has a strongly-marked nodular ridge near the top, and another, slightly smaller, at the base; between these are two, sometimes perhaps three, thread-like lines, and there are indications of a fine line at the top and another at the base between the suture and the larger ridges. The base of the last whorl is rounded and marked by four to six longitudinal lines. The whorls are crossed obliquely by strong ribs, eight of which may be seen at one time on the lower whorls. The ribs are large above and rapidly attenuate below, and where they cross the longitudinal lines produce nodular markings.

Compared with the Speeton Clay *C. aculeatum*, it will be noticed that in the latter the ridges and ribs are more sharply cut, and the thread-like lines at the top and base of each whorl are more definite; and, further, each whorl has three longitudinal lines between the two larger ones; also, about nine ribs may be counted on one side of each whorl.

LAMELLIBRANCHIATA.

Astarte (*Venus*) *striato-costata*, Forbes.—There are several small specimens of an *Astarte* with few and strongly-marked ribs, which without doubt are the same as some from the Lower Greensand in the Museum of Practical Geology, and there is no question as to these being the forms called by Forbes *Venus striato-costata*. One of the Moreseat specimens, however, shows a very definite lunule, and the margins of the shell are crenulated; so that its reference to *Astarte* seems to us necessary. The correctness of Forbes' reference of these to *Astarte striato-costata* of D'Orbigny may be open to doubt, but for the present that name is retained.

Trigonia vectiana, Lyc.—Two or three small pieces of a *Trigonia*, which so far as they are preserved agree better with *Trigonia vectiana* than with any other form, are referred to that species.

Goniomya, sp.—One fragment of a *Goniomya* has been detected; but while there is no question as to the genus, it is not sufficient for specific determination; it might be *Goniomya Villercensis*, a doubtful example of which is in the Cunnington Collection in the Museum of Practical Geology.

Cyprina Fergusoni, Salter.—Many fragments appear to us to represent Salter's species, the type of which has been compared; but with them there are portions of another form, having similar thread-like markings, but a different outline, and these we refer to the following genus.

Lucina, sp.—Several fragments, and one or two nearly perfect moulds of the exterior, indicate the genus *Lucina*. The markings on these specimens are fine, concentric thread-lines, so like those of *Cyprina Fergusoni* that it is uncertain to which genus many fragments belong. The more perfect examples, however, have less prominent umbones than *Cyprina Fergusoni*, and they overhang the lunule; the entire shell is nearly orbicular. We have been unable to refer this definitely to any described species; the markings are similar to those of *Lucina Dupiniana* of D'Orbigny (pl. cclxxxi), but the produced anterior extremity of that shell, and its prominent umbones, are unlike ours. There are some specimens from the Upper Greensand, in the Museum of Practical Geology, somewhat resembling these Moreseat specimens, which have been doubtfully referred to *Lucina Dupiniana*.

Cucullæa carinata, Sby.—This is, perhaps, the most abundant fossil among the Moreseat specimens, and occurs both as internal and external casts, the largest being a little more than an inch long; it seems to us to agree with the true *C. carinata*, the strong ribs both at the front and back of the shell being of uniform size and not as described in *Cucullæa securis*, D'Orb., which is one of the forms occurring at Speeton.

Cardium Raulinianum, D'Orb.—Two or three examples of a finely-striated *Cardium*, about half an inch in diameter, are referred to this species.

Arca Raulini?, D'Orb. — One specimen, showing part of both valves, is in all probability this species.

Plicatula placunea, Lamk.—There are many specimens, more or less fragmentary, which are referred to *Plicatula placunea*; they are very strongly marked, and agree closely with examples in the Museum of Practical Geology. The variable nature of this genus may lead to doubt as to the correctness of this determination; but none of the Upper Greensand species are so coarsely marked as these from Moreseat, while those from the Lower Greensand agree precisely.

Lima Dupiniana, D'Orb. — Two specimens from Moreseat agree better with this species than with *Lima semisulcata*; the outline of the shell is less equilateral than in the last-named species. the ribs are sharp and fine, with little or no ornamentation, and the interspaces are wide. Salter gives *Lima semisulcata* in his list, but it is just possible that it may be the same form as the one we now have.

Gervillia solenoides, Defr.—This species is represented by one very perfect specimen, about two inches long, which agrees very closely with specimens from the Gault, and consequently is thus named.

LIST OF FOSSILS (CRETACEOUS) FROM MORESEAT, ABERDEEN,

SHOWING RANGE OF THE SPECIES.

Mitchell Collection.	Insch Collection.	Ferguson Collection.		Lower Greensand, Specton Clay, etc.	Gault.	Upper Greensand.	Chalk.
			Cœlenterata.				
		F.	Micrabacia coronula, Goldf.	—	—	x	x
			Echinodermata.				
		F.	Ananchytes [Holaster]	—	—	—	—
		F.	Diadema	—	—	—	—
		F.	Discoidea	—	—	—	—
		F.	Galerites [Echinoconus] castanea, Brong. ..	—	—	x	x
M.		F.	Enallaster (Toxaster) Scoticus, Salt. ..	—	—	—	—
M.			Echinocyphus difficilis, Ag.	—	—	x	x
			Annelida.				
	I.		Serpula	—	—	—	—
			Polyzoa.				
	I.		Entalophora?	—	—	—	—
			Brachiopoda.				
		F.	Rhynchonella compressa, Lam. [?=dimidiata]	—	—	x	—
M.	I.		Rhynchonella sulcata, Park.	x	x	x	—
M.	I.		Terebratula	—	—	—	—
M.	I.		Waldheimia hippopus *var.* Tilbyensis, Dav.	x	—	—	—

Mitchell Collection.	Insch Collection.	Ferguson Collection.		Lower Greensand, Speeton Clay, etc.	Gault.	Upper Greensand.	Chalk.
			Lamellibranchiata.				
M.			Arca Raulini ?, D'Orb.	x	?	—	—
M.	I.		Astarte (Venus) striato-costata, Forbes ..	x	—	—	—
M.	I.	F.	Avicula simulata, Baily	—	—	—	—
M.			Crassatella (probably)	—	—	—	—
M.			Cardium Raulinianum, D'Orb.	x	x	—	—
M.			Corbula	—	—	—	—
M.	I.	F.	Cucullæa carinata, Sow.	—	x	x	—
M.	I.	F.	Cyprina Fergusoni, Salt.	—	—	—	—
M.	I.		Exogyra ?	—	—	—	—
M.			Gervillia (near to rostrata ?)	—	—	—	—
M.			,, solenoides, Defr.	x	x	x	—
M.	I.		Goniomya, sp.	—	—	—	—
M.	I.		Inoceramus	—	—	—	—
M.			Lima Dupiniana, D'Orb.	x	—	—	—
		F.	,, semisulcata, Sow.	—	—	x	—
M.	I.		,, (near to abrupta)	—	—	—	—
M.		F.	Limopsis texturata, Salt.	—	—	—	—
M.	I.		Lucina ?, sp.	—	—	—	—
M.			Nucula	—	—	—	—
M.			Ostrea ?	—	—	—	—
	I.		Panopœa	—	—	—	—
M.			Pecten orbicularis, Sow.	x	x	x	x
		F.	,, (probably the P. corneus of Nils., not of Sow.)	—	—	—	—
		F.	Pectunculus umbonatus, Sow.	—	—	x	—
M.		F.	Pinna tetragona, Sow.	x	x	x	—
M.	I.		Plicatula placunea, Lam.	x	x	—	—
M.	I.		Spondylus	—	—	—	—
M.	I.		Trigonia vectiana, Lyc.	x	—	—	—
			Gasteropoda.				
M.			Actæon	—	—	—	—
	I.		Cerithium aculeatum, Forbes MS.	x	—	—	—
	I.		Phasianella (near to ervyna, D'Orb.) ..	—	—	—	—
M.	I.		Trochus pulcherrimus, Phil.	x	—	—	—
		F.	,, (small elongated form) [? = pulcherrimus]	—	—	—	—
M.	I.		Trochus (conical species)	—	—	—	—
M.		F.	Dentalium cœlatum, Baily	—	—	—	—
			Cephalopoda.				
M.	I.		Ammonites Mortilleti, P. and De Lor. ..	x	—	—	—
M.	I.		,, Speetonensis (*cf.* Payeri, Pav.)	x	—	—	—
		F.	,, Selliguinus, Brong. ?	—	—	—	—
	I.		Belemnites	—	—	—	—
M.	I.		Crioceras Duvalii ?, Lev.	x	—	—	—

BRACHIOPODA.

Rhynchonella sulcata, Park. — Several fragments of a coarsely-marked shell are believed, with little doubt, to represent this species.

Waldheimia hippopus var. *Tilbyensis*, Dav.—Two moulds of this brachiopod have yielded casts, so exactly resembling examples of this variety in the Museum of Practical Geology, that we have no doubt as to the determination.

ECHINODERMATA.

Enallaster (*Toxaster*) *Scoticus*, Salt.—Several more or less fragmentary specimens doubtless belong to the species thus named by Salter and Baily, which seems to be nearly allied to *E. granosus*, from the Neocomian; but as the Moreseat specimens are too imperfect to speak of positively, we prefer to allow the above name to remain.

Echinocyphus difficilis, Ag.—One very perfect example of this form we have detected in these collections, and its agreement with Upper Greensand specimens is so close, that it must be referred to this species. This specimen supplies the most definite evidence we have in the Moreseat collections of a form only recognized hitherto in the Upper Greensand, or newer beds.

A study of the list on pp. 252–3, with the distribution of the species, will suffice to show that the Moreseat fossils represent more than one of the horizons recognized in the southern parts of Great Britain; for while the *Echinocyphus difficilis*, *Micrabacia coronula*, *Galerites castanea*, and *Pectunculus umbonatus* indicate an Upper Greensand fauna, the *Ammonites*, *Crioceras*, *Trochus pulcherrimus*, *Astarte striato-costata*, *Trigonia vectiana*, *Cardium Raulinianum*, *Arca Raulini* ?, *Plicatula placunea*, and *Lima Dupiniana* point even more strongly to a Lower Greensand age. As already pointed out, the rock in which these fossils occur is so similar throughout—although some pieces, it is true, are a little harder than others, and some are stained with iron—that it is difficult to understand their being from different beds; it would seem, therefore, that the faunas which in the south mark the distinct horizons of Lower Greensand, Gault, and Upper Greensand, are, here in Aberdeenshire, included in one bed of nearly uniform character throughout. However that may eventually prove to be, it is clear that these Drift specimens have been derived from beds where a large part of the Cretaceous series of strata occurs; not only Upper and Lower Chalk, and Upper Greensand, as pointed out by Salter, but also beds of Lower Greensand or Speeton Clay age; but nothing so old as the *Belemnites lateralis* beds of Speeton has been detected.

What relations these beds may have to the Lower Cretaceous of Sweden, or to the Neocomians of Heligoland and North Germany, which are now occupying the attention of Dr. Dames and Prof. von Könen, it will be of interest to know; but this must await future investigation.

Note.—Salter's list of "Fossils found in Chalk-flints from Aberdeenshire" (Quart. Journ. Geol. Soc., vol. xiii, p. 84) includes some from Moreseat.

V.—On Zonal Divisions of the Carboniferous System.

By Wheelton Hind, M.D., B.Sc.Lond., F.R.C.S., F.G.S.

THE question of the zonal division of the Carboniferous system has been raised during the last twelve months, and certain fossils have already been mentioned as typical of a certain succession in a certain district or traverse of rocks. Having studied the Carboniferous system in most of the districts of Great Britain and Ireland where the beds are exposed, and chiefly from a palæontological point of view, I beg to offer for discussion a few of the facts of biological distribution which have come to my knowledge.

There exists, however, a great initial difficulty, one, indeed, which can be gradually overcome, and this is the involved and uncertain state of the nomenclature of Carboniferous Palæontology at the present time. True, that our knowledge of the Brachiopoda of this period is, through the labours of Davidson, well advanced, and that there is some degree of accuracy in the nomenclature of this group, and its synonymy has been well worked out; but if the other groups are in the almost hopeless muddle which I find to be the case with the Carboniferous Lamellibranchiata, I shall be not far short of the truth if I say that at the present time no reliance whatever can be placed on the species and genera, so glibly catalogued in the majority of the works on the Carboniferous system, as being present in, or characteristic of, certain strata.

Some time ago Mr. Morton attempted to define zones in the Carboniferous Limestone beds of North Wales. He did, indeed, succeed in establishing a certain definite sequence in the rocks, but biologically he is able to establish no zones or horizons typified by certain organisms which could be traced across country and recognized as one in different localities.

Before discussing the brief details of zonal distribution given by Messrs. Garwood and Marr,[1] it will be well to ask what is meant by *zonal succession*? I take it, that the idea in seeking for zones of rock, which can be identified by the restricted presence of certain forms of life in definitely marked horizons, is to establish a biological classification of strata. The presence of certain fossils in any given bed is not a simple matter, and is the result of many factors.

A classification of a series of rocks by the horizontal distribution of its fossils, may be always feasible locally, but such a classification is of little real value unless it can be shown to be constant over large areas. As a matter of fact, the distribution of marine organisms is dependent to a very large extent on the depth of water, and zones of life are those of isobathymetrical distribution. In order that the same fossils should be found at certain horizons over a large area, it would have been necessary that the sea-floor on

[1] Geol. Mag., Dec. IV, Vol. II, 1895, pp. 474, 550–2.

which the deposit accumulated was practically level over the same extent.

As a rule, fossils are not equally distributed through Carboniferous strata. Many feet of limestone beds contain nothing beyond microscopic forms of life, but every here and there the beds are crammed with fossil remains, generally speaking, not in the condition in which they lived, but Bivalves and Brachiopods often have their valves separated and are filled with other shells, and many forms which probably did not exist at the same depth are found together though the shells are not rolled.

The value of life zones can be well understood in a series of strata which was deposited without intermission on a floor which was sinking at a uniform rate, without oscillations of level; but even in such a case the beds deposited on the same line of accumulation, near the shore and out at sea, would contain a very different fauna. I shall show later on that such a condition of deposit was anything but characteristic of Carboniferous times.

While, therefore, *life zones* are not altogether to be relied upon in the identification of strata in widely separated areas, neither can they be regarded with any degree of absolute accuracy as indices of the contemporaneity of an extensive horizontal deposit, though similar faunas indicate similar conditions of deposit. Every ocean connotes a shore, and it is therefore obvious that deep-sea life is contemporaneous with littoral and terrestrial forms, and that in a slowly-sinking area, littoral, terrestrial (fluviatile), and pelagic forms would be entombed along the same line of sedimentary deposit, at any rate at right angles to the retreating shore-line, though narrow belts parallel to that line might be characterized by the presence of the same fauna at definite horizons.

If deposition were going on in a rising area the shore-line would gradually advance, and littoral deposits would be formed above the pelagic; but if, on the other hand, the area were gradually sinking, the marine sediments would be superimposed upon the littoral, and thus contemporaneous faunas would become successive.

The greater part of the Carboniferous areas of Great Britain consists of recurring series of sandstones, clays, coals, and limestones, indicating clearly a repeated oscillation of level, with intervening periods of rest, during which the terrestrial conditions necessary for the growth of the coal flora obtained. Such a series of oscillations could only result in repetitions of the faunas typical of terrestrial, littoral, and marine conditions at different horizons in the same vertical series. A good example of this state of things is to be found in the beds of the Calciferous Sandstone series of the Fifeshire coast. This series has been splendidly worked out by Mr. James Kirkby (Quart. Journ. Geol. Soc., vol. xxxvi, 1880, p. 559). Here, in 3,800 feet of strata, several marine bands occur separated by various depths of intervening beds, and containing a large and varied fauna of typical marine facies. True, that the fauna in each of these marine beds is not absolutely identical; but many of the same species recur in several of them. The intervening beds are sandstones, shales, and indurated clays, with thin beds of coal and many plant-remains. Such a succession points to complete changes in the conditions of deposition; and the beds of coal afford evidence of a suspension of the deposition, and point even to terrestrial conditions.

It would be inadmissible to suppose that the fauna of a marine bed died out when its environment no longer was suitable to its needs, owing to bathymetric change, and that its reappearance at a higher horizon was due to a redevelopment from primordial forms; because it is not probable that many forms would be again evolved on precisely the same lines.

The presence of a fauna at several horizons, with the complete absence of the same forms of life in the intervening beds, points to the continued survival of that fauna in some outside area during the whole of the time that the series of beds containing it were laid down, whence it could migrate in any direction in which the environment became suitable. The change of conditions from marine to littoral and littoral to terrestrial, and *vice versa*, must have been very gradual, giving time to the faunas to retreat and invade fresh localities, and allowing them to remain in an environment suitable for their survival. How long some species did survive, in some outside area, in Carboniferous times, may be judged from the reappearance of the typical Lower Carboniferous species *Productus semistriatus* and *Streptorhynchus crenestria*, amongst others, in the Coal-measures of North Staffordshire. These species are, of course, common enough in the Carboniferous Limestone of the district; but they recur only at one single horizon in the Yoredale series, and once in the Coal-measures. This fact affords undoubted evidence that, at some area, even towards the close of the Carboniferous period, a marine fauna was in existence. This fact at once raises the question as to whether the Carboniferous rocks of the world are contemporaneous. It is quite possible that a slow wave of depression, with occasional shorter waves of return, passed gradually over the surface of the world, that faunas migrated with these waves, and that deposits characterized by similar faunas in the different parts of the earth were anything but contemporaneous. But to follow this question would lead me too far astray for the limits of this paper; still, if American palæontologists are correct in recognizing very few of their fossils as belonging to European species, though generically the faunas are almost identical, such an interval of time may have been the main cause in the gradual change of specific form by the accumulated variations of successive generations.

The beds of the Carboniferous deposits are, as a rule, characterized by repeated alternations and recurrences of similar lithological strata, with recurrences, after great intervals, of similar floras and faunas; and it appears to me that such a series of strata is not as likely to be differentiated by well-marked and isolated zones of life as might obtain in a series of rocks formed by a steady deposit, continued for a long time. In the British Isles it is only in Central England, North and South Wales, Somersetshire, and parts of Ireland that any Carboniferous rocks exhibit such a persistence of conditions of deposit as the Carboniferous Limestone of Derbyshire; for the majority of the Carboniferous beds north of the Midlands, and in Scotland, exhibit, rather, characters indicative of successive changes. If the thick deposits of Carboniferous Limestone typical of North Staffordshire, Derbyshire, and South Yorkshire be traced north, it appears in the north of Yorkshire to be broken up into different, well-recognized beds, separated by beds of shale of varying thickness, the latter thinning out towards the south. The upper beds (Yoredale) in this district (Ingleborough) contain several beds of limestone, separated by shales, which do not occur in the same series further south. Moreover, many fossils are common to these limestones, and to the "Massif" further south.

Viewing the Carboniferous rocks of Great Britain as a whole, nothing is clearer than the fact that they do not for the most part fall in with the fourfold classification—

Coal-measures,
Millstone Grit,
Yoredale Beds,
Carboniferous Limestone—

of the textbooks. Such a classification will only be found suitable in the field in the North Midlands, and I believe that a twofold division as is made in North America would better represent the British Carboniferous strata.

Upper Carboniferous or Anthraxiferous division		Coal-measures. Millstone Grit series.		
Lower Carboniferous or Calcareous division	England...	Yoredale series. Carboniferous series.	Scotland...	Carboniferous Limestone series. Calcareous Sandstone series.

In this scheme it is not intended for a moment to make out that the two divisions of the Lower Carboniferous in England are the *equivalents* of those in Scotland, or to use the word *equivalent* in any other sense than that in Scotland certain beds are at the base of the series, whilst in England others are in this position. It would appear that in Scotland, Ireland, and the South of England, the Carboniferous period came in gradually, without any very marked change from pre-existing conditions, so much so that there has been much discussion as to the precise position where the line between Carboniferous and Upper Devonian beds should be drawn.

In Yorkshire, where alone in the Midlands the base of the Carboniferous Limestone is exposed, there are only a few feet of impersistent calcareous conglomerate between it and unconformable Silurian rocks. In this area marine conditions seem to have commenced suddenly, and the period of marine encroachment which would have given rise to littoral sediments, to have been of too short a duration to give rise to any deposit.

The majority of the limestone deposits of Carboniferous age are of marine origin; and a calcareous deposit differs essentially from those of sandstone and clays, in being to no great extent due to terrestrial denudation, and therefore, it may be presumed, that Carboniferous Limestone was laid down in a sea into which the muds and sands brought down by river action were not, or were prevented from being, deposited.

The Carboniferous series of Northumberland and Scotland are essentially characteristic of those deposited near a shore which occasionally became land, and occasionally was depressed deep enough to allow limestones to accumulate on its floor. The land which was the source of the muds and sandstones was probably of no great elevation, and consequently river action was not strong enough to carry the sediments far out to sea. As conditions changed the sea became shallower, and consequently the shore-line retreated south, with occasional intervals and retrogressions; so that in the north, marine, littoral, and terrestrial deposits are found superimposed in varying and recurring sequence, with the faunas peculiar to each also recurring at several horizons in a vertical deposit. Further south, however, constant marine conditions obtained at first for a long time. Deposition of sediment, however, seems to have been in the long run always in excess of the depression, for even in those areas where marine deposits are most constant there is distinct evidence that the sea was gradually becoming shallower, for we find the massive limestones gradually replaced by shale containing thin limestones, and these in turn covered by shales, and sandstones, and clays, during the deposit of which those terrestrial conditions obtained necessary for the growth of such a flora as was to result in the many beds of coal.

We may take it, therefore, that marine and terrestrial conditions existed contemporaneously during the whole of the Carboniferous epoch in Great Britain, and that there was a constant migration of species backwards and forwards, according as conditions slowly changed, and that many forms of life existed in areas where a steady uniformity of environment obtained throughout the whole of that period. Under such conditions zones of biological succession would be of little value as a means for the correlation of rocks over any great areas, with the possible exception of limited belts along the line of strike which would be the equivalents of isobathymetrical zones.

The few fossils quoted as characteristic of a certain succession of the North of England, by Messrs. Garwood and Marr, however indicative they may be of the sequence in a certain locality, seem to me to be singularly unfortunately chosen with regard to the British Carboniferous beds as a whole. The sequence given is—

Beds with *Productus* cf. *Edelburgensis*	Yoredale series.
,, *P. latissimus*	
,, *P. giganteus*	Mountain Limestone series.
,, *Chonetes papilionacea*	
,, *Chætetes septosus*	
,, *Spirifer octoplicata*	

Productus Edelburgensis, Phillips, was regarded by Davidson as a variety of "*P. giganteus* in which the valves are more coarsely striated with interspaces of almost equal or greater width." Phillips gives his localities as Addleburg, Bolland, Fountains Fell, but *P. giganteus* he states is from Aldstone Moor and Hawes. I have found the latter abundantly in beds of Yoredale series in Teesdale. Of course Davidson may have been in error in supposing that *P. Edelburgensis* and *P. giganteus* were the same species, but it would be advisable to prove conclusively that such was the case before the two forms are declared to be typical of different horizons.

In North Staffordshire *P. latissimus* and *P. giganteus* occur together in Carboniferous Limestone at Narrowdale, and in Derbyshire at Park Hill, near Longnor. In Cheshire, at the Astbury limestone quarry, and in the last two localities, *Chonetes papilionacea* also occurs. So that in these localities, at any rate, these three forms cannot be said to be characteristic of different horizons. In these localities *P. latissimus* and *P. giganteus* are very abundant indeed, with a very rich fauna of characteristic Lower Carboniferous facies.

P. giganteus also occurs abundantly in the Redesdale Limestone, Northumberland, a bed which is recognized as the base of the Upper Limestone series in that county, and supposed to correspond to the Yoredale series of Yorkshire. Both *Productus giganteus* and *P. latissimus* are quoted by Lebour ("Geology of Northumberland," p. 116) as occurring together in the Great and Four-fathom Limestones of Lowick, which occur above the Redesdale Limestone and high above the Melmerby Scar Limestone. *P. giganteus* also occurs in the Pipecross Limestone in the Carbonaceous or Lower Limestone series of Northumberland.

In the lists of fossils, arranged stratigraphically, contained in the Memoirs of the Geological Survey, Scotland, explanations of Sheets 23 and 31, *Productus latissimus* and *P. giganteus* are shown to occur together at many horizons, and to have exactly the same vertical range. In the palæontological notes to the memoir of the Irish Survey, "The Geology of the Country round Dublin," *P. giganteus* is stated to occur in three different beds with *Chonetes papilionacea*.

Chonetes papilionacea occurs abundantly in the limestone of Cauldon Low, North Staffordshire, one of the highest beds of the deposit, and probably a much higher horizon than the beds of Waterhouses and Narrowdale, where *P. giganteus* and *P. latissimus* occur. Neither *Chætetes septosus*, as far as my experience goes, nor any other coral occurs at Cauldon Low, which is characterized by abundance of the rare *P. humerosus*, and the stone itself has peculiar and distinctive lithological characters. Davidson quotes *Chonetes papilionacea* from Otterburn, but I can find no authenticated occurrence of this species in Northumberland.

Under such circumstances, therefore, the value of the fossils mentioned as distinctive of zonal succession can hardly be sustained, as the majority of them occur at more than one horizon, and are found in other localities not by any means in the vertical sequence given. Like many other Carboniferous fossils, they reappear at higher horizons after long intervals, and I have never been able to make out to my own satisfaction any life zones in Carboniferous rocks. What I have observed over and over again is, that a return of similar condition of deposit is accompanied by a return of similar faunas. At the same time, if I could be of any use to other observers in identifying the Lamellibranchiata and Brachiopoda, I should be only too glad to help in any work having for its object the better knowledge of the Carboniferous rocks.

VI.—The Fossils of the Warminster Greensand.[1]

By A. J. Jukes-Browne, B.A., F.G.S.

THE fossils of the Upper Greensand of Warminster have long been known to collectors and geologists on account of their number, variety, and excellent state of preservation; but little information has ever been published regarding the beds which yield them. Collections of the fossils are to be seen in most of the museums of the country, and the fauna represented by these collections has often been regarded as the typical fauna of the English Upper Greensand. This, however, is a mistake, for where fully developed, as in Wiltshire, the Upper Greensand includes two faunas which differ considerably from one another—(1) that of the malmstone and micaceous sand (Devizes Beds), (2) that of the greensands and chert beds (Warminster Beds). The complete succession of the Gault and Greensand Beds near Warminster is as follows:—

6.	Light greensand	Warminster beds.
5.	Chert beds	
4.	Greensand and sandstone	
3.	Green and yellow micaceous sands	Devizes beds.
2.	Malmstone	
1.	Micaceous clays = Lower Gault.	

When examining the district in 1889 for the Geological Survey, I made every endeavour to ascertain the exact locality or localities from which the so-called Warminster fossils came. I found that most of the fossils which had found their way into museums had been supplied by a man named Baker, who lived at Warminster, and collected them for sale. It was also known that he obtained most of them from a field near Shute or Chute Farm, which is situate about three miles on a straight line south-west of Warminster.

On going to this place I was shown the field in question and a depression which had been a sand-pit. The men employed on the farm informed me that Baker often visited this pit, but that many fossils could be picked up on the surface of the field after it had been ploughed. I had a trench dug down the slope of the old shallow pit, and this proved the existence of about two feet of hard glauconitic and gritty chalk with phosphatic nodules, passing down into softer sandy marl with a few such nodules, and below this a loose greensand of finer grain containing many of the characteristic Warminster fossils.

[1] Published by permission of the Director-General of the Geological Surveys.

It was evident, therefore, that when this pit was worked it exposed a soft fossiliferous greensand overlain by sandy "Chloritic Marl," which is also generally a bed rich in fossils; consequently it is highly probable that the collections made by Baker included all the fossils he could get from both horizons, and from the surface of the surrounding field.

At Rye Hill Farm (Ray Hill on the old Ordnance Map), half a mile south-east of Shute Farm, there are some small pits still open, which show the junction of Chalk and Greensand very clearly, a light-green fossiliferous sand passing up into greenish sandy marl with a few scattered phosphatic nodules, and further up the lane harder "Chloritic Marl" with more phosphates can be found. The chert beds crop out in the lane to the eastward, and the total thickness of the soft greensand cannot be more than ten feet.

The fossils in this sand are chiefly the small Echinoderms and Brachiopods, which are such well known "Warminster fossils." Small lumps of pale-yellow calcareous material also occur in the sand, and some of these are casts of *Ammonites varians* and *Am. curvatus*, which do not occur in any other state of preservation, and are easily distinguished from the casts in brown phosphate which are so common in the overlying Chloritic Marl.

This sand and the Chloritic Marl are not, however, the only sources whence Baker may have got his fossils. He had no knowledge of geology, and would naturally mix together all fossils which he obtained from greensands and sandstones near Warminster. The chert beds, which consist of greenish-grey sands with lenticular layers of chert and cherty stone, are dug for road-metal at Longbridge Deverill, Sutton Veny, Boreham, and Warminster. These beds yield siliceous sponges, some large Echinoderms, *Neithea quadricostata*, *Pecten asper*, and *P. orbicularis*. Still lower are coarse glauconitic sands with a layer of greenish calcareous sandstone, which is the home of four species of *Pecten*—*P. asper*, *P. orbicularis*, *P. Galliennei*, and *P.* (*Janira*) *quadricostata*. These beds are well exposed at Longbridge Deverill, and were doubtless laid under contribution by Baker in making up his collections, for I have detected specimens with this matrix in several museums.

The several beds of greensand above mentioned exhibit differences which enable one who is familiar with them to distinguish land specimens from one another, and the fossils of each can also be separated when sufficient matrix is attached.

Thus the matrix of the chert beds is a pale whitish-grey silty sand, fine-grained and powdery, with very small grains of glauconite; it is often cemented by silica into a hard siliceous stone. The stone-bed below is a rather coarse sandstone, decidedly green from the abundance of glauconite, and cemented by calcite.

The Rye Hill Sand is also rather coarse, with large grains of quartz but with less glauconite, so that in colour it is pale greenish-grey. The sand grains often cling closely to the fossils, and appear to be glued to them by a thin coating of silica.

None of these sands contain mica, so that any fossils imbedded in a micaceous sand or sandstone may be at once rejected, as they must have come from the lower beds of the greensand, which are so fossiliferous near Devizes.

The fact already mentioned that none of these beds contain phosphatic nodules is of the greatest importance, because it follows that all fossils in brown phosphate should be excluded from the fauna of the Warminster Greensand. Hitherto, nearly every collection has included some of these phosphatized fossils, which are principally casts; but as they have all come from the Chloritic Marl which overlies the Rye Hill Sand, they ought not to be left among the fossils of the Warminster Greensand.

Fossils were collected from the Rye Hill Sand, from the chert beds, and from the sands below, both by myself and by Mr. Rhodes, the fossil-collector of the Geological Survey, and the results are embodied in the following lists. From our observations it would seem that most of the so-called Warminster fossils come from the Rye Hill Sand, but that the large *Janira quadricostata*, most of the larger Echinoderms, and all the large sponges, belong to the chert beds, and, with the exception of *Cardiaster fossarius*, do not range in the upper sands. *Pecten asper* ranges throughout from the basal glauconitic sandstone to the top of the formation and into the Chloritic Marl above.

With regard to the sponges, Dr. Hinde has called my attention to a manuscript written by Miss E. Benett in 1816, and preserved in the library of the Geological Society, entitled "Sketches of Fossil Alcyonaria from the Greensand Formation at Warminster Common and in the immediate vicinity of Warminster." I am indebted to Dr. Hinde for the following extracts from this MS. Miss Benett says:—

"The valley on Warminster Common where these Alcyonaria are found is a poor thin peat covered with furze and heather. The quarries, if so they can be called, for they seldom exceed two feet deep, are on the sides of the hills, as I am informed that the stone on the tops of the hills is too flinty for the purposes for which it is required, and these flinty stones, as far as I have examined them, do not contain any organic remains. The local name of the stone is Burrs; they are used for building and for scythe-stones: these Burrs lie close to the surface in a fine yellow sand, immediately above the greensand, and the nodules containing the Alcyonaria are rather plentiful.

"At Whitburn, near Clay Hill, in the same neighbourhood, the greensand comes to the surface, and these fossils lie in it in the same situation. At Boreham, on the east side of Warminster, the grey sand is uppermost, and there we also found the same sort of fossils, but they are rare; it therefore appears to me that they belong to the top of the sand formation without regard to the sort of sand."

From this it is clear that the sponges were chiefly found to the west of Warminster, and when there in 1889 I found a small quarry open at Bugley in the burr-stone beds described by Miss Benett. It is a fact that on this side of Warminster there is less chalcedonic chert, and that there are layers and lumps of light-grey siliceous stone and others of calcareous stone in chert beds. The yellow sand mentioned by her is, of course, merely oxidized greensand, and the flinty stones on the hills are flinty cherts accumulated there as insoluble remnants by the gradual detrition and destruction of the chert beds.

I propose first to give a list of the fossils which have been found in the chert beds and in the greensands which underlie them. Those marked S are species which have actually been found *in situ* by Mr. Rhodes or by myself, while those marked M are in other collections, but are believed to have come from the chert beds. For the list of sponges I am indebted to Dr. Hinde.

LIST I.

	Chert Beds.	Lower Sands.
Fishes.		
Oxyrhina Mantelli, Ag.	s	s
Odontaspis	—	s
Pycnodus	—	s
Cephalopoda.		
Ammonites, sp.	—	s
Belemnites, sp.	s	s
Lamellibranchiata.		
Avicula gryphæoides, Sow.	s	s
,, sp.	—	s
Exogyra conica, Sow.	s	s
Inoceramus, sp.	—	s
Lima semisulcata, Sow.	s	s
Lucina, sp.	s	—
Ostrea vesiculosa, Sow.	s	s
Pecten asper, Lam....	s	s
,, Galliennei, D'Orb.	s	s
,, orbicularis, Sow.	s	s
,, (Janira) quadricostata, Sow.	s	s
,, ,, quinquecostata, Sow.	s	s
Polyzoa.		
Entalophora, sp.	—	s
Annelida.		
Ditrupa, sp.	s	s
Serpula antiquata, Sow.	s	s
Vermicularia concava, Sow.	?	s
,, umbonata (?), Sow.	s	s
Echinodermata.		
Cardiaster fossarius, Benett	s	s
,, Perezii, Sism. (Brit. Mus.)	M	—
Discoidea subucula, Klein	s	s
Echinospatagus Collegnii, Sism. (Brit. Mus.)	M	—
Epiaster Lorioli, Wright	M	—
,, polygonus, D'Orb. (Bristol Mus.)	M	—
Holaster lævis (?), Deluc	s	—
,, trecensis (?), Leym.	s	s
Pseudodiadema variolare (?), Brong.	s	—
Salenia, sp.	s	—

	Chert Beds.	Lower Sands.
Siliceous Sponges.		
Carterella cylindrica, Zitt.	M	—
Chenendopora Michelini, Hinde	M	—
Doryderma Benettiæ, Hinde	M	—
,, dichotomum, Benett	M	—
Hallirhoa agariciformis, Benett	M	—
,, costata, Lam.	M	—
,, ,, *var.* brevicostata, Mich.	M	—
,, ,, *var.* elongata, Hinde	M	—
Holodictyon capitatum, Hinde	M	—
Jerea Websteri, Sow.	M	—
,, reticulata, Hinde	M	—
Jereica cylindrica, Hinde	M	—
Kalpinella pateriformis, Hinde	M	—
,, rugosa, Hinde	M	—
Nematinion calyculussa, Hinde	M	—
Pachypoterion compactum, Hinde...	M	—
,, robustum, Hinde	M	—
Polyjerea arbuscula, Hinde	M	—
,, lobata, Hinde	M	—
Sclerokalia Cunningtoni, Hinde	M	—
Siphonia tulipa, Zitt.	M	—
Rhopalospongia gregaria, Benett	M	—
,, obliqua, Hinde	M	—
Trachysycon nodosum, Hinde	M	—
Calcareous Sponges.		
Corynella rugosa, Hinde	M	—
,, socialis, Hinde	M	—
Elasmostoma consobrinum, D'Orb.	M	—
,, Normannianum, D'Orb.	M	—
Peronidella furcata, Goldf.	M	—
Pachytilodia infundibuliformis, D'Orb.	M	—
Pharetrospongia Strahani, Sollas	M	—
Hydrozoa.		
Porosphæa urceolata, Phil.	—	S
,, sp.	S	—

It will be noticed that the list of Mollusca is not a long one, and that there is a remarkable absence of Brachiopoda. Echinoderms, again, are not numerous either in species or individuals, and as regards two of the species, *Cardiaster Perezii* and *Echinospatagus Collegnii*, it is very doubtful whether they came from this part of the Greensand: even if they really came from the neighbourhood of Warminster, it is more probable that they were obtained from the yellow sands above the Malmstone which belong to the zone of *Ammonites rostratus.*

Pecten asper is a common fossil in these beds, and so far as this district is concerned they might naturally be grouped as the zone of *P. asper.*

We now come to the fauna of the uppermost bed of greensand which overlies the chert beds, and which is specially fossiliferous on the farms of Chute and Rye Hill. It is from these localities that most of the so-called Warminster fossils have come, and the list which follows is believed to be a complete catalogue of the fauna of this Rye Hill Sand.

From it have been excluded all phosphatized fossils and all specimens which could be recognized by the matrix as having come from the chert beds below, or from the still lower beds of green sand, yellow sand, and buff micaceous sandstone which occur near Warminster, Westbury, and Devizes. There are, however, still some specimens about the exact *gisement* of which I feel doubtful, and it is possible that a few species have been admitted into this list which have not really come from the particular bed of Greensand in question. If, therefore, it is not a perfectly accurate list, it will err rather in comprehending too many than too few.

I have done all in my power, however, to make it as accurate as possible, and have to thank many friends and correspondents for assisting me in the matter. Messrs. G. Sharman and E. T. Newton have kindly looked at all the fossils labelled "Warminster Greensand" in the cases of the Museum in Jermyn Street, with the result that many were found to be phosphatic casts, and have consequently been excluded from the present list.

For the list of species entered under the second column (British Museum) I am indebted to Dr. W. F. Hume, F.G.S., who made a careful examination of the specimens in order to distinguish the true Warminster fossils from such as seemed to have come from other horizons.

The fossils in the Devizes Museum were examined and named by myself in 1888, to the best of my ability at that time. The list of those in the Woodwardian Museum, Cambridge, was made by Mr. H. Woods, F.G.S., but some specimens about which doubt existed were, with the permission of Prof. Hughes, sent to me for examination. In the same way I have to thank the Rev. H. H. Winwood for allowing me to see most of those in the collection at Bath.

The list of Polyzoa is taken from the "Catalogue of the Cretaceous Fossils in the Museum of Practical Geology" (1878); there is also a collection of them in the British Museum, but they are being revised by Dr. J. W. Gregory, who informs me that the nomenclature of the Polyzoa (both genera and species) is in a very unsettled state.

The nomenclature of the Lamellibranchiate Mollusca is also greatly in need of revision. The species of *Pecten* and *Lima* mentioned in the following list are especially open to correction: thus, the names *elongatus* (Lam.), and *Raulinianus* (D'Orb.), are attached to certain *Pectens* in most of the museums, but I doubt if they are correctly so named. Again, the *Pecten* I have called *P. Galliennei* (D'Orb.), has usually been named *P. interstriatus* (Leym.), although D'Orbigny pointed out in his Prodrome that Leymerie's name was given to another *Pecten* by Munster in 1841. Moreover, the species occurring at Warminster agrees more closely with that named *Galliennei* by D'Orbigny, than with the Aptian form which he renamed *Aptiensis*.

With respect to the *Limæ* I have united those which are named *L. globosa* and *L. albensis* in different museums, though it is possible there are two species. I have also entered under the head of *L. ornata* (D'Orb.), some which have been named *L. Rauliniana* (D'Orb.), which is a kindred but different species.

LIST II.

Fossils from the Rye Hill Sand.

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Reptilia.							
Ichthyosaurus campylodon, Carter	x	—	—	—	—	—	d. and up
Polyptychodon interruptus, Owen	x	—	—	—	—	—	d. and up
Pisces.							
Corax heterodon, Reuss	x	—	—	—	—	—	up
Edaphodon crassus, Newton	x	—	—	—	—	—	
Enchodus halocyon, Ag.	x	—	—	—	—	—	d. and up
Lamna appendiculata, Ag....	x	—	—	—	—	—	d. and up
,, gracilis, Ag.	x	—	—	—	—	—	d. and up
,, subulata, Ag.	x	—	—	—	—	—	d. and up
Oxyrhina Mantelli, Ag.	x	—	—	—	—	—	up
Plethodus expansus, Dixon	x	—	—	—	—	—	d. and up
Protosphyræna ferox, Leidy	x	—	—	—	—	—	d. and up
Ptychodus decurrens, Ag.	x	—	—	—	—	—	up
Pycnodus cretaceus, Ag.	x	—	—	—	—	—	
Cephalopoda.							
Belemnitella ultima, D'Orb.	x	—	—	—	—	—	d. and up
,, sp.	x	—	x	—	—	—	
Nautilus expansus, Sow.	—	—	x	—	—	—	up
,, subradiatus (?), D'Orb.	x	—	—	—	—	—	d. and up
,, sp.	—	—	—	x	—	—	
Ammonites curvatus, Mant.	x	x	—	—	—	—	up
,, falcatus, Mant.	x	x	x	x	—	—	up
,, complanatus, Mant....	—	x	—	—	—	—	up
,, Mantelli, Sow....	x	x	x	—	—	—	up
,, navicularis, Mant.	—	x	—	—	—	—	up
,, planulatus, Sow.	—	x	—	—	—	—	d. and up
,, varians, Sow.	x	x	x	x	—	—	up
,, ,, *var.* Coupei, Brong....	x	x	x	x	—	—	up
Hamites Parkinsoni (?), Flem.	—	—	x	—	—	—	?
,, sp.	x	—	—	—	—	—	
Turrilites Wiestii, Shpe.	—	—	x	—	—	—	up
,, Morrisii, Shpe.	—	—	x	—	—	—	up
Baculites baculoides, D'Orb.	x	—	—	—	—	—	up
Gasteropoda.							
Aporrhais oligochila, Gardner	—	x	—	—	—	—	up
,, sp.	x	—	—	—	—	—	
Fusus bilineatus (?), Pict. and R.	—	—	x	—	—	—	d. and up
Gibbula levistriata, Seeley	—	x	x	—	—	—	d. and up
Littorina, sp.	—	x	—	—	—	—	
Pleurotomaria allobrogensis, D'Orb.... ..	—	x	—	—	—	—	
,, Mailleana, D'Orb.	—	—	x	—	—	—	up

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Pleurotomaria perspectiva (?), Mant.	—	x	x	—	x	—	up
,, Rhodani, D'Orb.	—	x	—	—	—	—	d. and up
,, Thurmanni (?), P. and R. ...	—	—	x	—	—	—	d. and up
,, vraconnensis (?), P. and C. .	—	—	x	—	—	—	?
,, sp.	x	—	—	—	—	—	
Solarium ornatum, Sow.	—	x	—	—	—	—	d. and up
Trochus variabilis, Seeley (=cancellatus, Seeley, and indecisus, D'Orb.)	—	—	x	—	—	—	d. and up
Scalaria, sp. (casts)	x	—	x	—	—	—	
Turritella, sp.	x	—	—	—	—	—	
Lamellibranchs.							
Anomia, like convexa, Sow.	x	—	—	—	—	—	
,, like radiata, Sow.	x	—	—	—	—	—	
Avicula gryphæoides, Sow.	x	—	—	—	—	—	d. and up
Exogyra conica, Sow.	x	x	x	x	x	x	d. and up
,, haliotoidea, Sow.	—	—	x	—	—	x	d. and up
Ostrea canaliculata, Sow. (=O. lateralis, Nilsson)	x	—	—	x	—	—	d. and up
Ostrea carinata, Sow. (=frons, Park.) ...	x	x	x	x	—	—	d. and up
,, vesicularis, Lam.	x	—	—	x	—	—	d. and up
Pecten asper, Lam.	x	x	x	x	x	x	d. and up
,, elongatus (?), Lam.	x	—	x	x	—	—	
,, Galliennei, D'Orb....	x	x	x	x	x	—	down
,, like fissicosta, Eth.	—	—	—	x	—	—	
,, orbicularis, Sow.	x	x	x	—	—	x	d. and up
,, Puzosianus, D'Orb.	x	—	—	—	—	—	up
,, like Raulinianus, D'Orb.	x	—	x	x	—	—	
Janira æquicostata, Lam.	x	?	—	—	—	—	d. and up
,, cometa, D'Orb.	x	x	x	—	—	—	up
,, quinquecostata, Sow.	x	—	x	x	—	—	d. and up
Hinnites, sp.	x	—	—	—	—	—	
Plicatula inflata, Sow., variety of P. pectinoides, Sow....	x	—	x	x	—	x	d. and up
Lima asper (?), Mant.	x	—	x	—	—	—	up
,, cenomanensis, D'Orb.	x	—	—	x	—	—	up
,, compositus (?), Sow....	—	x	—	—	—	—	down
,, globosa, Sow.	x	—	—	x	—	—	d. and up
,, intermedia (?), D'Orb.	x	x	x	x	—	x	up
,, ornata, D'Orb.	x	x	x	—	—	—	up
,, rothomagensis (?), D'Orb.	x	—	—	—	—	—	
,, semiornata, D'Orb.	x	—	—	x	—	—	up
,, simplex (?), D'Orb.	—	—	x	—	—	—	
,, new sp.	x	—	—	—	—	—	
Spondylus striatus, Sow.	x	x	x	x	—	x	up
,, like hystrix, D'Orb.	—	—	x	x	—	—	
Inoceramus latus, D'Orb. (*non* Sow.) ...	x	—	?	—	—	—	up
,, sp.	x	—	—	—	—	—	
Lithodomus, sp.	x	—	—	—	—	—	
Modiola, sp....	x	—	—	—	—	—	
Trigonia aliformis, Park.	x	—	x	—	—	—	down
,, spinosa (?), Park....	x	—	x	—	—	—	down
Arca mailleana, D'Orb.	x	—	x	—	—	—	d. and up
Cyprina quadrata, D'Orb.	x	—	?	—	—	—	up
Crassatella regularis (?), D'Orb.	x	—	—	—	—	—	
Cypricardia, sp.	x	—	—	—	—	—	

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum	Bath Museum.	Range.
Pholadomya, sp.	x	—	—	—	—	—	
Panopæa, sp.	x	—	—	—	—	—	
Solecurtus, sp.	x	—	—	—	—	—	
Brachiopoda.							
Argiope megatrema, Sow.	—	—	—	—	x	—	up
Lingula subovalis, Dav.	—	x	—	—	—	—	down
Megerlia lima, Defr.	x	—	—	x	—	—	d. and up
Rhynchonella convexa, Sow.	x	x	x	x	x	x	d. and up
,, dimidiata, Sow.	x	x	x	x	x	—	d. and up
,, Grasiana, D'Orb.	x	x	x	x	x	x	up
,, Mantelliana, Sow.	x	—	x	—	—	—	up
,, Martini, Sow.	x	x	—	—	—	—	up
,, sulcata (?), Park.	—	x	—	—	—	—	down
,, Schloenbachi, Dav.	x	x	—	—	—	—	d. and up
Terebratula biplicata, Sow.	x	x	x	x	x	x	d. and up
,, obesa, Sow.	x	x	x	—	x	—	up
,, ovata, Sow.	x	x	x	—	—	—	down
,, phaseolina (?)	—	—	x	—	—	—	down
,, squamosa, Mant.	x	—	—	—	—	—	up
Terebratulina gracilis, Schloth....	x	—	—	—	—	—	up
,, striata, Wahl.	x	x	x	—	x	—	d. and up
Terebratella pectita, Sow.	x	x	x	x	x	x	d. and up
,, Menardi, D'Orb.	—	—	x	—	—	—	d. and up?
Rhynchora lyra, Sow.	x	—	x	x	x	—	up
Waldheimia, like Juddii, Walker	x	—	—	—	—	—	
Polyzoa.							
Bidiastopora lamellosa, D'Orb.	x	—	—	—	—	—	
Ceriopora polymorpha, Goldf.	x	—	—	—	—	—	
Choristopetalum impar, Lons.	x	—	—	—	—	—	
Clausa micropora, D'Orb.	x	—	—	—	—	—	
Diastopora Sowerbyi, Lons.	x	—	—	—	—	—	
,, tubulus (?), D'Orb.	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Entalophora ramosissima, D'Orb.	x	—	—	—	—	—	
,, cenomana, D'Orb.	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Eschara cybele (?), D'Orb....	x	—	—	—	—	—	
,, sp.	x	—	—	—	—	—	
Heteropora, sp.	x	—	—	—	—	—	
Radiopora pustulosa, D'Orb.	x	—	—	—	—	—	
Spiropora cenomana, D'Orb.	x	—	—	—	—	—	
Truncatula pinnata, Röm.	x	—	—	—	—	—	
Crustacea.							
Cyphonotus incertus, Carter	—	x	—	—	—	—	down
Necrocarcinus Bechei, Deslong.	x	—	—	x	—	—	down
,, tricarinatus, Bell	—	x	—	—	—	—	down
,, Woodwardii, Bell...	—	x	x	x	—	x	down
Hemioon Cunningtoni, Bell	—	x	—	x	—	—	down
Plagiophthalmus oviformis, Bell	—	x	—	x	—	—	
Hauthosia gibbosa, Bell	—	x	—	x	—	—	
Crustacean claws	—	—	—	x	—	—	
Scalpellum lineatum, Darw.	x	—	—	—	—	—	up
Pollicipes, sp.	x	—	—	—	—	—	

	Jermyn Street.	British Museum.	Woodwardian Museum.	Devizes Museum.	Bristol Museum.	Bath Museum.	Range.
Annelida.							
Ditrupa difformis, Lam.	x	—	—	—	—	x	up
Galeolaria filiformis, Sow.	x	x	x?	x	—	—	d. and up
,, plexus, Sow.	x	x	—	—	x	—	d. and up
Serpula ampullacea, Sow.	x	x	—	—	—	—	d. and up
,, annulata, Reuss	x	—	—	—	—	—	up
,, antiquata, Sow.	x	x	x?	—	x	x	d. and up
,, ilium, Sow.	x	—	—	—	—	—	up
,, macropus	x	—	—	—	—	—	
,, plana, Woodw.	x	—	—	—	—	—	up
Vermicularia concava, Sow.	x	—	x	—	—	—	down
,, umbonata, Sow.	x	—	—	—	—	—	d.?andup
Echinodermata.							
Cidaris vesiculosa, Goldf.	x	x	x	x	—	—	up
,, velifera, Ag.	—	x	—	—	—	—	
Cottaldia Benettiæ, König	x	x	x	x	—	x	
Discoidea subuculus, Leske	x	x	x	x	—	x	d. and up
Echinocyphus difficilis, Ag.	x	x	x	—	—	—	up
Glyphocyphus radiatus, Hön.	—	x	—	—	—	—	up
Goniophorus lunulatus, Ag.	x	x	x	x	—	—	up
Peltastes clathratus, Ag.	x	x	x	x	—	x	up
,, umbrella, Ag.	x	x	x	x	—	—	up
Pseudodiadema Benettiæ	x	x	x	x	—	x	up
,, Michelini, Ag. (=Ps. Bonei, Forbes)...	x	x	x	x	—	x	
Pseudodiadema Rhodani, Ag.	x	x	—	x	—	—	
,, variolare, Brong.	x	x	x	x	—	—	up
Salenia petalifera, Desor	x	x	x	x	—	—	up
,, gibba, Ag.	—	x	—	x	—	—	
,, Desori, Wright	—	x	—	—	—	—	
,, Lorioli, Wright	—	x	—	—	—	—	
Caratomus rostratus, Ag.	x	x	x	—	—	x	
Cardiaster fossarius, Benett	?	x	x	—	x	x	down
Catopygus columbarius, Lam.	x	x	x	x	x	x	d. and up
Echinobrissus lacunosus, Goldf.	x	x	x	x	—	—	down
,, Morrisii, Forbes	—	x	—	—	—	—	? down
Holaster lævis (*var.* carinatus)	x	x	—	x	x	—	d. and up
,, subglobosus, Leske	x	—	—	x	—	—	up
Hemiaster minimus, Ag.	x	x	x	—	—	—	d. and up
Pyrina lævis, Ag. (Dr. Wright's coll.) ...	—	—	—	—	—	—	
Pentacrinus Agassizi, Hagenow	x	x	x	x	x	—	up
Glenotremites paradoxus, Goldf.	x	—	—	—	—	—	
Actinozoa.							
Micrabacia coronula, Goldf.	x	x	—	x	—	x	up
Astrocænia decaphylla, E. and H.	x	—	—	—	—	—	?
Stephanophyllia Bowerbankii, M. Edw. ...	x	x	—	—	—	—	up
Trochosmilia, sp....	x	—	—	—	—	—	
Hydrozoa.							
Porosphæra urceolata, Phil.	x	—	—	—	—	x	d. and up
Parkeria, sp.	—	—	—	x	—	—	
Spongida.							
Trematocystia Orbignyi, Hinde...	x	x	x	—	—	—	
,, siphonioides, Mich.	—	x	—	—	—	—	

When we come to study the components of this fauna we find it to be a curious mixture of species, many of them being species which are common in the Chalk Marl, and are not known to occur below this particular bed of sand or its equivalent on the south coast, while others are species which do not range higher, or are, at any rate, not found in the Chalk Marl. Considering the stratigraphical position of the Rye Hill Sand and the upward passage from it to the Chloritic Marl, it is not surprising to find that the fauna also exhibits a transitional character. It will, however, be useful to discuss the evidence afforded by the members of each class or order separately.

Cephalopoda.—All the Ammonites and most of the other Cephalopods are species which characterize the true Chloritic Marl (zone of *Stauronema Carteri*) and the Chalk Marl (zone of *Ammonites varians*). So far as my experience goes, none of them, except *Belemnitella ultima*, *Nautilus subradiatus*, and *Ammonites planulatus*, range down to lower horizons.

Gasteropoda.—It is doubtful how many of these really occur in the Rye Hill Sand; they are certainly rare, and most of those in museum collections have come from the Chloritic Marl. Of those admitted to my list, the range of most is probably upward as well as downward.

Lamellibranchiata.—The distribution of these is remarkable; only four of them range down, no less than 10 have an exclusively upward range, while 12 range both up and down, and six are doubtfully identified with French Cenomanien species. This part of the fauna, then, has decidedly closer relations with that of the Chalk Marl than with that of the Greensand.

Brachiopoda.—Of these, again, only four are exclusively Greensand species; and one of these, the supposed *Rhynchonella sulcata*, is probably an extreme variety of *Rh. dimidiata.* Seven species belong decidedly to the Lower Chalk fauna, and eight are believed to range both up and down.

Crustacea.—Of these, five range down to the Gault, two are peculiar to the Rye Hill Sand, and only *Scalpellum lineatum* ranges into the Chalk. The Brachyurous Crustacea seem, therefore, to be the relics of an older fauna, and as none have yet been found in the Chalk Marl it would seem as if the physical conditions of that deposit were unsuitable to them.

Annelids.—These are long-lived creatures, but most of the species in the list range upward; and though some range down as well, only one is specially a Greensand species.

Echinodermata.—Out of a total of 28 species nine are rare fossils, either unknown elsewhere in England at present, or found only in the Cenomanian of Devon. Deducting these nine, the remainder is 19; and of these, 11 range upward, occurring either in Chloritic Marl or Chalk Marl, five range both up and down, while only three are not known to occur at higher horizons. One of the last, *Cardiaster fossarius*, is very characteristic of the higher part of the Upper Greensand in the south and south-west of England. It is common in the Chert Beds near Warminster, but seems rather rare in the Rye Hill Sand.

No fewer than 13 of the species occur in the Chalk Marl, and it is clear that there is a preponderating Chalk Marl element in the Echinoid fauna of the Rye Hill Sand. The fact has been noted before, though it has not been stated correctly; thus, Dr. Wright, in his Monograph on the Cretaceous Echinodermata, makes the following remarks: "I have long noticed nearly all the Upper Greensand Echinidæ are found in the Grey Chalk, and that the specimens from the latter stratum are in general larger and more fully developed, as if they had been better nourished, than those collected from the arenaceous beds of the Upper Greensand of Wiltshire and other localities."

The mistake Dr. Wright and everyone else have made is in regarding all these Warminster Echinoderms as characteristic Upper Greensand species. They are really Chalk Marl species, and the very topmost bed of the Greensand at Warminster and elsewhere is, for many of them, *the limit of their downward range.* In other words they are not Greensand species, but Chalk species which make their first appearance at this horizon.

Actinozoa.—Only four corals have been obtained from the Rye Hill Sand, and three of these are Chalk forms, the fourth being *Astrocœnia decaphylla*, for which the only other known locality is Haldon, in Devonshire, and as the coral bed there is at the top of the Greensand it may not be older than the Rye Hill Sand.

Reviewing the above palæontological evidence, we find that the total number of species which range up into the Chalk Marl is much greater than the number of those which range down through the Upper Greensand, and this is so after the exclusion of many species which have hitherto been admitted as Warminster fossils, but which really came from the Chloritic Marl. Roughly speaking and setting aside those which range both ways, the species ranging upward are nearly three times as many as those ranging downward.

If the Rye Hill Sand were only known as an outlying patch, situated further west, and we had only the evidence of the fossils to guide us in determining its geologic age, it might have been regarded as a shallow-water deposit of the age of the Chalk Marl, and the Ammonites might have been appealed to as strong evidence in support of the contention. Nor would the conclusion have been very far wrong, for the bed is only just below the Chalk Marl.

This preponderance of upward-ranging species in the Rye Hill Sand accounts for the idea put forward in 1874 by Mr. C. J. A. Meyer[1] that "the fossiliferous portion of the so-called Upper Greensand of Warminster is, properly speaking, 'Chloritic Marl,' instead of 'Upper Greensand,' as usually stated." Judging from the collections of Warminster fossils seen in museums, and without the stratigraphical knowledge which has since been obtained, it was a very natural conclusion on his part, though it is not strictly correct.

The limitation of the so-called Warminster fauna to a few feet at the top of the Upper Greensand has an important bearing on the Cenomanian question, for it will show our French *confrères*

[1] Quart. Journ. Geol. Soc., vol. xxx, p. 381.

that the fauna which they rightly regard as so essentially Cenomanien, is not a typical Upper Greensand fauna, nor even the fauna of the Greensand chert beds; but is the fauna of a special bed which lies only just below the horizon that is taken by Mr. Hill and myself as the base of the Cenomanian both in France and England.[1]

The fact that this bed contains so many precursors of the Chalk Marl (or Cenomanian) fauna does not seem to me a sufficient reason for excluding it from the Upper Greensand; though doubtless most French geologists would think so. D'Orbigny's doctrine, that every system can be divided into stages, the faunas of which are sharply marked off from one another, has greatly influenced French opinion, and they still seem to have a tendency to put a higher value upon the evidence of fossils than upon other lines of evidence.

My own experience as a field geologist has taught me that exposures which are twenty or thirty miles apart, generally show some little differences in the distribution of fossils, above and below any line of separation which can be taken between two stages. When localities are still further apart, the range of species differs more; no one now supposes that a species appeared everywhere at the same epoch of time, and we must not allow the evidence of fossils to override plain stratigraphical facts.

Appendix.

The following is a list of the species to which the specimens preserved in brownish phosphate included in many collections of Warminster fossils belong. It will be seen that many species have been excluded on this account from the previous lists; but there is no doubt that some occur both in the matrix of the Rye Hill Sand and in that of the Chloritic Marl, though all are more common in the latter.

Ammonites Coupei, Brong.
,, curvatus, Mant.
,, falcatus, Mant.
,, complanatus?
,, Mantelli, Sow.
,, navicularis, Mant.
,, planulatus, Sow.
,, varians, Sow.
Scaphites æqualis, Sow.
Turrilites Bergeri, Brong.
,, costatus, Lam.
,, Gravesianus, D'Orb.
,, Morrisii, Sharpe.
,, tuberculatus, Bosc.
Nautilus Deslongchampsianus, D'Orb.
,, Fittoni, Sharpe.
Avellana cassis.
Aporrhais Parkinsoni? and other species.
Columbellina, sp.
Emarginula Gresslya, P. and C.
,, sp.
Dentalium ellipticum, Sow.
Crepidula, sp.
Fusus bilineatus?
,, sp.
Pleurotomaria Rhodani, D'Orb.
,, Thurmanni, P. and R.
,, vraconnensis, P. and C.
Phasianella, sp.
Turbo, sp.
Solarium Martinianum, D'Orb.
,, dentatum, D'Orb.
,, ornatum, Sow.
Scalaria Rauliniana, D'Orb.
Natica gaultina, D'Orb.
Pterocera inflata, D'Orb.
Cucullæa glabra, Park.
,, ligeriensis?, D'Orb.
Arca Mailleana, D'Orb.
Cyprina quadrata, D'Orb.
Unicardium Ringmeriense, Mant.
Nucula pectinata, Sow.
Lutraria carinifera, D'Orb.
Catopygus columbarius, Lam.

[1] See Quart. Journ. Geol. Soc., vol. lii, pp. 105, 119.

REVIEWS.

I.—The Extinct Vertebrata of the Moray Firth Area. By R. H. Traquair, M.D., LL.D., F.R.S. [Reprint from Brown and Buckley's "Vertebrate Fauna of the Moray Basin" (Edinburgh, 1896), pp. 235–285, pls. i–ix.]

MESSRS. BROWN AND BUCKLEY have done good service to Vertebrate Palæontology by inducing Dr. Traquair to contribute to their recently published volume on the vertebrate animals of the Moray Basin, a summary of the known fossil fishes from the Old Red Sandstone of that area. The supplement occupies fifty pages, and is illustrated by nine plates of Old Red fishes drawn by Dr. Traquair himself; only ten pages of it are devoted to the enumeration of the vertebrata of the Triassic, Jurassic, and Pleistocene deposits. Six of the nine plates are occupied with useful restorations, some already published elsewhere, but the majority quite new, and giving a much more correct idea of the Old Red Sandstone fishes than any restorations previously attempted. They are only marred by the process of reproduction, which imparts to them an inartistic coarseness.

After some preliminary remarks on the distribution and divisions of the Old Red Sandstone in the Moray Basin, accompanied by an enumeration of the literature of the subject, Dr. Traquair proceeds to treat of the fishes of the Lower Old Red Sandstone (Orcadian Series). They are systematically arranged, though not technically described; and the known localities for each species are carefully enumerated. The Acanthodians are named *Diplacanthus striatus*, *D. tenuistriatus*, *Rhadinacanthus longispinus*, *Mesacanthus pusillus*, *Cheiracanthus Murchisoni*, and *C. latus*. Restored figures of *Diplacanthus* and *Cheiracanthus* are added. The subclass Ostracodermi and the order Antiarcha are admitted, three species of *Pterichthys* (*Milleri*, *productus*, and *oblongus*) being recorded here. Of the Dipnoi, the sole representative is *Dipterus Valenciennesi*, of which a new restoration is given. Though common in the Caithness Flags, this fish is very rare in the Moray Firth area. The subclass Teleostomi (Dr. Traquair no longer speaks of Ganoidei) includes *Glyptolepis leptopterus*, *Gyroptychius microlepidotus*, *Osteolepis macrolepidotus*, *Diplopterus Agassizi*, and *Cheirolepis Trailli*, while the characters of all, except the first, are shown in restored figures. The "Order Placodermata" is placed "incertæ sedis" under the Teleostomi. *Coccosteus decipiens* and *Homosteus Milleri* are recorded here, the first a very common fish, the second known in the Moray area only from Hillhead quarry, near Dalcross.

The fishes of the Upper Old Red Sandstone of Moray are shown to represent two distinct faunas—that of Nairn in the west, that of Elgin in the east. These are treated separately, and a table of localities at the end indicates at a glance the species found in each. The first species mentioned from Nairn, *Asterolepis maxima*, was described by Dr. Traquair in great detail in the Palæontographical

Society's volume for 1894. The three remaining species are known only by fragments, but seem to be new to the locality, if not entirely new. Some detached scales (one figured) are identified with *Holoptychius decoratus*, Eichwald, sp., from Wenden, Livonia. Imperfect Rhizodont jaws are described and figured as *Polyplocodus leptognathus*, sp. nov.; while the anterior median ventral plate of a large Coccostean is regarded as indicating a new species, *Coccosteus magnus.* The species from the Elgin district are more numerous and more interesting. The curious Elasmobranch armour-plates described nearly two years ago as *Psammosteus Taylori*, are treated in detail, and Dr. Traquair incidentally gives the new generic name, *Turinia*, to the *Cephalopterus* of Powrie (preoccupied 1809) from the Lower Old Red Sandstone of Turin Hill, Forfar. There are further valuable notes on the Elasmobranch spine, *Cosmacanthus Malcolmsoni*, which proves to be a paired spine, not bilaterally symmetrical as supposed by Agassiz. A restored outline of *Bothriolepis major* is given, and this is described as the largest known Asterolepid, the total length of the armour being sometimes probably not less than a foot and a half. Three portions of armour from Rosebrae Quarry, near Elgin, are regarded as indicating another species, *Bothriolepis cristata*, sp. nov., distinguished by an elevated crest on its dorsal surface. *Phyllolepis concentrica*, *Conchodus ostreiformis*, and *Holoptychius nobilissimus* are merely recorded; but a figure of *Holoptychius Flemingi* (from Dura Den, Fifeshire) is added to complete the series of restorations. *Holoptychius giganteus* is believed to claim many detached teeth besides the characteristic scales. Fragments of jaws seem to belong to *Polyplocodus*; and a brief reference to *Glyptopomus minor* concludes the enumeration.

We hope this is only the forerunner of a more extensive work on the Palæozoic Fishes of Scotland, which would summarize the results of Dr. Traquair's numerous papers, and make them more readily accessible to non-specialists. Most geological and biological handbooks still display lamentable ignorance of the subject, and a general treatise like the present would do much towards enlightenment. A. S. W.

II.—Mollusques Éocéniques de la Loire-Inférieure. By M. Cossmann. (Bull. Soc. Sci. Nat. Ouest France, 1895, Tome V, pp. 159–197, Plates v–vii, Fascicule 1.)

M. COSSMANN, who undoubtedly ranks as the leading Tertiary Malacologist of France, is preparing a Monograph of the Eocene Molluscan fauna of Brittany, the first part of which is now before us. The majority of the shells have been obtained from special excavations made at Bois-Gouët, in the Saffré Basin, under the direction of M. Dumas; others have been collected at Coislin and La Close, near Camphon; whilst the remainder come from the dolomitic district of Arthon. These different localities, situated in the department of La Loire-Inférieure, have yielded a number of new species as well as all those listed in Vasseur's treatise, "Recherches Géologiques sur les terrains tertiaïres de la France occidentale": Stratigraphie, first part. Bretagne (Annales Sciences Géologiques, 1881, vol. xiii). Many of the shells in Vasseur's work have hitherto had only a manuscript value, as the intention of that author to fully describe and figure them in a second part was never realized, if we except a few plates of fossils which were subsequently issued without text. Although through courtesy the name of Vasseur is still attached to these species, now described for the first time, there is no doubt that M. Cossmann must claim their real authorship.

The present work, judging from this first part, promises to be a large and important one, as all the species, whether new or otherwise, are fully diagnosed and figured. A large number of the shells, we are told in the preliminary remarks, can be undoubtedly paralleled with Paris Basin forms; a few being of Lower Eocene age, whereas the majority belong to the upper portion of the Middle Eocene. The groups now considered are: the Cephalopoda and the Pulmonate and Opisthobranchiate Gasteropods.

One of the most interesting facts brought out with reference to the Cephalopoda is the discovery of a second specimen of James de Carle Sowerby's *Beloptera anomala*; the only known example prior to this was the type specimen from the London Clay at Highgate, upon which Frederick Edwards founded the genus *Belemnosis*. The principal distinguishing character of the genus, according to Edwards, was the large aperture "which forms a communication between the alveolar chambers and the sac in which the shell was lodged." If such an aperture were normal, it would constitute a serious anomaly in the organization of the Cephalopoda; and Messrs. R. B. Newton and Geo. F. Harris suggested that it was due to the imperfection of the Highgate specimen, which bears traces of having been rolled. The last-mentioned authors showed that the so-called ventral aperture was in reality only the initial chamber of the shell brought to light by the removal of a thin projecting part of the rostrum consequent on ill-usage. It is interesting to note that the more perfect specimen discovered by M. Cossmann, and described in the work under review, fully bears out the theoretical conclusions of Messrs. Newton and Harris. The latter, however, included the species in the genus *Spirulirostra*. M. Cossmann thinks that the points of difference are of sufficient importance to warrant the retention of Edwards' generic name: "les *Belemnosis*," he remarks, "sont des *Spirulirostra* sans rostre, et à phragmocône moins spiral." Without analyzing afresh the interesting details brought forward by Messrs. Newton and Harris respecting the generic position of this shell, we are inclined to accept their theory; the question of the length of the rostrum or whether it is obtuse or pointed, not being, in our view, a prime generic factor. Out of fifty-five shells reviewed, the following are recorded as new species:—Cephalopoda: *Belosepia Dufouri*. Gasteropoda (Pulmonata): *Limnæa Bourdoti*, *L. Gouëtensis*, *L. adela*; *Bulimus Dumasi*; *Auricula namnetica*, *A. simplex*, *A. Heberti*, *A. Monthiersi, A. citharella, A. Ludovici, A. Douvillei, A. Houdasi; Scarabus Bonneti; Ophicardelus sinuosus; Marinula labrosa; Siphonaria Tournoueri, S. granicosta.* GASTEROPODA (OPISTHOBRANCHIATA): *Actæon Octavii, A. Dumasi; Crenilabium suturatum; Scaphander tenuistriatus; Bullinella brachymorpha, B. Rideli; Plicobulla* (subgen. nov.) *Dumasi; Cylichnella Bourdoti; Amphisphyra subcylindrica; Ringicula Morleti.*

III.—PROF. G. VICENTINI ON EARTHQUAKE-PULSATIONS.

(1) "Osservazioni e Proposte sullo studio dei Movimenti Microsismici": Atti della R. Accad. dei Fisiocritici (Siena), v, 1894.

(2) "Microsismografo a registrazione continua; Cenno sui movimenti sismici dei giorni 14 e 15 Aprile, 1895": Bullettino della Soc. Veneto-Trentina di Scienze Naturali (Padova), vi, 1895, pp. 5–12.

(3) "Microsismografo a registrazione continua": Bollettino della Soc. Sismologica Italiana, i, 1895, pp. 66–72.

(4) "Osservazioni sismiche": Atti della R. Accad. dei Fisiocritici (Siena), v, 1894.

(5) "Movimenti sismici registrati dal microsismografo nella prima metà del luglio 1894": *ibid.*

(6) "Intorno ad alcuni fatti risultanti da osservazioni microsismiche": Atti e Memorie della R. Accad. di Scienze, etc., in Padova, xii, 1896, pp. 89–97.

In the first three of these papers, Prof. Vicentini describes the instrument with which his investigations have been made at Siena and Padua; the fourth and fifth contain an account of the records at Siena from February 17 to July 14, 1894, and are accompanied by copies of some of the more interesting diagrams; the last and most valuable of the series summarizes the conclusions at which he has so far arrived.

The microseismograph is a heavy pendulum, about $1\frac{1}{2}$ metres (or a little less than five feet) in length. The centre of the base of the mass which forms the bob of the pendulum is connected with the upper end of the short arm of a light vertical lever, so that every movement of the mass is magnified by the lower end of the lever. A further magnification is obtained by means of two horizontal levers at right angles to one another, the shorter arms of which are connected with the lowest point of the vertical lever. The other ends of the horizontal levers consist of sharp points, which rest lightly on a strip of smoked paper driven underneath them by clockwork. When the pendulum is at rest, these points trace straight lines upon the paper. When it is disturbed in any manner, the path of the centre of the heavy mass is determined by combining the curves traced by the two points.

The cost of the paper on which the records are made being very small, an unusually rapid movement can be allowed, and thus the diagrams are to a great extent free from that confusion caused by overlapping which can hardly be avoided when the more expensive process of photographic registration is employed.

The character of the diagrams is found to depend on the strength of the earthquake and on the distance of the place of observation from the epicentre.

In the case of slight local earthquakes, the first movements are rapid vibrations superposed on small oscillations of longer period. When the vibrations cease, the oscillations become more marked, and, as a rule, the mean position of the pendulum undergoes a continuous change, showing that the ground receives a tilt which, after reaching a maximum value, disappears more or less slowly. On May 25th, 1895, for example, a slight earthquake occurred at Rovigo, which lies about twenty miles south of Padua. Joining the mean points of all the oscillations recorded by the two pens, the components are obtained of the path along which the pendulum would have moved if it had followed the tilts of the ground slowly and without oscillating. The resultant path is found to be nearly a straight line running N. 32° W. and S. 32° E. During the first ten seconds the tilt of the ground took place slowly; in the next twelve seconds it rapidly increased to a maximum of about 6″; and then, during the next ten seconds, it returned as rapidly towards its original position, which, however, it only reached after other small oscillations of about twenty seconds' duration.

The more distant the epicentre, the longer is the first phase of the movement, namely, that which consists of rapid vibrations superposed on small oscillations. As a rule, both of these take place about a line indicating a very slight tilt of the ground. If the shock be strong and the epicentre distant, this first phase may last for about a minute. The second phase consists of large oscillations with various maxima, which begin and end suddenly. The third and last phase is characterized by small irregular oscillations, much slower than the preceding. Throughout both of these phases, the mean position of the pendulum continually changes, as if long, slow waves, with a period of at least twenty seconds, were at the same time propagated across the ground.

In the diagrams corresponding to disastrous shocks with a very distant epicentre (such as, for example, the Japanese and Argentine earthquakes of 1894), the different phases of the movement are separated from one another. The first consists of vibrations, of abrupt displacements, and small oscillations; in the second phase, the lines are irregular and deeply sinuous, though interrupted by sudden displacements of small amplitude; while, in the third, the lines become regular and sinuous, indicating a slow and gentle rocking of the ground with a period of about thirty seconds.

C. Davison.

IV.—Fish-remains from Phosphatic Chalk in France. (Sur les Poissons de la Craie Phosphatée des Environs de Péronne.) By F. Priem. Bull. Soc. Géol. France [3], vol. xxiv, pp. 9–23, pls. i, ii (1896).

The stratigraphical distribution of fossil fishes in the Chalk is a subject deserving more careful attention than it has hitherto received. Detailed descriptions of remains from definite horizons are thus very welcome, and M. Priem's recent paper on teeth and other fragments from the phosphatic chalk of Péronne, Somme (zone of *Belemnitella quadrata*), is an interesting contribution of this kind. The author is a pupil of Prof. Gaudry, and has determined the specimens in the Laboratory for Palæontology in the Jardin des Plantes, Paris. The species represented are *Ptychodus latissimus*, *Oxyrhina Mantelli*, *Lamna appendiculata*, *Scapanorhynchus* (*Odontaspis*) *rhaphiodon*, *S.*? (*O.*) *subulatus*, *Corax pristodontus*, and a form of *Protosphyræna*, possibly *P. ferox*. The two illustrative plates are beautiful photographs of the actual fossils.

REPORTS AND PROCEEDINGS.

ZOOLOGICAL SOCIETY OF LONDON.

March 17th, 1896.—Prof. G. B. Howes, F.Z.S., in the Chair.

Mr. A. Smith Woodward, F.Z.S., read a paper on some extinct fishes of the Teleostean family Gonorhynchidæ. He described a new specimen of *Notogoneus osculus* from the Eocene (Green River Shales) of Wyoming, U.S.A., confirming Cope's determination of this fish as a member of the family Gonorhynchidæ. He also pointed out that the so-called *Sphenolepis squamosseus* and *S. Cuvieri*, imperfectly described by Agassiz from the Eocene of France, are generically identical with *Notogoneus*. In proof of this identification, he gave an account of new specimens in the British Museum. The Gonorhynchidæ were thus shown to have comprised fresh-water fishes in the early Tertiary period both in Europe and North America.

GEOLOGICAL SOCIETY OF LONDON.

I.—April 15th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The PRESIDENT announced that a portrait in sepia of Prof. Bonney, executed by Mr. Trevor Haddon, had been presented to the Society by 34 subscribers, Fellows of the Society.

The following communications were read:—

1. "The Junction-Beds of the Upper Lias and Inferior Oolite in Northamptonshire.—Part I. Physical and Chemical." By Beeby Thompson, Esq., F.G.S., F.C.S.

The author, while combating the view that a considerable unconformity exists between the Upper Lias and the Inferior Oolite of Northamptonshire, brings together much evidence to illustrate the effects of slipping, and to show that these effects may be mistaken for those of unconformity. He also applies the evidence which he has collected to illustrate certain points in the physics of valley-formation.

After giving details as to the horizon of the springs of the district, the distribution of water in the Inferior Oolite, and the development of the springs, he argues that every valley of the district has been elongated in the direction which it now has by a stream originating in a spring always at its head; and that the development of channels towards particular points of discharge has been the chief agent in initiating the formation and guiding the direction of all the minor valleys of the river-system within the influence of the same set of beds. A description of the characters of the slopes follows, and their significance is discussed. The structure of the hills and valleys of the district occupies the next portion of the paper, and the author considers that corresponding to the deepening of a valley by denudation there is uplifting of the beds below it, and at the same time an outward and upward thrust along the hillside which lifts beds there; also, that hills are reduced in height by sinking as well as by denudation of their upper parts. In discussing the question of unconformity between the Inferior Oolite and Upper Lias, the rarity of exposures of true junctions is noted, the junctions which have been chiefly examined by other observers being obscured by slipping; and reasons are given for inferring an absence of unconformity at the horizon, both on account of the character of the true junctions and from other considerations. The author, however, gives reasons for believing that a slight unconformity occurs in the Upper Lias, so that the lower part of the *jurensis*-zone is absent, and not its upper part as has been elsewhere inferred.

2. "Contributions to the Stratigraphy and Palæontology of the *Globigerina*-limestones of the Maltese Islands." By J. H. Cooke, Esq., F.L.S., F.G.S.

A bibliography of the *Globigerina*-limestones is followed by some remarks on the physical features and general distribution of the strata. The limestones are divided into nine subdivisions, lettered A to I, the former being uppermost. Four seams of phosphatic nodules form the subdivisions B, D, G, and I, and local nodule-bands also occur in E. The subdivision G serves as a line of demarcation between the Langhian Series (Miocene) and the Aquitanian (Oligocene). Details of the lithological and palæontological characters of the various subdivisions are given, and the author concludes that I, and the lower part of H, were laid down on a sinking sea-floor, in about 300 fathoms of water; that the upper part of H, and G, F, E, D, composed to a large extent of *Globigerina* and other pelagic organisms, were probably deposited in about 1000 fathoms; while C, B, and A, were probably laid down, like I, and the lower part of H, in about 300 fathoms of water.

3. "On the Geology of the Neighbourhood of Carmarthen." By Miss Margaret C. Crosfield and Miss Ethel G. Skeat. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec. G.S.)

The area described lies approximately within a four-mile radius of Carmarthen. The beds of the district have been subjected to complicated foldings, amongst which an earlier set, giving rise to a number of small anticlines with north-and-south axes, and a later more extensive set, due to the series of earth-movements which produced the great Condrusian ridge, producing anticlines and synclines having a general east-and-west trend, can be made out. The rocks forming the subject of the present paper occur in one limb of a complex anticline produced during the latter set of movements. In this limb beds of the following ages occur: Tremadoc Slates, Lower and Upper Arenig, Llanvirn, Llandeilo, and Bala. These beds are described in detail. A regular succession of strata from Tremadoc Slates to *Dicranograptus*-shales is found, while the Bala beds of Mount Pleasant abut on Arenig strata, and the reason for this irregularity has not yet been decided by the authors. The beds are compared with those of other areas. The Tremadoc Slates are equivalents of Stage 3*a* of the Christiania district; the Lower Arenig Beds with *Phyllograptus angustifolius*, and the Upper Arenig with *Didymograptus nitidus*, etc., resemble those of other British areas; the Llanvirn Beds contain *Didymograptus bifidus* and other fossils; the *Didymograptus Murchisoni*-beds are well known elsewhere. The Llandeilo Limestone is probably presented by sandy beds with *Asaphus tyrannus*; and the *Dicranograptus*-shales are like those of the Haverfordwest region. The Bala Beds of Mount Pleasant contain *Stygina Murchisonæ* and other fossils found elsewhere in Bala rocks.

A description of new fossils forms the concluding portion of the paper.

II.—April 29th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The following communications were read:—

1. "Descriptions of New Fossils from the Carboniferous Limestone.—(1) On *Pemmatites constipatus*, sp. nov., a Lithistid Sponge. (2) On *Palæacis humilis*, sp. nov., a new Perforate Coral; with Remarks on the Genus. (3) On the Jaw-apparatus of an Annelid, *Eunicites Reidii*, sp. nov." By George Jennings Hinde, Ph.D., F.G.S.

(1) The *Pemmatites*, belonging to a genus hitherto only known from the Permo-Carboniferous beds of Spitzbergen, was discovered in the Yoredale Beds of Yorkshire by Mr. J. Rhodes, and is the only fairly complete sponge which has hitherto been detected in the Yoredale Beds of North-west Yorkshire. The author gives a full description of the species.

(2) The *Palæacis* was found by the Rev. G. C. H. Pollen in the Carboniferous Limestone and Shale Series, on the banks of the Hodder, near Stonyhurst. The specific characters of the form are given by the author, who then remarks upon the genus *Palæacis*, which has been placed alternately with the corals and sponges, though latterly it has been generally regarded as a perforate coral. Nevertheless, its real characters had not been definitely settled: the uncertainty, in the author's opinion, being due to the fact that some writers have placed in the genus certain forms which differ widely from the typical species, and have then defined the characters of the

genus largely from these foreign forms. The author, in the light of the information now supplied, gives a fresh definition of the genus, which appears to represent a distinct family of perforate corals, in some features more nearly allied to the Favositidæ than to the Madreporidæ or Poritidæ.

(3) The third specimen was discovered by Miss Margery A. Reid in the Lower Carboniferous Beds of Halkin Mountain, Flintshire, and is named in honour of its discoverer. A description of it is given, and it is stated that, notwithstanding certain peculiarities, the individual pieces correspond so closely with those of the recent *Eunice* family that it may well be included in the genus *Eunicites*.

2. "The Eocene Deposits of Dorset." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The new survey of the western end of the Hampshire Basin shows that the Reading Beds become fluviatile and gravelly in Dorset (as was already known), and contain, in addition to Chalk flints, many fragments of Greensand chert. The London Clay thins greatly and becomes more sandy, but is apparently still marine. The Bagshot Sands become coarser and more fluviatile, changing rapidly west of Moreton Station, till they consist mainly of coarse subangular gravel. These gravels, formerly referred to the Reading Series, are now shown to be continuous with the Bagshot Sands, which as they become coarser cut through the London Clay and Reading Beds to rest directly on the Chalk. The Bagshot gravels contain, besides Chalk flints and Greensand chert, fragments of Purbeck marble and numerous Palæozoic grits and other stones probably derived from the Permian breccias of Devon.

Thus there is evidence of disturbance and overlap in Cretaceous or early Eocene times, causing Reading Beds to rest on Upper Greensand. Later disturbances allowed the Bagshot river to cut into Greensand, Wealden, Purbeck, Permian breccia, Culm Measures, and granite. Folding of the strata seems to have taken place during at least four different periods in the district between Dorchester and Weymouth, which appears to have been a region of special weakness.

The Eocene gravels contain all the foreign rocks known to occur in the Plateau-gravels between Brighton and Dorchester. The fragments of Greensand chert, so abundant in the Plateau-gravels, have not been derived, as supposed, from the central axis of the Weald. They come, as already-formed pebbles, from the Eocene of Dorset, and originally from the Greensand of Devon.

3. "Discovery of Mammalian Remains in the Old River-gravels of the Derwent near Derby."—Part I. By H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

A few mammalian bones were found in sinking a well at Allenton. On April 8th, 1895, the authors commenced further excavations, and were successful in finding the lower jaw, 26 vertebræ, the os innominatum, left femur, tibia, fibula, calcaneum, cuboid, IV metatarsal, right fibula, calcaneum, cuboid, IV metatarsal, astragalus, left lunare and scaphoid, and portions of ribs of a *Hippopotamus*, also part of the breast-bone of an *Elephas*, and part of the tibia of a *Rhinoceros*. The *Hippopotamus*-bones were well preserved, and probably belonged to one animal. The body was most likely stranded in an old channel of the River Derwent, and quickly covered up with sand and clay, but not before the bones were somewhat disturbed. They were found in a dark-coloured sand above the river-gravel, at a depth of 9 feet 8 inches below the surface.

Mr. Clement Reid found some twenty or more species of plant-remains in the sand. These plants "indicate a moist meadow or swampy ground, and a temperate climate. The species are all widely distributed."

Part II. By R. M. Deeley, Esq., F.G.S.

The deposits in which the bones were found occupy a wide trench which occurs on the inside edge of a gravel-terrace stretching for several miles south of Derby, at a height of 15 or 20 feet above the modern alluvial plain. The gravels are of later age than the Great Chalky Boulder-clay, and were formed at a time when the rivers were removing from their pre-Glacial valleys the older Boulder-clays, with which they had been partially filled. Gravels of two ages are recognized: (*a*) recent gravels well stratified, undisturbed, and covered in many places by a thick layer of brick-earth; and (*b*) high-level gravels showing "trail" and contorted bedding. It is in these latter gravels that the trench containing the mammalian remains occurs. The deposits occupying this old waterway and the contorted high-level gravels are placed together in the same period; and the author gives reasons for supposing that they are both of Interglacial age, the contortions and surface-disturbances having been produced during a recent cold period, most probably by a lobe of ice which passed down the Trent Valley. Several peculiar physical features of the valleys, such as the flowing surface-outlines of the higher gravel-terraces, and the occurrence of lacustrine deposits in the low-level area occupied by Sinfin Moor, are instanced as supporting this view.

III.—May 13th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "An Account of a Head or Gateway driven into the Eastern Boundary-fault of the South Staffordshire Coal-field." By William Farnworth, Esq., F.G.S.

The author describes certain peculiarities observed during the driving of a head towards the fault separating the Coal-measures and Permian rocks, from a pit situated four miles east of Walsall, at the southern extremity of the Cannock Chase Coal-field.

2. "Dundry Hill: its Upper Portion, or the Beds marked as Inferior Oolite (G 5) in the Maps of the Geological Survey." By S. S. Buckman, Esq., F.G.S., and E. Wilson, Esq., F.G.S.

The authors give an account of previous geological work relating to Dundry Hill, especially that which refers to the correlation of its strata. Then they describe the different exposures on the Hill, together with the results of various excavations carried out by quarrymen under their superintendence for the purpose of the present communication. Besides demonstrating the sequence of the strata of Dundry Hill, the authors are able to show as special results—

The rapid easterly attenuation of the Freestone.

That there is a non-sequence in the Dundry deposits.

That the chief fossiliferous bed—the Ironshot Oolite—extends over a very small area.

That the absence of this bed is due to removal by almost contemporaneous denudation.

That in the easternmost portion of the Hill this bed and all the other beds of what is called Inferior Oolite have been removed by this denudation, so that only a thin cap of what would be called "upper beds of Inferior Oolite" rests on a thick clay-bed of the age of the Midford Sands.

That deposits contemporaneous with what are called "Upper Lias" and "Midford Sands" in other places are found in some thickness at Dundry Hill, attaining as much as 65 feet.

That the Lias Marlstone-rock is present at Dundry Hill and outcrops in many places on its flanks, but that this rock-bed is also wanting from many parts of the Hill.

That the Geological Survey have presumably mistaken this Marlstone-rock (which is an Ironshot stone) for the Ironshot Oolite—the chief fossiliferous bed of the Dundry Inferior Oolite, and formerly called *Humphriesianum*-zone — beds nearly 100 feet apart.

That, as a consequence, the map of the Geological Survey shows round the greater portion of the Hill the boundary-line of the base of the Inferior Oolite drawn as much below the Marlstone as would be correct if this rock had actually been the well-known Ironshot Oolite.

That, as a further consequence of this, the map of the Geological Survey shows coloured as Inferior Oolite, strata which would be mapped as Lower Lias, Middle Lias, Upper Lias, and Midford Sands in other localities, and that in places the limit for Inferior Oolite, according to the Survey, is as much as 600 yards beyond that of the authors.

The authors append a map of the strata of Dundry Hill, coloured on a palæontological basis, and they show how it may be compared with the map of the Survey and with a map by Saunders.

3. "On the Geographical Evolution of Jamaica." By J. W. Spencer, M.A., Ph.D., F.G.S.

The object of the paper is to set forth the physical and geological characteristics of Jamaica which bear upon the problem of its late high elevation and former connection with the continent, and to trace across the neighbouring seas and islands to the mainland the evidences of the former linking of Jamaica to North and South America. The first part of the paper treats of the growth of the island, and the following events are described. After the formation of the mechanical sediments, limestones, and igneous rocks which constitute the basement of the "White Limestones," the latter group was accumulated in later Eocene and early Miocene times to a thickness of 2000 feet, and they indicate a subsidence of 3000 feet below sea-level. Their formation was followed by a Pliocene or Mio-Pliocene elevation in an epoch of long duration ; the uplift was inferior to a later (post-Layton) one, but sufficient for the removal of Miocene limestone below sea-level. The period was one of general elevation, general dislocation of strata, and great erosion. The formation of the Layton marly beds with loams and gravels which succeeded this period is referred to the end of Pliocene times. In early Pleistocene times the "post-Layton" elevation occurred, causing an uplift of from 7000 to 11,000 feet above sea-level. The strata were not greatly deformed. but the epoch was one of enormous erosion. A subsidence somewhat resembling that of the Layton formation followed this erosion in late Pleistocene times, and caused the accumulation of the loams and gravels of the Liguanea formation. In modern times minor changes have occurred, causing the formation of terraces, of channels over banks, of coralline limestone, and of the modern coral terraces.

The second part of the paper treats of the continental connections of Jamaica. The author gives details of the submerged plateaux and drowned valleys which are analogous to those still existing above sea-level. They indicate that the former altitude of the West Indian plateau and some portions of the adjoining continent reached two and a half miles. But the floors of the Mexican Gulf and Honduras and Caribbean Sea formed low plains draining into the Pacific Ocean, for at the time the eastern region was high the Mexican area was generally low.

There was a generally high elevation of the Antillean region during the great Mio-Pliocene period, with probable continental connection ; at the close of the Pliocene period a general subsidence flooded the coastal plains of the continent. and reduced the West Indies to fewer and much smaller islands than those which now exist. But the earlier portion of the Pleistocene period was that of the great continental elevation, when the lately-formed Pliocene topography was deeply dissected by rain and rivers, yet there were apparently several pauses of terrestrial movements at different altitudes, as indicated by the various base-levels of erosion. At this time Jamaica and other islands formed a mountainous tableland bordering the Mexican and Caribbean plains. Afterwards the later Pliocene continent was depressed so as to flood most of the coastal plains of the continent and reduce the islands to small proportions, and since then the minor oscillations have brought the old continent to the present conditions. Whilst the east was going down, the Mexican region and western lands were being raised to form high tablelands.

CORRESPONDENCE.

GEOLOGICAL SURVEY OF CAPE COLONY.

Sir,—In accordance with a resolution of the House of Assembly, carried last year, a Commission has been appointed in terms of the accompanying Notice, "for the purpose of organizing, controlling, and directing the work of Geological Exploration and Survey in this Colony."

The Commission has now appointed the undermentioned gentlemen to begin the work of surveying and mapping the country:—

Geologist: G. S. Corstorphine, B.Sc. (Edin.), Ph.D. (Munich).
Assistant Geologist: A. W. Rogers, B.A. (Cantab).
" " E. H. L. Schwarz, A.R.C.S.

As early as possible the Commission will publish and distribute a bibliography of South African Geology.

C. L. Lloyd,
Acting Secretary to Geological Commission.

Geological Department, South African Museum,
Cape Town, Cape of Good Hope.
February, 1896.

DISCOVERY OF INTERGLACIAL SHELL-BEDS IN AYRSHIRE.

Sir,—I beg to intimate that I have discovered Interglacial Shell-Beds at fourteen localities in Ayrshire, ranging from 55 to 740 feet above sea-level.

The Interglacial Beds attain a thickness at parts of over 100 feet, the usual arrangement being:

Upper Boulder-clay (*ground moraine*) with well-striated blocks up to 8 feet in diameter ...	76 feet
Sand Bed	a few "
Shelly Pebbly Clay	14 "
Sharp sand, gravel, and muddy sand ...	over 100 "
Lower Boulder-clay with large well-striated blocks	30 "

This is taking the beds at their thickest, but not seen in any one section.

The shells are all in *pebbly clay*, which I take to indicate that this bed was deposited *in deep water by surface-currents* carrying clay, and *shore-ice* carrying stones and gravel. I say shore-ice advisedly, as only a *few* of the stones in this bed reach a diameter of 20 inches. (Had this bed been deposited by *bottom currents*, the *clay* ought to have been swept away.) In some of the sections the shells are abundant, but mostly as *sharp-edged* fragments. Where there is a sand-bed between the shell-bed and the Upper Boulder-clay, the shells are in the best state of preservation, the sand-bed having acted as a *cushion* against the *trail* of the Upper Boulder-clay (*ground moraine*). Where there is no sand-bed in this position, the shells are more fragmentary and sometimes *scratched*.

I have traced the Interglacials, as gravel, sand, and muddy sand-beds, in the Bowbrone, Garpel, and Guelt valleys, to an altitude of 900 feet above sea-level. The shell-beds occur in the parishes of Loudoun, Sorn, Auchenleck, and Colmonell. The Interglacials range from Dalry to Colmonell, and inland to Muirkirk.

John Smith.

Monkredding, Kilwinning.
April 29th, 1896.

AMMONITES (ACANTHOCERAS) MAMMILLATUM IN THE ISLE OF WIGHT.

Sir,—In the Geological Magazine for May, 1896, p. 199 (footnote 2), Mr. R. B. Newton calls attention to *Ammonites mammillatum* having been recorded from the Chloritic Marl in the Geological Survey Memoir on the Isle of Wight, second edition, p. 279, and suggests that there is a mistake. In this I think he is probably right. The table in the Memoir was drawn up in such a way as to show the authority for every fossil. *A. mammillatum* was inserted on the authority of Captain Ibbetson ("Note on the Geology and Chemical Composition of the various Strata in the Isle of Wight," 1849, p. 22), who quotes *A. monile* from the Chloritic Marl. *A. monile*, Sow., according to D'Orbigny (Pal. Franç. Terr. Crét. 1840–1, p. 249), Bronn (Index Pal. 1848, p. 51), and Morris (Cat. Brit. Foss. 1854, p. 297), is *A. mammillatum*, Schloth. The mistake probably lay in the determination of Ibbetson's specimen as *A. monile*.

A. Strahan.

12, Marloes Road, Kensington, W.

ICE-WORK.

Sir,—The author of the excellent summary of my book on Ice-Work (see Geol. Mag. for last month, pp. 228–231) seems to have misunderstood me in one respect. In regard to the parallel roads of Glenroy, he states—"the objections to a marine origin for these 'roads' are regarded as insuperable." I think that a comparison of pages 94–107 with pages 163–198, will show that this is not my opinion. Indeed, I have more than once maintained the contrary. I venture on this correction lest I should be supposed to have changed my mind.

23, Denning Road, Hampstead, N.W. T. G. Bonney.
May 16th, 1896.

MISCELLANEOUS.

Guide to the Museum of Practical Geology.—The "Descriptive Guide" to this Museum, of which a fourth edition was published in 1877, has long been out of print, and a new edition has been urgently needed. This has now been supplied by the Curator. Mr. F. W. Rudler; but the original form has been somewhat modified, the work is now "A Handbook," it has been revised throughout, and in large part rewritten, and the type is larger. It deals with the history of the Museum. and gives a particular account of the Building and Ornamental Stones, Slates, Grindstones, Cements, and Minerals, with general references to the Pottery, Fossils, etc. Regarded as a handbook of economic geology, it will prove exceedingly useful for reference in the study as well as in the Museum. The price is 6*d*.

Geology in the Transvaal, South Africa.—Dr. Molengraaff, of Amsterdam, has been appointed State Geologist by the Transvaal Government.

Geological Survey of Great Britain.—The Annual Report of the Director-General of the Geological Survey for 1895 was issued early in April, and as it contains a full record of the progress of the Survey in various parts of England, Wales, the Isle of Man, Scotland, and Ireland, the subject-matter will interest all geologists.

Spitzbergen.—Sir W. Martin Conway is about to start for Spitzbergen, accompanied by Mr. Trevor Battye, Dr. J. W. Gregory, F.G.S., of the British Museum, Mr. E. J. Garwood, F.G.S., and several other gentlemen, to make a geographical and geological exploration of that island during the summer months. Dr. Gregory will undertake the geological work, and Sir Martin Conway the geographical part of the expedition, which has received the support of both the Royal Society and the Royal Geographical Society; and there is every prospect of good results in valuable observations and specimens, to be brought home in October. Although Spitzbergen possesses a remarkably rich fossil fauna and flora, representing Miocene or Eocene, Cretaceous, Jurassic, Triassic, Carboniferous, and Devonian formations, none of the fossils have as yet found their way to this country; but several Continental museums have been enriched by acquisitions from this high northern land.

Guides to the Fossil Mammals and Birds and to the Fossil Reptiles and Fishes in the Department of Geology and Palæontology in the British Museum.—The seventh edition of these popular guides has just been issued (price sixpence each). They have been carefully revised and corrected, and the part relating to the Fossil Fishes has been entirely rewritten by Mr. Arthur Smith Woodward, F.G.S.

The Guide to the Fossil Invertebrata and Plants, etc., is now in the press, and will shortly be issued.

A Catalogue of the Jurassic Bryozoa in the British Museum, by Dr. J. W. Gregory, F.G.S., has just been printed by order of the Trustees, and will appear in the next few weeks.

THE

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ORIGINAL ARTICLES.

I.—A Note on the Geology of Somali-land, based on Collections made by Mrs. E. Lort-Phillips, Miss Edith Cole, and Mr. G. P. V. Aylmer.

By J. W. Gregory, D.Sc., F.G.S.

Since the famous expedition[1] of the late F. L. and W. James, of E. Lort-Phillips and G. P. V. Aylmer, in 1884–5, opened the Somali plateau to European exploration, the country has been repeatedly traversed. A valuable series of geographical memoirs, hunting journals, and bluebooks has described the main features in the topography of the country, and given many suggestions as to its geological structure. The collections of Dr. Révoil[2] and Prof. Keller[3] have proved that Neocomian beds occur there, and thus have shown that it is of greater interest than most of the monotonous unfossiliferous wastes of East Africa.

In the winter of 1894–5 Messrs. E. Lort-Phillips and G. P. V. Aylmer, two members of the James' expedition, returned to the country, accompanied by Mrs. Lort-Phillips and Miss Edith Cole. Their expedition made some very important botanical and zoological collections, which have been already described.[4] Shortly after their return Mrs. Lort-Phillips kindly entrusted me with the examination of the geological collection which she had made. Subsequently Miss Edith Cole and Mr. Aylmer were also so kind as to lend me their collections. These together enable an outline geological section to be drawn from the coast at Berbera on the main Somali plateau; while, moreover, by the proof of the occurrence of marine Jurassic rocks in this country, they make an important addition to our knowledge of the geological history of Somali-land.

The specimens all came either from the district of Guban, the tract of country between Berbera and the foot of the inland plateau,

[1] F. L. James, "The Unknown Horn of Africa," 1888.

[2] Described by T. de Rochebrune in Geo. Révoil, "Faune et flore des pays Çomalis," p. 39, pls. i–iv. Paris, 1882.

[3] Described by C. Mayer-Eymar. "Ueber Neocomian: Versteinerungen aus dem Somali-land": Vierteljahrschrift Naturfors. Gesells. Zürich, Jahrg. xxxviii, 1893, pp. 249–65, pls. i, ii.

[4] "Diagnoses Africanæ," pt. vii: Bull. Misc. Inform. Kew, No. 105, 1895, pp. 211–30. E. Lort-Phillips, *ibid.*, 1895, pp. 211–30.

or from the Golis Range, on the northern edge of the plateau. The general physical geology of the country has been well described by Captain Swayne.[1]

II. List of the Collections.

Mrs. Lort-Phillips' collection consists of a series of rocks and fossils, of which the following is the list :—

Fossils.[2]	Locality.
Belemnites subhastatus, Zieten	Bihin, in river-bed, 15 miles from Berbera.
Parallelodon Egertonianus, Stoliczka	Do.
Rhynchonella Edwardsi, Chapuis and Dewalque ...	Do.
Rhynchonella subtetrahedra, Davidson	Do.
Coral (gen. et sp. indet)	Fara-Daro.
Cryptocœnia Lort-Phillipsiæ, n.sp....	Duba.
Rocks.	
1. Sedimentary.	
Compact, hard, light-grey limestone	Duba, eight miles from Berbera.
Quartzose, coarse-grained, red hæmatite, passing into a loose, coarse grit, stained by hæmatite.	Loc. ? No doubt from summit of plateau.
Purple, roughly-bedded, quartzose grit	Daar-Ass, Golis Range. Alt. 5000 ft.
Hard nodules of brown hæmatite; sometimes show crystalline form; they generally show structure, and are apparently concretionary in origin ...	From summit of plateau; weathered out of sands.
Chert; sometimes chalcedonic, sometimes transparent, and at others opaque, milky-white ...	Summit of plateau.
Jasper concretions	Do.
2. Igneous.	
Coarse, quartzo-orthoclase pegmatite	Golis Range.
Thin-bedded, very quartzose muscovite-biotite gneiss	Do.
Pebbles of hornblendic gneiss, with numerous veins and crystals of epidote.[3]	

Miss Edith Cole's collection contains similar rocks, including pegmatite, chalcedonic chert, hæmatite nodules, calcareous tufa, wind-polished limestone from Bihin, and some fragments of roughly-chipped chert flakes.

Mr. Aylmer's specimens contain much the same, with several interesting additions. There is a large specimen of very coarse pegmatite from the face of the Golis, which contains large flesh-coloured crystals of orthoclase, broad tabular crystals of muscovite, aggregates of red garnets, and some long acicular crystals of apatite.

[1] H. G. C. Swayne, "Seventeen Trips through Somali-land," 1895, pp. 361–7.

[2] The Belemnite, the Lamellibranch, and the two Brachiopods have been determined respectively by Messrs. G. C. Crick, R. B. Newton, and F. A. Bather. Notes by Mr. Newton and Mr. Crick are published herewith, and a selection of the specimens has been presented by Mrs. Lort-Phillips to the Geological Department of the British Museum (Natural History).

[3] To determine the character of the mineral in this rock, as it throws light on the nature of some rocks collected by Dr. Donaldson Smith much further to the south, Mr. L. J. Spencer has kindly measured one of the crystals, and has determined them as epidote.

He has also brought back some large mica crystals, which are sufficiently large and clear to suggest that a supply may be obtained of economic value.

His last addition to the series is a lump of an intensely altered hornblendic gneiss from the summit of Wein Deimoleh (or Deymole). This is of interest as proving that outcrops of the Archean series occur in the Maritime Mountains.

III. Description of a new species of coral.

Cryptocœnia Lort-Phillipsii, n.sp.

Diagnosis.—*Corallum* massive, hemispherical.

Calices circular, deep.

Septa hexameral; of two orders. The primary septa are thin, and in length are equal to a third the width of the calix. Secondary little more than rudimentary.

Costæ conspicuous. The confluence of the costæ of different calices is well marked.

Intercalicinal areas very narrow.

Dimensions.—Diameter of calices, 2 mm.; distance of calicinal centres, 3 mm.; number of septa, 6 large and 6 rudimentary; length of primary septa, $\frac{2}{3}$ mm.; height of corallum, 45 mm.; diameter of corallum, 55 mm.

Distribution.—Limestone of Maritime Mountains at Duba, 8 miles south of Berbera, Somali-land.—Presented to the Geological Department by Mrs. E. Lort-Phillips.

Affinities.—This species belongs to the group of *Cryptocœniæ*, in which the septa are hexameral. Of known species it is most allied to *Cryptocœnia Neocomiensis* (E. de F.).[1] From this, however, it clearly differs by having only two orders of septa, and by having thinner intercalicinal areas. Of Jurassic *Hexacryptocœniæ*, it is nearest to *Cryptocœnia Thiessingi*, Koby,[2] from the Swiss Sequanian; but from this it differs owing to the greater amount of cœnenchyma and greater size of the secondary septa in the Swiss species.

There is some doubt as to the age of the Duba limestone. From stratigraphical considerations one would be inclined to regard it as part of the same series as the limestones at Bihin. But it may be Neocomian. The single fossil found does not afford ground for an opinion, though it resembles the Lower Cretaceous and Upper Jurassic *Cryptocœniæ* rather than the Bathonian species.

It is to be hoped that the next traveller along the road to the Sheikh Pass will endeavour to collect more fossils from the Duba limestone.

IV. Section across the Guban and the Golis.

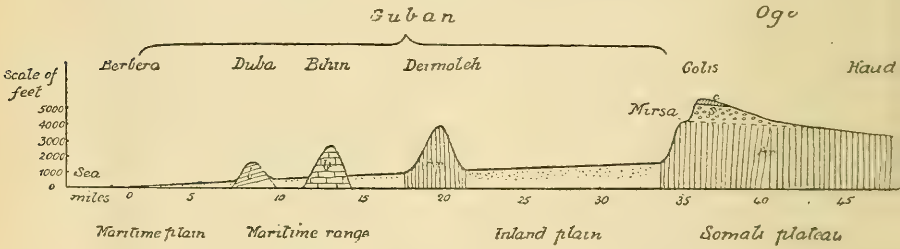
After having thus enumerated the specimens contained in the collection, we may proceed to consider what light they show on

[1] *Cyathophora Neocomiensis*, E. de Fromentel, "Description des polypiers fossiles de l'Etage néocomien," p. 41, pl. v, figs 11, 12. Paris, 1857.

[2] F. Koby, "Monographie des Polypiers Jurassiques de la Suisse," pt. 2, p. 86, pl. xxix, fig. 2: Mém. Soc. pal. Suisse, vol. viii, 1882 (1881).

the general geological structure of the country. The accompanying section shows the topographical features, according to Capt. Swayne's map and some notes given me by Mr. Aylmer.

South of Berbera there is a low plain composed of recent marine deposits, mostly covered by blown sand and soil. Eight miles inland is the first of a series of east and west ridges which form the "Maritime Mountains." These extend for about twelve miles. Then follows the "Inland Plain," which is a continuation of the coast plain: it ends abruptly at the height of 1800 feet, at the foot of the north scarp of the Somali plateau. A steep track leads up the face of this scarp to the Sheikh Pass, at the height of 4000 feet, which leads on to the plateau. East and west of the pass the north edge of the plateau is much higher, rising at one point to 6819 feet. As a rule this northern edge is from 5000–5500 feet in height, while a terrace a mile or two in breadth, known as Mirsa, runs along its northern face at the height of about 4000 feet. The northern edge of the plateau is jagged, and, seen from the north, looks like a mountain range, and is therefore known as the Golis Range. The whole of the low country to the north, consisting of the Maritime Plain, Maritime Mountains, and Inland Plain, is known to the Somalis as the "Guban." To the south of the Golis the plateau descends gradually across the Haud to the valley of the Webi Shebeyli. These topographical features may easily be explained by the collections described.



Alluvium. Limestone of Duba. Bathonian Limestone, [Bihin.

Cherts and Limestones of the Golis.

Red and Purple Sandstones. Archean Rocks.

(The dotted line from Mirsa to the Haud is the level of the Sheikh Pass.)

SECTION ACROSS NORTHERN SOMALI-LAND.

The Maritime and Inland Plains are both occupied by alluvium, marine and subaerial. Through these rise three ridges. The first two are formed of limestone. That at Bihin is unquestionably Lower Oolitic, and no doubt Bathonian. That at Duba may be a part of the same limestone, or a later one, possibly Neocomian in age.

The highest and furthest inland of the three ridges consists of Archean gneisses, and is an outlier from the main Somali plateau.

Whether it has been separated by denudation or earth-movements, there is not at present sufficient evidence to show.

The Somali plateau itself consists in the main of a mass of gneiss and rocks of the Archean series. As usual, this gives rise to the sandy scrub-covered plains, with many mimosa and Sanseviera. The Archean series is penetrated by pegmatite dykes of the same type, but coarser in grain than those of British East Africa. It is capped by rocks of two series—(1) red and purple unfossiliferous sandstones, often passing into impure hæmatite; (2) some limestones associated with beds of chert, probably of Neocomian age. These form the cap of the plateau and the summits of the Golis Range. The ledge of Mirsa and the summit of the Sheikh Pass are both on the upper surface of the Archean series (4000 feet).

The Somali-land sequence therefore consists of the following:—

1. Marine and subaerial recent deposits.
2. Neocomian limestones and cherts.
3. Duba limestone of uncertain age.
4. Bathonian limestones of Bihin.
5. Red and purple sandstones—unfossiliferous.
6. Archean series. (Gneisses penetrated by pegmatite dykes, etc.)

V. The Origin of the Somali-land Fauna and Flora.

The discovery of the Bathonian fossils is of great interest. Bathonian rocks are known in Abyssinia from the work of Blanford,[1] Ferret and Galinier,[2] Aubry and Douvillé.[3] They are also well known from the west coast of India in Cutch. They occur in Northern Somali-land, exactly on the line joining these two localities. Mrs. Lort-Phillips' fossils are especially of value, as Rochebrune,[4] on the basis of Révoil's collections from Somali-land, has disputed the accuracy of the determination of the Jurassic age of the Abyssinian limestones. The presence of Bathonian fossils in Somali-land, however, shows that, apart from the Abyssinian limestones, there are fossiliferous marine deposits of both Lower Jurassic and Neocomian age in this region of East Africa.

The occurrence of one species (*Parallelodon Egertonianus*, Stoliczka) in Somali-land and in India helps to strengthen the idea of the former connection of the Bathonian rocks of India and Somali-land, which is suggested by the apparent extension of these rocks along an east and west line, from Cutch to Shoa. This is of interest, as it throws light on the origin of the interesting fauna and flora of the Golis Range. The report on the collection of plants made in the Golis Range, published in the Kew Bulletin of Miscellaneous Information (No. 105, September 1895, pp. 211–30), shows that the flora of this district contains a very

[1] W. T. Blanford, "Observations on the Geology and Zoology of Abyssinia," 1870, pp. 176–80, 199–203, pl. viii.

[2] Ferret and Galinier, "Description géologique du Tigré et du Samen Voyage en Abyssinie," t. iii, 1847, pp. 54–6.

[3] H. Douvillé, "Examen des fossiles rapportés du Choa par M. Aubry": Bull. Soc. géol. France, sér. 3, t. xiv, 1886, pp. 223–41, pl. xii.

[4] Rochebrune, in Révoil, *op. cit.*, p. 26.

high proportion of endemic species (69 species out of 350 were new). This appears to be due to two reasons. In the first case, the Golis hills appear to contain limestones, which support a more varied flora than the soil formed by the weathering of the gneiss and schist. As travellers generally cross from the lowlands to the plateau by the Sheikh Pass, which has been cut down to the Archean series, they had previously missed this interesting flora.

In the second place, the high proportion of endemic species and the fauna and flora of these hills may be explained by their being inhabited by a group of species which entered the country from land which formerly extended to the east. In the discussion at the Geographical Society on Dr. Donaldson Smith's paper on his journey to Lake Rudolf, Dr. Bowdler Sharpe remarked that some of the Somali-land birds were allied to those of the Cape, and were unlike the representative species that live in the intervening parts of East Africa. It is most probable that the Jurassic rocks of Somali-land are part of a band which once extended eastward into the Indian Ocean, and may have been part of the hypothetical continent of Gondwana-land or Lemuria. This continent was probably separated from Equatorial East Africa, but was connected with the Cape. Thus it is quite possible that some species may have reached both the Cape and Somali-land without entering Equatorial Africa. Hence one of the constituents of the fauna and flora of Somali-land may be a remnant from those of the lost continent of Gondwana-land and Lemuria.

VI. Points for Further Inquiry.

Considering how many travellers are now visiting Somali-land, it may be advisable to refer to some of the principal points in reference to the geology of Somali-land on which material is especially desired.

1st. Collection of fossils from Duba; from any cherts or limestone on the Golis Range; and from Fara-Daro.

2nd. Information as to the dip of the limestones at Duba, Bihin, or Fara-Daro.

3rd. A sketch-map, on the scale of one or two inches to the mile, of any part of the Golis Range which includes the ends of river-valleys running northward to the coast and southward to the Haud. The information especially desired is the course of the valleys, and their relations to the watershed.

4th. A comparison of the succession of rocks seen in the ascent of Wein Deimoleh with those seen in the ascent of the plateau scarp at the nearest point.

II.—On the Occurrence of an Indian Jurassic Shell, *Parallelodon Egertonianus*, in Somali-land, Eastern Africa.

By R. Bullen Newton, F.G.S.

Mrs. E. LORT-PHILLIPS, during her journey in Africa, collected some well-preserved *Arca*-like shells from a river-bed at Bihin, in Somali-land, which have been entrusted to me for determination. The specimens, belonging to one species, are of various sizes, quite black in colour, and covered in places with a lightish-brown matrix.

Externally they resemble *Byssoarca*, having very anterior, distant, and incurved umbones, with a wide ligamental area between, through the centre of which runs a long and straight hinge-line. An examination of the internal characters of the hinge-plate, obtained through sectioning one of the specimens (the valves of all the examples being united), reveals the presence in the left valve of seven or eight small, parallel, and oblique teeth at the anterior end of the hinge; and succeeding these are two long rib-like teeth, arranged parallel with the hinge-line and extending to its posterior termination.

The exposure of this dentition has enabled me to refer the shells to the genus *Parallelodon* of Meek and Worthen, a name substituted by those authors for the better known *Macrodon* of Lycett, which had, unfortunately, been previously used by Müller for a fish. When Lycett first diagnosed this genus it was only known from the Inferior Oolite of the Cheltenham neighbourhood, his type being called *Macrodon rugosus*. Since this, however, it has been discovered in much older rocks, and we now find it recorded as ranging from Devonian times to the present day, recent examples having been described from the seas of the Antilles[1] and Japan.[2] As the Secondary shells of Africa frequently present a strong Indian facies, a comparison had to be instituted before the Somali species could be definitely named or its horizon determined.

Among the Northern Himalayan fossils in the British Museum, two shells were detected corresponding in every detail with those from East Africa, and clearly referable to Stoliczka's *Macrodon Egertonianus.* This species was first figured by Everest in 1833, as an *Arca*; subsequently Blanford mistook it for the Cutch form of *Cucullæa virgata*, J. de C. Sowerby; and still later it was recognized as entirely new by Stoliczka, when it received the name of *Macrodon Egertonianus.*

The Niti rocks and Spiti shales of the Northern Himalayas, which have both yielded this species, besides such well-known forms as *Trigonia costata*, *Rhynchonella varians*, *Camptonectes lens*, *Stephanoceras Braikenridgei*, *Parkinsonia Parkinsoni*, etc., are regarded as of Lower Oolite or "Dogger" age; we may therefore safely assign the African representative of this species to the same position in the Jurassic series.

Genus Parallelodon, Meek and Worthen.

Proceedings Chicago Academy, 1866, vol. i, p. 17.

Macrodon, Lycett [*non* Müller, 1842], Murchison's "Geology of Cheltenham," 1845, pl. v, fig. 5, pp. 98, 99.

Type—*Macrodon rugosus*, Lycett.

[1] *Macrodon asperula*, Dall, Bull. Mus. Comp. Zool. Harvard, 1881, p. 120; *ibid.*, 1885, pl. viii, fig. 4, p. 244.

[2] *Macrodon Dalli*, E. A. Smith, "Challenger" Report [Lamellibranchiata], 1885, pl. xvii, fig. 10, p. 269.

PARALLELODON EGERTONIANUS, Stoliczka.

Arca, Everest, "Asiatic Researches" (Calcutta), 1833, vol. xviii, pt. 2, p. 114, pl. ii, fig. 27.

Cucullæa virgata, Blanford, Journ. Asiatic Soc. Bengal, 1863, p. 136; and Blanford and Salter, "Palæontology of Niti, Northern Himalaya," 1865, p. 103; *non* J. de C. Sowerby, 1840.

Macrodon Egertonianum, Stoliczka, Mem. Geol. Surv. India, 1865, vol. v, p. 89, pl. viii, fig. 7.

DIAGNOSIS.—*M. testa oblique-elongata, convexa, angusta, costis radiantibus rugosis ornata; costis ad marginem anteriorem paucioribus, ad marginem posteriorem prope obsoletis; striis concentricis inæqualibus, undulatis, interdumque lamellosis.*—Stoliczka.

Shell obliquely elongate, convex, narrow, with radiating costæ; costæ fewer towards the anterior margin and nearly obsolete at posterior end; concentric striæ unequal, undulating, sometimes lamellose.

DIMENSIONS.

Length	40 to 65 millimetres.
Height	20 to 25 ,,
Breadth	25 to 40 ,,

Remarks.—The Somali specimens exhibit the above characters as given by Stoliczka. In addition it may be noted that a difference exists in the ornamentation of the two valves. The right valves of all examples, whether from Africa or India, show a series of intermittent ribs between the prominent radiating costæ, which are entirely absent on the other valve, where the costæ are rather fewer and wider apart. This is referred to because in his observations on the species, Stoliczka merely states that the costæ "have usually no intermittent ribs between them." The extensive ligamental area is beautifully ornamented with numerous closely-set grooves. Lastly, a curious lithological resemblance may be observed between the Indian and African representatives of this species: both series of shells are of a lustrous black colour, relieved in places by a lightish-brown matrix. If the specimens from Niti in the British Museum were mixed with those from Somali-land, it would be somewhat difficult to separate them, so closely do they approximate to each other in almost every detail.

It is interesting to note, in conclusion, that Mrs. E. Lort-Phillips has very kindly presented five of her best specimens of this species to the Geological Department of the British Museum.

III.—NOTE ON SOME FRAGMENTS OF BELEMNITES FROM SOMALI-LAND.

By G. C. CRICK, F.G.S.

ALL the fragments appear to be referable to the same species. There is not a complete specimen among them; some show the alveolar region, but the majority exhibit only the post-alveolar part, and there is not an example with the apex preserved.

Transverse sections of the guard show that the species here represented belongs to the group *Canaliculati*, as defined by Neumayr.[1]

[1] Verhandl. d. k.-k. geolog. Reichsanstalt, 1889, pp. 52–6.

The guard appears to have been not very long, only very slightly hastate, with a moderately elongated apex; ventral surface with a strong, rather broad furrow, extending the whole length of the guard, disappearing only near the apex, a little narrower on the alveolar region; sides of the guard narrowly rounded, with dorso-lateral vascular impressions, well-marked on the alveolar region, very feeble on the rest; dorsal area broadly rounded, rather flat; angle of the phragmocone 20°; alveolar region nearly circular in section, the post-alveolar region depressed; siphuncle on the same side as the deep groove.

The species resembles *Belemnites Tanganensis*, described by Futterer[1] from Tanga, on the east coast of Africa, where it occurs in association with Lower Oxfordian Ammonites. But Futterer's species is more compressed in the alveolar region, and less depressed in the post-alveolar region, than the Somali specimens. In these respects the latter agree better with the specimen figured by J. de C. Sowerby as *Belemnites canaliculatus*, Schlotheim (=*B. Grantanus*, D'Orb.[2]). The alveolus is shown in one of the Somali specimens; its angle (20°) agrees with that given by Waagen for *B. subhastatus*,[3] to which species he refers the *B. Grantanus*, D'Orb.

The Somali specimens in form agree with certain of the figures that Oppel gives of his *B. Gerardi* (Pal. Mittheil., pp. 273, 296, pl. lxxxviii, figs. 1–3, particularly figs. 1 and 2), which species Oppel states to be narrower and more depressed than Zieten's *B. subhastatus*. In the explanation of the figures, Oppel adds "*B. Grandianus*, D'Orb. MS." This possibly referred to the name *B. Grantanus*, which D'Orbigny gave to the specimen figured by Sowerby as *B. canaliculatus*; and, if so, it would seem that Oppel regarded *B. Grantanus*, D'Orb., and his own *B. Gerardi*, as the same species, although he does not place the former name in the synonymy of the latter.

Stoliczka[4] regarded the *B. sulcatus* described by Blanford[5] from the Spiti Shales as identical with *B. canaliculatus*, Schlotheim, and he also considered the specimen described by Sowerby from Cutch as *B. canaliculatus*[6] rightly determined, and further he thought it was probably for this species that Oppel proposed the name *B. Gerardi*. He adopted, however, the name *B. canaliculatus*, Schloth. A comparison of the specimens from Spiti figured by Blanford with the example from Cutch figured by Sowerby, shows that the latter is more depressed than the former.

In a postscript to the "Palæontology of Niti" (p. 106) H. F. Blanford placed Oppel's *B. Gerardi* as a synonym of *B. sulcatus*, and adopted the latter name for the species.

[1] Zeitschr. deutsch. geol. Gesell., xlvi (1894), p. 30, pl. v, figs. 2, 2*a–c*, 3, 3*a–c*.
[2] A. D'Orbigny, "Prod. de Paléont. stratigr.," vol. i, p. 326, 1850.
[3] Zieten, Verst. Württemb. 1832, p. 27, pl. xxi, fig. 2.
[4] Mem. Geol. Surv. India, vol. v, pt. 1, 1865, p. 111.
[5] H. F. Blanford in J. W. Salter and H. F. Blanford, "Palæontology of Niti, in the Northern Himalaya," 1865, p. 76, pl. x, figs. 1–8.
[6] Trans. Geol. Soc. London [2], vol. v, pl. xxiii, fig. 2 and explanation. 1840.

In his "Jurassic Fauna of Kutch" Waagen [1] refers *B. Grantanus* and *B. Gerardi* to distinct species, regarding the former as a synonym of Zieten's *B. subhastatus*.

Among the fossils brought by M. Aubry from Choa, Douvillé found only one Cephalopod—a single fragment of a Belemnite—which appeared to him to belong to the group of *Belemnopsis sulcata*.[2] It seems to have been associated with *Trigonia pullus*—a form which in this country occurs in the Lower Oolite—and may be identical with that occurring in Somali-land.

The Somali specimens are intermediate between the Spiti specimens [3] which were figured by Blanford as *B. sulcatus* and the Cutch specimen [4] figured by J. de C. Sowerby as *B. canaliculatus*, the transverse section of the Somali specimens being somewhat less compressed than the former, and not quite so depressed as the latter; they appear, however, to come rather nearer to the Cutch specimen, and I have therefore placed them with this species, and have adopted Prof. Waagen's identification of the same as *B. subhastatus*, Zieten.

Horizon.—Waagen states that *B. subhastatus* "is not very common in the Kutch Jura, and is apparently restricted to the beds with *Steph. macrocephalum*," [5] and that *B. Gerardi* "is entirely wanting in the true *Macrocephalus* beds, but begins immediately above it, and extends from here through the whole of the upper part of the Charee group—in other words, it is found in Upper Callovian and Lower Oxfordian beds." [6] In Germany *B. subhastatus* characterizes the *macrocephalus* zone.

IV.—The Dislocation and Disintegration of the Chalk in Eastern England and in Denmark.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

I PROPOSE in the following paper to continue and complete the story which I have partially printed in the Geol. Mag., Feb. 1896, p. 58; but first, a few words about the Yorkshire evidence, which I had overlooked.

Mr. J. F. Blake, speaking of the Yorkshire chalk, says it "has been subjected to the action of some force, which has been strong enough to take hold of huge masses and contort them and stand them on end. A remarkable folding in the rocks was noticed many years ago at Scale Nab, on the coast, by Professor Sedgwick—an equally noteworthy instance of similar action has come under my observation on the summit of the crest between Sherburn and Weaverthorpe. On ascending the hill from Sherburn is a large quarry with the chalk perfectly horizontal, and not more than 20 feet above the level of its upper surface are found beds belonging

[1] Pal. Indica, ser. ix, "Jurassic Fauna of Kutch," vol. i, pp. 13, 14, 1873.
[2] Bull. Soc. Géol. France [3], vol. xiv, p. 223.
[3] Now in the Brit. Mus. Coll., Nos. C. 2566–72.
[4] Now in the Museum of the Geological Society of London.
[5] *Op. cit.*, p. 15.
[6] *Op. cit.*, p. 13.

to the next higher portion of the series standing up nearly vertical, having a dip of 70° to the south. . . . The same beds are seen crossing the surface of the road to a length of nearly 70 feet, so that we must have as much as 60 feet thus set on end. . . . . If we continue upwards a little higher we find a still more marked disturbance about the 500 feet level. Not only are the beds tilted up, but they are actually inverted, so that instead of dipping south at a very low angle they are dipping north at about 45°, having been turned through an angle of 135°. The date of this disturbance is also indicated by these chalk beds actually lying upon stratified Quaternary sand, which forms the mound on which they were stopped. These phenomena indicate a powerful force coming from the direction of the north, during a season in which the lower levels were protected from its influence." (Proc. Geol. Assoc., vol. v, pp. 267–8.)

Again, he speaks of a quarry at Weaverthorpe, in which a mass of chalk stands nearly vertical, and dips actually northward into the hill. . . . The quarry has, in fact, been opened in a huge mass which has broken off the rest, and has fallen or been forced over on to its end.

In another passage Mr. Blake remarks that "In some quarries every fragment has its surface covered with parallel lines at different levels, like a broken mass of basalt in miniature, or even like the appearance of a worn massive coral. . . . This peculiarity has been noticed before by Mr. Mortimer, who thought it was actually due to coral growth; that it is not, is of course proved by the total absence of any real animal structure. . . . The slickensided chalk may be found all over Yorkshire, but *it is nowhere so remarkable as near the change of direction of the line of outcrop*—that is, a little north of its highest elevation." (Blake, Proc. Geol. Assoc., vol. v, pp. 265–8. *The italics are ours.*)

These effects seem to me to be all due to one cause, and that a very recent one, namely, the same cause which gave the Yorkshire wolds their present contour, and which could be no other than a powerful subterranean impulse. How is it possible for anyone who has studied the work of ice in its native home to attribute these effects jauntily, as Mr. Blake does, to the action of ice? "Geologists," he says, "will see in this [*i.e.* in the faulting and bending of these solid beds of chalk], doubtless, another form of those glacial forces which have strewed the bottoms of the valleys, and in some instances hollows at high elevations with boulders and clay." What fantastic writing is this? As an alternative in another case, Mr. Blake suggests that these contortions and upheavals of solid chalk beds have been due to the wasting effect of springs. Uniformitarian champions ought surely to fall back on Mrs. Partington's mop. That would be a real instrument of denudation.

The large boulders referred to in my former paper as occurring further south, are also found north of the Humber. Thus, Mr. Jukes-Browne says:—"Large masses of chalk occur in the gravel; one such mass, with flint-bands nearly vertical, and now half-quarried away, must have measured some eight yards in length; according to the workmen's account, the part left is ten feet wide by eight feet in height. Another mass, eight feet broad, was just being exposed at the time of my visit, June 1883; while near the entrance there was a third, long tabular mass of chalk about 20 feet long, and passing into reassorted white marl; but the greater part having its bedding so little disturbed that it might have been *in situ.*" Speaking of this latter, he continues:—"The seam of dark-grey marly clay at the base of the chalk was from two to six inches thick, and exactly like the bands which so frequently occur in the chalk-with-flints. It would seem, therefore, that a mass of chalk, together with the clay-band, had been quarried out of the hill and embedded in the gravel without disturbance of its bedding or destruction of the clay." ("Geol. North Lincolnshire and South Yorkshire," p. 171.) It seems to me that facts like these are only consistent with the cause I urged in my previous paper.

The great earth-movements that raised the chalk wolds of Yorkshire, in doing so necessarily caused transverse fissures at right angles to the anticlinal lines, thus forming the steep-sided transverse dales which mark them. This was well seen and urged by the older geologists, who had studied mechanics and physics, and did not construct their camels out of their imaginations only. The most important of all these transverse valleys is probably that in which the Humber flows, and which, if not a fissure, presents to us the chalk bent down or sunk to a great depth below high-water mark, and the hollow filled up by the chalky clay, etc., showing that it was made at the same time as the great depressions of the chalk marked by the well-borings at Boston, in Lincolnshire, and Yarmouth, in Norfolk.

The steep sides of these buried valleys are remarkable. Thus, Mr. Jukes-Browne says of a gravel-pit west of Wold Newton church: "From this depth of 40 feet the chalk rises steeply on either side in a series of rough slopes" (*op. cit.*, p. 171). Again, Mr. C. Reid says: "Great Limber is partly on gravel and partly on chalk, the gravel having its limit generally well defined by a sharp rise of chalk. . . . . The abrupt rise of the chalk at Limber brickyard is very curious; for one of the cottages belonging to the pit is on chalk, while not 80 yards away, on the same level, there is at least 37 feet of sand and warp" (*id.*, p. 180).

Turning to the valley of the Humber, Mr. C. Reid, in his "Geology of Holderness," tells us that under it "there is evidently a considerable thickness of boulder-clay, though none of the borings yet made have shown the full depth of the old, probably pre-Glacial, Humber valley. . . . . They prove that boulder-clay, interstratified with sand and gravel, *reaches a depth of at least* 83 *feet below the present level of high-water*; and, judging from the dip, there will be a still greater thickness in the old channel." He quotes other cases thus: one boring, 300 yards east of Hessle ferry, reached chalk at 42½ feet below high-water; a second, immediately within the Humber bank, reached it at 44 feet; another, in 26 feet of water, reached it at 24½ feet; another, in 33 feet of water, at 22 feet; another, in 33 feet of water, at 23 feet. In one case, a boring in 25½ feet of water, chalk was not reached at 58½ feet. In another, where the bore-hole started at 3 feet below high-water, chalk was not reached at 72½ feet. (*Op. cit.*, pp. 39, 151.) In a bore-hole at Reed's Island, in the Humber, chalk was reached at 185 feet.

Mr. Reid speaks of the chalk south of Barton as glaciated (that is, in ordinary language, broken and dislocated) to a depth of several feet; and the irregular depths at which it occurs from the surface show that it must be much crumpled, bent, and warped; and inasmuch as the hollows created by the flexures, which go down considerably below low-water, are filled in by boulder-clay only, it is virtually certain that they occurred either coincidently or just before the clay was distributed.

That these flexures and dislocations were caused by a very different force than any that could be exercised either by glaciers or icebergs, seems evident when we test the problem in the true inductive way, namely, by placing side by side the phenomena in question from Eastern England with those from Dorsetshire, where we have effects largely of the same kind and degree, in an area where ice-sheets and icebergs cannot be postulated. The dislocation about Purbeck and in the Dorsetshire Chalk are good indices that the effects in question were due to subterranean forces, and not to the great ice monster continually invoked by the wilder glacialists.

Let us now turn our glance further east. It is a great pity that so little has been done during the last half-century to illustrate the constitution of the sea-bottom of the German Ocean. We know its contour well enough, but the distribution of the rocks that form its bed we can hardly be said to know, and yet materials are available. At Southwold and other places on the east coast, the so-called "crabs" to which the fishermen fasten their boats, are piled up with subangular masses of rock, including lumps of chalk, of Coralline Crag, as well as of crystalline rocks, which have been trawled, and about whose provénance the fishermen have collected considerable details; and it is a great pity that the Geological Surveyors, who have spent so much time on this coast, have not made more inquiries on the subject, and furnished us with more materials for settling some doubtful questions.

Two things, however, seem perfectly plain: one is, that the folds and bends which mark the chalk in East Anglia, Lincolnshire, and Yorkshire, also mark the beds underlying the German Ocean; and inasmuch as we meet with the chalk again in folds when we reach Denmark, it seems probable that the Cretaceous beds were once continuous right across the North Sea. I am informed by a distinguished hydrographer, that when the Trinity House proposed to erect a lighthouse on the Goodwins a boring was put into the ground, and that chalk was rapidly reached. This shows that the Goodwin Sands form an anticlinal saddle or down. The Admiralty charts show a chalk bottom off the eastern coast of England, both off Kent and Essex, indicating that this depression is a synclinal hollow in the chalk.

It is equally probable, although of this we have not the same direct evidence, that the Dogger Bank is another chalk down covered with sand, and it is not unlikely that some of the chalk lumps brought in by the Southwold fishermen have been dredged on the Dogger. Between that bank and Denmark there has been some denudation, for when we reach the Danish coast, some of the beds below the chalk are exposed: perhaps this has been an area stripped of its covering of chalk, like the Fen depression and the Weald.

Proceeding still eastward, we come to the chalk of Jutland, and then to the broken and dislocated chalk beds of Moen and the other Danish islands, which present such a remarkable parallel to the dislocated chalk beds of England, and the discussion of which by the foremost German geologists has apparently largely escaped our own writers — the only person known to me who in recent years has referred to them, and he only casually, being Professor James Geikie.

I will give a short conspectus of the most recent views. First, as to Lyell's observations and conclusions. He says:— "The chalk in the cliffs at Moen, which are from 300 to 500 feet high, is in beds partially vertical, partly curved, and has undergone extreme disturbance. As we find a range of the English chalk in Purbeck and the Isle of Wight, where the strata are much dislocated and thrown on their edges, while in the immediate neighbourhood of the line of convulsion strata of similar chalk are traced over a wide area in horizontal or slightly tilted position, so in Denmark we remark the like contrast between the state of the white chalk-with-flints which occurs in the neighbouring islands of Seeland and Moen. . . . The Moen cliffs are subdivided by deep ravines into separate and distinct masses. . . . They are, in fact, narrow clefts, coinciding with lines of fracture and dislocation. . . . The first opening or narrow valley is near a rock called Taleren: a deep ravine here comes down at right angles to the line of coast. . . . Another great line of fracture further south, at Sommerspiret, where another ravine, filled with clay and sand, comes down to the sea. Here, as afterwards, in a third break in the cliffs further south, I observed the strata of chalk dipping on the opposite sides of the ravine towards the hollow.... The cliff called Dronningestolen is between 300 and 400 feet high, nearly three-fourths of which are perpendicular, but the lower part is a sloping mass of solid chalk-with-flints, the beds of flint being highly inclined towards the sea. . . . Two rents descend perpendicularly, and terminate, the one at a depth of 100 feet and the other of more than 150 feet, from the top of the cliff. They are filled with sand, and near the termination are two caves, one of which is 14 feet and the other 16 feet high. They may be sections of subterranean passages, and are distinctly connected with dislocations in the chalk." . . . . Lyell suggests, that the upper portions of some of the chasms may have closed again. . . . . "Their movements," he said, "have produced sharp curves in some places, and in others great faults in the strata of chalk, which are beautifully marked by the lines of black flints. Occasionally a mass of chalk, divided by regular layers of enclosed flints, abuts abruptly against another in which no flints, or scarcely any, are visible. Almost every other imaginable form of dislocation may sometimes be met with. I did not see any flints shattered *in situ*, and I am told they have rarely been observed." Lyell compares the phenomena at Moen with the large masses of chalk in the Norfolk cliffs, and says the appearances are strictly analogous, but in Norfolk are on a much smaller scale. "*In both cases, they compel us to assign a comparatively modern date for an era of partial but violent convulsion, by which the chalk has been deranged.*" (Trans. Geol. Soc., 2nd ser., v, pp. 252–7.)

In the abstract of this paper, which was read before the Geological Society, on May 13th, 1835, Lyell says:—"In consequence of the disturbances the chalk has been made to alternate on a great scale with interposed and unconformable strata of clay and sand. These alternations cannot be explained by supposing the detritus of the superincumbent strata to have been washed by running water into clefts; *but masses of the Tertiary beds seem rather to have been engulfed.*" (Proc. Geol. Soc., ii, 192.) He further adds, that Dr. Forchhammer had discovered similarly disturbed chalk in the Danish island of Seeland.

In his address to the Geological Society in 1836, Lyell again refers to these dislocations, and says:—"The movements have been on so great a scale that masses of the overlying clay and sand have subsided bodily into large fissures and chasms, intersecting the chalk to the depth of several hundred feet. *Some of the intercalations of clay and sand, in the midst of great masses of unconformable chalk, can only, I think, be explained by supposing engulfments of superincumbent matter, such as are described to occur in earthquakes.*" (*Id.*, p. 366.)

Dr. Beck, in a paper communicated to the Geological Society in 1835, speaks of the masses of gravel and sand which in Moen have, in consequence of great disturbances, become entangled with portions of disrupted chalk. In the neighbourhood of Thisted, at Thye, to the north of Mors, and in the island of Füür, *Dr. Beck observed in* 1831, *dislocations which affect equally the Tertiary strata and the Chalk.* He further says that since the sandy beds of Denmark sometimes contain shells identical with those now living in the German Ocean, it is evident that the chalk in Denmark has been submerged since the existence of the living species of testacea. (Proc. Geol. Soc., ii, p. 217, etc.)

The next reference I can find to these dislocated chalk beds is in a memoir by C. Puggaard, entitled "Uebersicht der Geologie du Insel Moen," published at Berne in 1851. Lyell speaks of him as a most able and reliable authority. To be clear, he says:—"The escarpment of Moens Klint is about 18,000 metres in length; along this length of cliff it is only at each end that the chalk and the superincumbent soft beds lie in a horizontal position. In the intermediate space the strata of chalk are twisted, curved, and bent in all ways, in the form of an S or a Z, in a semicircle or stirrup-shape, or, again, cut by chasms, forming enormous faults, and interlaced in the most extraordinary fashion. About the middle of the scarp, at a place called Dronningestol, the confusion attains its maximum, and there the cliff rises to its highest point, 420 metres. The dip of the strata also varies greatly and changes continually, in some places passing abruptly from a horizontal position to a vertical one; and, what is most remarkable, the inclination of the strata seems less marked at the summit of the scarp, and the inclination of the beds increases rapidly as we go down, and sometimes the beds are more than vertical, the chalk resting on the diluvian beds, but always in order" (toujours en stratification concordante). He gives several sections showing how in several ravines in the island the layers of clay and sand follow the exact lines of the chalk. In other ravines it is only on one side that we have this continuous superposition; on the other the drift beds are sharply cut off, and often plunge below the chalk, so that the chalk lies on the drift in discordant fashion. The faults are often difficult to find, especially those occurring where the strata are much inclined. By means of these breaks and faults, beds of clay and sand often look as if intercalated in the chalk; but on examining the place closer, it is found that where the chalk looks as if it rested on the clay it is separated from it by a breccia filled with angular pieces of flint and mixed with clay containing rolled pieces of granite.

It is often found that the edges of the inclined strata in the ravines are bent over in a direction opposite to the run of the ravine, showing whence the force has come which made them. The hills in the centre of the island have very steep sides, with pronounced outlines, and are separated by deep ravines, showing that notwithstanding the soft surface mantle, the contour of the country is really due to subterranean forces. The lines of fracture extend to Denmark, and are marked there by fjords, etc. "I am convinced," says Puggaard, "that the surface of Denmark owes its contour much more to the bending and plication of its strata, and to subterranean movements, than could at first sight be supposed from a mere examination of its surface beds." *He further argues that the dislocations in the Isle of Moen referred to, all date from about the same geological epoch*; but from the different directions of the rents, he attributes them to different shocks. In addition to the principal dislocations, there are secondary ones almost at right angles to the former.

Puggaard gives many details about the changes in the dip of the strata in various parts of the island, and many sections to show the actual facts; and he concludes that the dislocations were the result of some very violent lateral pressure, which he attributes to the shrinkage of the earth's crust, and which gave way in certain weak places. From the fact of the lower strata being more affected than the upper, he judges that it was rather the result of collapse than of elevation, and that the effects so remarkable in Moen were the result of the sinking in of the bed of the surrounding sea to the depth of 500 to 600 feet; this affected the whole island, together with Denmark, which afterwards rose again covered with its mantle of sand and clay and boulders. Then it was that the scarped cliffs of Moen were formed, and became the subject-matter of attack by the waves of the Baltic, reinforced by the waters of the Arctic Ocean, coming by way of the then open Bothnian Channel. He considers that this sinking probably affected the whole of the North and East European districts where the drift phenomena occur, and also extended to the mainland of Denmark and of Scandinavia, and he considers the Swedish Åsar and the Danish sand rücken as due to the same cause. The depth to which he carries this sinking is apparently based on the height above the sea-level at which marine shells have occurred in Scandinavia and England. *He attributes the dislocations in the strata of Moen to about the time of the so-called Glacial age, and adds the notable words*—"Ich glaube dieses Ereigniss als eine bequeme Grenze der Tertiären und Quaternären Periode für Nord Europa ansehen zu können obschon eine scharfe Scheidung der beiderseitigen Bildungen nur ausnahmsweise möglich ist." (*Op. cit.* See also Puggaard, "Sur la geologie de l'île de Moen": Bull. Soc. Geol. France, 2nd ser., viii, p. 532, etc.)

Lyell, the great champion of Uniformity and a very keen critic of the work of others, adopts and incorporates the arguments and results of Puggaard in his "Antiquity of Man."

We must now pass on a few years. In his memoir published in 1874 on the dislocations in Moen and Rugen, F. Johnstrup endeavoured to account for them by appealing to ice.

Against this view more than one famous German geologist protested. Von Koenen, in examining the broken and dislocated chalk of the Danish islands, contests the possibility of ice having anything to do with it; he traverses Johnstrup's case in detail, and compares the phenomena discussed by him with the very similar phenomena he has himself described in Hessen and on the Weser, and notably in the districts of Kreiensen, Göttingen, Marburg, Hersfeld, Geisa, and Vacha, where no traces of northern erratics or ice-work occur, and where they cannot, therefore, be attributed to ice. He especially quotes the underpinning of the great chalk masses by boulder-clay and sand, which he compares with the reversed strata at Hüggel, near Osnabruck, where the Middle and Upper Lias are thrust in below the beds of Zechstein. He compares the hollows and basins of various shapes occurring in Rugen with the similar hollows in Central Germany, which he had already shown to be due to the sinking of the ground; he points out that the faults which occur in this district are of Pleistocene age, and argues that the general dislocations were coincident with a sinking of the bed of the Baltic. (See A. von Koenen, "Ueber postglaciale Dislokationen": Jahrbuch der Königl. Preuss. geologischen Landesanstalt und Bergakademie, 1886, pp. 1–19.)

In 1889, Berendt published a paper in which he reverted to Johnstrup's explanation, and argued at considerable length in his favour. This, again, was answered, with great force and in great detail, in a memorable and, as it seems to me, conclusive memoir by R. Credner, in which he made the position so long ago sustained by Lyell unassailable. The fact is the more remarkable since R. Credner is himself a champion of extreme glacial views. He tells us, that the view held by von Koenen was strongly supported by the geologists who went on an excursion after the Geological Congress at Greisswald in 1889. They noted also that the dislocations in the cliffs north and south of the Kiel Brook, formed a row of parallel ruptures extending from SSE. to NNW., and were accompanied by a series of step-like sinkings of the intervening strata. R. Credner adds, that during his own numerous excursions, and especially in 1890 and 1892, when he spent several weeks on the island of Moen, he was satisfied of the justice of von Koenen's conclusions, that the disruptions were due to the forces which gave the island its contour, and not to ice-action at all. The paper is too long to condense here, and those who still need convincing had better turn to its elaborate descriptions, arguments, and especially to the sections, to see how utterly inadequate ice, in any form we know it, would be to bend these great masses of chalk into reversed folds, into arches and synclinal hollows, and to do so frequently when the chalk was coated, and had its surface therefore padded, with layers of soft materials—sand, clay, etc. Credner's paper has not been answered, or criticized even; and it seems to me not only conclusive in itself, but to be a very eloquent complement to the evidence of the disturbed chalk of Britain presenting the same features and preaching the same lesson.

Let us now revert somewhat. As we have seen, the Geological Surveyors in East Anglia and the German geologists in Denmark attribute the flexures and dislocations of the chalk to the same period, namely, that in which the boulder-clay was distributed. This is confirmed when we turn to the submerged downs of the North Sea, over all of which, over the Dogger Bank, the Goodwin Sands, the Haslow Oyster Bank, the Knole Sand, etc., numerous remains of mammoths and their contemporaries have occurred. This, it seems to me, can only be explained by the submergence of the North Sea being subsequent to the formation of the land-surface on which the mammoths lived. If, as some have held, these remains found under the North Sea were carried down by the Rhine (another of the postulates of Uniformity which outrage common-sense), it is extraordinary that they should occur so unweathered and unrubbed, not in the hollows where the river may have flowed—if it then existed, which is very doubtful—but along the ridges. The widely-spread area of the North Sea where the unrolled remains occur, and the fact that they are so often found on the submerged ridges and downs, make it plain that we have to do here with a wide area which has been recently submerged.

The fact of these bones and teeth being so fresh and unweathered, shows us further that the submergence was not gradual, the result of continuous cutting back of a sea-coast by diurnal causes, but a widespread and cataclysmic one, or these bones would not be found in some cases articulated, and in all cases with their finest muscular attachments intact, but would be rubbed and converted into a kind of bony shingle.

In this behalf I should like to quote an opinion of Murchison, now perhaps forgotten. Referring to the existence of mammoth bones in a submarine forest off the Norfolk coast, he said that this commixture had been pointed to as indicating long and slow action. He viewed it as evidence of sudden movement. "When examining a similar submarine forest," he says, "with the trunks of trees still erect, the late eminent Dr. Forchhammer, of Copenhagen, came to the conclusion, as he informed me, that the movement by which they were submerged must have been sudden. He argued that the rapid immersion of the trunks, and their having been quickly surrounded by marine mud, could alone have preserved them; for if the trees had been gradually sinking at the rate of an inch or two in a year, they would have been entirely decomposed under the atmosphere long before their submergence." ("Siluria," ed. 5, p. 491.)

These conclusions are further confirmed by another, for which I have fought very hard in these pages, namely, that the chalky clay of Eastern England is shown, by every case where the evidence is clear, to overlie the land-surface on which the mammoth lived. Mr. Horace Woodward has quoted some cases bringing into close chronological sequence the destruction of the mammoth and the disintegration of the Chalk of Eastern England. Thus he quotes the discovery, about the middle of the last century, of "part of the horn and palm of a deer, found in a chalk-pit at a village called Baber, four miles east [west] of Norwich, at the depth of 16 feet, and almost converted into a chalky substance." S. Woodward confirmed the discovery by Arderon of deer's horns in the disturbed chalk at Whitlingham and Sprowston. Arderon describes a man's skeleton as having occurred in the same bed. Since this time, says Mr. Horace Woodward, Mr. J. W. Ewing, Mr. Fitch, and Mr. Bayfield have brought many specimens, including shed antlers, under the notice of the Norwich Geological Society. These include the mammoth, the red deer, and another species, like the roe deer; while the localities of Thorpe, near Norwich, Hartford Bridge, Markshall, and Eaton, have been added to the list.

E. primigenius has been found in the cutting below the viaduct near Hartford Bridge, and in chalk rubble, Norwich; while antlers of deer have been found at Norwich, Trowse or Lakenham, Markshall, Eaton, and Whitlingham. On March 4, 1868, Mr. J. W. Ewing exhibited before the Norwich Geological Society several portions of antlers found in the rubble or disturbed chalk in his grounds at Eaton. Mr. Gunn says he was struck with the marks of cutting and abrasion, by some blunt instrument, of the pedicle of one specimen of the red deer, and of sawing on another. A stone implement was said to have been found with the bones of deer. (H. B. Woodward, "Geology of the Country round Norwich," pp. 137 and 138.)

I will now endeavour to sum up in a few phrases the main conclusions which seem established by the evidence.

1. Before the distribution of the Drift, the Chalk extending from Norfolk, Lincolnshire, and Yorkshire, to Scania, in Sweden, was, so far as we can judge, a perfectly continuous deposit, neither bent into folds nor marked by conspicuous alternations of valley and down.

2. This great stretch of more or less level chalk was overlain, either completely or partially, by beds of Eocene age, consisting of variegated clays and of smoothed and rounded flint pebbles, of which considerable remains still exist under the Drift in East Anglia; while the débris of those which have been denuded and broken up now form the shingle beds and various gravels of Eastern England, there not being in that area, so far as we know, any pebble gravels *whose constituent* pebbles do not date back to Tertiary times.

3. Over these Eocene beds were placed the Crags. How far the Crag beds extended over the bed of the North Sea, we do not know; but among the lumps dredged by the Southwold fishermen are several of the White, or so-called Coralline Crag; while, as is well known, in more than one place in the North Sea area, dead shells of later Crag age have been dredged.

4. Over these Crag beds, again, was a land-surface, on which the mammoth and its companions roamed, and which extended from Denmark to Yorkshire. We have no evidence to show that the Rhine flowed through this now submerged land. It may be, on the contrary, that its drainage was entirely reversed and that it then flowed southwards.

5. The beds above named, from the Chalk or perhaps the Oolites upwards, were presently affected by a great movement, of which other examples occur in geological history, by which they were bent and moulded into a succession of wolds and intervening valleys. This movement led to their very considerable dislocation and disintegration, and to the denudation of large areas, such as that occupied by the Fenlands; and it was by this movement that the present contour of Eastern England, of the bed of the North Sea, and of Denmark, were shaped.

6. The products of this disintegration, in the shape of chalk-rubble, were subsequently moulded and mixed into what we know as the Chalky Clay, which was afterwards distributed in its present form. How this came about, I may be able to show on another occasion. This view, which I reached independently, is very largely the same conclusion arrived at by the father of the Woodwards, who in his "Geology of Norfolk," published in 1833, says that "the elevations in the neighbourhood of Cromer originated in the disruption of the Chalk strata, and are most probably of the same age as the valleys. The natural section of the cliffs shows, in the disrupted chalk, the origin of the Beacon hill at Trimingham; and to the westward of Cromer is seen a large mass of chalk

at the upper part of the cliff in a perpendicular position. These are beyond a doubt effects of the same cause. On the lighthouse hill at Cromer also, the chalk is forced up to the surface, 200 feet above its natural level, and a limekiln is worked on the spot. The valleys of Norfolk are such as are denominated '*valleys of elevation*'; that is, they were formed by the upheaving of the chalk and its consequent fracture. This is demonstrated by the agreement of the 'salient' with the 're-entering angles' of their borders, and from the fact of the layers of flint in the chalk, on each side of the valley, being found to decline from its line of fracture." In describing the general results of his inquiries, S. Woodward, *inter alia*, urges that the chalk was disrupted subsequently to the period when the great mammals lived in Norfolk, when, he argues, this country was separated from the continent, at the same time forming the valleys of Eastern Norfolk and the drainage of the county. (*Op. cit.*, pp. 6–9.)

V.—Clays, Shales, and Slates.

By W. Maynard Hutchings, F.G.S.

In pursuance of my studies of clays, shales, and slates, I have recently been examining some specimens to which a good deal of interest attaches. Some of them are Carboniferous shales from deep collieries in South Wales. Another, also a Carboniferous shale, is from a deep boring in the Isle of Man.

The object in view, in examining these specimens, was, in the first place, to see how far they agree in general nature and chemical composition with the very numerous Carboniferous clays and shales which I have investigated from other districts. In the second place, it was desired to see whether these shales from considerable depths had made any perceptibly greater advance towards becoming slates, than those derived from points very much nearer the surface; whether they were harder and more compact; and whether they showed a corresponding change in the nature of their minerals, or of the arrangement of these in the *structure* of the rock.

As regards the chemical composition, I have made the following analyses. *A* is the deepest of the Welsh shales, from 1300 feet. *B* is the specimen from the Isle of Man, but I do not know the exact depth from which it was taken.

A.			B.		
Silica	66·10	per cent.	Silica	58·75	per cent.
Alumina	20·55	,,	Alumina	19·15	,,
Ferric oxide ...	1·67	,,	Ferric oxide ...	3·90	,,
Lime	1·40	,,	Lime	1·15	,,
Magnesia	0·84	,,	Magnesia	1·95	,,
Potash	2·85	,,	Potash	3·48	,,
Soda	0·78	,,	Soda	1·54	,,
Water and organic matter	6·55	,,	Carbon dioxide ...	1·36	,,
			Water and organic matter	8·87	,,
	100·74	,,		100·15	,,

The analysis *A* shows an unusually low amount of iron, but with this exception the composition corresponds pretty closely with similar rather quartzy shales from other coalfields, as, for instance, with No. 1 of a series of six analyses which I published (Geol. Mag., January, 1894, pp. 36 and 64) of fireclays from a borehole at Aspatria, near Carlisle. Notably, the relative proportions of potash and soda, the great excess of the former, are here maintained.

The analysis *B* shows in general a similar composition, but this shale contains a noticeable amount of grains of a carbonate (probably of lime, magnesia, and iron) more than I have seen in any other Coal-measure clay or shale. Also, the excess of potash over soda is less than is usual in these deposits. I am not aware from what exact position in the Carboniferous beds the specimen was taken.

The Welsh shale is a decidedly quartzy and coarse-grained specimen, as compared with the finest-grained, hard fireclays from the borehole at Aspatria and elsewhere. It still shows a considerable amount of clastic muscovite in good-sized flakes, and here and there even a bit of not yet wholly decayed biotite may be seen. These Welsh specimens are very deeply coloured with organic pigment, which makes sections of them very opaque and bad to examine, in comparison with the much less pigmented grey shales and clays from some other sources; but the general nature is still easily made out, being the same as in the other cases. There are the rutile-needles, small anatase crystals, and other minerals as usual, and the finest-grained "base" of newly-formed micaceous material.

The same remarks apply in all principal respects to the Isle of Man shale, though it is not so quartzy as the Welsh specimens, and contains, as before stated, some carbonates disseminated through it.

So far as concerns the physical condition, and development towards slates, these specimens differ only from those previously examined inasmuch as they are considerably *less* advanced than many which have come from very much smaller depths. They are, in fact, just very hard clays; they can easily be cut with a knife, and when ground with water they are quite plastic. They have, in fact, not made any advance at all beyond that of the considerable *chemical* changes and the very moderate *physical* progress which is common to all the clays and shales of the normal Carboniferous beds; and it does not appear that we can look for any gradually higher stages, among these deposits, to assist us to bridge over the interval between soft shales and well-developed slates, or to understand what it is which takes place in them during the passage through the intermediate stages.

Such fully-developed slates we can only study, in this country at least, among the older formations, with the exception, possibly, of certain local occurrences in the Culm of North Cornwall, etc. In other regions highly-developed slates are found among rocks younger than the Carboniferous. It is not, by any means, simply a question of geological age.

In considering these higher phases of "slates," as contrasted with soft shales and indurated clays, it is not so much the mechanical question of cleavage, etc., which is of interest, as the mineralogical nature and inner structure.

In the rocks we call "slates" we are accustomed to see a more or less high degree of cleavage, and, indeed, to commonly more or less associate this development of fissility with the very name. But with this cleavage we usually find that other changes have been brought about, which are petrologically of far greater interest and importance, —great alterations in the component minerals and in their arrangement in the rock.

We know that the development of cleavage is a purely mechanical affair, which may be brought about in any fine-grained rock, sedimentary or otherwise, by pressure. In dealing petrologically with "slates," we are not tied to this quality of cleavage. We can have bodies of sedimentary rock around igneous masses, which have had their former cleavage obliterated by the effects of the intrusion of these masses, but which we must still call slates. And we may have beds of soft shales, converted by such igneous masses direct into contact-rocks without any cleavage at all; which are mineralogically and structurally slates, and to which we could not at present conveniently apply any other name.

It is just these mineralogical and structural developments of the deposits, which accompany the change into slates, which are of so much interest for us to endeavour to follow out; to find, if possible, the different causes to which we must attribute the variations in these developments, both in kind and in degree, which become apparent to us when we study sufficient examples of slates, or going further forward, of phyllites and schists.

It may be as well to take a general review of the subject of the origin and development of the deposits from which our normal sedimentary slates, and allied rocks, may be traced; and to take stock of such facts concerning this development as seem, on microscopical, chemical, and general evidence, to be either fairly demonstrated or rendered highly probable.

In the first place, then, all the evidence we can gather appears to justify the belief that the great bulk of these slates is derived from the sediments consisting of the waste of vastly older granitic and gneissic rocks, and that in the indurated clays and soft shales of the Carboniferous beds we have a series of closely similar deposits, of like origin, preserved for us in a relatively early stage of their history. Any observations, therefore, which we can make on these Carboniferous deposits, will assist us to a general understanding of the progress of all such sediments into slates, and of the alterations which these, again, may undergo at later stages of their existence.

If we take for our study mainly the finer-grained parts of these deposits, we shall best arrive at the desired conclusions; because any increase in coarseness of grain simply leads on to the more quartzy slates and grits, and finally to the argillaceous sandstones; in all of which rocks the original nature and subsequent changes of the finer argillaceous portion of the materials are the main points to be considered.

It has been shown that *chemically* such clays and shales are very exact counterparts of quite typical clay-slates and phyllites. If we compare the average analysis of a series of the one, with that of a series of the other, we cannot point out any marked, or in any way essential, difference whatever, excepting that the combined water in the slates is less than in the clays and shales.

Again, a minute examination of these clays and shales under the microscope, in thin sections and in the products of fractional levigation, has led to the conclusion that mineralogically, also, there is a great resemblance to the slates, inasmuch as they consist mainly of a micaceous mineral. And a careful study of this micaceous mineral, combined with the fact that in these finer portions of such deposits there is a disappearance of all the felspar, practically all the biotite, and a large part of the original clastic white mica (all of which can be proved to be in abundance in the accompanying coarser beds), leads to the recognition of the nature of this micaceous mineral as a new formation in the clays and shales, since they were deposited.

In comparing such clays and shales with most slates and phyllites there is, however, one difference to note, and it is a matter of much importance in following out the history of such beds. It consists in the fact that whereas in the slates and phyllites the micaceous mineral is accompanied by a good deal of a chloritic substance, with which it is more or less intimately interwoven, we do not see this in the clays and shales.

It was pointed out in an earlier paper (Geol. Mag., June and July, 1890) that chlorite does not result from the decomposition of brown mica in these deposits. A certain small amount of it may be seen in them, especially in the rather coarser portions, but it is easily recognized as clastic, and is doubtless due to the decay of biotite in the original rocks whose waste has supplied the material for these beds. In the processes of chemical interaction which have taken place in these early clays and shales, chlorite has not been formed; and we are justified by all that we can ascertain, chemically and microscopically, in concluding that the micaceous mineral which does result contains within it those components—magnesia, ferrous and ferric oxides, alumina—which would be capable of combining with silica on their own account to yield a chlorite. We have, in fact, in these clays and shales a micaceous mineral which is very complex in its nature, is highly hydrated, and does not correspond to any definite species of mica. It is of a pale-green, or yellow-green to yellow colour, and does not polarize quite as vividly as do minute flakes of muscovite.

In the beds of the Coal-measures in undisturbed bands (not connected directly with coal-seams), suitable sections of clays and shales show that the micaceous mineral is very nearly all flat in one plane; but in some of the more indurated, and what might be called more *advanced*, samples examined this is not so completely the case. The great bulk of it is still flat in one plane, in which it gives, in polarized light, a dim speckled field; but this field is crossed by little veins and strings and wider bands, highly inclined or even vertical to this plane, of a minutely-felted and wavy mass of flakes of the same or a similar mineral, but obviously in a more developed stage. There is no mistaking that these veins and bands have been formed later than the main mass seen in the section, and that they represent a further development and crystallization of a micaceous mineral which is still in general nature and appearance the same as the main mass, though with crossed nicols it shows more vivid tints; and the peculiar felted and wavy structure of the little veins is very noticeable.

If we now pass at once to the consideration of what we may call fully-developed slates of Silurian or Cambrian age, limiting ourselves for the present to occurrences concerning which there is no evidence that they have ever been affected by igneous intrusions; and if we compare these rocks with the clays and shales we have just left, we find, as before pointed out, only one chemical difference, viz. the decrease in the amount of combined water. But careful mineralogical study of the slates with the microscope results in our being able to note two main points of variation between them and the clays and shales. The degree of these differences varies very much, as the exact condition of the slates varies in different occurrences, but in nearly all cases we can see the points in question. There is a higher development of the micaceous mineral, and concurrently there is the separation in the rock of a chloritic substance, to which reference was made above.

By higher development of the micaceous mineral is meant, not only a development in size, for this is sometimes not at all striking, but an advance towards the nature of *muscovite*, often with a noticeable clarification as to colour, and increase in the vividness of polarization-tints.

The chloritic mineral which has been formed at the same time is very intimately interwoven into the texture of the rock. Often it is mainly in minute mixture with the mica, flake for flake as it were, but usually this form of occurrence is accompanied by the formation of streaks and lenticles of chlorite, in which mica is seen to a much less extent, or from which it is even absent.

It seems quite evident that what has taken place in the rock during its progress from a clay or shale, has consisted mainly in this further development and crystallization of the micaceous mineral, during which it has rejected some of the components of the original more complex combination, which components have then given rise to the formation of the new chloritic mineral.

This chloritic mineral varies in its nature and appearance according to the chemical composition of the rock in question, the principal condition being, apparently, the amount of iron present, and more especially that portion of it which is in the form of ferrous oxide. Thus, sometimes the mineral is dark green and very dichroic, with decided "polarization"—is, in fact, *chlorite*, and can be proved to be such,—while in other cases it is very pale in colour and optically very faint; and in some few rocks it is, in the thin sections used, quite colourless and optically inert. For convenience we will speak of it in all cases as "chloritic," without attempting to specify its exact nature and composition.

It is often difficult to make out how much of this substance is present, even when it is of a decided green colour, because of its very intimate intermixture and the smallness of some of its flakes; and when it is verging on colourless it is even difficult to detect it at all in ordinary sections. But for the study of this class of rock it is of very great use to take specimens, of suitable size for cutting sections, and heat them to dull redness for some time. This dehydrates the chloritic mineral, and when it is of green colour leaves it with more or less deep shades of brown or of red, in which condition it can be easily detected, even in a most minute and intimate state of subdivision. And even when it is nearly or quite colourless, it is thus rendered more opaque, becomes tinted, and can be seen where it was previously invisible. Sections made from these dehydrated specimens are, therefore, of the greatest value when used in conjunction with those of the normal rock.[1]

They show, too, another useful and interesting point. The more impure and less developed mica is also affected by dehydration and by the oxidation of the iron it contains, taking on colours which range from yellow to various shades of brown, and even to good strong red, according to the degree and nature of impurity. Where these colours are sufficiently deep, they destroy the optic characteristics of the mica; but even when they are only very pale it is seen that such mica, after heating, is much less active in polarized light than when in the normal state. Thus the micaceous mineral is more or less affected according as it is more or less developed towards muscovite, which is not so altered by moderate ignition, its colour and polarization-tints being not perceptibly influenced. In this manner we are enabled to make very instructive comparisons between slates in various stages of evolution.

It is of interest to note that this test applies also to the new micaceous mineral of the clays and shales. I described (Geol. Mag., April, 1891) the results of some very careful levigations carried out on a typical "fireclay," and stated that, in the finest parts of the products obtained, a considerable proportion consisted of very minute flakes of a pale yellowish or greenish mineral, most of which could only be well seen when mounted in water. I consider that this portion of the products largely represents the new mineral formed in the clays and shales in question.

If it be heated to redness, and then mounted in balsam in the

[1] There is no harm in here reiterating a caution as to the necessity of *very thin* sections, this being especially important for those cut from dehydrated specimens. Personally, I have never seen any made by English cutters which are of the least value for studying this class of rocks. It is decidedly a case of things "made in Germany" being better! The vagueness and indistinctness of many descriptions given of slates, etc., are well accounted for when one sees the sort of paving-slabs which have often done duty as "thin sections," and when one sees them mounted on such thick glasses, and covered with such thick covers, that no use of higher powers or proper illumination is possible.

manner described in the paper referred to, it is seen to have taken on quite a reddish tinge, to be more opaque, and quite easily seen even in its minutest flakelets.

I have endeavoured to ascertain something as to the chemical composition of this new micaceous mineral in clays and shales; but, for obvious reasons, it is a rather unsatisfactory task. I took the two finest portions, called A and B in my former description of these levigations, made one sample of them, and carefully determined in it the percentage of several of the constituent bases.

In these finest slimes there takes place a concentration, not only of the new micaceous mineral, but also of a large proportion of the rutile-needles, anatase crystals, and ilmenite-flakes of the original material; also of a certain amount of epidote in small grains and crystals, some very fine quartz-powder, and the bulk of the organic matter of the fireclay. One can only make a rough estimate as to the quantity of these things which may be present in the levigated slimes, but, after much examination, I consider that it is safe to say that there is 25 per cent. of material other than the micaceous mineral.

Making an increase, in this proportion, in the actual figures found by analysis, the micaceous mineral will contain—

	per cent.
Potash	4·62
Soda	1·16
Magnesia	2·94
Alumina	32·31

A small portion of the alumina will be due to epidote, to which mineral we may also ascribe most of the lime present in the material (0·90 per cent.).

If we take the figures for the alkalies and magnesia, and approximately for the alumina, and if we consider that with them must also be included a good deal of ferrous oxide, some ferric oxide, and several per cent. of water, we get as near an idea of the constitution of the bases of this complex micaceous mineral as the conditions of the case allow us to obtain; and we see how it is that such a substance, under other conditions, gives rise to a mixture of a mica, more or less developed to muscovite, and of chloritic minerals.

We get this crystalline development of slates, as before remarked, in very varying degrees, and there are rocks of this class, of which the actual condition is at present universally accepted as being due to "regional" metamorphism only, in which the mica has really, so far as can be made out, become all *muscovite*.[1]

If, now, we look at slates in the neighbourhood of intrusive

[1] It may very likely be the case that in some slates, in which a larger proportion of soda than usual is present, the mica formed is largely paragonite. And in other cases there may be a mixture of muscovite and paragonite, or some mica may result which is chemically intermediate between the two. It would rarely be possible to make quite sure of this; but in any case the exact nature of this regenerated mica would not affect the considerations involved, and for convenience we may speak of it in general as muscovite.

igneous masses, we find that here, too, a development of the mica and a separation of chloritic matter have taken place, with a more or less considerable advance in the crystalline structure of the rock, up to very high stages indeed, even when none of the special "contact-minerals" are yet formed.

The consideration of these different cases brings us face to face with the most interesting, and as yet quite unsolved problem, as to how far such rock-development can be shown to go without calling in the aid of "contact-metamorphism,"—the only agency of which we really *know* that it is capable of carrying the crystalline development of these sedimentary rocks to its highest degree. There are three agencies by which we may assume that such crystalline slates or phyllites may be produced, and in many cases we may have very little or no *direct* proof or evidence as to which of them has been the cause. These three agencies are dynamic action, contact-action, and finally another action which is neither dynamic nor contact, but is simply due to long-continued submission to depth-temperature and pressure in deeply-buried sediments.

As regards the first of these agencies, the dynamic, it is, perhaps, really not at all possible to consider it alone. In all rocks which have been subjected to it, we must take into the question the amount of influence which the *third* agency has possibly exerted, both previously to, and concurrently with, the actual dynamic action.

Then, again, contact-action will often be due, and in its most striking developments will probably always be due, to the effects of intrusions on rocks which have already been a long time under the influence of more or less considerable depth-conditions, and which have undergone whatever changes these conditions may be capable of causing in them.

No problem of petrology is of deeper and wider interest than that involved in the question here concerned; none demands more careful study or more freedom from hasty bias; and none has been more prejudiced by immense and authoritative generalizations on insufficient data.

One point, I think, is worthy to be insisted upon. It is of the greatest importance that investigation of the higher phases of development of these rocks should be based, first of all, upon a minute study of the lower forms of them in clays and shales, so as to understand as fully as possible what it is from which the evolution starts; what is the condition, chemically and mineralogically, into which the sediments have passed at the earliest stage of their history at which we can begin to regard them as having become rock-bodies at all.

Taking, firstly, dynamic action (but bearing in mind what has just been said as to its probable association in all cases with other influences), the tendency has been, among many geologists, to accept it as capable of causing almost anything in the way of crystallization and regeneration of sedimentary materials. It has even been made to include, as it were, other agencies within it, contact-metamorphism having been explained as due simply to the *dynamic* effects which have accompanied igneous intrusions. This may perhaps be regarded as the high-water mark of enthusiasm in this direction, and would find but few followers now, extreme views as to dynamic metamorphism being apparently much less in favour than they were a short time since, and many of us who were to a considerable extent believers having become rather more sceptical.

But dogmatic opinion in an opposite direction is quite as much to be deprecated. It is always desirable to bear in mind that though we may have to consider any number of cases of highly-developed crystalline slates, phyllites, and schists, demonstrably derived from sedimentary deposits, and equally demonstrably affected in a high degree by dynamic action, we are not yet, therefore, in a position to assert that the crystalline and mineralogical development of those rocks is *caused by* this dynamic action. It may conceivably be due to the contact-action of concealed igneous masses, or it may be due to the other agency which we are considering. The dynamic action may have accompanied either of these, and possibly assisted them, but may have had really very little, if any, share in the causation of the effects with which we are now concerned. And on the other hand, it is perhaps still more important to give due weight to the evidence of those cases in which we have dynamic action of the most intense description, and yet find that the rocks so affected, while chemically and mineralogically closely resembling those just considered, are very much less developed, and have, indeed, in this special direction very little to show for the work done on them.

(*To be continued in our next Number.*)

VI.—*Archæodiadema*, a New Genus of Liassic Echinoidea.

By J. W. Gregory, D.Sc., F.G.S.

Owing to the absence from England of any marine fossils of Triassic age—except the few obscure shells described by Mr. R. B. Newton[1]—the Lias yields the first English representatives of the Neozoic Echinoidea. The fauna is not rich in species, and as a rule the specimens are small; but it is of interest, as its members are primitive in character, and as they foreshadow many of the main lines of evolution followed by the rich Echinoid faunas of the Oolites. Some months ago Mr. Beeby Thompson showed me some specimens from the Upper Lias of Northamptonshire, which form an interesting addition to the primitive types of Liassic Echinoidea; they belong to a new genus, which is the simplest known form of the Diadematinæ, and occupies the same relation to the remaining members of that subfamily that *Eodiadema* occupies to the Orthopsinæ.

Archæodiadema, nov. gen.

Diagnosis. — Diadematidæ Diadematinæ[2] with the following characters :—

[1] R. B. Newton, "Note on some Molluscan Remains lately discovered in the English Keuper": Journ. Conch., vol. vii, Nos. 11 and 12, 1894–5, pp. 408–13.

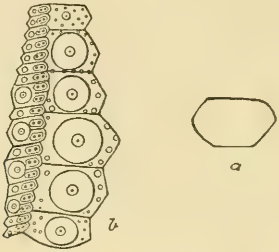
[2] P. M. Duncan, "Revision of the Genera and Great Groups of the Echinoidea": Journ. Linn. Soc., vol. xxiii, 1890, pp. 58–9.

Test small, turban-shaped.

Apical system large, area equal in width to half the diameter of the test; arrangement of plates unknown.

Ambulacra of simple, primary plates near apical area; of compound plates formed by union of three primary plates at ambitus. The pore-pairs are in a straight, single series. Ornamented by granules and a small primary tubercle on some of the ambital plates; the primary tubercles are perforate and non-crenulate.

Interambulacra of plates which, in comparison with the size of the test, are high and large; the plates are unituberculate, each bearing a single, primary tubercle, which is perforate and non-crenulate.



Distribution.—Lias: England.

Type Species.—*A. Thompsoni*, n.sp.

Affinities.—This genus is based on some small but admirably preserved specimens from the Upper Lias of Higham Ferrers, in Northamptonshire. They were collected by that indefatigable worker on the Midland Lias, Mr. Beeby Thompson, F.G.S., by whom they have been presented to the British Museum.

It is clearly a member of the family Diadematidæ as defined by Duncan. Of the four subfamilies of that great group, it differs from the Orthopsinæ by having compound plates in the ambulacra, and from the Diplopodinæ and Pedininæ by having the pore-pairs in simple vertical series, instead of their being biserial or triserial. The specimens agree, on the other hand, in all points with the Diadematinæ. Among this subfamily the new genus is most nearly allied to the genus *Diademopsis*, from which it differs by two characters: 1st, the pores in *Diademopsis* are either crowded or occur in arcs near the peristome; 2nd, the interambulacral plates in the same genus are lower and broader, and each bears two primary tubercles, which are lower and smaller than those of this new form. It differs from *Hemipedina* by the same characters, for the intimate affinity between this genus and *Diademopsis* is now generally admitted. In some respects *Archæodiadema* resembles *Microdiadema*, Cotteau, from which, however, it differs by three very definite characters: 1st, the apical area is equal to half the diameter of the test, instead of about one-fifth of the diameter; 2nd, the tubercles are perforate and non-crenulate, instead of perforate and crenulate; 3rd, there is one row of primary tubercles in each series of interambulacral plates, instead of several series.

The only Echinoid known to me, in addition to the type species, which may be referable to this genus is one figured by Quenstedt[1] as *Echinopsis nattheimensis*, which Desor and De Loriol-Lefort[2] have refigured as a *Hemipedina*. The figure of the latter authors shows the pore-pairs in a single series to the peristome, and if this be the case, then the species must enter the new genus. But these authors also showed some species, such as *Hemipedina elegans* (Des.), with the same character; and these, according to the more detailed figures of Cotteau,[3] have the normal arrangement of *Hemipedina*.

The small size and primitive characters of the specimens render it necessary to consider whether they are only young *Diademopsis*; but the specimens seem to be fairly abundant, and yet are generally of about the same size; the whole appearance of the Echinoids suggests that they are adult.

Archæodiadema Thompsoni, n.sp. (See Woodcut, p. 318.)

Diagnosis.—*Test* small, turban-shaped; sides tumid; abactinal half depressed; actinal half somewhat conical; circular.

Apical system large, regularly pentagonal; arrangement unknown.

Ambulacra narrow, inconspicuous. About four fair-sized primary tubercles in a vertical row on the ambitus; these gradually decrease into small secondary tubercles above and below.

Interambulacra of vertical series of from six to nine plates; the scrobicular circles are complete above, but incomplete at the ambitus. There is one row of primary tubercles, and the number of granules is small; these mainly occur in a band down the middle of interambulacrum.

Peristome large, circular, with conspicuous branchial slits.

Dimensions.—Diameter, 6 mm.; height, 3 mm.; diameter of apical area, 3 mm.; diameter of peristome, 3 mm.; width of ambulacrum at ambitus, 1 mm.; width of interambulacrum at ambitus, 3 mm.; number of primary ambulacral plates in vertical series, 19; number of interambulacral plates in vertical series, 7.

Distribution.—*Cerithium* beds or Lower *Leda ovum* beds[4] of Upper Lias: Higham Ferrers, Northamptonshire.—British Museum Coll. Presented by Beeby Thompson, Esq., F.G.S.

VII.—Notes on Professor Bonney's "Ice-Work."—Glen Roy.

By Dugald Bell, F.G.S.

BESIDES his numerous papers intended for experts in geological science, Professor Bonney is to be congratulated on the lengthening list of his more popular writings on the subject.

[1] Quenstedt, "Handb. d. Petref.," 1852, p. 582, pl. xlix, fig. 37; also in "Petref. Deutsch.," Bd. iii, 1874, p. 349, pl. lxxiv, figs. 10, 11.

[2] Desor and De Loriol, "Echinol. helvét.," 1871, p. 194, pl. xxxiii, fig. 3.

[3] Cotteau, "Pal. franç. Terr. jurass.," t. x, pt. 2; "Echinides réguliers," livr. ii, 1883, pl. cccxciii.

[4] Beeby Thompson, "The Upper Lias of Northamptonshire," part vi: Journ. Northampton Nat. Hist. Field Club, vol. v, 1888, p. 54; the section is described on p. 63.

A general notice of his recently-published volume on "Ice-Work" has already appeared in these pages.[1] The present writer desires, with all respect, to add a few notes on some points in which Scottish readers are more particularly interested.

In his preface, the author states that, in this book, he has "endeavoured to follow the example of a judge rather than of an advocate; that is, to sum up the evidence on each side of a case, and leave the verdict to the jury." He admits that, "like any such official," he has his "own view as to what the verdict should be, and this doubtless will be disclosed to those who can read between the lines." In other words, he does not claim that his summing-up is absolutely without bias; but that, as his opinion "has not been formed hastily or without experience." the bias is in the right direction. In such a case, it may safely be said, the assumed or ostensible office of judge is very apt to merge altogether into that of advocate, for extremely "thin partitions do their bounds divide." Indeed, we think, there are many parts of the book which are far more the work of an advocate—a very skilled advocate, we admit—than of a judge.

No doubt there are many things in all departments of science which are not yet settled, and which require careful revisal and restating from time to time. But the line of this "debatable ground" is constantly being carried forward; numbers of such disputed points are always being disposed of, and taking their place among the substantial additions to knowledge; so that, unless some new and unexpected evidence has emerged, further discussion of them becomes out of date and unprofitable. We think that at this time of day, a good many points in Glacial geology may be taken to be in this position—practically settled, and placed in the category of *Res Judicatæ*. Professor Bonney, however, reopens several of them, about which there can hardly be said to be, or to have been for many years, any question.

One conspicuous instance of this is with regard to the well-known "Parallel Roads" of Glen Roy.

"It is agreed," remarks Dr. Bonney, "that these 'Roads' are *beaches*"; but "the cause which brought the water to these levels is still a matter of dispute. By some authorities they are considered to have been formed by the sea when the land stood at a lower level than at present; the highest being the oldest, and the second and third marking pauses in the process of upheaval. By other authorities they are attributed to fresh water, and are supposed to have been formed on the shores of lakes which were held up by glaciers during some part of the Ice Age."[2]

The "dispute" is thus represented as still pending, one on which "authorities" are divided; the truth being that there has been little or no "dispute" on the subject for nearly thirty years, the advocates of the glacier-lake theory being generally considered to have proved their case, and the "authorities" being, for all that time, practically

[1] Geol. Mag., May, 1896.
[2] "Ice-Work," pp. 94–7.

ranged on their side. Agassiz and Buckland, twenty years earlier, Mr. Jamieson, Sir Charles Lyell, Sir Henry James, Sir Archibald Geikie, Dr. James Geikie, Professors Tyndall and Prestwich—Darwin also, who at first favoured the marine theory—have all in succession adopted and illustrated this view. What "authorities" can be named on the other side? Professor Bonney himself excepted, we are aware of none since the late Professor Nicol, of Aberdeen, who wrote on the subject thirty years ago.

Ten or twelve years before that time, Sir Charles Lyell, in the earlier editions of his "Manual," observed with regard to the formation of these "Roads"—"The problem is only solved in part; a large number of facts must be collected and reasoned upon before the question can be finally settled."[1] But seven or eight years afterwards so much progress had been made in this work, by Dr. Jamieson and others, that Sir Charles, reviewing the whole evidence anew, was satisfied that "the Glen Roy terrace-lines, and those of some neighbouring valleys, were formed on the borders of glacier-lakes."[2] We take Sir Charles to have been an ideal "judge" in geology; clear, impartial, painstaking, competent; always prepared to follow where well-tested evidence led. We ask, what has transpired since then that we should now be taken back to the point which he abandoned more than thirty years ago? Why should his later decision in the matter be ignored, the evidence on which it rested set aside, and the history of these "Roads" still spoken of as 'likely to remain among the controversial questions of geology,"[3] as if nothing had been attempted, nothing done, no fresh facts collected or additional light gained, for more than a generation?

It will be admitted that among the first merits of a good judge are precision in the citation of similar cases ("chapter and verse" being usually given), and clearness in distinguishing between those which bear directly on that in hand, and those which only affect it remotely, if at all. But even the "common juryman" can see that Dr. Bonney's "instances" are frequently of the vaguest and most unsatisfactory kind.

"The advocates of the marine origin," we are told, "call attention to the fact that terraces of a *rather similar* kind occur at *lower levels* in other parts of Scotland, especially on the western coast" (p. 97). Doubtless some one, to us unknown, has used the argument in this form (the italics are ours); but we wonder that Dr. Bonney should repeat it as of any value. The essential points to be stated are, *Where*, and at *what level*, are the "terraces" referred to; and then we may be able to judge how far they assist us in Glen Roy. Again, with regard to the difficulty, on the marine theory, of the uniformity of the subsequent re-elevation—it being "improbable that the whole valley, about ten miles long, would be uplifted to the same amount"—Dr. Bonney gives as the answer to this, that "in other parts of Scotland, terraces admitted to be of marine origin alter their level

[1] Fifth edition, 1855, p. 89.
[2] "Antiquity of Man," p. 264 (1863).
[3] "Ice-Work," p. 107.

but slowly" (p. 98). Nothing can be made of this without further particulars.—Once more, in noticing the difficulty that "no marine organism has been detected among the materials of the roads," Dr. Bonney gives the answer, without any indication of its insufficiency, that the objection "might be urged with equal force in regard to many of the terraces in Scotland . . . the marine origin of which is not disputed" (p. 99). For the third time, we wonder *what* terraces are referred to. We know of none admitted to be marine, though destitute of marine remains. And though this were so, we presume that laxity of inference in one case cannot be cited as justifying similar laxity in another.

The "sea-marks" in Norway are more than once alluded to by Dr. Bonney; but it is not asserted that they even approximately coincide with the terraces in Glen Roy; in reality, the highest of them is much lower than the lowest in that glen, and they are quite different in position and other essential respects, so that it is not apparent how they help the case. Why do not the Glen Roy terraces, if marine, extend along the present coast like those in Norway? Next, "the coast of Peru" is mentioned—a "far cry," indeed, from Lochaber!—and, finally, after this circuit, Moel Tryfaen, Gloppa, and "other localities," which, as Dr. Bonney is doubtless well aware, are all "in dispute" at present, and some of which, including Moel Tryfaen, are being largely given up as proofs of submergence.[1]

Coming to other difficulties which have been urged against the "marine theory," Dr. Bonney continues to indicate the "replies," in all cases, as if perfectly sound and satisfactory. Thus, "if these beaches have been formed by the sea, it is difficult to understand why they do not occur more generally"—[or rather, why they do not occur at all]—"in the neighbouring valleys, and in other parts of Scotland." This is a difficulty which Lyell thought had never been got over. But Dr. Bonney calmly continues: "To this it is answered, that there is *a beach* in Glen Gluoy, and *some traces* are found, *though at different levels*, in Glen Spean *and elsewhere*"![2] We turn to our fellow-occupants of "the box," to see what they think of this answer. It seems to us that the beach in Glen Gluoy, instead of lightening the difficulty, immensely increases it. That beach does not correspond with any of the terraces in Glen Roy, as it should certainly do, had both glens been alike occupied by the sea; it is higher than any of them. Why is this so? Why did not the sea form *as high* a line in Glen Roy as in Glen Gluoy, and as *many lines* in the one glen as in the other? Nor is anything gained by referring to terraces "at different levels" in Glen Spean; these are all part of the very phenomena under discussion, and are explained by one of the parties in the case as due to the same local cause. What is wanted are similar beach-lines *at similar levels* in many other glens of Scotland, which the sea, if it ever stood at that height, must have formed. Where are they? Dr. Bonney says they are "elsewhere"!

[1] See Dr. J. Geikie's "Great Ice-Age," 3rd ed., p. 371.
[2] "Ice-Work," p. 98. (Italics ours.)

But, it is added, terraces of this kind "are only formed under exceptional circumstances, and are accordingly local in occurrence" (p. 98). This is just what has to be explained, and what we think the "glacier theory" does explain. Can Dr. Bonney indicate what exceptional circumstances, in the event of a submergence, favoured the formation of these beaches in Glen Roy rather than in Glen Gluoy, and in many other glens nearer the coast and opening more directly on the sea? Why, for example, should these alleged sea-beaches not be found in the neighbouring Great Glen, which, in the event of a submergence, must have been powerfully acted upon by the sea; as also in the Tay valley, the Forth and Clyde valley, the Tweed, Annan, and Nith valleys, and others? We can see no answer to these questions.

Noticing again the discrepancy between the terrace in Glen Gluoy and the highest in Glen Roy, which "ought to agree" (the heads of the glens being only a few hundred yards apart), instead of the former being some 15 feet higher,[1] Dr. Bonney adds that "the facts stated merely require that the land in rising should be tilted slightly upwards towards the north, while it remained nearly at the same level towards the west" (p. 98). We are not aware that the roads have been observed to rise towards the north, or are appreciably higher in the upper part of the glen than in the lower. All the earlier observers and surveyors dwell on their "perfect horizontality"; but we know that later measurements show certain —after all, unimportant—deviations. Prof. Prestwich pointed out that instead of a perfect level, the roads are "slightly waved," forming partial "curves," there being a difference of a good many feet between the highest and the lowest points of each, bearing a very small proportion, however, to their entire length. "To all appearances," he admits, "they are perfectly level." Sir Henry James, the former Director-General of the Ordnance Survey, stated that they "deviate slightly from horizontality in those parts where streams from the mountains above have cut small watercourses through them"[2]—which is just what might be expected. Indeed, we think the marvel is that, in spite of the loose and sandy nature of the material, these remarkable lines are still so perfect and so nearly level. There is no evidence that we are aware of in favour of any "tilting to the north," nor do we think that the sudden difference of 15 feet between the terrace in Glen Gluoy and the highest in Glen Roy, "only a few hundred yards apart," can be so explained. Besides, Glen Gluoy lies to the *westward* of Glen Roy, where Dr. Bonney supposes the land to have "remained nearly at the same level."

The truth is that, while Dr. Bonney thus labours on these minor points, a greater difficulty is all the time placed before him, which he simply passes by—viz., the fact that each "road" coincides with a *col* or opening out of the glen in which it occurs. Why should

[1] We may here repeat the figures as an aid to the reader's memory. Terrace in Glen Gluoy, 1166 feet; those in Glen Roy, 1151, 1067, and 855 feet.

[2] Notes to the Survey Map of the district.

this be if these shelves were formed by the sea? The line in Glen Gluoy, so much higher than any in Glen Roy, corresponds with its higher *col*; the three in Glen Roy all correspond with openings out of that glen and Glen Spean into the greater valley of the Spey. Did the "pauses" in elevation, "during which the roads were made," vary in these glens, and not affect others at all? It is surely impossible to imagine that the degree of submergence, and then of re-elevation, had any reference to the height of these *cols*; or that these "pauses" happened to take place, in every instance, just when the sea reached their level!

This fact, in our humble judgment, is of itself conclusive against the "marine submergence" theory; and, indeed, constitutes, as Mr. Jamieson has remarked, a *fourfold proof* in favour of the alternative, or "lake-theory." It shows, we think, in the clearest manner possible, that these "roads" were due to a *local cause*—to this particular group of glens being at one time blocked to the level of their highest *cols*, and subsequently in a smaller degree, to that of the side-*cols*; and that then the water, the natural drainage of the glens, found egress successively by the lower outlets, as these became available for it.

REVIEWS.

I.—The Great Rift Valley, being the Narrative of a Journey to Mount Kenya and Lake Baringo; with some account of the Geology, Natural History, Anthropology, and Future Prospects of British East Africa. By J. W. Gregory, D.Sc. (Lond.), F.G.S., F.R.G.S., F.Z.S., of the British Museum (Natural History). With Maps and Illustrations. Royal 8vo, pp. xxii and 422. (London, 1896: John Murray. Price 21*s*.)

(WITH PLATE XI.)

THE story of Dr. Gregory's adventurous journey to Mount Kenya and Lake Baringo, which the author has now placed before the world in the admirable volume just published by Mr. Murray, is not wholly unknown to many of us, for, on his return, he delivered an excellent evening lecture before the British Association at Oxford in August 1894, he also gave an account of his journey in a paper to the Royal Geographical Society, so that we have already learned from his own lips the main facts connected with that very plucky and (fortunately for the world of science) successful expedition. Anyone, however, who has a love of travel—whether he has heard Dr. Gregory tell his story or not—will take up this volume with interest, and will probably do, as we have done, *read* the book, instead of writing a review of it! For the story of British pluck and endurance, the dogged determination to overcome obstacles, however trying and apparently insuperable, always commends itself to the Anglo-Saxon, and makes his heart beat with pleasure and pride to claim such an one as a man and a brother.

In addition to the narrative, which of course occupies a large

THE SOUTHERN SHORES OF THE VICTORIA NYANZA (*after Gedge*).

THE WESTERN WALL OF TANGANYIKA (*after Giraud*).

Two types of African Lake-Shores.

Reproduced by permission of Mr. John Murray, from Dr. Gregory's "Great Rift Valley."

proportion of the book, there is abundance of matter for the political economist, for the geographer, anthropologist, and the geologist. Botany and zoology have also gained by the varied novelties that Dr. Gregory has brought back. Some interesting cases of mimicry were observed by the author, one of which (drawn by Mrs. Gregory), representing a cluster of insects (*Flata nigrocincta*) grouped so as to resemble a flower-spike, forms a charming frontispiece to this volume.

Reverting to the title of the book, one is led naturally to seek for explanation of the term "the Great Rift Valley." We find an answer (on p. 3) where the author refers to Mr. F. Galton's statement, when discussing Mr. Thomson's paper on his journey through Masailand, namely, that the great depression or trough in which Naivasha and Baringo lie, is part of one "which begins with the Dead Sea, extends down the Red Sea, and ends at Tanganyika."

A study of the Lake-system of East Africa enables us to see clearly that the lakes are developed according to two absolutely different types. "Some are rounded in shape, as the Nyanza; others are long and narrow, as Tanganyika and the Nyasa." An examination of the lakes themselves shows "that the round lakes have low shelving shores, and that the long ones lie like fiords, between high, precipitous cliffs."

"The map shows us that these two types of lakes are not distributed haphazard, but on a definite plan. The long fiord-like lakes occur on two lines, which pass one on either side of the Nyanza and meet at Basso Narok (Lake Rudolf). Thence the line continues northward as a long strip of low land, dotted with lakes and old lake-basins, and sinking in places below the level of the sea. This extends to the southern end of the Red Sea, which repeats the structure of these fiord-like lakes on a larger scale: it is long and narrow, and, excluding some strips of coast deposits, has high, precipitous shores. From its northern end the Gulf of Akaba leads to another valley with similar characteristics, and from this the Dead Sea and Jordan valley continue the same type of geographical structure, till it ends on the plains of northern Syria.

"From the Lebanons, therefore, almost to the Cape there runs a valley, unique both on account of the persistence with which it maintains its trough-like form, throughout the whole of its course of 4,000 miles, and also on account of the fact that scattered along its floor is a series of over thirty lakes, of which only one has an outlet to the sea.

"This valley and its lake-chain are so different from anything else on the surface of the earth, that it is natural to ask whether different portions of it have been formed independently, or whether it was all formed at the same time and by the same process. The final answer to this question must be given by geology, but history affords us some useful hints. All along the line the natives have traditions of great changes in the structure of the country. The Arabs tell us that the Red Sea is simply water that did not dry up after Noah's deluge. The Somali say that when their ancestors crossed from Arabia to Africa there was a land connection between the two, across the Straits of Bab-el-Mandeb. The natives of Ujiji, at the southern end of the line, have a folklore that goes back to the time when Lake Tanganyika was formed by the flooding of a fertile plain, rich in cattle and plantations. And at the northern end of the valley we have the accounts of the destruction of the towns of Sodom and Gomorrah.

"There is geological evidence to show that great earth-movements have happened along this Rift Valley, as it may be termed, at a recent date, which makes it distinctly probable that these traditions are recollections of the geographical changes.

"The structure of the Rift Valley has, therefore, very varied interests—geological and geographical, on account of its connection with the history of the eastern basin of the Mediterranean, and ethnographical, on account of its explanation of some of the best-known stories in our folklore. But it comes in contact with the problems of science on yet another side." "If all the air and water were removed from the earth, then the Rift Valley would present much the same aspect to the inhabitants of the moon as some of the larger of the lunar rills present to us. So the exploration of the Rift Valley has the additional attraction of offering the possibility of explaining the nature of some features in the surface of the moon."

From the days of Murchison in 1852 to the publication of Prof. Suess's memoir in 1891 writers in general on Africa seem to have held to the view of the great simplicity of Tropical Africa, and the long conservation of its ancient terrestrial conditions. If we turn to the Geological Map of British East Africa (p. 217) we shall see that a vast area is here covered with lava-flows on so gigantic a scale, that those of Vesuvius and Etna sink into insignificance beside them; they can only be compared with the great lava-sheets of America and the Deccan traps in India; the latter cover an area of 200,000 square miles, and those of the Western States of America have been estimated to occupy a tract as large as Great Britain and France combined. Richthofen and Geikie have suggested that these great lava seas were discharged from subterranean reservoirs through fissures possibly hundreds of miles in length, instead of through simple circular vents.

Dr. Gregory suggests that instead of a long line of fissure eruptions the plateau was probably traversed by a double series of lines of weakness crossing one another like a network, and that from the intersection of these lines numerous flows of lava would occur which would coalesce into continuous sheets. He describes these as plateau eruptions, rather than as fissure eruptions (p. 219). He then goes on to describe the mode of formation of the Great Rift Valley, contrasting it with the sinuous course and rounded slopes produced by denudation such as we are familiar with in England. "On emerging from the Kikuyu forests, we entered one which was straight in direction, and was bounded by parallel and almost vertical sides; its characteristic features were that its lines were straight, and that its angles retained some of their original sharpness, for the direct action of faults and earth-movements still dominated the scenery. An hour after entering this valley, we reached the edge of the Great Rift Valley, which, like the former, must be directly due to earth-movements. Once the plateaux of Mau and Kikuyu were continuous across the site of the Rift Valley; a double series of north and south [faults] cut through the plateaux and allowed the block of material between them to subside. This left a great open Rift Valley (or, to use Prof. Suess's term, a 'Graben'). In this method of valley formation strips of country have fallen owing to a series of parallel cracks or 'faults,' and thus a valley has been formed with precipitous, and sometimes step-like sides. Such valleys have long been known in America, and the extraordinary steepness of their bounding walls may be seen in photographs of the Yosemite Cañon in California" (p. 220). We have dwelt rather more fully upon this part of Dr. Gregory's book, because he tells us that the desire to obtain more precise information as to the structure and origin of this Great Rift Valley was the main reason for his undertaking the journey described in this volume.

We commend Dr. Gregory's book most highly for its many-sided and suggestive views on a great variety of subjects, which are most ably discussed, and with a freedom of opinion and an absence of prejudice truly refreshing. We were much struck by the author's remarks that much of the political trouble in East Africa has arisen in consequence of our interference with that most ancient and well-recognized institution of slavery, which has doubtless been maintained by the Arabs for more than 3,000 years in the country, and could not be interfered with save by provoking the deadly hatred of this most powerful and intelligent race. "We have tried to destroy that which was an integral part of the social system of the ruling race, without realizing how vast a cavity would be produced, and how fatal it would seem to them.

* * * * * * * * * *

"At Melindi, at Mambrui, and Magarini, in fact all along the coast, extensive plantations are being abandoned owing to the impossibility of obtaining sufficient labour. The Arabs see their property being ruined, and are naturally hostile to British rule." . . . . . . "The system of slavery in East Africa is really that of serfdom, and has been as necessary in the development of the country as feudalism was in Europe. Under the laws now in force the slaves will gradually die out and be replaced by freemen, and the change had far better come slowly than by a sudden revolution" (p. 380).

We must now bid the author adieu. We advise those who would enjoy a delightful and attractive volume to procure Dr. Gregory's charming book and read it for themselves.

By the kindness of Mr. John Murray we are permitted to reproduce on our Plate XI two types of African lake-shores, namely, that of Victoria Nyanza and the western wall of Lake Tanganyika, both taken from Dr. Gregory's work, p. 3.

II.—The Students' Lyell: a Manual of Elementary Geology. Edited by John W. Judd, C.B., LL.D., F.R.S., Professor of Geology, and Dean of the Royal College of Science, London. With a Geological Map and 736 Illustrations in the text. 8vo, pp. [24] and 636. (London, 1896: John Murray. Price 9s.)

THE editor of the students' textbook before us says—"The writings of Sir Charles Lyell occupy so undisputed a position among the classics of science that no apology is needed for the issue of the present work." Still the question may not unnaturally be asked what is the claim, what is the secret charm, of Lyell's writings which have attracted men of science and the public so strongly to accept his teachings, and even now, after he himself has passed away more than twenty years, his name is still a talisman to the seeker after geological truths, and his deductions are still held to be the guiding principles of our science.

If we look carefully into our Lyell we shall find that the writer is not only the historian and teacher, but he is also the observer and the inquirer. He takes us with him and shows us the action of rain and rivers on the surface of the land; the formation of river-valley terraces and deltas; the action of the sea, the wasting of cliffs, the formation of shoals and sandbanks, and the transport of materials along our coasts. We can pry with him into the extinct craters of the Auvergne or watch the still active volcanoes of Etna or Vesuvius. We learn from him the effects which have been brought about by the upheaval and foldings of the earth's crust, and the changes produced in the configuration of our continents by the agents of denudation during the gradual elevation of the land, and subsequently by the slow but untiring efforts of those subaerial agents ice, frost, snow, rain, and rivers, through vast periods of time over the broad surfaces of the earth.

Under Lyell's guidance we are led step by step from the operations of Nature now taking place around us, to reason upon the condition of the earth's surface in past ages, how these earlier physical changes were brought about, and what was their effect upon climate and life.

As we pursue our inquiry further and further back into the past, we perceive that, notwithstanding the numerous changes which our earth has undergone, and the appearance and disappearance of some entire groups of organisms, other persistent types have survived, often but little modified through the lapse of vast eons of time down to our own day. The conclusion is strongly pressed upon us that we are not dealing, as the earlier writers supposed, with a series of detached and isolated geological events or periods, each separated from the other and heralded by a huge catastrophe which swept away all pre-existing life and was succeeded in each case by a brand-new creation of its own. We now know that notwithstanding the varied changes of land and sea conditions which our earth has witnessed, there never was a period of total extinction of life since the first organic beings made their appearance on our planet, but that the seeds of living organisms have persisted through all ages from the dawn of that life in pre-Cambrian times down to the present day.

It is no doubt largely due to the doctrine of evolution which Lyell has applied to geology, and to his sound methods of reasoning, based upon the study of the phenomena of existing Nature as furnishing us with the safest interpretation of what has taken place in the past history of our earth, that has given to his writings their worldwide reputation and their greatest charm.

In looking back upon the past history of the "Students' Elements," as it was formerly called, we shall only be enhancing its value by mentioning that its previous editions received, in addition to the hand of Lyell himself, the labour of the late Prof. P. M. Duncan, Mr. S. V. Wood, David Forbes, as well as of Robert Etheridge and Prof. T. G. Bonney, so that its reissue under the able editorship of Prof. Judd ought to assure for it a further profitable and protracted term of existence. The introductory chapter, dealing with geology in relation to other physical sciences and the causes which have retarded the progress of geology, is new and gives an interesting review of the science from the pen of one who is daily engaged in its exposition.

The illustrations are mostly excellent, and include not only 136 figures added since the last edition, but also a carefully prepared and coloured geological map of England and Wales as a frontispiece. The last six pages, devoted to appendices of living forms, should be carefully revised in a new edition. By the adoption of double columns and smaller type for the matter at the end of each chapter, much additional information has been introduced without enlarging the work more than by about 14 pages, nor has the price been increased.

We wish the work every success, and feel sure that its sale will be as large and its merit as lasting as the remembrance of the name of Lyell himself.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 27th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that a portrait in oils of the late Prof. Huxley had been presented to the Society by Sir John Evans, K.C.B., For.Sec.G.S.

The following communications were read :—

1. "On the Pliocene Deposits of Holland, and their Relation to the English and Belgian Crags; with a Suggestion for the Establishment of a new Zone 'Amstelien,' and some remarks on the Geographical Conditions of the Pliocene Epoch in Northern Europe." By F. W. Harmer, Esq., F.G.S.

The author draws attention to some papers by Dr. J. Lorié, of Utrecht, describing the strata met with in some deep borings in Holland, which show that the Newer Pliocene is in that country nearly 500 feet thick, and that it has been depressed more than 1000 feet below its original position. He inquires whether this subsidence can be connected with the elevation of the Older Pliocene in Belgium and Kent, and how far these earth-movements can be traced in East Anglia and influenced the deposition of the English Crag.

He gives particulars of the alterations in level which have taken place during and since the Crag period in England and on the Continent, showing that the two movements of upheaval and subsidence have much in common, and especially that they regularly increase in degree to the north and south respectively.

He gives a map showing the extension of the Diestien deposits of Belgium, and their probable connection with the Lenham Beds, and opposes the view of M. Dollfus that the Diestien sea was closed to the south, though the connection with it was probably cut off by the elevation of the southern part of the area at the close of the Diestien epoch, which also caused the Scaldisien sea to retreat to the north. At the close of the Scaldisien period the sea retired from Belgium altogether, no beds equivalent to the Upper Crag of England being known in that country. A similar alteration of the margin of the Crag sea can be traced in East Anglia.

He analyzes the fauna of the Scaldisien and Poederlien, and shows its close correspondence with that of the Walton bed, and the difference between it and the Upper Crag, which contains Arctic shells.

He describes the beds met with in the Dutch borings, regarded by Dr. Lorié as Diestien and Scaldisien, and their fauna, at some length. He concludes that a large part of them are altogether newer than the latter formation, and are equivalent to the Butley Crag, and he proposes for them the term "Amstelien."

He doubts whether any deposits of similar age to the Norwich Crag or Chillesford Beds have been met with in the *sous-sol* of Holland, which he considers became at that time a land-area; and he gives a section to show wherein his classification of the Dutch strata differs from that of Dr. Lorié.

The distinction between the divisions adopted by the author comes out more clearly from the consideration of the abundant and characteristic species only, of each of which he gives lists.

Although the Amstelien beds are more than 400 feet in thickness, they contain a shallow-water fauna, and were deposited in a basin which subsided *pari passu* with their accumulation.

In the map an attempt is made to show the limits of the sea of the Anglo-Dutch basin during the various stages of the Pliocene epoch.

It is suggested that the Chillesford Clay was deposited in an estuary through which the Rhine discharged into the North Sea, its presence in the western portion of the Pliocene basin being caused by the elevation of Holland after the deposition of the Amstelien and a subsidence in Suffolk, which carried the Chillesford Beds over an area which was not covered by the Norwich Crag sea.

No equivalents of the Weybourn Crag or of the Cromer beds (Forest Bed series) have been found in the Dutch borings. These are to be referred to the Pliocene, as pointed out by Mr. Reid, but possibly some of the unfossiliferous pebbly gravel of Norfolk and Suffolk may be Pleistocene.

The Weybourn Crag marks a re-invasion of East Anglia by the sea; but previously to the deposition of the Cromer beds the southern margin of the Pliocene gulf had again retreated to the north, and an estuary, similar to that of the Chillesford Clay but situated farther east, received the waters of the Rhine, which brought down the drifted remains of mammalia and some southern mollusca.

The newest portion of the Cromer deposits is of an Arctic character, and seems to show that no great interval separated the Pliocene and the Pleistocene periods.

A second subsidence of the Dutch area took place in Pleistocene times; the Glacial and post-Glacial beds being 600 feet thick under Amsterdam. No Till or contorted Drift similar to the deposits occurring in East Anglia and in the district north-east of the Zuyder Zee has been met with in these borings. The glaciation of Holland proceeded from the Baltic, and not from Norway, and the Baltic ice does not seem to have reached the Dutch coast; still less could it have travelled thence in the direction of East Anglia.

The two prominent physical features of the Pliocene period were the Rhine and the basin of the North Sea. The hypothesis of a permanent basin with shifting shore-lines, in contiguity to which the shallow-water deposits of the Upper Crag were deposited, seems to agree with all the facts of the case, and to throw light on the geographical conditions of the Pliocene epoch.

2. "The *Lingula*-Flags and Igneous Rocks of the Neighbourhood of Dolgelly." By Philip Lake, Esq., M.A., F.G.S., and S. H. Reynolds, Esq., M.A., F.G.S.

The area dealt with in this paper lies south and west of Dolgelly, between the Arthog road and the hill called Mynydd Gader, which lies in front of the precipices of Cader Idris. The stratified rocks belong to the Middle and Upper *Lingula*-Flags and Tremadoc Slates. The Middle *Lingula*-Flags (Ffestiniog Series) consist of bluish slates with grit-bands containing the usual *Lingulella*, passing into Upper *Lingula*-Flags (Dolgelly Series) consisting of dark slates with *Orthis lenticularis*, *Parabolina spinulosa*, etc., and containing two andesitic lavas. These pass into the basal Tremadoc Slates, with *Dictyograptus flabelliformis*, surmounted by an upper volcanic series with rhyolitic lava. Subsequent intrusions of diabase occurred, of a laccolitic character, but of such a nature as to lead the authors to suggest the possible intrusion of the diabase along a line of unconformity in one case; there is, however, no newer rock above the diabase to indicate of what date the overlying beds would be if such unconformity occurred. It is further shown that the important faults in the area were produced both before and after the diabase intrusions, and in one case the movement appears to have been in one direction before the intrusions, and in the opposite direction afterwards.

3. "The Kildare Inlier." By S. H. Reynolds, Esq., M.A., F.G.S., and C. I. Gardiner, Esq., M.A., F.G.S.

The area described in this paper is occupied by four prominent hills composed of Lower Palæozoic rocks rising as an inlier from beneath Carboniferous beds. The authors give the following succession of rocks in descending order:—

6. Green and grey micaceous grits and shales of Dunmurry.
5. Red and black shales.
   Gap: no exposure seen.
4. Limestones of the Chair of Kildare.
3. Contemporaneous igneous rocks.
2. Fossiliferous ash of Grange Hill House.
1. Green gritty shales (unfossiliferous).

Nos. 5 and 6 are referred with some doubt to the Llandovery Series, and perhaps also to higher series. The gap may conceal the uppermost beds of the Bala succession. The limestones of the Chair of Kildare are separated by the authors into four subdivisions of the same general age, and *Agnostus trinodus, Illænus Bowmanni, Remopleurides longicostatus*, and *Cyphoniscus serialis* range throughout. The contemporaneous igneous rocks of Grange Hill and of the Hill of Allen are shown by the fossils found in the pyroclastic rocks to be of Middle Bala age. The lavas consist of basalts and andesites, which the authors separate into four groups distinguished by their lithological characters. Petrographical details of these various rocks are given in the second part of the paper. The age of the lowest beds which have not yielded any fossils is doubtful.

II.—June 10th, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Foliated Granites and their Relations to the Crystalline Schists in Eastern Sutherland." By J. Horne, Esq., F.R.S.E., F.G.S., and E. Greenly, Esq., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The crystalline schists of Eastern Sutherland are traversed by great numbers of granitic intrusions, chiefly in the form of lenticular sills. These generally lie parallel to the foliation-planes of the schists, but transgressive junctions are also frequent. Thin seams of granite also occur in such abundance as to constitute with the schists a banded gneissic series; but these seams can often be seen to transgress the schistose folia, and even often to proceed from large masses of granite. The granites contain numerous inclusions of the schists which they traverse, such inclusions retaining, usually, the dip and strike of the surrounding rocks.

There are no chilled edges; and, moreover, the component crystals of schist and granite mutually interlock along the lines of junction.

The authors give an account of the foliation of the granite. In some rare cases a foliation parallel to that of the schists traverses granite-veins. It is generally, however, parallel at once to the sides of the sill and to the foliation of the schists; and many of the structures are the remains of biotite-folia belonging to schists whose quartzo-felspathic elements have been incorporated with those of the granite. But many sills or veins, traversing the schists at various angles, are foliated parallel to the line of junction, and so discordantly to the structures in the schists; and foliated granites may even be observed to cut each other's foliation. These can hardly be anything but original igneous structures; but, if coexistent with the last-named, would be indistinguishable from it.

The country-rocks are various types of biotite-schist or gneiss, with quartz-schists at Kildonan, and a scapolite-limestone at Armadale. They are almost all holocrystalline, but it is certain that sedimentary rocks enter into the complex. The whole series is powerfully folded.

The granites increase in size and numbers north-westward from Kildonan, the intimate intrusive relations above described becoming more highly developed in the same direction. The schists, at the same time, become more and more highly crystalline, sillimanite also appearing in them. About Kinbrace they are coarse sillimanite-biotite-gneisses, with large striated felspars.

Igneous contact is not held to be the sole origin of metamorphism, though the cause which brought about the introduction of the granites has evidently also produced these high types of crystallization. The evidence of powerful movement which the schists everywhere present suggests that such movement was the initial cause of the whole series of phenomena. Movement recurred throughout, though all cataclastic structures (if such existed) have been wholly effaced by crystallization; introduction of granite being the final stage in the production of the complex, and a high temperature (as shown by the absence of chilled edges) being maintained to the very end.

With regard to the granites, the authors find it difficult to believe that they are wholly foreign matter, but remark that it is here necessary to observe the utmost caution.

2. "The Geology of the Eastern Corner of Anglesey." By E. Greenly, Esq., F.G.S.

The notes contained in this paper embody the principal results obtained during a survey of Anglesey on the six-inch scale.

The schists of the south-east of the island are succeeded unconformably by the slates of Careg Onnan, which appear to be separated by a strong unconformity from the Ordovician shales. The Careg Onnan slates appear (pending confirmation from other sections or direct fossil evidence) to be of pre-Cambrian age, and the author records the existence of sponge-spicules therein.

The ashy grits and bedded tuffs of Baron Hill, near Beaumaris, appear to have been moved somewhat from the ENE. along a thrust-plane. They are traversed by planes of mylonization, and are much broken and folded.

The Ordovician rocks consist chiefly of sparingly fossiliferous dark shales and mudstones, but contain a group of volcanic tuffs on the horizon of the pisolitic ironstone.

The Carboniferous rocks appear to be about 700 feet thick, and contain conglomerates, sandstones, and shales, with plant-remains about the middle of the series.

The glacial striæ sweep round from SSW. at the north, to S.W. and WSW. at the south end of the district. In the Penmon area there is cross-hatching with a series running SSE., and it is suggested that this is due to fluctuations in the power of the Carnarvonshire glaciers to deflect the ice coming from the north, combined with the local influence of certain high ground.

3. "Seismic Phenomena in the British Empire." By M. F. de Montessus de Ballore, Captain of Fortress Artillery at Belle-Île-en-Mer. (Translated by L. L. Belinfante, B.Sc., B. ès L. Communicated by Sir Archibald Geikie, D.Sc., F.R S.)

The author gives a brief outline of a plan that he has elaborated for studying Seismology. He has separated his work into four parts—I. The formation of an Earthquake Catalogue. 2. Refutation of the empirical laws previously enunciated. 3. Description of the globe from a seismological point of view. 4. Investigation of the characters which differentiate stable from unstable regions.

He gives a method by which the relative *seismicity* (or instability as regards earthquakes) of regions may be obtained and registered, and indicates some of the results which he has derived from his study, including the intimate relationship between instability and surface-relief, and the independence of seismic and volcanic phenomena.

The main part of the paper is a section of the third division of the author's work, and deals in detail with the earthquakes of the British Empire. In this part of the paper, the recorded earthquakes of the British Isles, India, Australia and New Zealand, British Africa, Canada, and various scattered possessions are described.

CORRESPONDENCE.

EOCENE BEDS AT BINCOMBE, DORSET.

Sir,—In your last issue (p. 247) Mr. Fisher says that if I had seen the section of Eocene beds at Bincombe open as he did, I might not have been at a loss to find room for the full thickness of chalk below them. But though I did not see the section, I had seen what was next best to it, and that was Mr. Fisher's account of it, showing the Eocene to be vertical. The chalk also is almost certainly vertical, or nearly so, between the Eocene and the mouth of the tunnel, where we are close to its base, but even so I was not able to pack in its full thickness, and had therefore to assume an overlap by the Eocene.

Mr. Fisher explains the occurrence of the Eocene gravels on the theory that they are wedged into the chalk by two faults, and do not occur as an outlier in the usual sense of the word. This explanation involves certain difficulties. The shape of the outlier, as I still think it must be called, is roughly oval; the mass dropped in would therefore be cone-shaped. If it were a case of piping, which I do not think it is, this might be intelligible, but it is difficult to conceive a fault taking such a form. Nor is the difficulty lessened by the occurrence of several other small outliers in the immediate neighbourhood.

The structure seemed to me to be the same as that of the narrow strip of Tertiary beds near Lulworth, as Mr. Fisher suggests, except in one detail. In both cases the chalk, after running horizontally, or even dipping gently southwards, turns abruptly up so as to dip at 80° or more northwards; and in both, Tertiary beds, reposing naturally upon the Chalk, have shared in the flexure, and have been preserved from denudation in the elbow of the fold. But while at Lulworth the Isle of Purbeck fault coincides with the abrupt upturn of the strata, and thus runs between nearly horizontal Chalk and Eocene and nearly vertical Chalk, at Bincombe the Ridgeway fault runs at the base of the Chalk, and between it and Oxford Clay. I was not able to find any faulting there between the Chalk and the Eocene. That the abrupt upturn traverses the Bincombe outlier, we know by the fact that the gravels composing it are partly vertical, as shown by Mr. Fisher, and partly gently inclined, as proved by an exposure close to the western end of the outlier, where the chalk dips at only 15°. I quite agree with Mr. Fisher that in passing from south to north he is reading an ascending section in the Eocene strata.

A. Strahan.

Cardiff, *8th June*, 1896.

THE AYRSHIRE "SHELL-BEDS."

Sir,—Many of your readers have doubtless been interested by Mr. John Smith's letter in your last number regarding his discovery of "interglacial shell-beds" at various heights in Ayrshire. Mr. Smith also read a paper on the subject at a recent meeting of the Geological Society of Glasgow.

While fully acknowledging Mr. Smith's great industry and perseverance in tracing out these "shell-beds," I would ask leave through your columns to repeat a *caveat* which I ventured to express at the meeting referred to, viz., against assuming offhand that the deposits are necessarily "interglacial," or true marine deposits *in sitû*. It appears to me that there are many hints and indications that they may be accounted for in another way, and that it will require further prolonged and careful observations before we can pronounce upon them with any certainty. There can be no doubt, to begin with, that the Clyde ice extended in great force over the lowlands of Ayrshire up to the feet of the Galston and Muirkirk Hills. Boulders of West Highland schists are found plentifully as far up as the neighbourhood of Loudon Hill, and in similar localities. The abundant deposits of sand, gravel, and silt in some of the side-valleys are just what might be expected in these circumstances. The crushed and fragmentary condition of the shells, or very many of them, also suggests caution in drawing inferences. In some places they are found in the typical boulder-clay of the district.

I have since had the pleasure of seeing some of the sections in Mr. Smith's company. All I say is, there are abundant materials for investigation, and it will be well not hastily to leap to conclusions. *Festina lentè* is a good motto—especially as regards shell-beds.

GLASGOW, 11*th June*, 1896. DUGALD BELL.

P.S.—By the way, the term "shell-bed" is apt to be misleading. It may suggest a well-defined layer or band of shells, fairly well preserved; but the actual "find" is often only some fragments scattered here and there throughout the clayey or sandy deposit, as the case may be.

OBITUARY.

THOMAS BEESLEY, J.P., F.C.S.

BORN MARCH 28TH, 1818. DIED MAY 15TH, 1896.

THOMAS BEESLEY, who was born at Banbury, commenced business as a chemist and druggist in 1844 at Chipping Norton; two years later he succeeded to a similar business in his native town, and from this he retired in 1887. He was a man of great literary and scientific culture, expert as an analyst, and one who had a wide acquaintance with botany, archæology, and geology. During the past thirty years he gave especial attention to geology, and in 1872 communicated a valuable paper on the geology of the neighbourhood of Banbury to the Warwickshire Naturalists' Field Club (see GEOL. MAG., vol. ix, p. 279). In the following year he acted with Prof. Morris in directing an excursion of the Geologists' Association to Banbury (Proc. Geol. Assoc., vol. iii, p. 197). The Lower Lias of Fenny Compton engaged much of his attention, and he made a fine collection of fossils, especially of Belemnites, from the zones of *Ammonites Jamesoni*, *A. armatus*, etc. (Proc. Warwick Nat. Club, 1877). Later on he gave an account of the sections exposed on the railway between Banbury and Chipping Norton; and at Easter, 1878, he acted in conjunction with Mr. Hudleston in directing an excursion of the Geologists' Association to Chipping Norton (Proc. Geol. Assoc., vol. v, pp. 165, 378). In 1883 he announced the discovery of a new local fossil, which he named *Discina Gunnii*; but as the fact was published in the *Banbury Guardian* of August 9th it can hardly be considered as a proper palæontological record. Kind-hearted and genial by nature, Mr. Beesley was ever ready to give help and information to those who sought it, and his memory will be cherished by all who had the happiness to know him.

H. B. W.

IT is with deep regret that we have to record the death of SIR JOSEPH PRESTWICH, D.C.L., F.R.S., F.G.S., F.C.S., which took place early on the morning of the 23rd June, 1896, at his country house, Darent Hulme, Shoreham, by Sevenoaks, Kent, in his 84th year. For an account of his life and works, with an excellent portrait, see the GEOLOGICAL MAGAZINE, Dec. III, Vol. X, June 1893, pp. 241–6.

Skeleton of a large extinct Rail,

Diaphorapteryx Hawkinsi, Forbes.

FROM THE CHATHAM ISLANDS.

About one-fourth natural size. From a photograph by A. Gepp, Esq.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. VIII.—AUGUST, 1896.

ORIGINAL ARTICLES.

I.—Note on the Skeleton of *Diaphorapteryx Hawkinsi*, Forbes, a large extinct Rail from the Chatham Islands.

By C. W. Andrews, B.Sc., F.G.S., of the British Museum (Natural History).

(PLATE XII.)

It is a well-known fact that many islands in which there is no indigenous mammalian fauna, have been, and in some cases are still, inhabited by flightless birds, which are usually of considerable size. Mauritius and Rodriguez are good examples of such islands; in the former the dodo and aphanapteryx, in the latter the solitaire and erythromachus, existed at least as late as the beginning of the seventeenth century, when, owing to their inability to escape from their foes by flight, they fell easy victims to the crews of ships touching at the islands, and also to the various domestic animals, such as dogs, cats, and pigs, introduced by man.

A notable addition to the ranks of such islands was made in 1892 by Dr. H. O. Forbes,[1] by his discovery of the remains of several forms of flightless birds on the Chatham Islands. This group lies in the South Pacific, about 500 miles east of New Zealand, in about latitude 44°; it consists of one large island (Wharekauri) and several smaller ones, the geological structure of which indicates that they form part of an old continental area, and are not oceanic islands.

The birds, as might be expected, belong for the most part to species found also in New Zealand, but such characteristic flightless forms as *Aptornis*, *Cnemiornis*, the Dinornithidæ, and *Apteryx* are wanting. Instead of these, however, we find *Diaphorapteryx Hawkinsi*, a large extinct coot (*Palæolimnas Chathamensis*), and *Cabalus Dieffenbachii*. all of which are now extinct, although the only known specimen of the last-named was killed as lately as 1840. Several species, such as *Palæocorax moriorum*, in which the wings had not undergone reduction, likewise occur in a fossil condition only. The bones are usually found either in the kitchen middens of the aboriginal Moriori or in the blown sands round the coast.

[1] Nature, vol. xlv, p. 580.

The most interesting of the extinct flightless birds discovered by Forbes is *Diaphorapteryx Hawkinsi*, a nearly complete skeleton of which is figured on Plate XII. This remarkable bird is a rail closely allied to *Ocydromus*, of which several species, all incapable of flight, inhabit New Zealand. It is also very similar to *Aphanapteryx Broecki*, of Mauritius—indeed, Forbes has referred it to the same genus, although for a time he placed it in a separate one, *Diaphorapteryx*. In a detailed account of the osteology of this bird by the present writer,[1] it was shown that it differed from *Aphanapteryx* in many points, particularly in the form of its metatarsus, and the name *Diaphorapteryx* was therefore adopted; in a recent memoir by Prof. A. Milne Edwards[2] on some of the Chatham Island birds the same conclusion is arrived at.

The skeleton here figured consists almost entirely of bones belonging to one individual, but the deficiencies have been made good from the immense collection of bird-remains lately obtained from the Chatham Islands by the Hon. Walter Rothschild, in whose museum at Tring the present specimen is preserved. The skull is chiefly remarkable on account of its relatively large size and long curved beak. In the vertebral column as mounted there are twenty-three free vertebræ, thirteen of which are cervicals, two cervico-dorsals (with short free ribs), and eight dorsals; the number of cervicals is no doubt correct, but it is possible that a dorsal too many may have been introduced. The pelvis, as in most flightless birds, is relatively large; it is very similar to that of *Ocydromus*. The pelvis figured by Milne Edwards in the memoir mentioned above (pl. xi, fig. 7; pl. xii, figs. 1 and 2) is certainly not that of *Diaphorapteryx*, or, indeed, of any rail, but seems rather to belong to some anserine bird. The hind limbs are long and powerful, well adapted for running, and also, judging from the stoutness of the metatarsus, for scratching in the earth. In *Aptornis*[3] the metatarsus is even more massive, so that in this respect, as in several others, *Diaphorapteryx* comes midway between that bird and the living Ocydromine rails. The sternum is very like that of *Ocydromus*, but the keel is still more reduced. The coracoids are very small, and appear to have made an obtuse angle with the scapulæ, as is usually the case in birds incapable of flight. The wings are very small in proportion to the bulk of the bird, the metacarpus especially being extremely short.

I am indebted to the Hon. Walter Rothschild for permission to figure this specimen, and also to my colleague, Mr. A. Gepp, for the photograph reproduced.

[1] "On the Extinct Birds of the Chatham Islands." Pt. I. The Osteology of *Diaphorapteryx Hawkinsi*.—Novitates Zoologicæ, vol. iii (1896), p. 73, pl. iii.

[2] "Sur les Ressemblances qui existent entre la Faune des Îles Mascareignes et celle de certaines Îles de l'Océan Pacifique Austral": Ann. Sci. Nat. (Zoologie), ser. viii, vol. ii, p. 117, pls. xi–xv.

[3] A skeleton of *Aptornis defossor* was figured about one-sixth natural size on Plate X of the present volume.

II.—The Origin of Nitrate in Chili.

By Dr. William Newton, F.I.C., F.C.S.

FROM the first discovery of nitrate in these provinces it has been an interesting question as to what caused it to come into existence here in such abundance, and, as far as our present knowledge goes, nowhere else in the world in such quantities.

Many theories have been formed attempting to explain the presence of these deposits of nitrate; the most popular, and a theory also accepted in scientific works, being, that in past ages the nitrate pampas were sea-beaches, and that an enormous quantity of seaweed was piled up on them. In course of time these beaches were elevated above sea-level and the seaweed decomposed, leaving its nitrogen in the state of nitrate and its small quantity of iodine as iodate.[1]

Darwin suggests that the plain of Tamarugal was either a lake or an arm of the sea. If it were an arm of the sea, he at once jumps his previous estimate of 400 feet elevation of the coast of Peru to 3,000 feet and over. The sea-shells which he notes are only found with caliche (the raw nitrate) in one or two places where the nitrate bed is in contact with the Chalk, and are evidently the remains of organisms from that formation. It is unfortunate that in the great naturalist's short visit to the nitrate districts, he was apparently not informed of the periodical floods which come down from the Cordilleras on an average about every seven or eight years, and flood the whole of the plain for a short time.

The present surface soil of the pampa is evidently due to the silt carried by these floods, and as far as borings have gone the underlayers of alluvial, and, indeed, the whole filling up of the valley, are due to the same periodical action.

Apparently the plain has never been the bed of a lake, at any rate in geological times commensurate with the soluble surface deposits, unless these occasional floods can be called lakes.

The origin of this sea and seaweed theory is chiefly due to the fact, that previous to the time of producing iodine from nitrate liquors, the only source of iodine was "kelp," the ash of burnt seaweed. The decomposition of seaweed, as also all organic matters under certain circumstances, does produce nitrate. The presence of large salares on the pampas, in proximity to the nitrate, also gives colour to the idea of the former presence of the sea.

But one must bear in mind that even the salt of the sea is derived originally from the washings of the land. There is no more reason to suppose the salares are evaporated sea-water than that any of the inland salt lakes of the world were originally connected with the sea. Inland salt lakes derive their salt from the washings of the soil surrounding them. The water running into the lakes may not be very salt, but if there be no outlet from the lake, the constant evaporation, especially in hot climates, gradually concentrates the salt in them, sometimes all the water being evaporated and only a salar left.

[1] Darwin's "Naturalist's Voyage"; Watts' "Dictionary of Chemistry, etc."

Salares are also formed by the water below the surface of the soil being drawn up by capillary attraction and constantly evaporated, giving place to fresh supplies and evaporation.

To the seaweed theory of the formation of nitrate there are at least three insurmountable objections. The first is that seaweed contains bromine as well as iodine. Most of the caliche in this province does not contain bromine, as it would have done if it were derived from seaweed. There is no process in nature which could completely separate bromides from a mixture of iodates, chlorides, and nitrates. Secondly, there are seldom sea-shells or other sea débris in or near the nitrate deposits. There would necessarily be these if it had been a sea deposit. Thirdly, the stones in the caliche and its neighbourhood are sharp and jagged, showing no signs of being water-worn, as they would do if they had existed on a sea-beach.

There is another suggestion which finds much favour—that is, that nitrate may have been derived from the decomposition of ancient guano deposits. As evidence towards this, is put forward the presence of birds and their remains in the caliche. These birds have, however, apparently been always insignificant in numbers. The same birds exist at the present day, building their nests in crevices in the ground, and they have sometimes been blown up alive in the calicheras. Their guano, although in a few spots on the pampa rather prominent, is in reality little more than a colour, and the amount of nitrate which could be produced from it must be more insignificant than that of the village sewage. The great disproof of the guano theory, however, is that we find no accumulation of phosphate which would necessarily occur in a corresponding amount to the nitrate, if this idea were true.

There are other theories also put forward to explain the caliche deposits, which are scarcely worth discussing, among them being one attributing the presence of nitrate vaguely to some volcanic action. The well-known principle in scientific investigations, "Never to invent exceptional theories as long as the ordinary workings of nature are sufficient to explain the facts," should be applied in this case.

Nitrate exists in small quantities all over the world, in every fertile soil. Vegetation cannot grow without it. How, then, does it originate in these ordinary soils? It originates from the oxidation of the organic materials and ammonia in the soil. This oxidation is brought about by the action of microscopic organisms, called "nitrifying germs."

Prof. Warington by his experiments has shown that the most favourable conditions, for the active life and work of these nitrifying organisms, is a porous soil containing plenty of vegetable or animal organic matter, together with sulphate of lime and an alkaline base such as carbonates of potash, soda, or lime. Given a soil of this character, the amount of nitrate produced by the action of these organisms will vary with the temperature; the rate of manufacture of nitrate being more rapid in a high summer temperature, and diminishing as the weather gets colder.

In ordinary agricultural soils, unless they are lying fallow, this nitrate is greedily absorbed by the plant almost as fast as it is produced. In fact, except in the case of leguminous crops (clover, beans, peas, etc.), it is almost certain that the plant can only absorb the nitrogeneous food necessary for its growth when it is in the form of nitrate.

Now, in the enormous plain of Tamarugal we have a porous alluvial soil containing organic matter, chiefly of ancient vegetable origin. The soil contains also sulphate of lime and is basic in its nature, the water percolating through it containing carbonate of soda. The temperature is high, and, in fact, we have all the conditions which Prof. Warington has pointed out as favourable to the rapid conversion of the nitrogen of organic matter into nitrate. On account of the absence of rain in this district, there is now no growing vegetation to absorb the nitrate, and therefore it must accumulate.

Now let us look at the conformation and situation of the plain of Tamarugal. On one side we have the high Cordilleras running north and south; then we have this alluvial plain about 30 to 40 miles wide with a very gradual downward slope to the west, where it is again shut in by the coast-line of hills running practically parallel to the Cordilleras. The waters of the western side of the Cordilleras have no escape, except by passing through the soil of the plain. At the western side of the plain the waters are stopped by the coast-line of hills, forming a complete wall from north to south. At the foot of the eastern or landward side of this wall of hills, some thirty miles from the sea, and at the lowest about 2,500 feet above sea-level, these drainage waters of the plain gather and evaporate, giving up all the salts they have dissolved in their long passage through the soil. The mountain floods which swamp the plain of Tamarugal, at intervals of seven or eight years, are chiefly responsible for the transportation of nitrate from the superficial layers of the pampa soil. It is along the line at the foot of these hills that all the nitrate grounds are situated. Their situation, always on the landward side, is an indication that the caliche is derived from the land, and in itself almost an absolute disproof of the guano or seaweed theories. The occurrence of the nitrate so often up the first slopes of the hills seems at first view strange. But we can see by a simple experiment how this could have happened. If we put some nitrate or salt dissolved in water in a saucer, and allow it to evaporate, we shall see that immediately it has evaporated, so far as to become a saturated solution, the deposit of crystals of nitrate or salt begins to creep up the sides of the saucer and even over and down the other side—just as the caliche has crept up the lower slopes of the hills through the porous earthy strata known in Chili as cova and congelo.

This origin of nitrate is important, amongst other reasons, because one of the great drawbacks to the sale of this material is that many farmers look on it with prejudice, calling it an artificial or chemical manure. It ought to increase its sale, when it is proved to them that, instead of being an artificial manure, it is in reality the concentrated fertility of the thousands of square miles of land between the watershed of the Cordilleras and the coast-line of hills.

The plain of Tamarugal is a huge, practically inexhaustible reservoir of nitrate. And this nitrate has been gradually washed down to its western or lower side. The alluvial of this belt of country is on an enormous scale; the same thing as the heaps of mud, organic refuse, and lime which the French farmers were by law compelled to make in the time of Napoleon I, in order that these heaps should ferment, and on washing yield nitrate for gunpowder.

There are some very important questions for Chile and the nitrate officinas which arise from the above facts. Among them are: How far does the present supply of water tend to deposit nitrate again in the same grounds? Can this action be assisted and accelerated by artificial means?—such as uncovering the ground down to suitably porous strata and allowing the sun to have its full evaporative action, collecting the nitrate as in the saltpetre soils of India and Burmah.

III.—On the Existence of Rich Phosphate of Lime in the London Basin.

By M. N. de Mercey, Collaborateur au Service de la Carte Géologique de France.

The proof which I gave in June, 1891,[1] of the production of "rich phosphate" by enrichment of phosphatic chalk through the influence of the Tertiary deposit called "bief," enabled us to foresee the existence of similar rich phosphate in the London Basin; since phosphatic chalk, analogous to that which I had described or discovered in Picardy, especially at Hardivilliers and Hallencourt, had been discovered by Mr. Strahan and described by him in an interesting paper "On a Phosphatic Chalk with *Belemnitella quadrata*."[2]

I have recently examined the Taplow chalk, and am indebted for facilities for doing this to Mr. Grenfell, on whose property it occurs. This examination enables me to record the existence of "rich phosphate" occurring under precisely the same conditions as in the French localities.

At Taplow, as in Picardy, the rich phosphate must be regarded as a product concentrated from the phosphatic chalk under the influence of the deposit at the base of the Tertiaries. The rich phosphate occurs as a sand of pale chamois colour, in a pocket similar to the pockets in the Chalk of Picardy.

The pocket at Taplow with the rich phosphate occurs at about two metres from the surface of the soil, and under a Tertiary deposit. The central part of the pocket is, as usual, filled with reddish sand, quartzose and argillaceous, and more or less agglutinated, the siliceous element being in grains or fragments, worn and rounded. The rich phosphate occupies the bottom of the pocket to a thickness of 1 metre 50 centimetres, and with a diameter of about 1 metre. An analysis of the phosphate gave 30 per cent.

[1] Bull. Soc. Géol. France, 3e sér., t. xix, p. 867 *et seq.*
[2] Quart. Journ. Geol. Soc., vol. xlvii, p. 356.

of phosphoric acid, corresponding to 65·40 per cent. of phosphate of lime. The proportion of iron and alumina is only 1·51 per cent. Here, then, we have in the London Basin the same kind of rich phosphate which is worked in Picardy.[1]

IV.—Clays, Shales, and Slates.

By W. Maynard Hutchings, F.G.S.

(*Concluded from the July Number*, p. 317.)

I HAVE recently been examining a series of specimens of Silurian slates from Scotland, specially collected because of the very intense shearing they have undergone. These and the accompanying other rocks are all crushed and torn out in a most remarkable degree, and the microscope shows how severely their constituents have been acted upon mechanically. Yet the crystalline and mineralogical development is seen to be but very moderate indeed. The micaceous mineral is all in one plane, and transverse sections, in polarized light, show that it is a felted, wavy, and puckered mass of interwoven flakelets, with chloritic substance intimately diffused among it, and still more apparent in separate little streaks and lenticles. The small amount of quartz present is rolled out into long, thin lenticles also. But the micaceous mineral itself is not at all far advanced, either as to size of its flakes or the nature of the mineral. It is still an impure, rather deeply-coloured greenish-yellow substance; not any of it has arrived at the stage of muscovite, and dehydration shows, in a remarkable manner, how very considerable its impurity still is. In its original condition, the slate gives sections which present a very uniform appearance under the microscope. The colour is the same all over, and the only indication of the presence of bands of varying nature is found in a very slight increase, in some layers, of the coarseness of grain and of the number of quartz-lenticles, and in the diffusion of the chloritic substance. But after heating the specimen, the effects seen in the sections are most striking. There are now many bands of different colours, yellow, red, greenish-brown, and brown, presenting very strong contrasts, and showing that noticeable differences in chemical composition must have existed in different thin layers of the seemingly homogeneous slate. Not only the interwoven chlorite, but also the micaceous mineral, has taken on these tints in very decided degrees. It must have been unusually impure. It has lost, after heating, nearly all its action in polarized light.

The lenticles and the small grains of quartz have also become much more apparent than before heating, and, indeed, this case serves as a good example of how useful this method can be made in assisting us to obtain a knowledge of the nature of rocks of this class.

[1] A specimen of the "rich phosphate" of Taplow was exhibited at the Geologists' Association at the meeting on July 3, 1896, and is now placed in the Museum of Practical Geology.

Analysis shows a specimen of this slate to contain 4·96 per cent. of total alkali, a total amount of iron equal to 7·64 per cent. of ferric oxide, and 6·24 per cent. of magnesia. This last is an unusually high figure for a slate of this class. It would correspond to a large amount of chloritic mineral, and the heating shows that a good deal more of such mineral is present than is made evident in ordinary sections; but still there is not enough to account for so much magnesia, and no doubt much of the latter is combined in the micaceous mineral.

Although these slates have resulted from very fine-grained deposits, there are still some small flakes of clastic muscovite unmistakably recognizable in the ordinary sections, and still more so in the dehydrated ones; and these seem strikingly to emphasize, by contrast, the above points as to the nature of the main mass of the new micaceous mineral of the rocks. The mere fact that these few small clastic flakes are still so distinct from the main mass, shows how little progress in development has been made, compared with what we see in more regenerated slates, in which great quantities of new muscovite have been formed, and in which original clastic flakes have either been absorbed into the newly-formed materials or are quite unrecognizable among them. In fact, if we compare these ancient and intensely sheared slates with some of the sections of shales previously alluded to, we see that the mica in them is practically the same as that in the more crystalline and felted bands which we have observed in the shales.

The same applies to strongly-sheared Cambrian slates from Saxony, and to many other examples studied.

All this emphasizes the fact, frequently pointed out, that intense dynamic action, even allowing for its influence being added to and associated with that of depth-conditions, does not necessarily bring about any commensurate effects, other than purely mechanical ones, in rocks similar in chemical and mineralogical composition, and in nature of origin, to others which we see very highly developed.

If, now, we turn to the question of the development of rocks in "contact-areas," it will be advisable, for our present purposes, to fix our attention, not so much upon the more intensely altered examples, with a large formation of special contact-minerals, as upon those which are less affected in this way, in which we can observe the increase in the regeneration of the already existing micaceous constituent, with the further separation and rearrangement of the chloritic substance.

In a considerable proportion of cases we have a formation of brown mica in quite early stages of the metamorphism, and this partly complicates the subjects to which we are at present paying attention, as the chloritic substance may be largely, or even wholly, used up in the production of this brown mica. This formation of brown mica also considerably obscures the white mica, and, indeed, there seem to be cases in which the impure complex mineral of the slates is altered, at once and directly, into a pale-brown mica which is something intermediate between muscovite and biotite.

But we can find examples enough of contact-slates in which brown mica and chloritic mineral are developed together, and accompanying a recrystallization of the micaceous mineral to muscovite; or we may have rocks in which a very high degree of recrystallization has been reached without any brown mica being formed at all. In such rocks we see, among the main mass of the slate-mica, the crystallization of undoubted muscovite, at all angles to the plane in which the slate-mica lies flat; and we may see this in all degrees up to the point at which we get a completely regenerated rock, consisting mainly of a criss-cross mass of muscovite-flakes and crystals.[1]

The newly-formed chloritic mineral is often seen to take a degree of crystalline development and of individualization proportionate to that taken by the mica; where this latter mineral forms sharply-bounded plates, they are not infrequently grown together with equally sharply-defined individuals of chlorite, sometimes one of each, sometimes one sandwiched between two of the other, and clearly crystallized under the same conditions and at the same time. We also see the chloritic matter sometimes take the form of larger indefinite bodies, in which crystals of muscovite lie in all directions, their cross-sections giving a structure exactly comparable to the "ophitic" of igneous rocks; or again, we see it jammed in the angles among intercrossing mica crystals, in just the manner which is called "intersertal" in the case of the ground-mass of basalts, etc.; all these structures distinctly showing the simultaneous origin of the two minerals.

In studying these recrystallizations due to contact-action, we come again upon the question of the "spots" which are so frequently found largely produced in just those less highly altered portions of contact-areas which we are now considering. About two and a half years ago I made some remarks and suggestions on these little-understood spots (Geological Magazine, Jan. and Feb. 1894). Since then I have paid a good deal of attention to the subject, and examined a large amount of material, the result being, I hope, to throw a little more light on their nature and mode of origin, and to connect a large part of them with the processes of rock-development which I have endeavoured to outline above. In the paper in question I wished to show what good reasons we have for a conviction that the striking recrystallizations we see in contact-rocks are brought about by the means of some sort of mineral solution which is formed in the sedimentary rock; the components of the original materials of the rock being more or less taken up into this solution, and again crystallized out of it in new forms of the same or other minerals.[2]

[1] By *crystals* are here meant those individuals of muscovite which stand out in distinct and definite plates, with perfectly parallel edges, sharply marked off from any more confused mass of irregular flakes.

[2] For the consideration of the question here involved, it is quite immaterial whether this solution is formed entirely by the action of heat and contained water on some of the components of the sedimentary rock, or whether it has received additions in the form of alkaline liquids from the intruded igneous mass.

I suggested, tentatively, that some of the "spots" were possibly due to portions of this solution, which, in the outer portions of the contact-aureoles, "would tend to draw together as little spots and patches," and so consolidate among the other ingredients of the rock. I still think that this, to a considerable extent, expresses the state of the case; but that it needs a little amplification. These spots, although in the outer contact-areas, do not occur except where a decided amount of recrystallization is already taking place. This recrystallization, as we have seen, consists largely in a development towards muscovite, with a rejection of the chloritic constituents of the original micaceous mineral. These constituents pass over into the solution which permeates the rock, and are themselves, in these cases, deposited out of this solution, and with residual portions of it, in the manner suggested to form the "spots."

I formerly described in detail the nature and appearance of many of these "true spots" in several occurrences. They are, in fact, due simply to another form of the concurrent separation from the slate-mica of purer mica and of chloritic bodies. Like the interwoven chloritic matter, they vary in all degrees of green and yellow tints, and some, again, are almost colourless in thin sections. They vary also in degree of optic activity in a similar manner; we get spots of true chlorite, and we get all gradations from this of apparently quite indefinite compounds.

The frequent aggregation in the spots of iron-ores, of ilmenite-flakes, of rutile, anatase, etc., is to a large extent part of the same process of separation and recrystallization of formerly combined materials.

In my former notes I urged that it was desirable to make a strict separation between "true spots" and certain indefinite grains, or imperfect crystals, of particular minerals. But this opinion I would now modify and partly withdraw, after more extended observation. One sees so many cordierite grains which exactly resemble spots in mode of occurrence; and here and there one sees such clearly apparent cases of gradual transition from chloritic spots into definite cordierite, that a strict separation is not practicable. The passage from a chloritic substance to cordierite does not require any *qualitative* change. It only needs the removal of water, and a certain degree of molecular interchange with a permeating solution; and thus we so often see the occurrence together of chloritic and cordieritic spots, or the giving way of the former to the latter as the contact-action increases in intensity.

Similar considerations apply to staurolite, but the transition is not, in any case that I know of, so apparent; nor does this mineral occur nearly so frequently as cordierite.

Again, spots of chloritic nature pass over in a similar manner into biotite, and here also no line can be drawn;—the biotite is often as truly a spot as is the chloritic substance.

We may thus satisfy ourselves, by examination of a sufficient number of contact-slates, that here, again, the main change in them, in their earlier stages, before we come to the more intense actions of the inner zones, is based upon this same tendency of the micaceous mineral to take higher development and to reject some constituents; and that to these rejected constituents is due the formation of chlorite and allied bodies (often taking the form of "spots"), of biotite, of cordierite, and of staurolite. And we may note that even in very moderate degrees of contact-action, we can get effects which are not in any way approached by those of some very intense manifestations of dynamic action.

As regards the third agency for the crystalline development of slates, it is not possible to say much, because *direct* evidence of any value is practically absent, excepting what is rather on the negative side. That is to say, we have plenty of cases in which we know that rocks have been at one time under enormous thicknesses of cover, so that if simple depth-conditions could bring about the sort of crystalline development we are considering, we might look for its very marked appearance; yet we do not see any striking degree of it, but only such very moderate stages as we have already noted in some of the sheared slates.

On the other hand, we have rocks in which such development is carried to a very high point, in a manner closely paralleled in contact-areas, but without any proof at all of contact-action, and with strong evidence in the rocks themselves that this development was not accompanied by crushing and shearing. We cannot here deny the possibility that what we see is the result of simple depth-conditions; but it is quite open to us to say that a much more probable cause is the action of concealed igneous masses; and, indeed, this view seems rather the more rational, having regard to the strong evidence for the very moderate effects of depth-conditions, either alone or together with dynamic action.

We can only leave this question an open one, awaiting further evidence; and simply note the fact, that where we have these cases of high development, not directly accounted for, they are always on the same lines exactly as in contact-areas, and are often plainly not dynamic.

The main point important to emphasize in all such observations appears to be that both in contact-development, and in this development which we cannot definitely ascribe to contact-action, we always get more or less of a decided advance to muscovite; whereas, in so many cases of intense dynamic action, we see that the micaceous mineral is not nearly so far advanced. There has been some progress, but it does not seem to be able to go beyond very moderate limits, and it leaves the slate with an impure mass of felted mica, of complex nature, among which no well-marked separate flakes and crystals have begun to develop themselves. Moreover, even this very moderate degree of progress we cannot safely place to the credit of dynamic action, as depth-conditions may have caused it. And, indeed, in other cases not dynamically affected, we may see that just such a moderate crystalline development has taken place on much the same lines.

It may be, and it does not seem at all improbable, that a sufficiently extended investigation of slates, over many and large areas, would show us that there is a form of mineralogical and *structural* development which, even in its very beginnings and early stages, could be sharply distinguished from anything which could be produced either by dynamic action, or by depth-conditions, or by a combination of these causes, operating on the same original materials. If such a distinctive development could be recognized and established, it would obviously be of very great value in geological work. But, equally obviously, another great difficulty comes in, which I can best illustrate by an example.

I have before me a rock which represents an extremely and unusually high development of the kind to which I allude. All the mica is muscovite in fine large crystals, lying in all directions. Not a trace of impure original mica is left. Chlorite is largely developed, and is to a considerable extent as well crystallized as the mica.

There are the usual accessory constituents of highly-altered sedimentary slates. There is no parallel structure now remaining; the rock may have been sheared to any extent *before* this crystalline development took place, but shearing did not accompany the development, and it has not suffered at all from such action *since*.

But if it *had* suffered shearing in a sufficient degree, at a later period, all trace of the present *structure* would be destroyed; the rock would be a perfect muscovite-chlorite schist, with these minerals rolled out and arranged more or less parallel.

It might then be claimed as a dynamically-produced rock; and though this would be quite true of its structure, it would be quite untrue of its mineralogical development, with which the shearing would have had nothing whatever to do. This is probably the history of a great number of schists and allied rocks, which have been derived from ordinary slates by other causes and afterwards sheared. It is this obvious danger of a double causation being wrongly ascribed to one source only, which makes it so important to investigate carefully, whenever possible, all cases of separate action, so far as any really separate action has ever taken place.

In studying the alterations in mineralogical and structural condition caused by igneous intrusions, it is not at all necessary to limit our observations to the larger manifestations of contact-action around masses of granite or allied rocks. On the contrary, basic intrusions of less magnitude will often serve even better to bring to notice some of the particular points we have been considering; and of all the rocks I have examined in this connection, none have been more instructive, or clearer in their indications, than a large series of Lower Carboniferous shales altered by the intrusion of the Whin Sill.[1]

In these we can see what effects have been produced on such simple shales as I have described in this and former papers. We

[1] These rocks form part of a large number collected by Mr. E. J. Garwood during a long period of detailed work on the geology of the Whin Sill in Durham and Northumberland.

have these quite early and undeveloped stages of the materials of which slates are made, and we see them altered direct into contact-rocks, with development of muscovite, and with a totally new *structure.* And as they have been left for us in a condition practically not affected by any dynamic action since their alteration, they present us with a particularly good material for study.

We find that soft shales have become hard compact rocks, and microscopic examination of many of these shows that they consist more or less largely of a criss-cross network of flakes and crystals of regenerated mica, with no relationship whatever to the original plane of the micaceous mineral of the shales. The degree of this regeneration is, of course, variable; but in the most advanced cases it is very complete.

The development of chloritic material concurrently with the mica is again well seen. In many cases the mica is largely formed into tufts and radiating sheaves and bundles; and in these we frequently see that it and the chlorite have crystallized together into such aggregates.

It is very rare to find biotite formed in these Whin Sill rocks, so that when we are examining the more advanced phases of alteration of very quartz-free shales, we usually have a product made up almost wholly of mica and chloritic material.

"Spots" are exceedingly abundant in many of these rocks; and though much smaller than at most granite-contacts, they are exactly analogous in all other respects, and vary similarly in colour, etc. Indeed, their nature and mode of origin are more easily made out here than in most contact-areas. Just as we have rocks at granite-contacts which have not formed any spots, so we have them here, the chloritic element being diffused among the mica in all stages, from quite indefinite and almost isotropic matter to more highly-developed chlorite; while in other cases we have these same varieties of chloritic matter collected into crowds of spots. It is curious to observe how, sometimes, the organic pigment of the shales is concentrated in the spots, leaving the micaceous areas clear of it; whilst at other times the converse is the case, the spots being free and the pigment remaining in among the muscovite.

As an instance of these spotted rocks I may mention one from Rowntree Beck, which occurs 18 feet below the Whin Sill. It is mineralogically quite regenerated, no remnant of original mineral being seen; but it still contains fossils. It was a shale practically free from visible quartz, and is now altered into a mass of white mica and chloritic matter, of which latter a very large part is in the form of almost spherical spots, averaging $\frac{1}{200}$ of an inch in diameter, of dirty yellow-brown colour, into which most of the organic pigment has concentrated. These very abundant spots lie in a field mainly of pure white mica, large portions of this field being relatively clear and colourless in ordinary light, and showing with crossed nicols well-developed flakes and crystals in all directions, and a good many sheaves and spherulitic aggregates. Among this mass is disseminated a good deal of yellow-green chloritic matter, and the sheaves and radiating groups are partially composed of it.

Apart from mere size of constituents, it would not be possible to find more characteristic recrystallization than we see in this and some other of these shales, the whole mode of development being the same as at granite-contacts.

In connection with the subject of certain developments in sedimentary rocks, apart from any demonstrable contact-action, and with which developments dynamical and regional causes are credited, I would like again to allude to some of the occurrences in the Ardennes. In a former paper (Geol. Mag., March and April, 1895), I pointed out the occurrence of abundant "spots" in the coticule of Viel Salm, and in the dark slate with which it is associated. I particularly described these spots from their special points of interest, as they are perfectly colourless and absolutely indistinguishable in ordinary light, and are uniformly dark and isotropic between crossed nicols.

The thin bed of pale-yellow coticule does not differ from the accompanying dark rock in the nature or degree of its development. But it does differ very much in the fact that it is free from iron ores or other dark matter, so that sections of it enable us to study, without impediment, its mineralogical and structural condition. We see that its mica is all quite clear muscovite, and that nothing is left of any original impure micaceous mineral. No chloritic matter can be made out in sections from the specimens I have examined; what there is of it is quite colourless and invisible in thin slices. The rock is unusually free from iron. Renard gives in its analysis only 1·05 per cent. of ferric oxide and 0·71 per cent. of ferrous oxide, with 1·13 per cent. of magnesia. He calculates from these data that the rock contains 8·74 per cent. of "chlorite"; but, of course, this is only an approximation, as the calculation supposes a definite composition of the chloritic mineral, which there is not any reason for thinking that it possesses.

A thin transverse section cut from a specimen of coticule after dehydration, brings to view the chloritic mineral as a light greyish-brown substance now quite conspicuous among the mica at some parts of the slide; it is not evenly diffused all over it. The muscovite is not in any way altered by the heating.

A very interesting point brought about by examining the dehydrated rock, is that the spots in it are not in any way affected, but remain just as indistinguishable in ordinary light as before. Whatever is their real nature, it is clear that they do not consist of a hydrated chloritic material. And, indeed, it must be borne in mind that, though spots of the chloritic nature we have been considering are so frequent as to make out a very large proportion of these interesting bodies, there are also other varieties of them which do not come under this description, and which are due to the formation of other combinations during the recrystallization of the rock-constituents.

V.—Change of Form by Expansion as an Element in Mountain-Building.

By T. Mellard Reade, C.E., F.G.S., etc.

SOME critics of my theory of the "Origin of Mountain Ranges" appear to have strangely lost sight of one of the essential principles upon which it rests. This seems to have arisen through their attention having been too much engrossed with what I have said on the subject of cubical or voluminal expansion.

In my original work it was shown that the calculations of the earlier investigators on the vertical lifting of a given thickness and area of the earth's crust, by a given rise of temperature, must be multiplied by three to arrive at a correct result, as they omitted to consider the expansion in two horizontal directions at right angles to each other, confining their attention to linear expansion in a vertical direction. But, while calling attention to this oversight, it was certainly not my contention that expansion would affect the earth's crust like the expansion of water in an inexpansible vessel.

The effect of expansion on a solid body like the earth's crust by differential heating is to set up stresses and strains which relieve themselves in the direction of least resistance, and in doing this an internal movement and change of form ensue. A change of volume of a section of the earth's crust therefore involves internal movement, distortion, and change of form.

This principle I illustrated by experiments on the ridging up produced by heating sheets of lead; by the distortion of a sheet of zinc and iron, rivetted together, and placed in an ordinary oven; by the well-known wrinkles and folds that occur in lead gutters, lead-lined baths and sinks; and since, by the permanent expansion which frequently takes place in terra-cotta copings of walls through differential heating by the sun's rays.[1] I could add considerably to this list, but it is sufficient for my present purpose. The ridgings up and distortions were shown in all these cases to be the cumulative result of compressions and tensions set up by successive expansions and contractions, due to alternations of temperature, ending in a permanent extension in the case of a sheet, which is compensated for by folds or wrinkles, or in the case of a bar by lengthening.

Applying this principle to the probable effect of changes of temperature in the earth's crust, I showed that the strata of which mountain chains are composed have a wide areal extension, as in the plains of Russia, which are composed of the Silurian and other rocks involved in the Ural uplift. The same principle was shown to hold true with the Appalachians; and later, in this Magazine, I have called attention to British geology as teaching us a similar truth.[2] These strata out of which mountain ranges are evolved may be considered as wide and extended sheets almost paralleled on a small scale, excepting for the variable thickness distinguishing geologic deposits, by the sheets I experimented upon.

[1] Geol. Mag., Dec. III, Vol. V, pp. 26, 27.
[2] Geol. Mag., Dec. IV, Vol. II, pp. 557–565.

Without, however, considering the *causes* of changes of temperature in the earth's crust, which I have treated of in other communications, it is sufficient for our present purpose to accept the fact that profound changes do occur. Beginning with Hutton and Playfair, I can think of no geologist who has written upon the subject of metamorphism and geological dynamics who fails to call to his aid, in some form or other, the effect of heating upon the sediments which compose the rocky covering of our globe.

If it be assumed, then, that a great sheet built up of various strata of sedimentary origin, with, perhaps, intercalations of ashy and igneous beds, combinedly reaching in places thicknesses measured by miles, is by slow degrees subjected to a fluctuating rise of temperature, it is evident from the illustrative experiments referred to that not only a linear vertical expansion will ensue, but that the horizontal expansion, as much greater in proportion as the areal extent is greater than the thickness, will produce, by small increments and minor alternations, a creep, ending in an anticlinal fold in a position determined by several conditions.

It is thus seen that an actual movement or displacement of material proportionate to the amount of expansion has taken place.

The excess of the material of this compound sheet, or what may be called the strata-plate, over the space it originally occupied, is compensated for by a heaping up by folding along a line of maximum pressure or least rigidity. In this way a permanent feature in the form of a fold has been built up upon the earth's crust, which may be increased in amplitude by future expansions, but which will remain unaffected by any succeeding contractions of the strata-plate.

Let us now consider how a contraction of the strata-plate can be compensated for. I have shown in my original work that it may be met, in the case of small contractions, by what I have called compressive extension, which is a lengthening of the strata by the compression of the overlying strata going on *pari passu* with the contraction due to a fall of temperature, so that, instead of separating by fissuring, the strata are made to continually occupy the same superficial horizontal space while, at the same time, becoming thinner by compression. As the greatest expansion takes place at the base of the deposits, or in the underlying crust, there is, in most cases, a load sufficient to act upon and mould the contracting bed, and in this way convert horizontal into vertical contraction, the rigidity of the strata and power of conveying lateral thrust being at the same time preserved. Therefore, in the case of a general rise of temperature of the strata-plate, but with minor fluctuations and falls of temperature, the effect of every rise, however small, will—whether the compensation be by compressive extension or by minor faulting and keying up—tend to still further lengthen the strata and develop the anticlinal fold, or to add to it other parallel anticlinals until a complete folded range is finally formed ; or, as in the more extreme cases, such as the Alps, a central core or a series of ellipsoidal domes of gneissic rocks is forced up from below, throwing back the folds in fan-like form, and further compressing them. Certain secondary effects may follow, such as the folding and formation of foot-hills by the gliding of the upper beds down the sloping flanks of the older beds; but it is unnecessary for me to dwell upon them here, as my object is to enable those to grasp who have not yet done so, the idea of successive cumulative expansions, as I conceive them to have acted in the building up of mountain chains.

But these expansions, caused by a general but fluctuating rise of temperature, diminish, and finally cease, by the dying out of the cause producing them. In the absence of compression no more folds are initiated, nor is the amplitude of the old folds increased. Meantime, the ever active elements in the form of air and water are busy at work, reducing and carving out of these folds domes and ridges, the mountain forms and scenery we are familiar with. Thus the cycle of change is completed, and the broken-up rocks are returned as detritus to the sea.

A general but fluctuating fall of temperature now sets in, and the rocks composing what I have called the strata-plate contract. This contraction can only be met in one of two ways—either by stretching or fissuring. In their nature rocks are incapable of stretching by tension, excepting it be in a very minor degree, and compressive extension could only partially compensate for the profound changes of volume which take place. No doubt the strata-plate will be eaten into, and underlain to a considerable extent, by semi-molten matter in a plastic condition; and the shrinkage of this, combined with the irregular shrinkage of the non-homogeneous material of the sedimentary strata, must inevitably initiate fractures. These fractures, we know, take the form of two series of normal faults, each series of which has a more or less definite direction and parallelism, and are classified as strike or dip faults, accordingly as they roughly follow the strike or dip of the strata. The voluminal contraction of the strata-plate is met by the sinking of wedge-like blocks of strata along and between these lines, or, rather, shear planes called faults, and the earth's crust thus remains solid by keying up. In adapting themselves to the voids these blocks are continuously or intermittently sinking, and certain secondary folding along a large fault often occurs. This is fully explained by the fact that the strata nearest to the earth's surface shrink least, so that the wedge, in adapting itself to the void below by sinking, is often in compression in the upper layers, which is met by the turning up of the edges of the strata against the fault-plane.

That this succession of events takes place in Nature, can be readily settled by appeal to any typical section of a mountain range, or to any of the numerous sections taken through the folded regions of Britain published by the Geological Survey.

This latter, it is almost needless to say, constitutes evidence of the best kind, as the authors were simply recording facts, having no thought in their minds of the theoretical relations here expounded. The posteriority of normal faulting to folding has been remarked upon by even so early an observer as Playfair.[1] Every section I have seen

[1] "Illustrations of the Huttonian Theory," pp. 62, 63.

shows normal faults cutting and displacing the folds where the faults and folds exist together, even in the case of those longer undulations into which the strata involved in the folding of the mountain range graduate in those great areas and plains flanking the range proper, which constitute a large proportion of what I have termed the strata-plate. May we not justly infer from these phenomena that normal faulting on a large or general scale never *precedes*, but invariably *follows*, folding, excepting in the case of previously faulted and folded strata involved in the general compression and uplift. Another feature distinguishing folded regions, such as Scotland, is the prevalence of enormous strike-faults, showing that normal faulting and folding, though arising from movements in opposite directions, are yet closely related.

This short restatement of some of the leading principles of my theory of the origin of mountain ranges seems necessary in view of certain misconceptions which have arisen, doubtless due to the complexity of the subject.

VI.—Note on a Section at the North Cliff, Southwold.

By Horace B. Woodward, F.R.S., F.G.S.

THE damage done to the land at the north end of Southwold by the "moderate gale" of May, 1895, has been described by Mr. J. Spiller.[1] One result of this damage was the opening up of an interesting geological section along the base of the low cliffs, a short account of which I brought before the last meeting of the British Association at Ipswich.

Before publishing this account, it was hoped some evidence might have been obtained of the age of a fresh-water bed that had been exposed. In this I have been disappointed, but as the sea continues its ravages all traces of the bed may ere long be removed, and it seems desirable, therefore, to delay no longer in making known the particulars of the section.

From the neighbourhood of two old pits that occur on the margin of the present cliffs to the north of the coastguard station, the lower portion of the cliffs has been bared of the talus so far as they extend northwards, and certain deposits have been revealed which were not previously to be seen, while other strata are more clearly exposed. Particulars of these are shown in the accompanying section.

By the present bathing-station, now just beyond the north end of the cliffs, there is a low bank of Boulder-clay that extends some ten yards north of the gravelly cove recently eroded by the sea. This cove shows a fine section of the Crag series, 15 to 18 feet deep in places, and extending for fifty yards. The beds comprise ochreous sand and pebbly gravel, somewhat irregularly accumulated, but on the whole fairly well bedded, and here and there current-bedded on a small scale. The stones are mainly flint pebbles, but many subangular fragments are present with the smaller stones, together

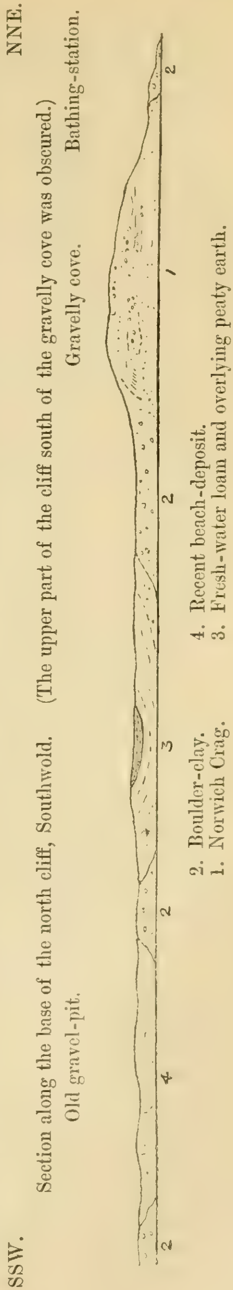
[1] Geol. Mag., Jan. 1896, p. 23. See also Howorth, Quart. Journ. Geol. Soc., vol. li, p. 496.

with quartz, etc. At the south end of this exposure there is an included small mass of shelly Crag. The shells are interspersed amid flint pebbles, and their preservation may perhaps be due to a thin overlying seam of clay.

Adjoining the Crag series on the south, the Boulder-clay is again seen, and here it has cut deeply into the Crag sands and gravels. The thin seam of clay (before-mentioned), which has protected the shelly Crag, has apparently been pressed down, so as to truncate the edges of the Crag layers; and it thus follows the course of the overlying Boulder-clay. This Boulder-clay extends for about thirty yards to the south, where it is overlain by a thick bed of loam and laminated peaty earth—a fresh-water deposit that extends forty yards along the base of the cliffs, and much more towards their upper part, as the strata are bent into a gentle syncline, supported further south (as on the north) by Boulder-clay.

The Boulder-clay to the south of this fresh-water deposit extends for fifteen yards, and is then overlain by recent accumulations for a space of forty yards, and then again the Boulder-clay is shown.

It was in these last-mentioned recent deposits that a human skeleton was discovered in 1895, and the strata were at first supposed to belong to the Boulder-clay. The material is in part an irregular, brown, stony loam, with scattered pebbles and subangular pieces of flint, etc., and with also a number of chalk stones; in part it becomes bedded, much more sandy, and contains many more pebbles. The entire deposit, shown to a depth of six or eight feet, is a recent one, being a beach accumulation made up largely of reconstructed Boulder-clay, the materials being commingled with sand and shingle from the beach, or from the old and half-eroded gravel-pit against which the deposit occurs. It is clearly to be distinguished from the bluish-grey Boulder-clay; and that it is not weathered Boulder-clay, is shown by the roughly-bedded and in part false-bedded character of the newer accumulation, and by its containing a much larger proportion of



Section along the base of the north cliff, Southwold. (The upper part of the cliff south of the gravelly cove was obscured.)

rolled flints than the underlying Boulder-clay. Moreover, the number of chalk stones tells of reconstruction, as from the brown-weathered Boulder-clay such materials have usually been removed by dissolution.

The masses of Boulder-clay seen at the several points noted in the section, form portions of one bed which formerly extended along the front of the low cliffs, as represented on the Geological Survey map by Mr. Whitaker. Traces of the Boulder-clay may still be seen here and there at other points at the foot of the cliffs, where the modern beach-shingle lies in thin patches. Elsewhere it forms projecting banks, as it has withstood the ravages of the sea better than the Crag deposits, the fresh-water beds, or the modern loamy beach accumulation. That it forms part of the well-known chalky Boulder-clay of East Anglia, admits of no doubt. It contains, in addition to chalk and flint, fragments of Kimeridge shale with *Lucina minuscula*; also *Belemnites* and *Gryphæa arcuata*.

The age of the fresh-water bed is not clear. At first sight it resembles a mass of the Forest Bed series, reminding one of the black peaty bed and Rootlet Bed that overlie the Chillesford Clay at Kessingland and Runton.[1] Fossil evidence is needful to determine its age, for one must bear in mind the "post-Glacial" river-bed of Mundesley, the fresh-water bed found by Mr. Charles Candler over the Boulder-clay at South Elmham, near Harleston,[2] and that at Hoxne, with any one of which it is possible the Southwold bed may correspond.

Mr. Clement Reid, who has kindly examined some of the materials from the fresh-water bed, has identified *Planorbis complanatus*, *Valvata piscinalis*, *Sphærium corneum*, and *Pisidium pusillum*; also *Ranunculus aquatilis*, *Comarum palustre*, and *Ceratophyllum demersum*. As both mollusca and plants range from the Pliocene (Forest Bed series) to the present time, they afford no clue to the precise age of the deposit.

It would seem natural to compare this fresh-water bed with the "post-Glacial brick-earth" worked a little further north, and briefly described by Mr. S. V. Wood, jun., and afterwards by Sir J. Prestwich, who recorded the occurrence in it of *Elephas primigenius*.[3] An examination of the present sections in the brickyard showed no strata that could be correlated with the beds seen in the cliff; moreover, the deposits are separated by the intervening mass of Crag beds. I am thus obliged to leave the age of the fresh-water bed an open question. That it does not occupy an undisturbed hollow in the Boulder-clay, is shown by the synclinal arrangement of the layers in the fresh-water deposit; and this fact, together with that of the striking resemblance to the characters of the Forest Bed series, suggested transportation. Mr. Reid has, however, drawn my attention to a

[1] It is interesting to learn that Mr. J. H. Blake observed beds that might belong to the Rootlet Bed (Forest Bed series) at Easton Bavent.—Whitaker, "Geol. Southwold," p. 70.

[2] Quart. Journ. Geol. Soc., vol. xlv, p. 504.

[3] See Whitaker, "Geol. Southwold," p. 62.

somewhat similar feature in a peaty bed overlying Boulder-clay at Kelsey Hill, which he has attributed to the subsidence of the Boulder-clay through the slipping of underlying sand.[1] In the present instance it is possible that subterranean erosion may have produced the syncline.

The junction between the fresh-water bed and the Boulder-clay is marked by an irregular band of bedded loam, with chalk stones, flints, and other gravelly materials, and this junction-bed is from one to nearly four feet thick on the northern side.

The section of the fresh-water bed may be noted thus :—

	ft.	in.
Laminated peaty bed	2	6
Brown, grey, and greenish micaceous loam, with much ferruginous matter ... ... Greyish loam, with fresh-water shells; and irregular pebbly layers of rolled and subangular flints (cemented into an iron pan),[2] with ochreous pebbles, bits of carbonaceous shale and lignite	8	0

With regard to the Crag, several questions arise. Is it part of the true Norwich Crag, or does it belong to the Southwold Pebble-beds, which were regarded as of subsequent age by the late Sir Joseph Prestwich. Are the Southwold Pebble-beds the same as the Westleton Shingle?

The shells in this exposure at Southwold are mostly broken or comminuted. I could only recognize *Cardium edule, Cyprina islandica, Mya,* and *Littorina littorea.*

The general character of the strata, and their position, led me to group them as part of the Norwich Crag; and in this opinion I find support in Mr. Whitaker's description of the section formerly seen near by, but a little to the south, being about 250 yards NNE. of the coastguard station at Southwold; and support is also given in the list of shells there obtained by Mr. S. V. Wood, jun., and Mr. W. M. Crowfoot.[3]

The occurrence of shelly patches in the pebbly gravels elsewhere near Southwold has been noted by Sir Joseph Prestwich and Mr. Whitaker, and the subject has been further discussed by Mr. Clement Reid and Sir Henry Howorth.[4] In no case has any evidence been brought forward to show that these shell-beds do not belong to the Norwich Crag. No shells have been found in the Westleton Shingle of Westleton; and those which have been found near Southwold usually occur low down in the pebbly gravels, and may in all cases belong to the true Norwich Crag. I do not feel confident that the Southwold pebble-gravels, so well shown on Southwold Common and in the adjacent railway-cutting, belong to the horizon of the Westleton-beds of Westleton. They may well belong to the pebbly sands of the Crag seen in the north

[1] "Geology of Holderness," p. 74.

[2] Some masses of modern beach-shingle, plastered against the fresh-water bed, have also been cemented into an iron pan.

[3] "Geology of Southwold," 1887, pp. 61, 81, etc.

[4] Reid, "Pliocene Deposits of Britain," 1890, pp. 104, 201, etc.; Howorth, Quart. Journ. Geol. Soc., vol. li, p. 498.

cliff, Southwold. I have again had the opportunity of examining the fine sections at Westleton, where the shingle is imbedded in buff sands, and presents an aspect quite different from that of the Bure Valley Beds of the Norfolk area and from the Crag Series at Southwold. Following the beds to the cliffs at Dunwich, they are seen to rest on a mass of buff sands, more like Middle Glacial Sand than anything else.[1] Where gravels and sands of variable character and different ages come together there is abundant room for diversity of opinion, and those who peruse Mr. Whitaker's Memoir on the Geology of Southwold will find a clear statement of the facts and of the conflicting views with regard to their interpretation.

During my visit to Southwold in the summer of 1895, the Crag was well exposed at the base of the low cliffs at Easton Bavent, but, while collecting a number of fossils, only one form proved to be new to the locality, and that was a tooth of *Microtus* (*Arvicola*), the identification of which was kindly verified by Mr. E. T. Newton.

VII.—Notes on some Rocks from the Solomon Islands.

By W. W. Watts, M.A., F.G.S.; with notes by E. T. Newton, F.R.S.

[Communicated by permission of the Director-General of the Geological Survey.]

AFTER he had published his account of the geology of the Solomon Islands,[2] Dr. Guppy was good enough to present to the Museum of Practical Geology a series of typical specimens showing the chief varieties of calcareous and argillaceous deposits met with in the islands. This collection includes rocks, washings, picked organisms, with a few microscopic slides, and it constitutes a series very valuable for reference.

During the surveying of the islands by the Admiralty in 1893–5, Lieut. A. Waugh has been able to collect many specimens of volcanic and sedimentary rocks, which have also been presented to the Museum. As some of these were collected at localities not visited by Dr. Guppy, and as a few of the types have not been previously described from the islands, it may be worth while to communicate to the Geological Magazine a short account of Lieut. Waugh's collections.

I.—*The Sediments.*

The classification adopted by Dr. Guppy for these rocks may be briefly summarized as follows. For further details the reader is referred to the original paper.

A. Volcanic débris mixed with organic remains and resembling the muds now forming round oceanic, volcanic islands.

(*a*) 5–20 per cent. of $CaCO_3$, minute foraminifera, and a few mollusca.

[1] See H. B. W., Geol. Mag. 1882, p. 455.

[2] "The Solomon Islands, their Geology, General Features, and Suitability for Colonization," by H. B. Guppy, M.B., F.G.S. (London, 1887): Trans. Roy. Soc. Edin., vol. xxxii (1887), p. 545.

(*b*) 30–35 per cent. of $Ca\,C\,O_3$, pteropods, gasteropods, lamellibranchs, foraminifera, etc.

(*c*) 60 „ „ fragments of corals, algæ, lamellibranchs, and a few foraminifera.

(*d*) Coarse rocks made of fragments of volcanic and coral rocks in rounded grains.

B. Organic constituents most abundant, 66–96 per cent. of $Ca\,C\,O_3$; volcanic materials quite subsidiary.

(*e*) Coral rocks with the original structures more or less obliterated, becoming drusy, saccharine, or compact.

(*f*) Coral rocks with algæ, fragments of mollusca, corals, and echinoderms; interstices filled with foraminifera and small calcareous organisms.

(*g*) Fawn-coloured, crystalline limestones made of the coral ooze of lagoons.

(*h*) Chalk-like coral limestones; corals, mollusca, algæ, etc.

(*i*) Foraminiferal limestones chiefly made of the tests of pelagic and bottom-living foraminifera.

C. A deep-sea clay.

The greater part of Lieut. Waugh's collection falls into these classes, as will be seen from the following account of the chief specimens.

A (*a*) *Foraminiferal mud.*—South coast of Tetapari Island (F. 303), "from between the blocks of coral." This resembles the earthy foraminiferous deposit described from Ugi and Treasury Islands by Dr. Guppy. It consists of fine argillaceous material, a few chips of volcanic minerals, and abundant foraminifera, some cells of which are empty, but others filled with a brown deposit insoluble in acid. On dissolving the tests in weak acid an earthy skeleton would sometimes persist for a moment, as though the perforations had been filled with some fragile, insoluble substance. A few sponge spicules were seen in the residue. Mr. Newton says that *Globigerina* is the most abundant foraminifer.

B (*e*) Coral rocks are of very common occurrence in New Georgia, and have been collected from the following localities on that and the neighbouring islands—Viru harbour, the south coast, Bili village, and Mbulo Island. They also occur on Ugi Island and on the mainland of Florida Island. They were found at the sea-level as well as at heights up to 130 feet, and as much as a mile inland. They correspond to Dr. Guppy's description, and need no further remark.

B (*f*) These might be called "mixed coral rocks." They are clastic limestones made up of broken bits of organisms, calcareous mud, and a small amount of terrigenous or volcanic material. They occur on the mainland of Florida Island, one at the water-level (F. 278), the second at 20 feet (F. 281), and the third at 40 feet, above it (F. 279), on the floor of a cave 20 feet below the surface on the island of Ereru, inside the lagoon (F. 272), and at the Charapoana entrance of the great barrier reef of New Georgia (F. 290). I append Mr. Newton's description of the rocks—

"These five specimens are hard limestones varying from fine, close-grained to coarsely cavernous rock. The first specimen from Florida Island (F. 278) has the finest, and the third (F. 279), the coarsest texture of the three. Under the microscope they are seen to be composed of similar materials, namely, fragments of nullipores, corals, and foraminifera, the last-named being chiefly in the finer material filling in the larger cavities. In the first (F. 282) of the other specimens the rock is much coarser and more cavernous than in the three above noticed, and some of the surfaces are covered by a calcareous coating (stalagmite?). Under the microscope, pieces of molluscan shells, corals, and possibly spines of echinoderms, were detected, as well as large foraminifera (*Amphistegina*, etc.). This rock closely resembles Dr. Guppy's figure.[1] The last of these coral rocks (F. 290) was found six feet above high-water mark. It is the coarsest rock of the series, and is chiefly formed of nullipores and corals, the cavities being filled in with débris, in which are foraminifera and other small organisms; few or no sponge spicules were detected in any of these fine coral rocks."

B (*h*) Under the name of *chalky coral rock*, Dr. Guppy describes a set of limestones which "in the general composition resemble the rocks of the second group of coral limestones [B (*f*)], but differ conspicuously in their chalk-like appearance and in being more friable." Microscopic examination of one of Dr. Guppy's specimens from the Shortland Islands bearing this designation (F. 299), does not accord exactly with this general description. The rock shows that minute crystals of dolomite are of frequent occurrence, and a chemical test reveals a small proportion of magnesia. This fact has already been made known by Dr. Guppy in a rock which corresponds closely with the following description.[2] Of this rock Mr. Newton remarks as follows:—"Under the microscope, nullipores are very distinct, and there is evidence that other organisms have been present, such probably as would make up an ordinary 'mixed coral rock,' but these are so decomposed as to leave mere traces of their original shape. It is worthy of remark that the nullipores seem to be able to resist the action which has caused the alteration of this rock better than any of the animal organisms, and perhaps this may be due to the different state of the carbonate of lime of which they are composed."

Specimens from the south coast of Mbulo Island (F. 297) and from the southern coast of New Georgia, on the other hand, appear to correspond with Guppy's general description. They are friable, white, chalky limestones, containing abundant relics of organisms, which are mostly in a fragmentary condition. They are set in a fine calcareous mud, in which I have seen no evidence of dolomite. Mr. Newton adds that the slide contains "pieces of corals, nullipores, foraminifera, molluscan shells, etc., and is, in fact, one of the 'mixed coral rocks' in a somewhat friable condition."

We now proceed to describe a few types of rocks not included in Dr. Guppy's classification.

[1] Trans. Roy. Soc. Edin., vol. xxxii (1887), pl. cxlv, fig. 3.

[2] "The Solomon Islands, their Geology," etc., p. 74.

At Bili village and on the south coast of New Georgia (F. 296) *tufaceous limestones* occasionally occur on the face of the cliffs. They are of spongy texture, and are evidently the result of springs percolating through coral rock and other calcareous deposits. Under the microscope they show the usual banded structure due to the deposit of minute calcite crystals.

At the western end of Tetapari Island (F. 304) was found a deposit of *volcanic mud* devoid of calcareous matter. Very little of this specimen is soluble in acid, and what is left is like the residue left on acting on the foraminiferal mud of the same island with acid. It is evidently a volcanic mud which happens to be almost devoid of organisms, either from the loss of them by solution, or more likely, as the rock is fairly compact, from the circumstances of its deposition.

On a hill summit, about a mile inland, on Ugi Island, Lieut. Waugh found a curious *rotten-stone* (F. 302). Fragments of coral showing structure were found in the same locality, so that the rock is almost certainly the result of the operation of solution on a foraminiferous mud like that already described in this note and like those described by Guppy in this island. The rock is cavernous, the hollows revealing the shapes of dissolved foraminifera. Very little of it is soluble in acid, and the residue consists of fine clay with a few chips of volcanic minerals, such as felspar, augite, and olivine. Mr. Newton remarks that "In one instance a foraminifer was itself preserved in some material which was not affected by acid."

Two examples of *siliceous deposits* were found—one in Florida Island, about 20 feet above high water-level (F. 280), and one on Gavutu Island, just opposite, at 10 feet above the same datum (F. 285). They are white or cream-coloured, banded rocks, rough and siliceous in feel, light in weight, and with one or two coarser layers which contain a preponderance of chips of volcanic minerals that are present in some quantity throughout the rock; these minerals include felspar, augite, hornblende, and olivine, with a little quartz. I append Mr. Newton's full description—

"A fine-grained, friable rock, which does not effervesce with acid, was examined both in section (F. 280) and also as a powder. Under the microscope it was found to contain numerous organic remains, chiefly the spicules of tetractinellid sponges, and these of many different forms, with fragments which indicate the presence of radiolaria. No foraminifera were detected.

"F. 285 is another specimen of a very similar rock. Like the last, it did not effervesce with acid, and under the microscope very few organisms could be found; but those that were present were similar sponge spicules and possibly radiolaria.

"It will be evident that the conditions under which these two rocks were formed were quite unlike those necessary for the formation of the coral rocks, and they may possibly indicate somewhat deeper water. The deep-sea clay mentioned by Guppy [1] is quite unlike these specimens, for that is somewhat calcareous and contains but few sponge spicules."

[1] Trans. Roy. Soc. Edin., vol. xxxii, p. 558.

II.—*The Igneous Rocks.*

The igneous rocks collected by Lieut. Waugh appear, with two probable exceptions, to be the products of recent volcanoes. Some of them are *andesites* corresponding very closely with those in the large series deposited by Dr. Guppy in the British Museum and described by the late Mr. T. Davies. By the kindness of Mr. Fletcher and Mr. Prior, I have been allowed to look over the slides of these rocks, and I desire to record my hearty thanks to these gentlemen for the privilege accorded to me. Some others of the rocks collected by Dr. Guppy are at present lodged at the Royal College of Science, and they have been examined by Prof. Judd. The latter has been so kind as to allow me to study his slides and specimens. He has not only given me every possible facility for working at them, but he allowed me to see his notes on the specimens, for which I desire to thank him cordially. His specimens have, however, little bearing on the present communication, except that he recognized orthorhombic as well as monoclinic pyroxene in some of the andesites. The plutonic rocks of Prof. Judd's collection are not represented at all amongst those which have been submitted to me from New Georgia and elsewhere.

There are, however, in New Georgia a number of much more basic rocks, *porphyritic olivine-basalts*, which, from the state of preservation of their minerals, are almost certainly recent volcanic products. No rocks quite like them are to be found in the British Museum collection or in Prof. Judd's series.

The occurrence of these two types of volcanic rocks in New Georgia confirms Dr. Guppy's surmise that the island would be found to be volcanic in structure. Although he was unable to visit it, he inferred from its geographical position that it would be made up of recent volcanic products, as it was situated on the important volcanic line proceeding from Bougainville Island.

The igneous rocks may be classed as follows :—

(1) Porphyritic olivine-basalts with very little porphyritic felspar.
(2) " " " " olivine.
(3) Augite-andesites.
(4) Hypersthene-andesites.
(5) Hornblende-andesites.
(6) Augitic trachytes.

(1) *Porphyritic olivine-basalts* with very little porphyritic felspar appear to be very common in the south-east of the island. One specimen comes from the summit (F. 289) and one from the foot (F. 287) of the Karu Mahimba Range, and three others from or near a river which drains the southern spurs of that range (F. 284, 292, and 293). They are dark-grey rocks weathering brown, and they show on the fractured surface fresh porphyritic crystals of green olivine and black augite, but no felspar. Under the microscope the augites are seen to be often aggregated into groups; the individual crystals are sometimes zoned, and they contain fair-sized patches of magnetite. They are slightly pleochroic, in colours of pale yellow

to pale-yellowish green. The olivine is frequently idiomorphic and tends to occur in single individuals rather than in groups; and although usually quite fresh, it has often a brown border, and is sometimes converted entirely into the substance known as iddingsite. Large grains of iron-ore are generally present, but phenocrysts of felspar are small and scarce, and they tend to graduate down to the smaller crystals of the ground-mass; the extinctions appear to indicate that this felspar is labradorite. The ground-mass consists of augite granules, iron-ore dust, and felspars in the form of stumpy prisms, laths, or needles, all of which are striated, with a very little brown mica. The felspars usually show flow-structure, and a little interstitial glass can be made out. One variety of this rock (F. 289) contains a rather larger number of labradorite phenocrysts, which are, however, not large in size.

(2) *Porphyritic olivine-basalt* with abundant phenocrysts of felspar occurs at the summit of Dubatina Mountain (F. 295) and at the summit of Kutelike Mountain (F. 283), portions of ranges which run north and south respectively from the Karu Mahimba Range. The rocks are rather darker in colour than the last type, and they show needle-like, twinned crystals of felspar on their broken surface, with occasional dark crystals of augite. The weather appears to penetrate deeply into them, and one of the specimens is coated with a thick brown crust. The principal phenocrysts consist of a felspar, apparently labradorite, with a high refractive index; usually it has a clear border which extinguishes at a lower angle than the core, and into this the twin striation penetrates. The augite is like that already described, but it is beautifully zoned, and the olivine which is not very abundant, is in small grains more or less replaced by serpentine. The ground-mass consists of stumpy felspars, augite granules, and magnetite dust, and it does not appear to contain any unaltered glass. In one specimen of this rock (F. 295) the felspar is commonly in cruciform twins, and the crystals possess cores or belts of minute inclusions with a border of clear felspar.

(3) The *augite-andesites* require little notice, as most of them are identical with those described in Dr. Guppy's book. One specimen (F. 286) was collected near the sea-level, and one (F. 291) at the summit (672 feet) of Marovo Island, which is practically the south-eastward extension of New Georgia. The rocks are light grey in colour, with an irregular fracture, and a rather horny surface which shows phenocrysts of felspar. No olivine is present, and augite is by no means so common as in the basalts. The principal phenocrysts are of plagioclase felspar, either as carlsbad or albite twins, the latter giving such extinctions as to show that the felspar is somewhere between andesine and labradorite. The interior of the felspars often exhibits a *moirée* structure, which is not observable in the outer shell. The ground-mass is made of elongated felspar microlites giving extinctions proving that they belong to the oligoclase-andesine series, with augite granules and a small quantity of iron-ore dust set in a brown glass, which passes locally into bright orange patches with a weak aggregate polarization, apparently a form of palagonite.

(4) Only one sample of *hypersthene-andesite* has reached me; it is from a rounded pebble found 40 feet above high-water level on a small island on the reef in the Gizo group (F. 244). It shows glassy felspars in a grey andesitic matrix. The section exhibits zoned plagioclase felspars, which belong to the more acid division of the labradorites, a few green hornblendes, small augites, and fairly abundant crystals of hypersthene, imbedded in a brown-tinted glass containing a few felspar microlites and black trichites in such plenty as to give the glass its brown colour. In the British Museum collection I have noticed similar hypersthene in the andesites from the Shortland Islands, and Prof. Judd has noted its occurrence on Simbo or Narovo Island.[1]

(5) The single example of *hornblende-andesite* comes from the summit of Evorai Mountain, on the north coast of New Georgia (F. 294), and is much decomposed. It is of a dirty grey colour, and has scattered through it large porphyritic crystals of hornblende, some of them being half an inch long. With a lens, felspar crystals and smaller ferro-magnesian minerals can be seen. The fine collection in the British Museum contains a large number of rocks of similar microscopic character, and in this collection every gradation from hornblende to augite-andesite can be studied. A specimen in Prof. Judd's collection from the north part of Piedu Island is also like this rock in macroscopic aspect. Plagioclase felspar, a labradorite, with zoning and multiple twinning, is abundant as a porphyritic constituent. The hornblende is deep brown in colour, and usually has an opaque black border, which sometimes extends into the crystal or even replaces the whole of it. Iron-ore granules and a few crystals of augite are present, and there are also pseudomorphic patches of chlorite and magnetite which appear to replace the latter mineral. The ground-mass is of minute felspar crystals, matted together in a clear glass, which also contains iron-ore dust and serpentinous replacements of a ferro-magnesian mineral.

(6) *Augitic trachyte.*—A remarkable rock, which probably belongs to this class, occurs on the slopes of Kutelike (F. 288). It is not like the other rocks, nor, indeed, is it quite like any one with which I am acquainted. It is light grey and granular in aspect, traversed by innumerable minute, joint fissures, and exhibiting on the broken surface crystals of black augite and occasional felspars imbedded in a white matrix. Under the microscope the bulk of the rock is seen to be made up of small crystals of felspar, which are rhomboidal in section, and are almost entirely devoid of twinning, except now and then on the carlsbad plan. They are beautifully zoned, the outside extinguishing at a lower angle than the interior. The refractive index, where it can be determined, appears to be higher than that of canada balsam. On placing the powdered rock in a diffusion column of methylene iodide, about half the felspar floats in liquid with a density of 2·57, proving that a good deal of the felspar is orthoclase. Another portion floats at 2·62. This seems to indicate that orthoclase and albite are present in about equal proportion, and it is quite

[1] "The Solomon Islands, their Geology," etc., p. 44, footnote.

possible that the crystals possess cores of albite surrounded by zones of orthoclase. A striated felspar has been found in a slide prepared from another rock from the same general locality. A few phenocrysts of green augite are present, and also one or two of hornblende. The ground-mass is obscure, but it appears to be made up of a smaller generation of similar felspars, augite prisms, and magnetite with little or no glass.

Only two other rocks remain for description. One from Vongi Mountain, on an island south-east of New Georgia, is a porphyritic *olivine-basalt* (F. 243) in which the minerals are somewhat altered, so that the rock may possibly belong to the rather older group referred by Mr. T. Davies to the diabases. A similar rock, but one in which the presence of olivine cannot be absolutely demonstrated, is that from Gizo Island (F. 245). The felspars are much decomposed, and the augite somewhat altered; the rock is a porphyritic basalt, which contains pseudomorphs after olivine or hypersthene—which, I cannot say.

III.—*Summary.*

The general result of the investigation of this collection is to show that New Georgia consists chiefly of volcanic rocks belonging both to the andesitic and basaltic division, and probably of recent date. At the edge of the island organic rocks have been deposited in connection with the great barrier reef, and no organic rocks have yet been detected at any considerable distance inland.

The chief rocks from Tetapari Island and the Florida group are made of organic material mixed with volcanic mud, the latter sometimes entirely excluding the former substance. Occasionally the calcareous matter is leached out of a rock of this nature, leaving a rotten-stone behind which can only be distinguished from a pure volcanic mud by its open texture and its casts of organisms. Another result of this action is the formation of tufas. On and near Florida Island there also occurs a peculiar deposit of siliceous material, made of the remains of sponge spicules and radiolarian tests.

Guppy notes that the interstices of coral rock are filled in with the relics of foraminifera and other small calcareous organisms. On Tetapari Island this foraminiferal material occurs in considerable quantity between the coral blocks in the limestone of the shore.

VIII.—Analysis of a Spherulite and the Matrix in a Natural and an Artificial Rock.

By H. H. F. Hyndman, B.Sc.; with Notes on their Microscopic Structure by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.

THE differences in chemical composition between spherulites and the matrices which contain them have been determined by many analysts. Michel Lévy, in a long and comprehensive paper,[1] quotes some former analyses by Delesse,[2] comparing them with his own, which they closely resembled. Lagario[3] gives many analyses

[1] Bull. Soc. Geol. France, v, 3rd series, p. 232 (1877).
[2] Ann. des Mines, xvii, 4th series, p. 116 (1850).
[3] See Teall's "British Petrography," p. 397.

which are especially valuable, as he compares results from acid with those from intermediate and basic rocks, and finds a distinct difference between them. The relations of these results will be briefly considered at the end of the present paper.

I. The Natural Spherulitic Rock.

The specimen examined was obtained by Prof. Bonney at Boulay Bay, Jersey, the noted locality for "pyromerides"; it did not, however, come from a rock *in sitû*, but was a loose, somewhat rounded block on the shore, measuring about eight inches across, and the spherulites are smaller than in the ordinary pyromeride. Still, he had no doubt that it had once formed part of the rhyolitic mass, for this exhibits many variations. The matrix is of a pale yellowish-green colour, something like sea-water, but looking rather opaque. The spherulites are reddish, sometimes pale red, becoming whitish towards the outside, sometimes with an outer zone of darkish purple red. They generally exhibit some indication (occasionally distinct) of radial structure.

Under the microscope the matrix is cracked and sometimes distinctly perlitic. The green tinge is evidently caused by a mineral which occurs in minute plumes, irregularly scattered, giving fairly high colours with crossed nicols, and belonging probably to the chlorite group. Microliths and granules, mostly ferrite, are not rare. With crossed nicols the matrix is seen to be devitrified, a mosaic of somewhat irregularly-shaped minerals, varying in size in different parts and affording rather low tints; quartz is certainly present, as well as felspar, but as the one mineral is often rather dirty, and the other is slightly decomposed and untwinned, it is not easy in all cases to distinguish them.

The spherulites, though the boundary is generally sharply defined, are less regular in structure than one would have anticipated; they are not unfrequently cracked and traversed by veins of chalcedonic quartz. Portions sometimes had been displaced before the matrix became solid. The outer part often exhibits a kind of lobate growth, which seemingly is developed from the surface inwards, comparable with that of a nullipore like *lithothamnion*, as seen in a slice of limestone. A radial structure is perceptible, though not very distinct, as in axiolites. Sometimes, however, this structure is exhibited in the usual way, throughout the outer zone, and is then replaced (for a space) by one less regular. The interior often presents a more distinctly radial structure, but it is minute, and crowded granules of clear quartz sometimes occur.

When the rock was sampled for analysis, it was found possible in many cases to break the spherulites out complete; only those which were perfect in this way were used. To obtain a good sample of the matrix was much more difficult. At first sight the rock left after breaking away the spherulites appeared fairly homogeneous, but on closer inspection it was difficult to find even a small portion which did not contain part of an incipient spherulite. The end was attained by carefully breaking away small pieces from the rock just surrounding the better-formed spherulites. This material possessed the sea-green colour mentioned above, and when finely powdered was white, while the spherulites gave a reddish powder. It was found that quite a minute portion of a partly-formed spherulite produced a distinct tinge. The results were as follows:—

	Spherulite.		Matrix.
$Si\,O_2$	73·23[1]	...	78·40[1]
$Bi_2\,O_3$ and oxides resembling it ...	0·51	...	0·58
$Al_2\,O_3$	11·45	...	8·81
$Fe_2\,O_3$	4·50	...	...
$Cu\,O$ and oxides resembling it ...	0·30	...	trace
$Fe\,O$	...	...	4·02[2]
$Ni\,O$	trace	...	0·29
$Ca\,O$	0·38	...	0·57
$Mg\,O$	0·02	...	0·20
$K_2\,O$	2·77[3]	...	2·62
$Na_2\,O$	5·14[3]	...	3·06
$H_2\,O$	0·81	...	1·53
	99·11		100·08

Oxygen ratio[4]—

	Spherulite.		Matrix.
$Si\,O_2$	39·05	...	41·81
$Bi_2\,O_3$	·05	...	·06
$Al_2\,O_3$	5·33	...	4·10
$Fe_2\,O_3$	1·35	...	...
$Cu\,O$	·06	...	...
$Fe\,O$	...	...	·88
$Ni\,O$	...	...	·06
$Ca\,O$	·11	...	·16
$Mg\,O$	...	...	·005
$K_2\,O$	·47	...	·45
$Na_2\,O$	2·10	...	·79
$H_2\,O$	·71	...	1·34

	Spherulite.	Matrix.
$R\,O : R_2\,O_3 : Si\,O_2$ ...	2·74 : 6·73 : 39·05	2·345 : 4·16 : 41·81
Including $H_2\,O$	3·45	3·68

The method of analysis employed for all except the alkali metals was thorough fusion in a platinum crucible with mixed alkaline carbonates. The spherulite gave a light greenish mass, and the matrix a still lighter one; they both dissolved easily in dilute hydrochloric acid, and were evaporated to dryness twice with this acid. The sulphuretted hydrogen precipitate was brownish black in both cases. After the separation of the aluminum and iron hydroxides, the nickel was precipitated by ammonium sulphide, and the amount being small it was weighed as sulphide. The double determinations of the silica were obtained by treating the preliminary qualitative examination as quantitative, until the silica had been separated.

In each case the powdered rock, spread out on a watch-glass, was heated for some hours, to about 110° F.; the loss of weight was small, only amounting to ·36 per cent. in the matrix. The powder was

[1] Mean of two. [2] All the iron is calculated as $Fe\,O$.
[3] Another calculated as $Na_2\,O = 7·48$.

[4] The oxygen ratio is equal to $\dfrac{\%\text{ oxide in rock} \times \%\text{ oxygen in oxide}}{100}$

then transferred to a platinum dish and heated over the blowpipe, the loss of weight being taken as equal to the combined water. The iron was determined in each case by the titration of an aliquot part of the solution, the result being calculated to Fe_2O_3 in the case of the spherulite, and to FeO in that of the matrix; since a preliminary test showed that this contained a considerable quantity of FeO, with probably a little Fe_2O_3.

The alkalies were determined by heating the finely-powdered rock with ammonium chloride and calcium carbonate, treating with water and precipitating the bases from the solution; the potassium was then separated, and weighed as potassium platino-chloride.

In the analyses of typical felspars, taking the Al_2O_3 as unity, the other constituents occur in the following proportions:—

	Orthoclase.	Albite.
Al_2O_3	1	1
SiO_2	3·49	3·50
K_2O	0·90	—
Na_2O	—	0·60

If, then, in the above analysis of the spherulite we suppose the K_2O to be present in orthoclase and the Na_2O in albite, we find, using these proportions, that the alumina is almost exactly the amount required, and that about 28·5 of the SiO_2 remains: that is to say, the spherulite must consist almost entirely of albite, orthoclase, free quartz, and some ferric oxide, and there is, roughly speaking, three times as much albite as orthoclase, the felspars making up rather less than two-thirds of the mass.

In the matrix the felspars occur in smaller quantity and in more nearly equal proportions (the albite still dominating), and there is a larger amount of free quartz.

Both these analyses could find parallels among the published bulk-analyses of felsites or volcanic glasses. Both (before devitrification) would represent dacites, but the matrix has the nearer relation to the rhyolites. These analyses accord with the conclusions of Lagario, especially in the larger proportion of soda in the spherulite, and in most of the cases given by him the silica percentage is higher in the matrix.

The following analyses of a spherulite and of the matrix are given by Michel Lévy (Bull. Soc. Geol. France, v, 3rd series, p. 248).

	Spherulite.		Matrix.	
		Oxygen ratio.		Oxygen ratio.
SiO_2	56·90	30·34	45·08	24·04
Al_2O_3	19·24	8·98	22·17	10·35
FeO	6·28	1·39	12·55	2·79
CaO	9·41	2·68	6·62	1·87
MgO	5·80	2·32	13·00	5·20
K_2O	0·59	0·10	0·65	0·11
Na_2O	4·16	1·07	1·59	0·41
	102·38		101·66	
Loss on heating	2·00		5·27	
$RO : R_2O_3 : SiO_2$		7·56 : 8·98 : 30·34		10·40 : 10·35 : 24·04

These analyses differ considerably from those given above. Here not only the silica is greater in the spherulite, but also the lime and alkalies: this gives a perfectly different relation to that found in the above analyses, as shown by the ratio of the oxides. The large quantity of magnesia may be responsible for the difference.

II. The Artificial Spherulitic Rock.

The specimen analyzed had been given to Prof. Bonney by Mr. F. Siemens, of Dresden. It was a bottle glass of a rich resin brown tint (such as is often seen in hock bottles), and the spherulites are of a pale-cream or yellow-ochre colour.[1] Under the microscope the glass exhibits only the very palest tinge of brown, and is almost free from microlithic enclosures; these, as far as they occur, being minute specks, like a dark dust. Crystallites, however, project from the border of the spherulite for a short distance into the glass. The spherulite consists[2] of (*a*) ferrite in small irregular patches; (*b*) an acicular clear mineral, clustered and radiating, forming the mass of the spherulite; (*c*) tufts consisting of a few clear acicular crystallites, diverging like a bundle of sticks loosely tied in the middle. With ordinary light the radial structure appears to dominate, zoned by concentric, more opaque bands, but with crossed nicols the tufted structure completely overpowers it in certain clearer-looking bands towards the exterior, and is more or less conspicuous in all the outer part of the spherulite, except for about the last one-thirtieth of an inch, where the radial structure is almost exclusively present. The feathery exterior of the spherulite appears to be formed of microliths grouped fern-leaf fashion; two sets of crystallites diverging at angles of about 50° from a central stem. The crystallites in the tufts certainly extinguish obliquely, though the angles are not large, perhaps within about 12° of the edge. It is difficult to ascertain the extinction of the radially grouped crystallites, but probably this also is oblique.

Analyses.

	Granite.[3]	Spherulite.	Matrix.
SiO_2	69·30	58·60	56·89
Bi_2O_3	...	0·42	trace
Al_2O_3	17·70	13·33	10·21
Fe_2O_3	1·10	...	3·13[4]
CuO	...	trace	2·47
FeO	...	2·76	...
CaO	1·60	8·30	1·71
MgO	0·13	0·28	1·06[5]
K_2O	3·45	5·62	6·20
Na_2O	5·20	10·31	17·81
	98·48	99·62	99·48

[1] In making this glass the principal material employed is a granite or granulite. See President's Address, Quart. Journ. Geol. Soc. 1885, Proc., pp. 88, 90.

[2] The description is written from a new slice, which is thinner than the one used in 1885.

[3] *Ut suprà.*—Of two analyses given of the original granite, the most likely one of the two is chosen.

[4] The iron here is probably too high.

[5] Probably contains some lime.

Oxygen ratio—

	Spherulite.	Matrix.
$Si O_2$	31·25	30·34
$Bi_2 O_3$ and oxides resembling it	·04	...
$Al_2 O_3$	6·21	4·76
$Fe_2 O_3$	...	·94
$Cu O$	...	·50
$Fe O$	·61	...
$Ca O$	2·37	·49
$Mg O$	·11	·42
$K_2 O$	·95	1·05
$Na_2 O$	8·66	4·60
$R O : R_2 O_3 : Si O_2$	7·06 : 5·70 : 30·34	6·7 : 6·25 : 31·25

The matrix, on fusion with mixed alkaline carbonates, gave a bright blue-green mass, and this dissolved to a yellow liquid on solution in dilute hydrochloric acid. The percentage of iron in the matrix appears to be high, and cannot be correct unless iron came in as an impurity in the materials, or was added for colouring purposes. The copper, which practically remains in the glass, has been undoubtedly added for this reason. The general processes of analysis and the method of determination of the alkali metals were carried on in the same manner as in the former analyses.

It is not easy to interpret the bulk-analysis of the spherulite, and we must bear in mind the possibility that, as it is an artificial product, the constituent minerals may not correspond with any that occur in nature. Comparing with the analysis of the original granite, it is evident that some lime, potash, and a considerable quantity of soda must have been added in some form or other. A rough calculation, however, indicates that if the potash were present as orthoclase, and some of the soda as albite, this would use up the alumina and about seven-tenths of the silica; the remainder of this, with the rest of the soda, the lime, magnesia, and iron protoxide, might form a mineral allied to the soda pyroxenes.

The silica percentage of the granite glass is comparable with that in the intermediate rocks, in which Lagario[1] has shown that the matrix tends to become a mixture of quartz and orthoclase. The analysis given above does not agree with this, as the matrix has less silica and more soda than the glass, but corresponds fairly well with one of Dumas' quoted by Professor Bonney in his presidential address[2]; but the ratios of the oxides are very different.

	Crystallized part.	Vitreous part.
$Si O_2$	68·20	64·70
$Al_2 O_3$	4·90	3·50
$Ca O$	12·00	12·00
$Na_2 O$	14·90	19·80
	100·00	100·00

Oxygen ratio—

	Crystallized part.	Vitreous part.
$Si O_2$	36·37	34·50
$Al_2 O_3$	2·20	1·59
$Ca O$	3·43	3·43
$Na_2 O$	3·84	5·11
$R O : R_2 O_3 : Si O_2$	8·54 : 1·59 : 34·50	7·27 : 2·2 : 36·37

[1] *Loc. cit.* [2] *Loc. cit.*

The higher percentage of soda in the glass is probably due to the artificial conditions; there is a large overdose of soda, which cannot crystallize. Michel Lévy, in the analyses given above and in others, finds that the silica percentage is greater in the spherulite, which is exactly contrary to the result obtained by Lagario. In this it will be seen that one of my analyses agrees with one authority, and the second with the other. It is evident that the differences between the matrix and spherulite may be small or large and one way or the other, so that at present it is not possible to prove any constant relation between them.

The following papers will be found useful for reference, including those given above:—

Michel Lévy. Bull. Soc. Geol. France, sér. 3, t. iii, p. 199; sér. 3, t. v, p. 232. Ann. des Mines, sér. 7, t. viii.

Delesse. Ann. des Mines, sér. 4, t. xvii, p. 116. Mém. Soc. géol., sér. 2, t. iv.

Bonney, T. G. Quart. Journ. Geol. Soc. 1885, Proc., pp. 88 and 90.

Potier. Bull. Soc. Geol. France, sér. 2, t. v.

Wallerant. Bull. Soc. Geol. France, sér. 3, t. xvi, p. 927; (Note on large Variolite), sér. 3, t. xvii, p. 447.

Rosenbuch. Zeitschrift der deutschen geologischen Gesellschaft, t. xxviii.

Lagario. See Teall's "British Petrography," p. 397.

IX.—On a new British Rock containing Nepheline and Riebeckite.

By T. Barron, A.R.C.S.

Introduction.

The mineral riebeckite was first discovered by Professor T. G. Bonney[1] in 1882, who, in a paper to the Royal Society describing a series of rock-specimens from the island of Socotra, noticed the occurrence in a granite of a mineral which, though presenting characters common to the hornblende group, he referred doubtfully to tourmaline.

Four years later Oebbeke[2] described a mineral from the island of Sikoku, Japan, which showed intense colour and pleochroism, but differed in other respects from glaucophane, to which he referred it. The following year Professor A. Sauer,[3] of Leipzig, in examining a series of specimens collected by Dr. E. Riebeck from the island of Socotra, noticed the blue mineral described by Professor Bonney. Having isolated and analyzed it, and determined its optical properties, he placed it among the amphiboles, naming it riebeckite. In the same year Rosenbusch[4] found a peculiar variety of hornblende in a syenitic lamprophyre, which agreed in its optical properties with the mineral described by Sauer.

In 1888 Professor Bonney[5] described "a peculiar variety of

[1] Phil. Trans., vol. clxxiv (1883), p. 283.

[2] Zeitschr. für Kryst., vol. xii (1886), p. 285.

[3] Zeitschr. der Deutsch. geol. Gesellsch., vol. xl (1888), p. 138.

[4] "Die massige Gesteine," Bd. ii (1886–7), p. 312.

[5] Mineralogical Magazine, vol. viii (1888), pp. 103, 169.

hornblende from Mynydd Mawr, Carnarvonshire," which resembled the Socotra mineral very closely in its general characters. He, however, referred it with some hesitation to arfvedsonite. In the same year Mr. A. Harker,[1] who had been studying this same rock independently, referred the blue mineral to riebeckite. The following year two other localities were added to the list of places in which it occurs. It was described in a granulite from Corsica by M. Urbain Le Verrier;[2] and in a rock of the same description from Colorado by Lacroix.[3] In 1891, Mr. J. J. H. Teall[4] recorded the occurrence of riebeckite in a micro-granite from Ailsa Craig. The following year it was described in a granitite from Southern Sikkim, India, by Mr. T. H. Holland.[5]

Riebeckite has also been described by Professor Grenville A. J. Cole,[6] from eurite-pebbles collected from the glacial drift of the Isle of Man and Moel-y-Tryfaen; and later at Greenore,[7] near Carlingford, Ireland. Professor Sollas[8] has also described it from the glacial drift at Greystones, co. Wicklow.

The object of this present paper is to add one more locality to the list of places from which riebeckite has been recorded, and to describe a rock in which nepheline is associated with riebeckite—a combination which has not hitherto been recorded.

Occurrence in the Field.

The area from which the rocks to be described were collected, may be seen by referring to quarter-sheet No. 25 of the Geological Survey of Scotland. The specimens were obtained from three hills in the valley of the Tweed, two of which (the Eildons) lie to the west, and the other (Black Hill) lies to the east of that river. Viewed from the east, these three hills stand out boldly from the surrounding country, forming a conspicuous landmark. They are isolated pieces of what was once a continuous mass of lava, which, by the action of disintegrating agents, has been cut into ridges having a general trend east and west. That ice has played an important part in the configuration of this district, may be seen by a glance at the disposition of the ridges and valleys; and as confirmatory evidence I have found glacial striæ on the rocks of the Black Hill. But the lava has not only been cut into ridges lying east and west; it has also been breached by the Tweed in a southerly direction. In this way the Eildon Hills have been separated from the rest of the mass. The eastern side of the Tweed valley is formed at this point by the escarpment of the Old Red Sandstone, capped by igneous rock; and it is part of this escarpment which forms the base of the Black Hill. The opposite side of

[1] Geological Magazine, Decade III, Vol. V (1888), p. 455.
[2] Comptes Rendus de Acad. des Sciences, tome cix (1889), p. 38.
[3] *Op. cit.*, p. 39.
[4] Mineralogical Magazine, vol. ix (1891), p. 219.
[5] Records, Geol. Survey of India, vol. xxv, pt. 3, 1892.
[6] Mineralogical Magazine, vol. ix (1891), p. 222.
[7] Nature, vol. xlvii, p. 464.
[8] Proc. Geol. Assoc., vol. xiii (1893), p. 118.

the valley is less steep, and is bounded by the Eildon Hills, which are also formed of a base of Old Red Sandstone capped by igneous rock.

The junction between the Old Red Sandstone and the igneous rock is well seen in a quarry on the south side of the Black Hill. It is marked by a layer of hard, white, siliceous rock twelve inches thick, which, as will be shown later, has undergone some alteration by contact with the lava. Underneath this layer, the sandstone is soft and friable for several feet, but gradually passes into hard sandstone. In this soft rock, scales of *Holoptychius* are found, proving the rock to be of Upper Old Red Sandstone age.

The character of the rock in the three hills from which the specimens were collected, is rather variable. The most westerly hill (Middle Eildon) is composed of a reddish-purple, close-grained, felsitic rock, which rises in a steep cliff towards the south and east, but slopes more gradually towards the north and west. On the north side, the rock shows a marked tendency to split into thin plates, which give a sharp, metallic sound, when struck with the hammer. So very marked is this tendency to split into thin plates, that it is extremely difficult to obtain a specimen of any thickness. On the south side, the rock is much more compact, and breaks with a conchoidal fracture.

The rock composing the Black Hill is somewhat different from that already described. When the hill is traversed from north to south, the rock is seen to vary on its two sides. On the north side the hill terminates abruptly in a vertical face of rock of a dull, brownish-pink colour. The rock is traversed by well-marked joints, which, in places, produce a rudely columnar structure; on weathered surfaces there is a tendency to split into slabs. In the lower part of the rock some exquisite flow-structure can be seen. This I was able to trace for about 20 feet from the base, although at times it was obscured by the lichens which cover the rock. Usually the banding of the flow runs parallel with the horizontal joints in the rock; but in certain places it is much contorted. At one place it deviated sharply from the horizontal line, and was traced in an almost vertical direction for 20 or 30 feet, where it was lost on account of the steepness of the rock.

On the south side of the hill, the rock is of a dull, reddish-pink colour, and is much more decomposed than that on the north side. The felspars have, in many cases, been dissolved out, leaving their casts, which are sometimes partly filled with chalcedony. This character is, however, not very constant; for in certain places the rock is hard and compact, ringing under the hammer and breaking into thin slabs.

Petrographical Description.

The rocks from Middle Eildon are all of felsitic texture. On a fresh fracture a few cleavage-faces of a clear felspar may be seen; and by the aid of a lens a bluish-green mineral can be recognized all through the base of the rock. In some of the specimens a banded structure is seen; this is accentuated by the segregation of iron oxide along the bands.

Under the microscope, the banded rock shows a trachytic structure; it is of a non-porphyritic character, only a few large sanidines being scattered through it. These show irregular outlines; are often corroded; and when examined between crossed nicols, break up into a granular aggregate. This arrangement of the larger felspar crystals is characteristic of this lava-flow. The sanidine crystals also show the irregular series of cracks at right angles to their direction of elongation, which is so characteristic of them in all lavas. The base of the rock is made up of felspar microlites, a bluish-green mineral, and a colourless mineral of low refractive index and double refraction.

The bluish-green mineral occurs in small pieces, often grouped together, and moulding the felspars in the same way as augite does in many of the basic rocks. Between crossed nicols these patches extinguish together, showing that they are parts of the same crystal. Many of the pieces show cleavage-lines parallel to their sides, and one or two likewise show the hornblende cleavages. The extinction angle, measured from the longitudinal cleavage-lines, was 5°. When rotated over the polarizer this mineral showed intense pleochroism. Owing to the small size of the pieces I was unable to obtain a satisfactory figure from which to determine the axes of elasticity; but referring the colours to the crystallographic axes, the scheme of pleochroism is as follows:—

Parallel to $\acute{c}$	...	...	deep blue.
„ „ $\acute{\bar{b}}$	...	...	deep blue-green.
„ „ $\acute{\bar{a}}$	...	...	pale yellow-green.

All the characters above cited point to the conclusion that the mineral is the soda-amphibole—riebeckite. But, as Rosenbusch has shown, it is the axis $\mathfrak{a}$, and not $\mathfrak{c}$, which makes an angle of 5° with the vertical axis; the scheme of pleochroism thus becomes $\mathfrak{a} > \mathfrak{b} > \mathfrak{c}$. This mineral forms fine ophitic patches with the felspar, but in certain parts of the rock it is replaced by a pseudomorph of iron oxide, which preserves intact the outlines of the original patch.

In one or two places glomero-porphyritic patches of sanidine and colourless diopside were observed; a few altered porphyritic augites and a little altered ægirine were also present in the section.

Scattered through the base of the rock are some brownish altered patches, which, when examined with a quarter-inch objective, are seen to consist of felspar microlites, and another mineral of lower refractive index, which remains almost isotropic when rotated between crossed nicols. This mineral occurs in irregular patches which extinguish in definite areas, and mould the felspar microlites. In certain places four-sided and irregular six-sided plates were observed, the former extinguishing parallel to their edges, and the latter giving a uniaxial, partial interference-figure in convergent polarized light. Nearly all the plates of this mineral were slightly altered, and some were in an advanced stage of zeolitization. In extremely thin sections the difference in the polarization-colours of this mineral and the felspar microlites was much more plainly seen. From these optical characters I have concluded that the mineral is nepheline. As a confirmatory test, another thin section was prepared, and exposed to the vapour of strong hydrochloric acid for half an hour. It was then washed with warm water, covered with a saturated solution of malachite-green, and set aside for fifteen minutes. (This material was chosen in preference to fuchsine, because, according to Behrens, it does not give accidental stains—a great drawback to the use of the latter substance.) The section was now washed once again with warm water, a camel's-hair brush being used to remove any superfluous staining material. After the section was mounted in canada balsam and covered, it was found on examination under the microscope that the mineral moulding the felspars had been etched and stained deeply, while the latter remained untouched.

By way of comparison, a thin section of the phonolite-trachyte from Traprain Law was prepared and treated in a similar way. The staining showed the relations between the nepheline and felspar in this rock to be different to those existing in that from Eildon; for, while in the latter, nepheline moulded the felspars, in the former it seemed to be present in more or less idiomorphic plates.

In general structure the two rocks are very similar, except that in the Traprain Law rock the ferro-magnesian mineral is ægirine, which is present in a granular condition, while in that from Eildon it is riebeckite, which is often ophitic.

On the south side of the hill, the rock assumes a much more felsitic character; its fracture is conchoidal; and porphyritic felspars are very rare. A blue mineral can be seen scattered in patches through the rock, which by the aid of a lens can be recognized as riebeckite.

Under the microscope, the rock is seen to consist of felspar microlites, and patches of riebeckite or pseudomorphs after it. Ferruginous alteration-products are scattered thickly through it, giving a pinkish colour to the section, and rendering the rock so dense that it requires great care to obtain a section thin enough to be transparent. A few granular aggregates of felspar (sanidine) are present in the slide, some of which show zoning, and a rude attempt at perthite structure when examined between crossed nicols. The riebeckite exhibits the same characters as in the previous rock, except that its pleochroism is more intense. Between crossed nicols, the base of this rock is seen to be under strain; it also breaks up into patches which polarize in two distinct tints. One set of patches gives the extremely low colours of nepheline, and when examined in ordinary light shows greater alteration than the other. Small rectangular sections, much altered, were also observed giving the same polarization colours. From the very close resemblance of these patches to those in the rock previously described, there seems to be little doubt that they are composed of nepheline.

Easter Eildon.

The rocks composing this hill are typical trachytes. In hand-specimen they show, on a fresh fracture, the cleavage-faces of a sanidine felspar, in some cases slightly kaolinized; they have the general rough appearance and feel which characterize trachytes.

Under the microscope the rock is seen to consist of porphyritic sanidines set in a base of felspar microlites, among which is scattered a good deal of limonite evidently pseudomorphous after riebeckite, as it retains the exact outlines of the original ophitic patch. The porphyritic sanidines are resolved into granular aggregates between crossed nicols. In some of these there has evidently been a growth of the crystal after the consolidation of the rock, as there is evidence in some cases of an attempt to assume a crystal form. A notable feature of the felspars of this rock is the number of sections which give a biaxial figure in convergent polarized light. Some of the larger crystals have been dissolved away and their places filled up by secondary quartz. Sections of the rocks from other parts of the hill did not show any very different characters; a special description is therefore unnecessary.

Between these rocks and that from Ailsa Craig described by Mr. Teall, there is a great similarity, Their ground-mass is almost identical with that of the Ailsa Craig rock; the riebeckite is in ophitic patches, and shows the alteration into pseudomorphs of iron oxide in both cases; and, except for a larger quantity of quartz in the latter rock, the resemblance is very striking. If similarity of structure and composition be of any value in determining the age of a rock, perhaps the fact of the rocks just described being of Upper Old Red Sandstone age may help to suggest the age of the Ailsa Craig rock.

Black Hill.

Banded Rock.—Macroscopically, this rock shows two sets of bands. One half consists of alternating bands of brown and greyish-pink $\frac{1}{32}$ of an inch broad, the other of bands $\frac{1}{8}$ of an inch in thickness. Porphyritic sanidines, somewhat altered, occur here and there, lying across and breaking the bands.

Microscopically, the rock consists of a finely felted mass of sanidine microlites with their long axes lying parallel to the banding. Porphyritic crystals are rare, and when present occur in granular aggregates. They are all more or less altered, and show the irregular cracks across the prism so characteristic of sanidine in the more recent trachytes. No ferro-magnesian mineral is present in this rock; but there is evidence of its presence at an earlier period of its history, in the ferruginous alteration-products which have been shown to be formed from riebeckite in the other rocks. These alteration-products have segregated along the flow-lines, thus producing the beautiful banded appearance.

The other rocks (unbanded) are very similar in microscopic structure to that described above; there is therefore no necessity for a detailed description.

Junction between Sandstone and Igneous Rock, on the South Side of the Hill.—Macroscopically, the rock resembles the claystone porphyrites in appearance. It shows signs of minute spherulitic structure near the junction with the sandstone. The line of junction is not straight and sharp, but the igneous rock has sent small offshoots into the sandstone. It is thus highly probable that the sandstone was in a loose unconsolidated state when the lava was poured over it.

Microscopic examination of a section shows the trachyte to be a good deal altered. It has evidently been originally a glassy rock containing a few porphyritic crystals of sanidine which are now replaced by chalcedony. The glass, which is now largely devitrified, is crowded with altered spherulites. The devitrified base has the appearance of the highly siliceous ground-mass of the felsophyres of the acid rocks. It is thus highly probable that a good deal of quartz has been fused and incorporated in the lava along the line of contact.

The sandstone also shows signs of fusion along the line of contact with the trachyte. The sand-grains are cemented together by a finely crystalline aggregate of quartz. Along the junction-line, the grains show much corroded outlines, and many of them show a ring of fused material having very indefinite boundaries. Where the trachyte has sent veins into the sandstone, lines of fusion are seen which much resemble the fluxion-structure of a rhyolite. Round these veins the quartz has been fused; it is now in the form of chalcedony. In the sandstone itself, mica is seen to be developing; and there is a good deal of felspar, mostly unaltered plagioclase showing lamellar twinning.

Another specimen of sandstone, taken one foot below the junction-line, had lost all traces of bedding, and broke with an irregular fracture. Scales of a silvery mica were seen lying in all directions and at all angles to the bedding-planes, thus proving that they have been developed subsequent to the deposition of the sandstone.

Under the microscope, the mica proved to be muscovite. Fresh plagioclase has also been developed; and the cementing material between the sand-grains has been made to assume a finely granular form.

The presence of fresh plagioclase in a sandstone is not an every-day occurrence, and it is necessary to find an explanation to account for it. Sandstone, being a porous rock, is not likely to contain the alkalies necessary for the formation of plagioclase felspar, because of their solubility in water. They must, therefore, have been derived from another source, that being the overlying igneous rock. It was noticed that no ferro-magnesian mineral was observed in the overlying rock; but there was a good deal of iron oxide scattered through it, which was shown to be derived from the alteration of riebeckite in the Eildon rock. This mineral, being a soda-amphibole, might, by its decomposition, supply the alkali necessary for building up a felspar such as albite; and I am inclined to regard this as the true explanation of the presence of fresh plagioclase in the sandstone.

I have only to add that this work has been done in the Geological Research Laboratory of the Royal College of Science; and to express my thanks to Professor Judd for the assistance and many valuable suggestions that he has given me.

REVIEWS.

I.—Catalogue of the Jurassic Bryozoa in the British Museum (Natural History). By J. W. Gregory, D.Sc., F.G.S., F.Z.S. (1 vol., 8vo; pp. 240, 11 Plates.) London: 1896. Printed by order of the Trustees. Dulau & Co., 37, Soho Square, W. Price 10*s.*

THIS volume is the first of a series, which, when completed, will form a Catalogue of the fossil Bryozoa in the British Museum. Dr. Gregory explains that he has begun with the description of the Jurassic Bryozoa, because "it is among the Jurassic deposits that we must seek the ancestors of existing types," and because the primary lines of divergence are here well marked, and not obscured by secondary variations of later periods. Further, it was necessary to work out the Jurassic fauna before attempting the Cretaceous, which, of all British Bryozoan faunas, is most in need of further investigation. Of the seventy-nine species here described, sixty-nine are included in the Cyclostomata, eight in the Trepostomata, and two in the Cheilostomata. The Cryptostomata, which occur so abundantly in Palæozoic times, and which are usually assumed "to take the place of" the Cheilostomata, have not been found in the Jurassic strata. The Trepostomata, which likewise prevailed in the Palæozoic strata, form a dwindling remnant in the Jurassic. The Cheilostomata, which preponderate in later times, have not yet risen into importance.

The classification of the orders is based on zoœcial[1] characters. The Trepostomata are characterized by the *change* in the nature of the distal as compared with the proximal parts of the zoœcial tubes, by the presence of mesopores, diaphragms, acanthopores, etc. The order Cyclostomata, which includes 87 per cent. of the species here catalogued, is separated from the others rather by its negative characters. Dr. Gregory divides this order into four suborders: 1, Articulata (including Crisiidæ); 2, Tubulata; 3, Dactylethrata; 4, Cancellata (including Discoporellidæ). The first and fourth do not occur in the Jurassic deposits. Accordingly, the Jurassic Cyclostomata fall into two groups—the Tubulata (including 65 species), in which the zoœcia are monomorphic; and the Dactylethrata (including 4 species), in which aborted closed zoœcia or "dactylethræ" are present in addition to the normal open ones.

It has always been a difficult matter to satisfactorily classify the forms (recent as well as fossil) included in the Tubulata. The zoœcial characters are of no use in the splitting up of this suborder

[1] *Zoœcium*, the individual tube or cell containing in life the polypide; *zoarium*, the colony of tubes or cells.

into families and genera, or in founding wholly artificial groups. Consequently the systematist is compelled to trust to zoarial characters. When he finds that a change in environment appears to bring about a change in zoarial habit in a species, and that types of zoarial growth characteristic of different "genera" may occur in the same specimen, and further, that transitional forms link together the types of zoarial growth assumed to be of generic or family importance, then it is that he feels the need of caution in applying such terms as family and genus to groups of forms classified according to zoarial characters. As a philosophical naturalist, Dr. Gregory is inclined to group at least the first section of the Tubulata under one genus. As a working palæontologist, he retains the well-known generic names, but with the understanding that such names are merely labels attached to certain groups, the members of which resemble each other more than the members of neighbouring groups. In place of the word "genus" Dr. Gregory suggests "circulus," a term applied to the groups of listeners which congregated round orators in the Forum.

Minor characters of the zoœcial tubes are made use of to distinguish species. Dr. Gregory has framed a very useful "variational formula," whereby "the range of variation within the limits of a certain specific group may be conveniently shown." The elements taken into account are the peristome or distal end of the zoœcia, the shape, the length, and the amount of aggregation of the zoœcia, four degrees (0, 1, 2, 3) of variation being calculated. By means of this formula, it is easy to accurately tabulate and compare the slight variations that may occur, let us suppose by way of example, in specimens of the same species occurring in consecutive strata or epochs.

We regret to have to point out that a short corrigenda list is necessary. The text is liberally illustrated by numerous woodcuts, and by eleven plates, the artistic finish of which is excellent.

Laborious research, scientific method, and artistic skill have contributed to form a volume which maintains the honourable traditions of the British Museum; and it is to be hoped that Dr. Gregory will complete the work he has so well begun.

II.—Bollettino della Società Sismologica, Vol. I, 1895. pp. 168 + 230.

De Rossi's valuable *Bullettino del Vulcanismo Italiano* was begun in 1874, and ceased to exist in 1889 or 1890 after a few parts of the seventeenth volume had been published. Its place is now worthily supplied by the *Bollettino* of the Italian Seismological Society, founded under the direction of Prof. Tacchini in the spring of last year. Though nominally a society, it does not appear that any meetings have been held; indeed, the members are so widely scattered, so few are collected in any one place, even in Rome, that regular meetings would be hardly possible, and the exertions of the members are wisely confined to the publication of their journal.

The first part of the volume contains 27 short papers. The second and larger part is contributed by the Central Meteorological and Geodynamic Office at Rome, and consists of notices of the earthquakes observed in Italy during 1895. It is not, however, of merely local interest, for many of the records are those of distant shocks, and supply valuable time-determinations for measuring the velocity with which the pulsations travel.

That the invention of new instruments continues to occupy Italian seismologists, is shown by the insertion of no fewer than eight papers. The Guzzanti microseismograph is described by its inventor, and the Cecchi microseismograph, which has been in use for some time, by G. Giovannozzi. Prof. G. Mugna describes an electrically-recording seismoscope; Dr. A. Cancani, a new type of seismic photo-chronograph; and Prof. G. Grablovitz shows how the horizontal pendulum may be adapted for recording the time of occurrence of a shock. Accounts are also contributed by their respective inventors of Vicentini's microseismograph, Agamennone's seismometrograph, and Grablovitz' geodynamic level, instruments which have already added to our knowledge of earthquake-pulsations.

Several interesting earthquake-studies are supplied by the staff of the Meteorological and Geodynamic Office. The well-known Director, Prof. P. Tacchini, describes the Roman earthquake of Nov. 1, 1895; while his assistant, Dr. M. Baratta, deals with the Lecco earthquake of March 5, 1894, the Viggianello earthquake of May 28, 1894, the Laibach earthquake of April 14, 1895 (so far as it was felt in Italy), the Florentine earthquake of May 18, 1895, the Adriatic earthquake of Aug. 9, 1895, and with the Florentine seismic district generally. Dr. G. Agamennone, the Director of the Constantinople Geodynamic Office, discusses the earthquake of Paramythia (Epirus) of May 13–14, 1895; and Prof. F. Omori determines the surface-velocity of several recent Japanese earthquakes.

The Italian volcanoes receive their due share of attention. Prof. G. Mercalli communicates Vesuvian notes from January, 1892, to June, 1895; and Prof. A. Riccò, notes on the state of Etna from the eruption in 1892 to the end of 1894. A summary of the principal eruptive phenomena in Sicily and the adjacent islands is added by S. Arcidiacono, and some observations made on Vesuvius on June 21, 1895, by Dr. M. Baratta. C. Davison.

III.—Miocene and Pliocene Mammals in Russia. Nouveaux Mammifères tertiaires trouvés en Russie. By Marie Pavlow. Bull. Soc. Imp. Nat. Moscou, 1896, No. 2, pp. 1–12 (reprint), with one plate.

Madame Pavlow's latest contribution to our knowledge of the extinct Mammalia of Russia is an interesting description of some fragmentary remains referable to an earlier date than the Pleistocene. *Anchitherium aurelianense* is recorded for the first time from Russia, on the evidence of the distal end of a metacarpal III from the neighbourhood of Nikolaew. *Rhinoceros Schleiermacheri* is represented by two molars, *Capreolus cusanus* by two imperfect antlers and one lower molar, and a *Cervus* (much like *C. Perrieri*) by a metacarpal, all from the sandy beds of Balta, in the Government of Podolsk. A lower jaw from Balta, believed to belong to *Mastodon turicensis*, is also described from a photograph, the original specimen having apparently been lost. According to Madame Pavlow's list of the mammals, the "sables de Balta" are characterized by a curious fauna. In addition to the species mentioned above, there are already identified *Dinotherium giganteum*, *Hipparion gracilis*, *Rhinoceros megarhinus*, *Mastodon ohioticus*, *Mastodon arvernensis*, and *Mastodon Borsoni*.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 24, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair.

Death of Sir Joseph Prestwich, D.C.L., F.R.S., F.C.S., F.G.S.

The President said: It is with deep regret that I have to announce to you the death of our dear and much-beloved friend, Sir Joseph Prestwich. He was elected into the Society in the year 1833, and we had come to look upon him as the father of our Society. He served it as Treasurer and President and was one of its Wollaston Medallists, and we feel that by his death our Society loses one of its truest friends. He always gave us of his best, and delighted to communicate his knowledge to his fellow-workers. He was in every respect a typical representative of our Society and its objects, for he passionately loved the science, fearlessly maintained what he believed to be the truth, and had that open mind and craving for knowledge which have ever characterized the best and noblest of its members. This is not the time to refer specially to his labours; but we may feel assured that such sterling work as he accomplished will ever hold an honoured place in the annals of British Geology. The Council, at their sitting this afternoon, passed the following resolutions, which I feel no doubt all the Fellows present will cordially endorse:—

(1) That the President, Council, and Fellows of the Geological Society of London desire to convey to Lady Prestwich the assurance of their heartfelt sympathy with her in the sad and irreparable loss that she has sustained, and at the same time to place on record their high appreciation of the lifelong geological work achieved by Sir Joseph Prestwich, who for sixty-three years was a member of their body alike respected and beloved.

(2) That this Resolution be placed upon the Minutes, and a copy of it be communicated to Lady Prestwich.

The above Resolutions were then passed unanimously.

Sir William Dawson, C.M.G., F.R.S., exhibited specimens and lantern-slides illustrating the general form, arrangement of laminæ, and distribution of the canals and tubuli in characteristic specimens of *Eozoon canadense*. He pointed out that an examination of these specimens and photographs might prevent mistakes likely to arise from the study of imperfect specimens or from supposing that laminated rocks resembled *Eozoon*, and also that they exhibited additional peculiarities observed since the original publication of the description of *Eozoon* in the Quarterly Journal of the Society in 1865. He did not wish to enter upon any argument as to the nature of *Eozoon*, but merely to show the appearance of the principal structures on which the conclusion that it was of animal origin had been based. He also pointed out that these structures might be misunderstood when studied in imperfectly-preserved specimens, and that the wonder was not that so many specimens were imperfect, but that any structure had been preserved. He also shortly noticed the growing probabilities in favour of the existence of a rich marine fauna in pre-Cambrian times, and some of the discoveries in this direction already made or in progress.

The following communications were read :—

1. "Notes on the Glacial Geology of Arctic Europe and its Islands. Part II: Arctic Norway, Russian Lapland, Novaya Zemlya, and Spitzbergen." By Colonél H. W. Feilden, F.G.S. With an Appendix by Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author gives an account of observations made in Arctic Norway which tends to prove that the shell-bearing terraces are true marine deposits indicating uplift since their formation, and that they were not formed by ice-dams. He then describes terraces recently formed in Kolguev Island, which illustrate the combined influence of pack-ice, sea-waves, and snow on the formation of terraces in a rising area. The glacial geology of the Kola Peninsula is next considered, and the distribution of the boulders noticed. There is no doubt that these boulders have been derived from local rocks, and that no ice-sheet from the North ever passed through Barents Sea or impinged on the northern coast of Europe.

The author saw no evidence of the former extension of an ice-sheet over the now frost-riven rocks of Novaya Zemlya. He found widespread deposits of boulder-clay with marine shells in this region, which he attributes to the action of floating ice. In the Kostin Schar many of the islands are connected by ridges covered with rounded stones pushed up by floe-ice, with solid rock beneath glaciated by the floe-ice. Several minor phenomena connected with the glacial geology of Novaya Zemlya are also described. The raised beaches of Franz Josef Land are noticed, and immense deposits occurring in Spitzbergen, which were originally formed under water in front of glaciers, alluded to. These, as well as other submarine deposits of glacio-marine origin seen elsewhere by the author, show no signs of stratification.

Prof. Bonney described specimens brought by Col. Feilden from Norway, the Kola Peninsula, and Novaya Zemlya. From an examination of the rocks obtained *in situ* in the last-mentioned region, Prof. Bonney confirms Col. Feilden's suggestion that the Kolguev erratics may have come from Novaya Zemlya.

2. "Extrusive and Intrusive Igneous Rocks as Products of Magmatic Differentiation." By Prof. J. P. Iddings, For. Corr. G.S.

The author, after pointing out the propositions concerning differentiation of magmas upon which he is in agreement with Prof. Brögger, discusses the points of difference, and describes the relation of the igneous rocks at Electric Peak to all of those which took part in the great series of eruptions which occupied almost the whole Tertiary period, and spread themselves over a vast territory in Montana, Wyoming, and Idaho. In Tertiary times the eruptions were at first largely explosive, and the accumulation of tuff-breccia formed a chain of lofty volcanoes, comparable with the Andes in size as well as in the nature of their material (andesite and andesitic basalt). After considerable erosion of these volcanoes, gigantic fissure eruptions flooded the region west of the denuded volcanoes. The massive lava-streams which welled from these fissures consisted at first of rhyolite with an average silica-percentage of about 74, alternating occasionally with basalt; but the great bulk of the basalt was poured out immediately after the rhyolite from fissures still farther to the west and south-west. In the case of these extrusive rocks, whose volumes are of such magnitude, the evidence drawn from the succession of their eruptions and from their composition is of a higher order than that derived from the smaller and more localized eruptions; and it is upon evidence of this order that the author ventured to enunciate the principle that in a region of eruptive activity the succession of eruptions in general commences with magmas representing a mean composition and ends with those of extreme composition.

CORRESPONDENCE.

MR. DUGALD BELL AND THE PARALLEL ROADS OF GLENROY.

Sir,—Did time allow, it would be easy to show that Mr. Dugald Bell's criticism of my remarks on the Parallel Roads of Glenroy (page 319) is a typical instance of forensic advocacy. But I am leaving England for the Alps, so that Lochaber must rest in peace. Whether on my return it will be worth while spending time in travelling over well-worn paths, is a doubtful matter. Nothing can be settled about Glenroy till some fresh evidence turns up. Meanwhile Mr. Dugald Bell may rest assured that I am not frightened at being in a minority. I have lived and been a geologist long enough to have watched the apparition and the fading away of many Brocken-spectres, not in our science only. T. G. Bonney.

July 3rd, 1896.

FOSSILS IN THE *OLENELLUS* SANDSTONE OF NUNEATON.

SIR,—The publication of the May number of the Quarterly Journal of the Geological Society has reminded me of a correction which I ought to have made before, and for which I am alone responsible. On page vi, in the first paragraph, in speaking of fossils collected by Professor Lapworth from the *Olenellus* Sandstone of Nuneaton, I give a list of determinations which were merely approximate, without any warning to that effect. I have since learned that these determinations were not intended to be final, and therefore I ought to have inserted the letters *cf.* before the six specific titles given in that paragraph. W. W. WATTS.

CORNDON, WORCESTER ROAD, SUTTON, SURREY.
June 10*th*, 1896.

MISCELLANEOUS.

RECENT ADDITIONS TO THE GEOLOGICAL DEPARTMENT OF THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD.

1. There has just been added to this gallery a very fine collection of flint implements, also numerous flint flakes, showing various stages and processes in their manufacture, and found associated with remains of *Rhinoceros antiquitatis* at Crayford, in Kent. Presented by F. C. J. Spurrell, Esq., F.G.S.

2. A collection of fossils from Devon and Cornwall, part of the museum of the late William Pengelly, Esq., F.R.S., comprising mammalian remains from Happaway Cave and Devonian Corals, Brachiopods, Trilobites, Cephalopods, etc. Presented by Mrs. Pengelly, of Lamorna, Torquay.

3. Remains of some remarkable extinct birds from the older Tertiary deposits of Santa Cruz, Patagonia. Many of these are of gigantic size: the lower jaw of one of the largest (*Phororhacos longissimus*) measured about twenty inches in length; the whole skull must have been fully two feet in length. The complete skull and mandible of a somewhat smaller form (*Phororhacos inflatus*) show the remarkable characters of the beak, which is hooked like that of a bird of prey, but at the same time is very deep and compressed. Acquired from Prof. Ameghino, of La Plata.

4. Some extremely well-preserved parts of skeletons of Plesiosaurs from the Oxford Clay of Peterborough have been mounted in one of the wall-cases. Part of the Leeds Collection.

5. Some remarkable reptiles, *Cynognathus* and *Gomphognathus*, from the Trias of South Africa, in which the teeth and skull had a superficial resemblance to those of carnivorous mammals. Presented by Professor H. G. Seeley, F.R.S., F.G.S.

6. A very rich collection of mammalian and reptilian remains from the Miocene Tertiary deposits of the "Bad-lands" of Dakota, North America, comprising many genera, such as *Titanotherium*, *Mesohippus*, *Oreodon*, *Poëbrotherium*, *Hoplophoneus*, etc. Acquired from Prof. W. B. Scott, F.G.S., of Princeton, New Jersey, U.S.A.

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SOME OF THE ORIGINAL MEMBERS OF THE PALÆONTOGRAPHICAL SOCIETY.

1. Prof. Sir JOSEPH PRESTWICH, D.C.L., F.R.S., Memb. of Council (1847).
2. Prof. JOHN MORRIS, F.G.S., Hon. Secretary (1847).
3. F. E. EDWARDS, Esq., F.G.S., Memb. of Council (1847).
4. SEARLES V. WOOD, Esq., F.G.S., Treasurer (1847–1884).

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. IX.—SEPTEMBER, 1896.

ORIGINAL ARTICLES.

I.—The Palæontographical Society of London.

(PLATE XIII.)

AMONGST the various interesting scientific events which this year has witnessed, none has probably been more heartily welcomed or more cordially honoured than the Jubilee of the Palæontographical Society, which was celebrated on the 19th June last.

The annual general meeting was held on that day, under the chairmanship of Dr. Henry Woodward, F.R.S., F.G.S. (the President-elect), at the rooms of the Geological Society, Burlington House; and the Council availed themselves of the occasion to give a brief account of the early history and subsequent progress of the Society.

The origin was mainly due to the prior issue of Sowerby's "Mineral Conchology," of which the first part appeared in June, 1812, and was followed by other parts for over thirty years. The portions of this work were brought out slowly and irregularly, and rarely illustrated more than ten species at one time. During the publication of this contribution to geological science, an association was formed (about the year 1836) called "The London Clay Club," the members of which were enthusiastic collectors of the shells of the Tertiary deposits in the neighbourhood of the Metropolis. At one of the meetings of the club about the year 1845, the late Dr. (then Mr.) J. S. Bowerbank suggested that as the "Mineral Conchology," at its then rate of issue, could not possibly depict all the British fossils within a moderate period, it would be well to have recourse to a new method. A proposition was immediately offered that subscriptions should be solicited for a larger and more complete publication. The idea was favourably received; Mr. Sowerby was asked to undertake the copper-plate engraving, and many geologists living in different parts of the country were communicated with. In the furtherance of this project, Mr. Bowerbank laboured with much zeal and energy. At the time it was considered that in five and twenty years all the British fossils would be figured.

On March 23, 1847, a meeting was held at the apartments of the Geological Society, Somerset House, with Sir Henry De la Beche in the chair, when it was resolved that a Society be constituted, the object of which should be "to figure and describe as completely as possible a stratigraphical series of British fossils." The meeting further determined that the annual subscription should be one guinea, that the word Palæontographical should be the name, and that the Society should consist of a President, Treasurer, Secretary, and Council of sixteen members. On that day Sir Henry De la Beche was elected President, Mr. S. V. Wood, Treasurer, and Mr. (afterwards Professor) J. Morris, Secretary. The members of the first Council were Professor T. Bell, Mr. J. S. Bowerbank, Mr. F. E. Edwards, Sir P. Egerton, Dr. H. Falconer, Dr. W. H. Fitton, Mr. J. W. Flower, Prof. E. Forbes, Mr. S. B. Ibbetson, Mr. (afterwards Sir) C. Lyell, Prof. J. Phillips, Mr. (afterwards Sir) J. Prestwich, Mr. D. Sharpe, Mr. J. Smith, Mr. N. T. Wetherell, and Mr. A. White. Of these one alone survives, Prof. Sir J. Prestwich.[1] In the May of the same year, Prof. Morris sent in his resignation, and Mr. Bowerbank was appointed his successor.

The first Annual Report was read on the 23rd March, 1848, when it was stated that 640 names had been forwarded for membership, that 363 subscriptions had been received, and that the first volume, "The Univalves of the Crag," by Mr. S. V. Wood, was ready for delivery. This book contains the earliest list of members, and shows that 568 persons and thirty libraries were entered on the list at that date.

On August 14, 1848, a report was presented to a special meeting at Swansea (where the British Association was assembled), in which it was mentioned that offers of monographs had been made on the Conchifera and Foraminifera of the Crag, the Shells of the London Clay, the fossil Reptilia of Great Britain, the Crustacea of the London Clay, the Corals of the Secondary formations, the Shells of the Fresh-water formation above the Crag, the Tertiary Shells of the Clyde, the Spongiadæ of the Chalk formation, the Fossils of the Magnesian Limestone, the Belemnites of the British formations, the Fossil Testacea of the Great Oolite, and the Entomostracous animals of the Chalk, Gault, and Greensand.

In the second Annual Report, read 23rd March, 1849, there is evidence that the Society had become established. The local secretaries are spoken of as being forty in number, and the enrolled members as many as 732. It is added that 615 persons had paid for the first volume, and that the receipts for the years 1848–9 were (irrespective of the balance from the previous year) £690 19*s*. Each succeeding year realized larger funds, until the maximum was reached in 1867, when over 800 subscribers had joined the Society. It is remarkable how many persons must have been enrolled as subscribers during the past forty-nine years, seeing that the whole of the original members have, with eight exceptions, passed away. Four of these are still subscribers. At present the subscriptions from Libraries exceed those from private individuals in the proportion

[1] Sir Joseph Prestwich died at his residence, Darent Hulme, Shoreham, Kent, a few days after the anniversary, namely, on 23rd June, 1896.

of about 8 to 7. This change, so different to what had been the case in the beginning, is mainly due to the fact that of late years strong efforts have been made to secure the accession of the Free Libraries.

Of the officers of the Society the Presidents have been five: Sir Henry De la Beche, from 1847 to 1855; Mr. W. J. Hamilton, from 1856 to 1867; Dr. Bowerbank, from 1865 to 1876; Sir R. Owen, from 1877 to 1892; and Professor Huxley, from 1893 to 1895. The Treasurers have been two: Mr. S. V. Wood, from 1847 to 1884, and Mr. R. Etheridge, from 1885 to the present time. The Secretaries have been three: Professor Morris, for two months in 1847, Dr. Bowerbank, from 1847 to 1862, and the Rev. Professor Wiltshire, from 1863 to the present time.

The publications of the Society have covered a large area of information, comprehending the fossil Plantæ, etc., fossils from the subkingdoms Protozoa, Porifera, Cœlenterata, Echinodermata, Annulosa, Mollusca, and Vertebrata.

Monographs have been completed on the Morphology of *Stigmaria ficoides*, the Ferns and Gymnosperms of the Eocene beds, the Foraminifera of the Carboniferous and Permian deposits, the Stromatoporoids, the fossil Corals, the Polyzoa of the Crag, the fossil Cirripedia, the Post-Tertiary, Tertiary, and Cretaceous Entomostraca, the fossil Estheriæ, the Trilobites, the fossil Merostomata, the fossil Brachiopoda, the Mollusca of the Crag, Eocene, and Great Oolite, the fossil Trigoniæ, the Cretaceous and Oolitic Echinodermata, the Lias Ammonites, the Permian fossils, the Tertiary, Cretaceous, Wealden, Purbeck, Kimmeridge Clay, and Lias Reptilia, the Red Crag Mammalia, the Mesozoic Mammalia, and the fossil Elephants.

Monographs are in progress on the Foraminifera of the Crag, the fossil Sponges, the Cretaceous Starfishes, the Carboniferous Mollusca, the Inferior Oolite Ammonites, the Fishes of the Old Red Sandstone, the Pleistocene Mammalia, and the Devonian Fauna.

At an early date monographs will be commenced on the fossil Cycadeæ, the Cretaceous Mollusca, and the Lias Gasteropoda, but many years must pass away before the whole of the British fossils are described, and the intention of the original founders of the Society fulfilled.

The fiftieth volume, for 1896, has the whole of its plates ready and more than three-fourths of its text printed off. Its contents will comprise the continuation of the monographs on the Crag Foraminifera, the Anthracomyæ, and the Devonian Fauna, the commencement of a monograph on the Carboniferous Mollusca, and the conclusion of the monograph on the Inferior Oolite Gasteropoda.

Within a week of the last annual meeting, Professor the Right Hon. T. H. Huxley (then President) passed away. The Council suggest that Dr. Henry Woodward, F.R.S., be elected President, that the vacant Vice-Presidentship be conferred on the Rev. G. F. Whidborne, that Mr. R. Etheridge, F.R.S., be re-elected Treasurer, and the Rev. Prof. Wiltshire, Secretary; that the retiring members of Council be Sir W. Flower, Prof. Liveing, and the Rev. H. H.

Winwood (Capt. Tyler having recently died), and that the new members of Council be the Rev. R. A. Bullen, Rev. A. Fuller, Dr. W. Hind, and Mr. J. E. Marr, F.R.S. (The Report was adopted *nem. con.*)

Referring to the past publications issued by the Society, it appears that they give to the annual subscriber more than an average of 280 pages of quarto letterpress, accompanied by an average of 38 quarto plates, with 700 figures in the plates and text, and yield an *average* of 134 described species to each volume. This is far and away beyond what has yet been accomplished by any Continental Palæontographical Society for a subscription of one guinea annually.

If anyone desires to know how so much valuable scientific matter can be obtained for so small a sum, we will reveal to the anxious inquirer and would-be annual subscriber the secret.

(1) The Authors of monographs are not paid for their contributions.

(2) The Officers cheerfully give their services, so that the cost of management is reduced to a mere bagatelle.

(3) The Geological Society of London most generously gives to the Palæontographical Society room for their stock in its apartments at Burlington House *free of charge*, and also allows them to hold their meetings in its rooms.

(4) So that almost the entire cost of the volumes issued is confined to the drawing and printing of plates, to the setting up and correcting the letterpress, and the printing, paper, and binding of the annual volumes.

We sincerely trust that, with the new volume, will also come many new members, who will eagerly desire to obtain, not only the newly printed "annual" as it appears, but ask for and secure the back volumes, some of which may still be had (with a liberal allowance for taking a series) on application to the Honorary Secretary, the Rev. Prof. Wiltshire, M.A., F.G.S., 25, Granville Park, Lewisham, near London, S.E.

The accompanying Plate XIII, from a photograph taken at Mr. Frederick Edwards' house, Hampstead, about 1856, represents four of the original members of the Society, namely: Sir Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S.,; Prof. John Morris, F.G.S.; F. E. Edwards, Esq., F.G.S.; and Searles V. Wood, Esq., F.G.S.[1]

II.—Classification of Dinosaurs.[2]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.; of Yale College, New Haven, U.S.A.

In the present review of the Dinosaurs, I have confined myself mainly to the type specimens which I have described, but have included with them other important remains where these were

[1] Professor Morris, Mr. F. E. Edwards, and Mr. S. V. Wood also contributed monographs.

[2] From the American Journal of Science, vol. L, pp. 491–8.

available for investigation. The extensive collections in the museum of Yale University contain so many of the important type specimens now known from America, that they alone furnish an admirable basis for classification, and it was upon these mainly that I first established the present system, which has since been found to hold equally good for the Dinosaurs discovered elsewhere. In the further study of these reptiles, it was also necessary to examine both the European forms and those from other parts of the world, and I have now studied nearly every known specimen of importance. These investigations have enabled me to make this classification more complete, and to bring it down to the present time.

Many attempts have been made to classify the Dinosaurs, the first being that of Hermann von Meyer, in 1830. The name Dinosauria, proposed for the group by Owen, in 1839, has been generally accepted, although not without opposition. Hæckel, Cope, and Huxley followed, the last in 1869 proposing the name Ornithoscelida for the order, and giving an admirable synopsis of what was then known of these strange reptiles and their affinities. Since then, Hulke, Seeley, and Lydekker, Gaudry, Dollo, Baur, and many others, have added much to our knowledge of these interesting animals. The remarkable discoveries in North America, however, have changed the whole subject, and in place of fragmentary specimens, many entire skeletons of Dinosaurian reptiles have been brought to light, and thus definite information has replaced uncertainty, and rendered a comprehensive classification for the first time possible.

The system of classification I first proposed in 1881 has been very generally approved, but a few modifications have been suggested by others that will doubtless be adopted. This will hardly be the case with several radical changes recently advocated, based mainly upon certain theories of the origin of Dinosaurs. At present these theories are not supported by a sufficient number of facts to entitle them to the serious consideration of those who have made a careful study of these reptiles, especially the wonderful variety of forms recently made known from America.

Further discoveries may in time solve the problem of the origin of all the reptiles now called Dinosaurs, but the arguments hitherto advanced against their being a natural group are far from conclusive. The idea that the Dinosauria belong to two or more distinct groups, each of independent origin, can at present claim equal probability only with a similar suggestion recently made in regard to mammals. This subject of the origin of the Dinosaurs and the relation of their divisions to each other will be more fully treated by me elsewhere.

A classification of any series of extinct animals is of necessity, as I have previously said, merely a temporary convenience, like the bookshelves in a library, for the arrangement of present knowledge. In view of this fact and of the very limited information we now have in regard to so many Dinosaurs known only from fragmentary remains, it will suffice for the present, or until further evidence is forthcoming, to still consider the Dinosauria as a sub-class of the great group of Reptilia.

Regarding, then, the Dinosaurs as a sub-class of the Reptilia, the forms best known at present may be classified as follows :—

Sub-class DINOSAURIA, Owen.

Premaxillary bones separate; upper and lower temporal arches; no teeth on palate; rami of lower jaw united in front by cartilage only. Neural arches of vertebræ joined to centra by suture; cervical and thoracic ribs double-headed; ribs without uncinate processes; sacral vertebræ united; caudal vertebræ numerous; chevrons articulated intervertebrally. Scapula elongate; no precoracoid; clavicles wanting. Ilium prolonged in front of the acetabulum; acetabulum formed in part by pubis; ischia meet distally on median line. Fore and hind limbs present, the latter ambulatory and larger than those in front. Head of femur at right angles to condyles; tibia with procnemial crest; fibula complete; first row of tarsals composed of astragalus and calcaneum only, which together form the upper portion of ankle joint; reduction in number of digits begins with the fifth.

Order THEROPODA (Beast foot). Carnivorous.

Skull with external narial openings lateral; large antorbital vacuity; brain case incompletely ossified; no pineal foramen; premaxillaries with teeth; no predentary bone; dentary without coronoid process; teeth with smooth compressed crowns and crenulated edges. Vertebræ more or less cavernous; posterior trunk vertebræ united by diplosphenal articulation. Each sacral rib supported by two vertebræ; diapophyses distinct from sacral ribs; sternum unossified. Pubes projecting downward and united distally; no postpubis. Fore limbs small; limb bones hollow; astragalus closely applied to tibia; feet digitigrade; digits with prehensile claws; locomotion mainly bipedal.

(1) Family *Megalosauridæ*. Lower jaws with teeth in front. Anterior vertebræ convexo-concave; remaining vertebræ biconcave; five sacral vertebræ. Abdominal ribs. Ilium expanded in front of acetabulum; pubes slender. Femur longer than tibia; astragalus with ascending process; five digits in manus and four in pes.

Genus *Megalosaurus* (*Poikilopleuron*). Jurassic and Cretaceous. Known forms European.

(2) Family *Dryptosauridæ*. Lower jaws with teeth in front. Cervical vertebræ opisthocœlian; remaining vertebræ biconcave; sacral vertebræ less than five. Ilium expanded in front of acetabulum; distal ends of pubes coössified and much expanded; an interpubic bone. Femur longer than tibia; astragalus with ascending process; fore limbs very small, with compressed prehensile claws.

Genera *Dryptosaurus* (*Lælaps*), *Allosaurus*, *Cœlosaurus*, *Creosaurus*. Jurassic and Cretaceous. All from North America.

(3) Family *Labrosauridæ*. Lower jaws edentulous in front. Cervical and dorsal vertebræ convexo-concave; centra cavernous

or hollow. Pubes slender, with anterior margins united; an interpubic bone. Femur longer than tibia; astragalus with ascending process.

Genus *Labrosaurus*. Jurassic, North America.

(4) Family *Plateosauridæ* (*Zanclodontidæ*). Vertebræ biconcave; two sacral vertebræ. Ilium expanded behind acetabulum; pubes broad, elongate plates, with anterior margins united; no interpubic bone; ischia expanded at distal ends. Femur longer than tibia; astragalus without ascending process. Five digits in manus and pes.

Genera *Plateosaurus* (*Zanclodon*), ? *Teratosaurus*, *Dimodosaurus*. Triassic. Known forms European.

(5) Family *Anchisauridæ*. Skull light in structure, with recurved cutting teeth. Vertebræ biconcave. Bones hollow. Ilium expanded behind acetabulum; pubes rod-like and not coössified distally; no interpubic bone. Fore limbs well developed; femur longer than tibia; astragalus without ascending process; five digits in manus and four in pes. (Figure 1.)

FIG. 1.—ANCHISAURUS COLURUS, Marsh. $\frac{1}{24}$. Triassic, Connecticut.

Genera *Anchisaurus* (*Megadactylus*), *Ammosaurus*, ? *Arctosaurus*, *Bathygnathus*, and *Clepsysaurus*, in North America; and in Europe, *Palæosaurus*, *Thecodontosaurus*. All known forms Triassic.

Sub-order CŒLURIA (Hollow tail).

(6) Family *Cœluridæ*. Teeth much compressed. Vertebræ and bones of skeleton very hollow or pneumatic; neural canal much expanded; anterior cervical vertebræ convexo-concave; remaining vertebræ biconcave; cervical ribs coössified with vertebræ. An interpubic bone. Femur shorter than tibia; metatarsals very long and slender.

Genera *Cœlurus*, in North America; and *Aristosuchus*, in Europe Jurassic.

Sub-order Compsognatha.

(7) Family *Compsognathidæ.* Skull elongate, with slender jaws and pointed teeth. Cervical vertebræ convexo-concave; remaining vertebræ biconcave. Ischia with long symphysis on median line. Bones very hollow. Femur shorter than tibia; astragalus with long ascending process; three functional digits in manus and pes.

Genus *Compsognathus.* Jurassic. Only known specimen European. (Figure 2.)

Fig. 2.—Compsognathus longipes, Wagner. $\frac{1}{8}$. Jurassic, Bavaria.

Sub-order Ceratosauria (Horned saurians).

(8) Family *Ceratosauridæ.* Horn on skull; teeth large and trenchant. Cervical vertebræ plano-concave; remaining vertebræ

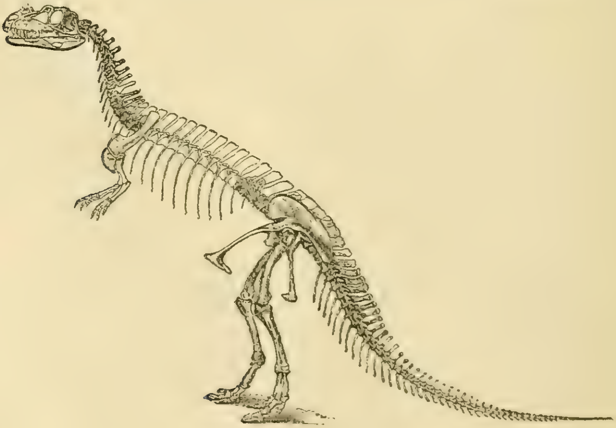


Fig. 3.—Ceratosaurus nasicornis, Marsh. $\frac{1}{60}$. Jurassic, Colorado.

biconcave. Pelvic bones coössified; ilium expanded in front of acetabulum; pubes slender; an interpubic bone; ischia slender, with distal ends coössified. Limb bones hollow; manus with four digits; femur longer than tibia; astragalus with ascending process; metatarsals coössified; three digits only in pes. Osseous dermal plates. (Figure 3.)

Genus *Ceratosaurus.* Jurassic, North America.

(9) Family *Ornithomimidæ.* Pelvic bones coössified with each other and with sacrum; ilium expanded in front of acetabulum. Limb bones very hollow; fore limbs very small; digits with very long, pointed claws; hind limbs of true avian type; femur longer than tibia; feet digitigrade and unguiculate.

Genus *Ornithomimus.* Cretaceous, North America.

Sub-order Hallopoda (Leaping foot).

(10) Family *Hallopidæ.* Vertebræ and limb bones hollow; vertebræ biconcave; two vertebræ in sacrum; acetabulum formed by ilium, pubis, and ischium; pubes rod-like, projecting downward, but not coössified distally; no postpubis; ischia with distal ends expanded, meeting below on median line. Fore limbs very small, with four digits in manus. Femur shorter than tibia; hind limbs very long, with three digits only in pes, and metatarsals greatly elongated; astragalus without ascending process; calcaneum much produced backward; feet digitigrade, unguiculate.

Genus *Hallopus.* Jurassic, North America.

Order Sauropoda (Lizard foot). Herbivorous.

External nares at apex of skull; premaxillary bones with teeth; teeth with rugose crowns more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; brain case ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs coössified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own transverse process, or sacral rib; no diapophyses on sacral vertebræ; neural cavity much expanded in sacrum; first caudal vertebra procœlian. Sternal bones parial; sternal ribs ossified. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no postpubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; astragalus not fitted to end of tibia; feet plantigrade, ungulate; five digits in manus and pes; second row of carpal and tarsal bones unossified; locomotion quadrupedal.

(1) Family *Atlantosauridæ.* A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ with lateral cavities; remaining caudals solid.

Genera *Atlantosaurus*, *Apatosaurus*, *Barosaurus*, *Brontosaurus*. Include the largest known land animals. Jurassic, North America. (Figure 4.)

(2) Family *Diplodocidæ*. External nares superior; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Ischia with shaft not expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow. Caudal vertebræ deeply excavated below; chevrons with both anterior and posterior branches.

Genus *Diplodocus*. Jurassic, North America.

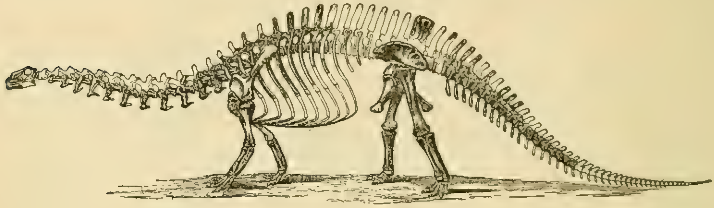


FIG. 4.—BRONTOSAURUS EXCELSUS, Marsh. $\frac{1}{180}$. Jurassic, Wyoming.

(3) Family *Morosauridæ*. External nares lateral; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front. Shaft of scapula expanded at distal end. Sacral vertebræ nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid.

Genera *Morosaurus*, ? *Camarasaurus* (*Amphicœlias*). Jurassic, North America.

(4) Family *Pleurocœlidæ*. Dentition weak; teeth resembling those of *Diplodocus*. Cervical vertebræ elongated; centrum hollow, with large lateral openings; sacral vertebræ solid, with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; middle caudal vertebræ with neural arch on front half of centrum. Ischia with compressed distal ends, meeting on median line.

Genus *Pleurocœlus*. ? Jurassic, North America.

(5) Family *Titanosauridæ*. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebra biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. ? Cretaceous, India and Patagonia.

(6) Family *Cardiodontidæ*. Teeth of moderate size. Upper end of scapula expanded; humerus elongate; fore limbs nearly equalling hind limbs in length. Sacrum solid; ischia with wide distal ends meeting on median line. Caudal vertebræ biconcave.

Genera *Cardiodon* (*Cetiosaurus*), *Bothriospondylus*, *Ornithopsis*, and *Pelorosaurus*. European, and probably all Jurassic.[1]

Order PREDENTATA. Herbivorous.

Narial opening lateral; no antorbital foramen; brain case ossified; supra-orbital bones; teeth with sculptured crowns; maxillary teeth with crowns grooved on outside; lower teeth with grooves on inside of crown; a predentary bone; dentary with coronoid process. Cervical ribs articulating with vertebræ; each sacral rib supported by two vertebræ. Ilium elongated in front of acetabulum; prepubic bones free in front; postpubic bones present; ischia slender, directed backward, with distal ends meeting side to side. Astragalus without ascending process.

Sub-order STEGOSAURIA (Plated lizard).

Skull without horns; no teeth in premaxillaries; teeth with distinct compressed crowns and serrated edges. Fore limbs small.

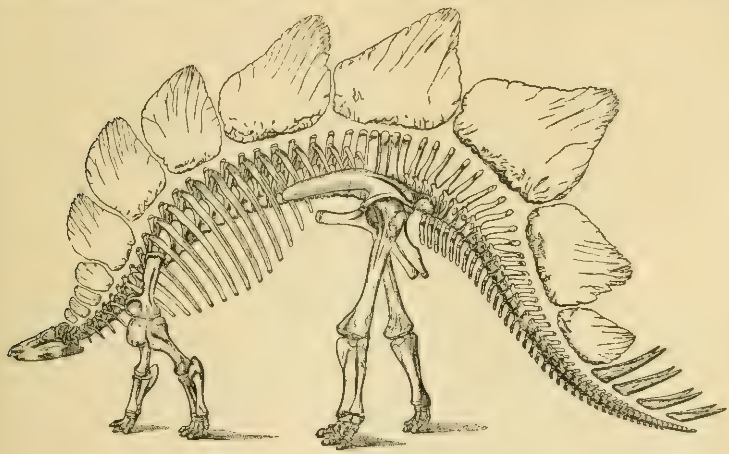


FIG. 5.—STEGOSAURUS UNGULATUS, Marsh. $\frac{1}{60}$. Jurassic, Wyoming.

Vertebræ and limb bones solid. Pubes projecting free in front; postpubis present. Femur longer than tibia; feet plantigrade, ungulate; five digits in manus and four in pes; second row of carpals and tarsals unossified; locomotion mainly quadrupedal. Osseous dermal armour.

(1) Family *Stegosauridæ*. Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Dorsal ribs T-shaped in cross section. Astragalus coössified with tibia; metapodials very short; five digits in manus; three functional digits in pes. Back surmounted by a crest of vertical plates; tail armed with one or more pairs of large spines. (Figure 5.)

[1] The Wealden is here regarded as Upper Jurassic, and not Cretaceous. See O. C. Marsh, GEOL. MAG., Decade IV, Vol. III, 1896, p. 8; and A. S. Woodward, pp. 69–71, "On the Affinities of the Wealden Fauna and Flora."

Genera *Stegosaurus* (*Hypsirhophus*), *Diracodon*, ? *Dystrophæus*, *Palæoscincus*, *Priconodon*, all from North America; and in Europe, *Omosaurus*, Owen. Jurassic and Cretaceous.

(2) Family *Scelidosauridæ*. Neural canal narrow; diapophysis of dorsal vertebræ supporting head and tubercle of ribs. Astragalus not coössified with tibia; metatarsals elongated; three functional digits in pes.

Genera *Scelidosaurus*, *Acanthopholis*, *Hylæosaurus*, *Polacanthus*. Jurassic and Cretaceous. Known forms all European. (Figure 6.)

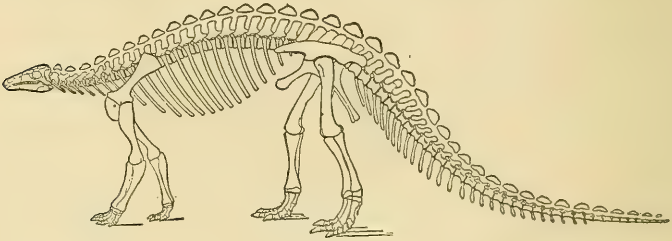


FIG. 6.—SCELIDOSAURUS HARRISONI, Owen. $\frac{1}{36}$. Jurassic, England.

(3) Family *Nodosauridæ*. Heavy dermal armour. Bones solid. Fore limbs large; feet ungulate.

Genus *Nodosaurus*. Cretaceous, North America.

Sub-order CERATOPSIA (Horned face).

Premaxillaries edentulous; teeth with two distinct roots; skull surmounted by massive horn-cores; a rostral bone, forming a sharp, cutting beak; expanded parietal crest, with marginal armature; ? a pineal foramen. Vertebræ and limb bones solid; fore limbs large; femur longer than tibia; feet ungulate; locomotion quadrupedal. Dermal armour.

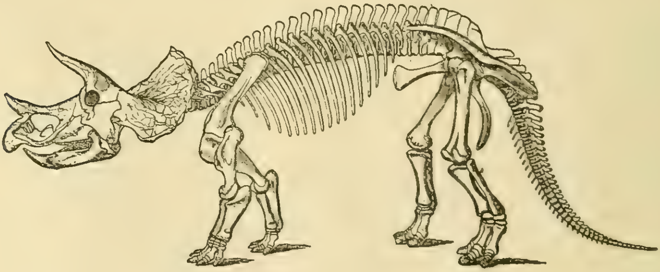


FIG. 7.—TRICERATOPS PRORSUS, Marsh. $\frac{1}{80}$. Cretaceous, Wyoming.

(4) Family *Ceratopsidæ*. Anterior cervical vertebræ coössified with each other; posterior dorsal vertebræ supporting on the diapophysis both the head and tubercle of the rib; lumbar vertebræ

wanting; sacral vertebræ with both diapophyses and ribs. Pubes projecting in front, with distal end expanded; postpubic bone rudimentary or wanting.

Genera *Ceratops, Agathaumas, Monoclonius, Polyonax, Sterrholophus, Torosaurus, Triceratops*, in North America; and in Europe, *Struthiosaurus* (*Cratæomus*). All are Cretaceous. (Figure 7.)

Sub-order ORNITHOPODA (Bird foot).

Skull without horns; premaxillaries edentulous in front. Vertebræ solid. Pubes projecting free in front; postpubis present. Fore limbs small; astragalus closely fitting to end of tibia; feet digitigrade; three to five functional digits in manus and three to four in pes; locomotion mainly bipedal. No dermal armour.

(5) Family *Camptosauridæ* (*Camptonotidæ*). Premaxillaries edentulous; teeth in single row; a supra-orbital fossa. Anterior

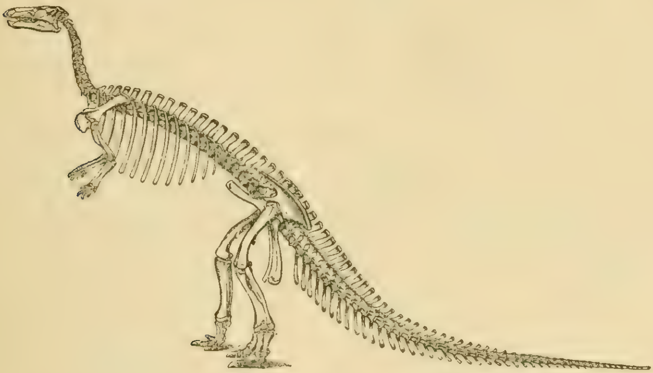


FIG. 8.—CAMPTOSAURUS DISPAR, Marsh. $\frac{1}{60}$. Jurassic, Wyoming.

vertebræ opisthocœlian; sacral vertebræ with peg and notch articulation. Limb bones hollow; fore limbs small; five digits in manus. Postpubis reaching to the distal end of ischium. Femur longer than tibia, and with pendent fourth trochanter; hind feet with four digits. (Figure 8.)

Genus *Camptosaurus* (*Camptonotus*). Jurassic, North America.

(6) Family *Laosauridæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ with plane articular faces; sacral vertebræ coössified. Sternum unossified. Postpubis reaching to distal end of ischium. Limb and foot bones hollow; fore limbs very small; five digits in manus; femur shorter than tibia; metatarsals elongate; four digits in pes.

Genera *Laosaurus* and *Dryosaurus*. Jurassic, North America. (Figure 9.)

(7) Family *Hypsilophodontidæ*. Premaxillaries with teeth; teeth in single row; sclerotic bony plates. Anterior vertebræ opistho-

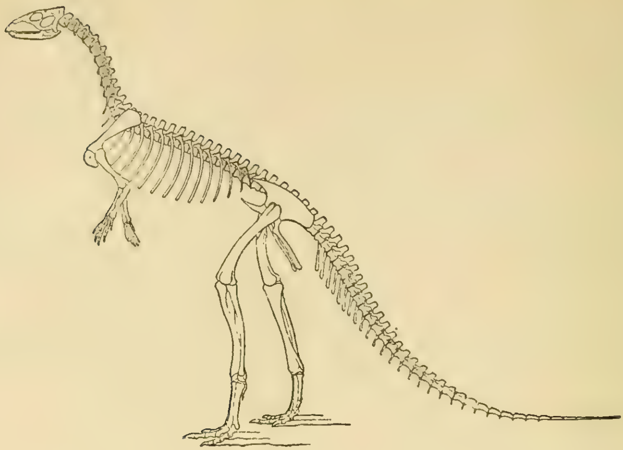


Fig. 9.—Laosaurus consors, Marsh. $\frac{1}{20}$. Jurassic, Wyoming.

cœlian; sacral vertebræ coössified. Sternum ossified. Postpubis extending to end of ischium. Limb bones hollow; five digits in manus; femur shorter than tibia; hind feet with four digits.

Genus *Hypsilophodon*. Wealden, England. (Figure 10.)

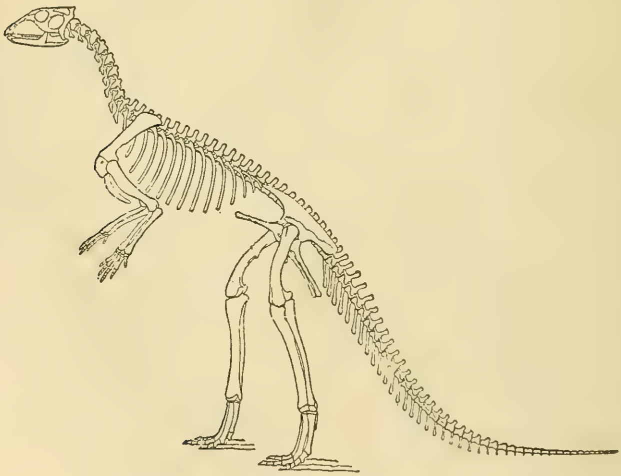


Fig. 10.—Hypsilophodon Foxii, Huxley. $\frac{1}{16}$. Cretaceous, England.

(8) Family *Iguanodontidæ*. Premaxillaries edentulous; teeth in single row. Anterior vertebræ opisthocœlian. Manus with five

digits; pollex spine-like. Sternal bones ossified. Postpubis incomplete. Femur longer than tibia. (Figure 11.)

Genera *Iguanodon, Vectisaurus.* Jurassic and Cretaceous. Known forms all European.

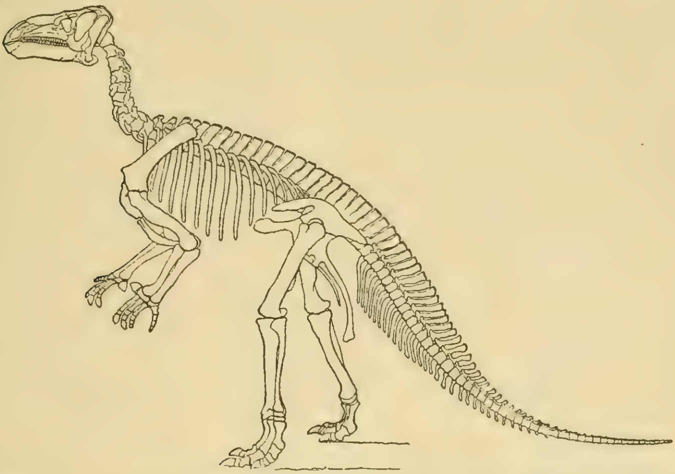


FIG. 11.—IGUANODON BERNISSARTENSIS, Boulenger. $\frac{1}{80}$. Cretaceous, Belgium.

(9) Family *Trachodontidæ* (*Hadrosauridæ*). Premaxillaries edentulous; teeth in several rows, forming with use a tessellated grinding surface. Cervical vertebræ opisthocœlian. Limb bones hollow; fore limbs small; femur longer than tibia.

FIG. 12.—CLAOSAURUS ANNECTENS, Marsh. $\frac{1}{80}$. Cretaceous, Wyoming.

Genera *Trachodon* (*Hadrosaurus, Diclonius*), *Cionodon.* Cretaceous, North America.

(10) Family *Claosauridæ.* Premaxillaries edentulous; teeth in several rows, but a single row only in use. Cervical vertebræ opisthocœlian. Limb bones solid; fore limbs small. Sternal bones parial. Postpubis incomplete. Femur longer than tibia; feet ungulate; three functional digits in manus and pes. (Figure 12.)
Genus *Claosaurus.* Cretaceous, North America.

(11) Family *Nanosauridæ.* Teeth compressed and pointed, and in a single, uniform row. Cervical and dorsal vertebræ short and biconcave; sacral vertebræ three. Ilium with very short pointed front, and narrow posterior end. Limb bones and others very hollow; fore limbs of moderate size; humerus with strong radial crest; femur curved, and shorter than tibia; fibula pointed below; metatarsals very long and slender. Anterior caudals short.
Genus *Nanosaurus.* Jurassic, North America. Includes the smallest known Dinosaurs.

In these restorations of Dinosaurian Reptiles the scientific name, the size, geological formation, and country where found, are given under each of the twelve figures. The skeletons here restored are represented in the same general position, to aid in comparing them with each other.

III.—On a Pebbly Quartz-Schist from the Val d'Anniviers (Pennine Alps).

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.

In 1893 I described in this Magazine[1] a group of quartz-schists which may be traced for many miles along the Alps—a group belonging to the series which appear to be the newest among the crystalline schists of that chain. I may refer to this paper for a description of their mode of occurrence, distribution, and structure, both macroscopic and microscopic, merely stating that, while considering them to have had a clastic origin—in other words, to be metamorphosed sandstones—I pointed out that they presented some material differences from ordinary quartzites, and that "original fragments [could not] be distinguished with certainty in any of them," though "here and there a clastic structure," of which I gave instances, "may be suspected."

In 1894 my friend Mr. J. Eccles, F.G.S., informed me, on his return from the Alps, that he had discovered pebbles in this quartz-schist in the Val d'Anniviers (Einfisch-thal),[2] showing me specimens of the rocks. I examined one of these under the microscope, and the results fully confirmed his determination in the field. This pebbly schist, he said, occurred on the western flank of the range between the Val d'Anniviers and the Turtman-thal, in an upland glen of the Tounot, about one-third of a mile ESE. of the

[1] Geol. Mag., Dec. III, Vol. X, pp. 204–210.
[2] It is the second valley to the west of the Vispthal, opening into the Rhône Valley opposite to Sierre.

well-known Weisshorn Hotel. As any indication of a coarse clastic structure in a true crystalline schist, so far as I knew, was a rarity, I determined to examine this rock in the field the next time that I happened to visit that part of the Alps. An opportunity presented itself during the summer of last year, when I had the good fortune to be accompanied by Mr. Eccles himself, as well as by another fellow-worker in Alpine geology, the Rev. E. Hill. We had intended to spend a week or two at Zinal, and therefrom to visit the sections discovered by Mr. Eccles, which can be reached by a rather long walk over the rough slopes of the range on the eastern side of Val d'Anniviers. This intention, however, was afterwards abandoned, as we found plenty of a similar rock in much more accessible situations.

The torrent from the Val d'Anniviers enters the Rhone Valley through a deep and narrow gorge. Thus a considerable ascent must be made in order to gain the slopes above it; and the road to Zinal, before entering the actual valley, mounts in a series of zigzags up its eastern portal from the level of the Rhone. As we ascended,[1] I passed the following rocks on the slopes: (1) rauchwacke, (2) a dark slaty rock, (3) *Pontiskalk*, (4) *Casanna Schiefer*; the outcrops not necessarily occurring in this order. The first of these four is the usual buff-coloured friable limestone, so common in the Alps (though often in patches only), which is generally admitted to be Triassic in age; the second, also, is a type not uncommon in the Alps—a black slate or phyllite, assigned to the Carboniferous system; the third is a more or less calcareous rock, rather variable in colour and character, but often a greyish or darkish limestone, in places subcrystalline, but very different in aspect from the calc-schists which are so largely developed in the Pennine chain a little further to the south, and are associated with the above-named quartz-schists. This *Pontiskalk* I believe to be more modern than the crystalline schists, and think it may belong to some part of the Palæozoic era. The fourth, the *Casanna Schiefer*, is a gneissic rock, not very coarse in texture, often considerably crushed, fairly micaceous, and generally of a dullish grey colour. A rock of a similar character often appears, in this region of the Alps, to underlie the aforesaid group of crystalline schists.

The floor, as it may be called, of the Val d'Anniviers is gained after an ascent of about 1300 feet, not far from Niouc, and about $3\frac{1}{2}$ miles beyond is Fang. Before reaching the latter hamlet, blocks of quartz-schist became abundant by the roadside, and it was soon evident that ample materials for study were close at hand, for many of them indubitably contained pebbles. Further examination showed that a great talus of these blocks extended up for some hundreds of feet to the foot of a cliff, obviously of the same rock. To this, however, we did not ascend, as we perceived that we should cross its outcrop higher up the valley. On reaching this we found good sections, and afterwards we discovered indications of

[1] An old mule path cuts off some of the zigzags of the carriage road. I have traversed both routes.

pebbles, though not often, in the quartz-schist near Zinal. Time will be saved by collecting together the results of our examination of the different sections.

This quartz-schist, according to the Geological Survey Map of Switzerland (*Blatt.* xvii and xxii), occurs in several localities on either side of the Val d'Anniviers, coming generally immediately above the *Casanna Schiefer.* It is overlain by a thick mass of schist, which for brevity I will designate calc-mica-schist,[1] though it may vary from an almost pure marble (rare) to a very slightly calcareous mica-schist; the latter being the more usual type in this valley. With these schists we find a third type, called on the map *Grüner Schiefer*, which may be an intrusive igneous rock, subsequently modified by pressure. As there shown, the quartz-schist strikes, very roughly speaking, from ENE. to WSW. In the lower part of the Val d'Anniviers it is dipping at a moderate angle towards the south,[2] and its outcrop rises rather rapidly up the mountain slopes on either side. Proceeding along the crests of these towards the same point of the compass, we see from the map that the quartz-schist occurs at intervals above the *Casanna Schiefer*, at elevations varying approximately from 8,800 to 9,800 feet above the sea. Presently, in the peaks of the Tounot and Roc de Budry (10,302′) on the east side, and in the Becs de Bosson (10,386′) on the west, it is capped by calc-schist. Then, south of the former, comes a slight interruption, for the Forcletta Pass (9,810′) is cut down to the *Casanna Schiefer*, and the calc-mica-schist, as the crest rises again, seems to rest for a short distance on this rock.[3] But the quartz-schist soon reappears at the base of the Diablons (11,850′), in its usual position, and thence descends towards the valley, disappearing at last beneath talus at some height above Zinal. On the western side of the Val d'Anniviers the quartz-schist, in a like position, runs southward from the Becs de Bosson, sweeps round the head of the Val de Moiry (a tributary of the main valley), passes along the flanks of the Corne de Sorebois (9,207′)—where it is capped by a fair thickness of the calc-mica-schist (very micaceous)—and then descends, reaching the bed of the valley opposite to Zinal, where it is well exposed. These facts seem to me explicable only on the hypothesis that the *Casanna Schiefer*, the quartz-schist and the calc-mica-schist, with the associated *Grüner Schiefer*, form part of a huge fold, the axis of which slopes up towards the north at a moderate angle. This, at first sight,

[1] It is called *Glanz Schiefer* (*schistes lustrés*) on *Blatt* xvii, and *Graue Schiefer, kalkhaltig*, on *Blatt* xxii. On the former its place in the table of colours seems to make it newer than the Carboniferous, but on the latter it is the older rock. So far as regards the calcareous and micaceous schists which are associated with the quartz-schist, I have no doubt that the whole group is pre-Carboniferous; but the other map appears to me to designate by the same tint two rocks which differ in locality, lithological characters, and geological age.

[2] I intended to make an exact measurement as I came down the valley, but was hurried by the on-coming of a heavy shower.

[3] I have not examined this part, so cannot say whether the quartz-schist is absent or the outcrop is too thin to be indicated on the map.

appears to warrant the identification of the Pontiskalk with the calc-mica-schist. But even a brief examination of the slopes on which the former rock occurs shows us that we are dealing with a very complicated piece of geology, and I have little doubt that the Pontiskalk is a much newer rock than the calc-mica-schist and its associates. But to give my reasons for this opinion—and these are not of an *à priori* character—would extend this paper to an unreasonable length.

The quartz-schist certainly varies considerably in thickness. But I made no measurements, for in a district like the Alps their value must often be uncertain, and this point had no bearing on the questions with which I was concerned. In places I think it exceeds a hundred feet. It also varies in character. It is distinctly pebbly near Fang, to the ESE. of the Weisshorn Hotel (*i.e.* under the Tounot), and on the left bank of the valley opposite to Zinal (though here the pebbles are generally small). It is often rather coarse and slightly "gneissose" in texture, owing to the presence of a filmy, pale-green mineral, but from this condition it passes into a nearly homogeneous, white rock,—as in places opposite to Zinal, and at the Alpe de Collier (on the right bank, about 1500 feet above the village). As a rule, the quartz-schist is not only less slabby than it is above Saas Fee (though that structure may be observed near the alp just named), but also (so far as I have seen) it wants that occasional distinct banding with a grey mica. The most pebbly part—where we examined it *in situ* south of Fang—was some four feet thick. The pebbles were in layers, the thickest of these being about fifteen inches, but they were not restricted either to the bands or to this part of the rock. They generally varied from well-rounded to subangular, and often seemed slightly distorted by pressure. Most of them were white vein-quartz, but I also noticed a reddish quartz (small), and a compact light-green rock, rather soft and flatter in shape, which sometimes seemed to merge into the films already mentioned.

In addition to the specimen from near the Weisshorn Hotel, I have examined microscopic sections from the following localities: Fallen pebbly blocks north of Fang; pebbly band *in situ* south of Fang; slabby, slightly fissile quartz-schist near Alpe de Collier; rather pebbly rock opposite to Zinal; most compact and white variety, in same mass. I may refer to my former paper for a general account of the microscopic structure of the quartz-schist, and content myself with calling attention to any differences exhibited by these specimens. In most of them the constituents vary much more in size than in those from Saas Fee, but the "matrix" in which the larger fragments are set is more fine-grained. The most uniform in character, as might be expected, are the examples from the Alpe de Collier and from opposite to Zinal (compact variety). The former consists usually of quartz granules rather less than ·0025″ in diameter, and of mica flakelets, which seldom attain ·025″ in length. But even here the matrix becomes a little coarser in places, the quartz-grains occasionally ranging up to ·02″; while the second specimen is throughout rather coarser, the quartz-grains in it attaining about double the last-mentioned size. All the other slices exhibit great variety in structure, the matrix being sometimes quite as fine as in the first instance, but generally more micaceous. The included fragments are mostly quartz, and their exterior (and this is also true of the granules) is "ragged" in outline, except in certain cases, when it is surrounded by a kind of envelope of mica, like a pellet wrapped in paper. Of these fragments the smaller are generally simple, the larger composite, being apparently vein-quartz, though one or two of them resemble a rather minute and highly altered quartzite. The others often exhibit strain shadows, are sometimes cracked (occasionally with slight displacement), and are again cemented with chalcedonic quartz. But there are cases where this material seems as if it had been the result of molecular change, without fracture, along a certain direction in the grain; and when it occurs at the exterior, as it not seldom does, it appears to have been formed by the same process rather than by accretion. Felspar is always present, though generally rather altered; cleavage may be observed, but I have not come across polysynthetic twinning. No doubt it represents original fragments, though at the present time it is not obviously clastic. Some of the felspar-grains may be seen to pass into a mass of minute mica, cemented by exceedingly fine chalcedonic quartz, and I think that the micaceous part of the matrix has been formed generally by the alteration of clayey or silty matter. The mica exhibits a very faint tinge of a greenish colour, and is probably not materially different from that in the Saas Fee rock. It occurs in fairly regular flakelets, and in most cases is clearly authigenous, though a few larger flakes possibly may be derivative; that is probably true of two or three bits of rather altered biotite. As in the other rock, I note occasionally small zircons, rutiles, and epidote or zoisite, with iron oxides and some brownish granules, which I think are garnets, though one or two suggest the possibility of idocrase; but quartz and mica (almost colourless), with some felspar, are the dominant constituents. One fragment may represent a very fine-grained micaceous schist. This, I suspect, belongs to the compact greenish rock mentioned above, of which, however, I failed to obtain a good piece in a position favourable for a section.

These specimens from the Val d'Anniviers present more resemblance to the crushed Torridon Sandstone and the "piped" quartzite mentioned in my last paper, than do those from Saas Fee, but they are by no means identical with either. They have been affected by pressure, but the mineral change is much more complete than in Scotch rocks, and there is nothing to show that this pressure was the chief agent in producing the metamorphism. They retain, probably owing to their greater coarseness and more heterogeneous character, much more distinct traces of their original condition than the quartz-schists from Saas Fee, but their differences from fragmental rocks in the Mesozoic or later Palæozoic systems in the

Alps, to my mind, increase the probability that they, and the calc-schists and mica-schists associated with them, are much more ancient than any of these—in other words, that they very probably belong to the Archæan era.

IV.—Notes on the Whitehaven Sandstone.

By T. V. Holmes, F.G.S.

It is not surprising that the earlier geological writers on the district north and west of the Silurian and other hills of Lakeland, and between the River Caldew and the Solway, should have arrived at diverse conclusions as to the affinities of certain sandstones and shales of reddish or purple-grey tint, which are now known to occur at various horizons in the Carboniferous series. For this district presents unusual difficulties to an understanding of the disposition of the rocks beneath the Glacial Drift.

In the belt of country nearest Lakeland, occupied by the Carboniferous Limestone series, which is mostly from about 400 feet to more than 1000 feet above the level of the sea, the various beds of limestone and sandstone are frequently traceable for a certain distance, and the presence here and there of a considerable thickness of Glacial Drift obscures, but does not wholly hide, the arrangement of the older rocks. But the obscurity greatly increases as we descend into the lower ground towards the Solway, in which the Upper Carboniferous, the Permian-Triassic,[1] and the Liassic rocks exist, for there the surface consists almost entirely of Glacial Drift and other superficial beds. Here and there, often at rare intervals, Carboniferous and Permian-Triassic beds may be seen in the banks of the rivers and streams, or as small patches elsewhere; but they make no definite features; the surface-ridges are composed wholly of Glacial Drift. And when, after long and laborious work in the field, approximate boundaries between the older formations can be made out, they are usually lines of fault. Coast sections, also, are few and far between. From a point about two miles north of Maryport to the mouth of the Eden at Rockcliff superficial beds only can be seen. Permian-Triassic (St. Bees) Sandstone appears at Maryport, but southward, between Maryport and Whitehaven, coast-sections in the older rocks are rare, though there is a continuous series of them from Whitehaven round the headland of St. Bees.

Then, in addition to the difficulties arising from the covering of Glacial Drift, we have (along the Carboniferous and Permian-Triassic junction from Maryport north-eastward) another in the reddish or purple-grey tint of many of the Carboniferous beds, which approximates so closely to that of the Permian-Triassic deposits as to make the task of distinguishing between them one of greater difficulty than usual. I may add, however, that when engaged on the Geological Survey in North Cumberland many years

[1] I use this term to include all the red rocks between the Coal-measures and the Lias.

ago, my colleagues and I had gradually learned from experience, that where junctions between these formations occurred, the reddish or purple-grey Carboniferous tints were always distinguishable from the more brick-red colour of the other series. On the other hand, it was found that there was no hue distinctive of any particular Carboniferous horizon, and that the position in the series of highly-coloured Carboniferous rocks in any locality could be learned only from the careful study of that and adjacent districts.[1]

In the cliffs on each side of the harbour at Whitehaven there is a mass of purple-grey rock, mainly sandstone, which lies with a certain amount of unconformity on the beds beneath. This appearance of unconformity, visible to every geological visitor, has necessarily excited much attention, and the affinities of the Whitehaven Sandstone, as it has been called for more than half a century, have been much discussed. For as it differs in colour from the beds on which it rests, and is also somewhat unconformable to them, it was by the earlier writers generally classed with the Permian-Triassic rather than the Carboniferous rocks. For example, I may mention that the late Matthias Dunn, in a paper on the Coalfields of Cumberland, published in vol. viii, Trans. North Eng. Inst. Min. Engineers (1859–60), calls it the "Lower Red Sandstone," to distinguish it from the Upper Red (or St. Bees) Sandstone, and remarks that they are usually divided by a bed of magnesian limestone. And as a result of looking at this and other rocks of similar colour as Permian he shows in the map illustrating his paper, Permian-Triassic rocks spreading eastward of Aspatria as far southward as the source of Shalk Beck, and about a mile north of the junction of the Caldbeck with the Caldew. A large area, widening eastward from Aspatria till it attains a breadth of more than three miles at Shalk Beck and the Cardew, was thus once classed as Permian-Triassic, which is now admitted to be Carboniferous.[2]

At the present day, however, there is no dispute as to which of the two formations just mentioned the Whitehaven Stone belongs. Such differences of opinion as now exist are as to whether Mr. J. D. Kendall has or has not satisfactorily identified as Whitehaven Sandstone certain rocks at various places in and beyond the limits of the West Cumberland Coalfield. Mr. Kendall, who has written much on this subject during the past fifteen years, thus describes the Whitehaven Sandstone in his latest paper, which was read before North of Eng. Inst. Min. and Mech. Engineers in October, 1895, and has since been published in the Trans. Fed. Inst. Min. Engineers. His opening paragraph is as follows:—

[1] My own experience in various parts of North Cumberland is given in a short paper "On the distinctive colours of the Carboniferous and Permian or Triassic (Poikilitic) Rocks of North Cumberland": Trans. Cumb. Assoc., part vii (1881–2), p. 79.

[2] Having spoken of the sandstone at Rosegill, near Bullgill railway-station, as "Whitehaven Sandstone" in the paper on the distinctive colours of the Carboniferous and Permian-Triassic rocks already mentioned, it may be well to say that I did so on Dunn's authority, not as the result of my own investigations.

"In the cliffs along the coast near Whitehaven, occurring interruptedly over the prolific Coal-measures, there is a purple-grey arenaceous rock known to geologists as the Whitehaven Sandstone. It is there, at least, 170 feet thick. The same rock, or rock of the same general character, also occurs over other parts of the coalfield, being sometimes interbedded to a considerable extent with shale, and attaining then an aggregate thickness of 500 or 600 ft. It is therefore convenient to include the whole of these rocks under the name of the 'Whitehaven Sandstone Series.'"

A little farther on are the following additional remarks on its composition:—

"It will be seen from these sections (Appendix A) that the Whitehaven Sandstone Series consists almost entirely of sandstone and shale, of a red, grey, or brown colour, as described in the sections, but the writer prefers to call it purple-grey. With these beds are intercalated, in the lower part of the series, rocks of the ordinary Coal-measure colour and a few thin coal-seams. Two thin beds of *Spirorbis* limestone have been met with in the series at Frizington Hall, and occasionally, in different parts of the district, inconstant beds of conglomerate appear, as in section No. 3. In the neighbourhood of Flimby and Maryport, the base of the series is formed by a thick sandstone, as seen in section No. 6. At Whitehaven, Cleator Moor, and Frizington, the base-rock is variable, being in some places argillaceous, in others arenaceous."

Mr. Kendall remarks that in 1883 he published a paper on "The Structure of the Cumberland Coalfield," which "for the first time dealt with the Whitehaven Sandstone Series over the whole field, showing it to be unconformable Upper Coal-measures." His object in his paper of last year is to reply to the objections of critics of his views with regard to the Whitehaven Sandstone, as expressed in his paper of 1883, and to reassert them with additional details. Incidentally, he considers the hypothesis that the purple-grey Carboniferous rocks owe their colour to Permian staining, and thinks that the evidence is against it, and that the colour is pre-Permian.

It is obvious that a formation so variable in thickness and composition as this "Whitehaven Sandstone Series" is (according to Mr. Kendall) very difficult to identify far from Whitehaven, unless its colour is almost unique, and its outcrop traceable across the country so that its unconformity to the other Carboniferous strata is thereby made manifest. But the unconformity would be shown in colliery workings, should the unconformable beds cross a coalfield in which they cannot be traced, because the surface beds consist of Glacial Drift, as in the present case.

In my paper, lately referred to, on the distinctive colours of the Carboniferous and Permian formations of Cumberland, I mentioned the Whitehaven Sandstone as occupying a position in West Cumberland analogous to that of the Red Rock of Rotherham in the Coalfield of Yorkshire. Having worked a good deal in the district about Rotherham when engaged on the Geological Survey in that Coalfield, I am enabled to give the following particulars about the Red

Rock. It was found to occupy an area of about ten miles in length and usually from one to two miles in breadth. It could be traced from place to place, and its relations to the ordinary conformable measures be thereby demonstrated. Its red colour made it almost unique in the district in that respect, and its lithological variations from place to place were slight and unimportant.

In Cumberland, as I have already stated, the outcrops of the harder rocks of the Coal-measures are not traceable, owing to the thick surface-covering of Glacial Drift. On the other hand, no aid from colliery workings was obtainable in the case of the Red Rock of Rotherham, which throughout its course remained geologically far above the horizons in which collieries then existed. But the Whitehaven Sandstone—according to Mr. Kendall—has an unconformity of much greater magnitude, and may be recognized from Whitehaven, at the south-west, across the whole area of the Coalfield to and beyond its north-eastern boundary. For on Lower Carboniferous ground, about 30 miles north-east from Whitehaven, the Whitehaven Sandstone is still recognized by Mr. Kendall in the 700 or 800 ft. of reddish or purple-grey sandstone and shale seen in Shalk[1] Beck at and near Nine Gills!

It is obvious that the only evidence which could demonstrate the truth of this view, that the Whitehaven Sandstone is to be recognized at various spots from Whitehaven to Shalk Beck, is that which might be obtainable from colliery workings. Fortunately the course taken by the Whitehaven Sandstone is—according to Mr. Kendall—along the whole length of the Coalfield. This would be a singular and somewhat improbable thing in itself, for, from Maryport eastward, the uppermost beds of the Coal-measures must have been very largely cut off by the long lines of fault which bring in the St. Bees Sandstone. Still, the evidence of a long chain of collieries, each showing *unconformable* masses of purple-grey rocks, might enable us to trace the Whitehaven Sandstone from one end of the Coalfield to the other, and show that, though lithologically variable, it yet formed a real unconformable series. But Mr. Kendall never appeals to evidence of *unconformity* at the base of the purple-grey rocks which he recognizes as Whitehaven Sandstone in colliery sections. And any other evidence for the purpose of showing that certain purple-grey rocks belong to the unconformable Whitehaven Sandstone series is manifestly worthless, unless it can be shown that both in lithological character and in colour the Whitehaven Sandstone series is unique. But where it can be seen at Whitehaven it presents no special and distinguishing lithological peculiarities, nor has it any fossils of a special kind. The interest attaching to it arises solely from its apparent unconformity to the beds on which it rests. As to its colour—rocks of a reddish or purple-grey tint may be seen in North Cumberland on Carboniferous horizons of every age, on the Esk, Line, Carwinley Burn, Hether Burn, and other Border streams, as well as in the Caldew, Shalk

[1] Shalk is sometimes written *Chalk* or *Shawk.*

Beck, and other rivers of West Cumberland. Again, the absence of coals of any thickness above a certain horizon in the Coal-measures gives no presumption whatever tending to show the presence of *unconformable* Whitehaven Sandstone. On certain horizons in coalfields it is usual to find few and thin coals, while 500 feet above or below they may become thick and numerous. In other words, it is usual to find alternations of conditions tending at one time mainly to the deposition of sandstones and sandy shales, at another of more clayey shales and of coals. Yet Mr. Kendall identifies as Whitehaven Sandstone measures distinguished only by purple-grey colour and absence of thick coals.

Towards the conclusion of his paper, Mr. Kendall remarks that: "In the area lying immediately to the north-east of the Coalfield, he [Mr. Holmes] has coloured as belonging to the Millstone Grit and Carboniferous Limestone series, rocks which also belong to the Whitehaven Sandstone series or Upper Coal-measures."

It will be noticed that Mr. Kendall admits that the area in question is "north-east of the Coalfield," or, in other words, that Lower Carboniferous rocks might naturally be expected there. When working in that district I found in Shalk Beck an unusually good series of sections, the beds consisting of sandstones and shales of a reddish or purple-grey colour, with a high but variable dip of from 15 to 60 degrees, and attaining a thickness of at least 700 to 800 feet. The direction of their dip was perfectly normal, looking at them as Lower Carboniferous beds; and in lithological character and in colour they resembled the Lower Carboniferous sandstones and shales that I had been familiar with in the district generally and in other localities. In short, I maintain that there are no grounds whatever for supposing them to be other than ordinary Lower Carboniferous sandstones and shales, such as would naturally be expected there. Yet Mr. Kendall, without a single scrap of real evidence in support of his view, asks us to consider these Shalk Beck beds as the "Whitehaven Sandstone Series," which has expanded from a thickness of 170 feet at Whitehaven to one of 700 to 800 feet thirty miles away! It seems to me that to admit so gigantic an assumption to be a bare possibility, is to make a very handsome concession to Mr. Kendall. And as the *onus probandi* falls upon his shoulders, I do not envy him the task of proving his case.

It may be worth while mentioning here, that in 1883, Mr. Kendall published a paper on "The Structure of the Cumberland Coalfield" (Trans. N.E. Inst., vol. xxxii, p. 319, and vol. xxxiii, p. 121), maintaining the general conclusions arrived at in his latest contribution to the subject. In a short paper entitled "Notes on the best locality for Coal beneath the Permian Rocks of North-west Cumberland" (Trans. Cumb. and West. Assoc. 1883–4), I commented briefly, *inter alia*, on Mr. Kendall's views as regards the Whitehaven Sandstone, pointing out the necessity of complete evidence of unconformity, and also that the sheet of sections illustrating Mr. Kendall's paper appeared to me to contradict his views. Some remarks in reply, by Mr. Kendall, appear in Trans. Cumb. and

West. Assoc. 1884–5, and a rejoinder by myself in Trans. Cumb. and West Assoc. 1885–6.

In 1891, a paper by Mr. William Brockbank, F.G.S., "On the Occurrence of the Permians, *Spirorbis* Limestones, and Upper Coal-measures at Frizington Hall, in the Whitehaven District," was read, and has since been published in vol. iv (fourth series), Mem. and Proc. Manchester Lit. and Phil. Soc. Frizington Hall is about three miles east of Whitehaven. The paper consists of the details of a boring made at Frizington Hall by the Vivian Boring Company in 1890–1. The Whitehaven Sandstone was pierced in this boring, and its details are of so much interest that I here give an abstract of it from Mr. Brockbank's paper.

Abstract of the Frizington Hall Section.

	Thickness. ft.	in.	Depth. ft.	in.
Surface clays	22	0	22	0
Permian breccia	20	0	42	0
Shales, chiefly red, with purple sandstone	69	1	111	1
Spirorbis limestone (reddish)	3	9	114	10
Purple sandy shales	10	8	125	6
Conglomerate	11	0	136	6
Grey and pink mottled shaly sandstones	6	0	142	6
Shaly conglomerate	39	1	181	7
Red and grey sandstone and shale	80	11	262	6
Spirorbis limestone	1	0	263	6
Shales and marls, variously coloured (sandstone 1 ft. 6 in.)	33	10	297	4
Brassey coal	0	4	297	8
Blue metal, with sandstone, 1 ft....	18	5	316	1
Coal...	1	0	317	1
Metal, chiefly blue, marl and fireclay	88	11	406	0
Coal...	1	3	407	3
Blue metal	10	8	417	11
Red or reddish sandstone and shale	42	9	460	8
Red and purple sandstone and shale	69	10	530	6
Conglomerate	11	10	542	4
Reddish-grey sandstone and shale	30	11	573	3

Boring ended.

Mr. Brockbank remarks that the three coals are in true Upper Coal-measures, and that he considers the rocks from a depth of 460 ft. 8 in. to the bottom of the boring to be the sandstones seen on the coast at Whitehaven, which they strongly resemble. He adds, that if he be correct in his identification, "they thus become Middle Coal-measure sandstones beyond doubt, as they are 214 feet under the lowest *Spirorbis* limestone." And he also states tha though the Whitehaven Sandstone is to be seen for a considerable distance on the coast where the strata above it have been denuded away, he believes this is the first time it has been recorded where its true position in the Coal-measures is shown. Mr. Kendall, on the other hand, claims the whole of the beds below the Permian as belonging to the "Whitehaven Sandstone Series." And to Mr. Brockbank's remark that the Whitehaven sandstones "thus become Middle Coal-measure sandstones beyond doubt, as they are 214 feet under the lowest *Spirorbis* limestone," Mr. Kendall simply replies—"But surely mere thickness of strata cannot, of itself, determine geological level."

It is to be regretted that the boring did not go deep enough to show us the nature of the rocks on which the Whitehaven Sandstone rests at Frizington Hall, so as to enable us to note the resemblances and differences in that respect between that place and the cliffs of Whitehaven, and possibly obtain information as to an increase or decrease of the unconformity eastward. A point of interest in the Frizington Hall boring appears to me to be the way in which the section is divided into zones. These consist of an upper one, mainly sandy, between the *Spirorbis* limestones; a middle one, in which shales, fireclay, and coals greatly predominate; and a lower, in which sandy conditions again prevail. And we may also note that in the upper sandy zone the colour is mostly reddish or reddish grey; in the middle, or shaly zone, the metals and shales are mainly blue; while, in the lower sandy zone, red and reddish-grey tints again appear almost exclusively.

I have already remarked that reddish or purple-grey Carboniferous rocks may be seen in North Cumberland on every horizon in that series. And this Frizington Hall section seems to me to point to the probable explanation of this fact, and also to explain why rocks so tinted are almost invariably either sandstones or sandy shales. It certainly gives a very strong support to a theory as to the origin of the purple-grey colour of these Carboniferous beds which I must confess to have looked at, till lately, with some distrust; I mean the theory that the purple-grey rocks have been stained by the red Permian-Triassic strata which once wholly covered them, though now so large an area of Carboniferous rock lies bare. The Permian-Triassic beds are highly unconformable to the Carboniferous, and rest here on lower, there on higher, members of the older series. Should, then, the older rocks owe their colour to the newer formations once resting upon them, it is obvious that we may expect to find that the lower as well as the higher Carboniferous beds have been stained. We may also expect to find that the rocks are stained or left unstained mainly in proportion to their permeability or impermeability. In other words, we should expect to see what we do actually see in this Frizington Hall section, sandy zones coloured purple-grey and a clayey zone uncoloured. And this is what we may expect elsewhere. Coal-seams are not likely to be found in purple-grey rocks, because coals are—as in the Frizington section—usually found with clayey, impermeable shales which are not likely to be stained. This section, too, is alone sufficient to refute the notion that there is any necessary connection between purple-grey colour and a certain Carboniferous horizon.

Another conclusion suggested by this Frizington section is that as the Whitehaven Sandstone, though not low down in the Coal-measures, occupies by no means the highest place, its unconformity, if considerable, is much more likely to have been noted (did it exist) in colliery workings, than would have been the case with a bed in the uppermost strata. That the unconformity has not been noted, only adds to the strong presumption that there is none to note, and that instead of increasing in magnitude from Whitehaven north-eastward to Shalk Beck it does just the reverse.

Indeed, it is time that we recognized that the magnitude of this unconformity, so certain to be noted by all geologists because conspicuous in a sea-cliff and accompanied by a change of colour, in a country where natural sections are so few, may have been immensely exaggerated. The Cumberland Coalfield is small and drift-covered, and it is impossible from observations in the field to learn much about the characteristics of its various beds. Even the railway cuttings generally show nothing but Glacial Drift. But if we turn to the Geological Survey Memoir on the Yorkshire Coalfield, a district practically free from Glacial Drift, we learn from Prof. Green's remarks in chap. ii much which illustrates the fact that the circumstances under which the Coal-measures were deposited were such as frequently to produce appearances of unconformity which are really mere local erosions. He notices, p. 14, that the sandstones are great wedge-shaped banks which sometimes, from a thickness of 100 ft., wedge out to nothing in a space of half a mile or less; that they are equally inconstant in composition or grain, a coarse, irregularly-bedded grit passing into a fine-grained, laminated sandstone, etc.; and remarks that these facts are easily explained if we suppose the sandstones "to have been deposited on an uneven floor, in shallow water traversed by numerous and opposing currents. Their wedge-shaped form may be sometimes due to their being banks piled up by currents running now from one and now from the opposite quarter, and may be sometimes caused by depressions in the bottom of the water having been filled in with sand."

Then we read on p. 24—"The junction of a sandstone with the overlying shale is often very uneven, as if part of the original sandbank had been cut away before the sand began to be deposited. In many cases, too, the top of a sandstone is furrowed by branching channels, such as would be cut out by a system of little rivulets. In such a case there can be little doubt that the surface of the sandstone bed was for a time a land surface traversed by streams of running water."

The general conditions under which the Coal-measures of West Cumberland were deposited were evidently identical with those prevailing during the Coal-measure period in Yorkshire, and would tend to produce similar results in each district. It seems, therefore, useful to remind those interested in this question both that the lithological character of Coal-measure sandstones is extremely liable to vary, and also that appearances of unconformity in Coal-measures are peculiarly liable to be deceptive. In the discussion which followed the reading of a paper by Mr. Kendall "On the Whitehaven Sandstone Series" at the Geological Society, on February 20, 1895, Mr. Strahan, of the Geological Survey, inclined to think that the appearances in the Whitehaven cliffs indicated simply local erosion, not unconformity of the least importance. He also thought the purple-grey colour due to staining. My own remarks were to the effect that Mr. Kendall's views could be established only by the evidence of colliery workings, and that no such evidence was forthcoming. Mr. Marr confirmed the existence of rocks of various ages around the Lake District which had been stained red. There were no other speakers. A brief abstract of Mr. Kendall's paper is given. So far as my memory serves it was practically identical with his latest contribution to the subject. See Quart. Journ. Geol. Soc., vol. li, part 2 (May, 1895), p. 235.

I would simply say, in conclusion, that the only evidence we have about the position among the Coal-measures of the Whitehaven Sandstone is that furnished by the Frizington Hall boring. That, as to whether the appearance of unconformity in the cliffs of Whitehaven indicates an unconformity of any magnitude or merely local erosion of no importance whatever, we have no direct evidence. But that from the frequency of cases of mere local erosion in Coal-measures, combined with the absence of evidence of any unconformable series in colliery workings, it seems most probable that the unconformity is but slight and local. That the purple-grey colour of Carboniferous beds on every horizon is due to staining, which has affected the more or less permeable strata and left the impermeable unstained. Consequently the presence of a belt of purple-grey sandstones and sandy shales, above an unstained belt of clayey shales and coals, is simply evidence of the coming in of sandy conditions and the cessation of clayey ones. Finally I would remark, that when the existence of a great unconformity at the base of the Whitehaven Sandstone, increasing north-eastward, is proved by the evidence of colliery workings, it will be time to consider whether the classification of the purple-grey beds of Shalk Beck needs revision. At present it appears to me that Mr. Kendall's views as to this unconformity and its effects are unsupported by any real evidence, and have no legitimate claim to consideration. It is for him to show that what seem now to be merely needless and baseless assumptions are founded upon solid grounds.[1]

V.—On *Goniatites evolutus*, Phillips, and *Nautilus tetragonus*, Phillips; with a list of the Species belonging to the genus *Subclymenia*.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

In 1836, Prof. J. Phillips[2] described and figured from the Carboniferous Limestone, *Goniatites evolutus*, and for this species D'Orbigny,[3] in 1850, instituted the genus *Subclymenia*.

In 1851, L.-G. de Koninck[4] described and figured his species *Nautilus Omalianus*, from the Lower Carboniferous Limestone of Visé, Belgium, and gave no synonymy. In 1880, the same author[5]

[1] It may prevent possible misunderstanding to state that the foregoing remarks express simply my own personal views.

[2] "Geol. Yorkshire," pt. ii, 1836, p. 237, pl. xx, figs. 65–68.

[3] "Prod. de Paléont.," vol. i, 1850, p. 114.

[4] "Animaux Fossiles," Suppl., p. 711, pl. lx, figs. 3*a–d*.

[5] "Faune Calc. Carb. de la Belgique," pt. ii, p. 83, pl. xlv, figs. 5, 6: Ann. Mus. Roy. d'Hist. nat. de Belgique, sér. Paléont., vol. v.

figured two Belgian specimens which he referred to Phillips' *evolutus.* He adopted D'Orbigny's generic designation, and united with this species his previously described *Nautilus Omalianus.* Whilst recognizing their generic affinity, Prof. Hyatt[1] appears to consider the examples referred by De Koninck to *evolutus* to be specifically distinct from Phillips' species, and for the Belgian form proposes the name *S. gibbosa.* He also considers *Nautilus Omalianus* to be specifically, though not generically, distinct from both.

In 1836, Prof. Phillips[2] also described and figured from the Carboniferous Limestone the species *Nautilus tetragonus,* which in 1854 Prof. Morris[3] referred to M'Coy's *Discites,*[4] regarding the latter as a subgenus of *Nautilus.*

Foord,[5] in 1891, considered *Nautilus tetragonus,* Phillips, and *Nautilus Omalianus,* De Koninck, to be identical; and, referring the species to M'Coy's *Discites,* accepted De Koninck's specific name, remarking that "according to the strict letter of the law of priority, Phillips' name should be adopted for this species, but his description and figures are so defective that it would be quite impossible to recognize the fossil thereby."

Phillips described his *Goniatites evolutus* as follows: "Volutions apparent, their section round in young, oblong in old whorls; septa with a deep, acute, dorsal sinus, and obtuse-angled first lateral lobe," giving as the locality "Flasby, etc." Of the specimens which he figured, the original of figs. 66, 67, and 68, is in the York Museum.[6] The writer is greatly indebted to the authorities of that Museum for the loan of the specimen; it is only the internal cast of four loculi, but a careful examination of the fossil has enabled him to identify with Phillips' species a splendidly preserved example, now in the Gilbertson collection in the British Museum.[7]

Of *Nautilus tetragonus,* Phillips gave the following description: "Flat, discoidal, whorls tetragonal, back slightly concave, with a small spiral ridge within the angles; striæ bent, sharp, rising into plaits on the edges; septa concave outwardly; (oblique undulations on the sides of the cast). *Var. β,* inner edges rounded"; and he mentioned as localities "Kulkeagh; Bolland; Northumberland." The description is accompanied by figures of at least three specimens, one of which (pl. xvii, figs. 26, 27) is, however, doubtfully referred to this species.[8] The writer has been able to examine only one of

[1] A. Hyatt, "Carboniferous Cephalopods," Second Paper: 4th Ann. Rep. Geol. Surv. Texas, 1892 (1893), p. 414.

[2] *Op. cit.*, pt. ii, 1836, p. 233, pl. xxii, figs. 33, 34; pl. xvii, fig. 24 (26? 27? in explanation of plate on p. 250).

[3] "Cat. Brit. Foss.," 2nd ed., 1854, p. 309.

[4] F. M'Coy, "Synop. Carb. Foss. Ireland," 1844, p. 17.

[5] "Cat. Foss. Ceph. British Museum," pt. ii, 1891, p. 87.

[6] H. M. Platnauer, "List of Figured Specimens in York Museum": Ann. Rep. Yorks. Philos. Soc. 1890, p. 79. The locality there given ("Flaxby") is an error; Mr. Platnauer informs me that it should have been "Flasby."

[7] B.M. No. C. 5336.

[8] A specimen in the Gilbertson collection in the British Museum (No. C. 237*c*) is believed to be this figured example. It is but a fragment, and greatly resembles "*Nautilus subsulcatus,*" Phillips (=*Cœlonautilus subsulcatus*). It certainly does

the other two specimens, viz. the original of pl. xvii, fig. 24, which is in the Gilbertson collection in the British Museum (No. C. 222); but Phillips' description seems to have been based chiefly upon the specimen represented in pl. xvii, figs. 33, 34, for fig. 33 represents the "back slightly concave, with a small spiral ridge within the angles," and in fig. 34 are depicted the "bent, sharp striæ, rising into plaits on the edges." Both these characters are to be seen in well-preserved specimens of *Cœlonautilus quadratus* (Fleming)[1]; and further, the section indicated in fig. 33, as well as the form of the septa given in fig. 34, agree so well with these characters in Fleming's species, that in all probability the fossil here figured is referable to this species; but a definite opinion cannot be given without an examination of the specimen. These characters, however, are not present in the specimen figured by Phillips, pl. xvii, fig. 24, which has the test well preserved; the transverse striæ are not nearly so much bent on the lateral area as in *Cœlonautilus quadratus*, and further, over about half of the width of the lateral area, and for more than one-half of the length of the fragment figured, the transverse striæ are thickened at regular intervals, so that they have the appearance of being crossed by spiral lines. The sculpture, in fact, is that of Phillips' "*Goniatites*" *evolutus*, as exhibited by the specimen to be referred to later on. The peripheral lobe of the suture-line also agrees with that of the same species.

Again, the periphery in *Cœlonautilus quadratus* bears a strong ridge at about one-quarter of the width of the peripheral area from each angular margin, and in well-preserved specimens there is sometimes a much more feeble ridge about half-way between each of these strong ridges and the angular margin; the transverse striæ are also very feeble. But in the specimen depicted by Phillips as *Nautilus tetragonus* in pl. xvii, fig. 24 (probably Phillips' *var.* β), the periphery bears near each margin about six longitudinal lines, which diminish in strength from the angular margin inwards; and the transverse striæ are much more pronounced, an ornamentation agreeing with that of Phillips' "*Goniatites*" *evolutus*, as exhibited by the specimen described below.

We conclude, then, that Phillips' *Nautilus tetragonus* is in part, and only in part, referable to that author's "*Goniatites*" *evolutus*.

Upon this latter species, as has already been stated, D'Orbigny in 1850 founded the genus *Subclymenia*; still, several subsequent writers[2] have regarded the species as a Goniatite. Although not a Goniatite, but a Nautiloid, the genus (*Subclymenia*) to which it is referred is

not agree with the specimen figured by Phillips in pl. xvii, fig. 24. The figure differs in some respects from the specimen. The periphero-lateral angles should have been represented more obtuse, and the suture-line with a narrower and shallower sinus on the periphery.

[1] *Nautilus quadratus*, J. Fleming, "Hist. Brit. Anim.," 1828, p. 231.

[2] J. Morris, "Cat. Brit. Foss.," 2nd ed., 1854, p. 303; G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., 1887, Appendix 1, p. 182: Mem. Geol. Surv.; R. Etheridge, "Brit. Foss.," vol. i, Palæozoic, 1888, p. 311; G. H. Morton, Proc. Liverpool Nat. Field Club for 1894, p. 23, 1895.

regarded by Hyatt[1] as the highest type of Nautiloidea, since with its "ventral V-shaped lobe and ventral siphon" it is "so like *Goniatites* that it can be separated only by its young and the gradations of forms which connect it with certain well-known Nautiloids."

The original of Phillips' fig. 66 is simply an internal cast of four loculi; there is no trace of the test. It has the following dimensions:—

		mm.
Length	...	48
Height of whorl at anterior end ...	...	22
Greatest thickness ,, ,, ...	...	19
Width of periphery ,, ,, ...	about	12
Height of whorl at posterior end	...	16·5
Greatest thickness ,, ,,	...	15
Width of periphery ,, ,,	about	9

The greatest thickness of the whorl is at about one-third of the height of the whorl from its inner edge. The periphery is flattened, and has no central channel such as Phillips represents in fig. 67; the siphuncle is well below the surface, its centre at the anterior end of the specimen being 2·75 mm. from the periphery. The peripheral (or external) saddle of the suture-line is depicted (fig. 68) much too acute; the anterior part of the specimen is here broken a little, causing this saddle to appear more acute than it really was.

A careful comparison with the type has enabled the writer to identify with this species a small but exceedingly well-preserved specimen (see accompanying figures), now in the Gilbertson collection in the British Museum (No. C. 5336), and to characterize Phillips' species more fully than has hitherto been done. It has the following measurements:—

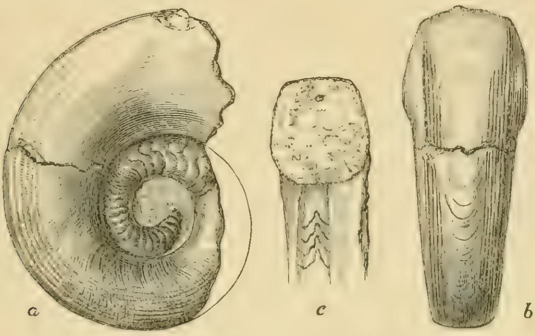
	mm.
Diameter	43
Height of outer whorl	17
Width of umbilicus (suture to suture) ...	15·5
Greatest thickness...	16
Width of periphery	11

The specimen, which is probably not quite complete, consists of nearly two whorls. There is a large central vacuity. The first third of the first whorl is free. The apex has unfortunately been very slightly chipped in clearing the specimen from the matrix. The first chamber is conical, a little more than 1 mm. deep, and with a ventro-dorsal diameter of 1·5 mm. at its anterior end. The free portion is sub-circular in section, but at the completion of the first half whorl the periphery is distinctly flattened and 3·5 mm. wide, the height or ventro-dorsal diameter of the whorl here being 4·5 mm., the greatest thickness being at a short distance from the inner edge. The shell increases rather rapidly, but maintains about the same form of transverse section.

Unfortunately the free portion of the fossil bears only fragments of the test. Near the apex the whorl is crossed by transverse lines

[1] A. Hyatt, "Fossil Cephalopoda in the Museum of Comparative Zoology": Proc. Amer. Assoc. for the advancement of Science, vol. xxxii, 1883, p. 333.

passing from the inner side obliquely backwards to the outer, but on the second third of the first whorl these transverse lines are crossed by longitudinal lines, so that the latter are distinctly crenulated. They cover the lateral area, and increase in strength as they approach the outer portion of the whorl. These ornaments on the lateral area gradually become fainter; at about the middle of the second whorl the transverse lines are much finer, and only a few of the longitudinal lines remain near the periphery, and these are very faint; at the extremity of the specimen only exceedingly fine lines of growth are present.



Subclymenia evoluta, J. Phillips, sp.

a, lateral aspect; *b*, peripheral aspect; *c*, front view with the outer portion detached, showing the position of the siphuncle and the peripheral lobe of the suture-line as it appears nearly at the end of the first whorl. Carboniferous Limestone: locality unknown.

Drawn from a specimen in the British Museum (Natural History), No. C. 5336. Natural size. (The specimen is quite symmetrical, although it scarcely appears to be so in fig. *c*, owing probably to the piece of matrix adhering to one side of the fossil and covering not only the lateral area of the whorl, but also a narrow portion of the periphery.)

The ornaments on the periphery at the middle of the first whorl consist of about six longitudinal striæ near each margin, diminishing in strength from the angular margin inwards, crossed by exceedingly fine transverse striæ, which in passing from the lateral angles cross the longitudinal striæ obliquely backwards, becoming on the median portion of the periphery more pronounced and forming a wide deep sinus concave forwards. As the shell increases in size, the longitudinal almost obliterate the transverse lines; while the ornaments on the median portion become very distinct, and are also crossed by very fine, obscure, longitudinal striæ. At the extremity of the specimen the longitudinal lines near the margins are more pronounced, and the central curved lines almost obliterated. The central area is slightly raised above the rest of the periphery, and is feebly concave.

The first suture-line is only slightly backwardly curved on the periphery, and the three following suture-lines have merely a very shallow, simply curved, peripheral sinus; but at the middle of the first whorl the suture-line has a distinct V-shaped peripheral lobe, and is on the whole almost similar to that of the adult shell.

The siphuncle is near the periphery, its centre being only 2·75 mm. from the surface, where the whorl is 13 mm. high. Judging from another specimen,[1] the siphuncle was more nearly central in the young shell, *e.g.* where the height of the whorl was only 2·5 mm.

The species may then be characterized as follows:—

Shell discoidal, evolute, rather rapidly increasing, with a large central vacuity; greatest thickness at about one-third of the height distant from the inner edge of the whorl, about three-eighths of the diameter of the shell; height of outer whorl rather more than three-eighths of the diameter of the shell. Whorls at least two; inclusion almost *nil*; umbilicus shallow, wide, nearly three-eighths of the diameter of the shell, its sides sloping and convex. Whorl truncated-oval in section, a little higher than wide, scarcely impressed by the preceding whorl; periphery flattened, the central portion slightly raised above the rest and feebly concave, broad, about two-thirds of the corresponding height of the whorl in width; sides—outer two-thirds flattened, very feebly convex, convergent,[2] the rest strongly convex and continuous with the convex, relatively broad, inner margin. Length of body-chamber not seen. Chambers rather shallow, measured at the middle of the lateral area about three-tenths of the corresponding height of the whorl apart; suture-line with a V-shaped peripheral lobe, nearly as wide as the periphery, a somewhat broader external saddle situated on the periphero-lateral angle, and a single, wide, shallow, lateral sinus, but nearly straight on the inner portion of the whorl, and with a well-marked annular (or internal) lobe. Siphuncle near the periphery, rather small. Test—the lateral area ornamented with fine transverse striæ, crossed by delicately crenulated longitudinal lines, both becoming finer in the adult, the latter losing their crenulations and gradually disappearing first from the inner portion of the sides, and afterwards from near the periphery, leaving in the adult merely fine transverse delicate striæ; the central portion of the periphery with exceedingly delicate backwardly-curved striæ, crossed by very obscure longitudinal lines, much coarser longitudinal lines (about six) occupying a narrow band near each boundary, and diminishing in strength from the angular margin inwards.

Unfortunately the locality of the specimen in the Gilbertson collection, which Phillips figured as *Nautilus tetragonus*, is not quite certain. It is labelled "Northumberland?"

One of Phillips' types of *G. evolutus*, now in the York Museum, came from Flasby, four miles north-west of Skipton, Yorkshire. The species has also been recorded from Chrome Hill, Derbyshire;[3] and from the Poolvash Limestone in the Isle of Man.[4]

Mr. G. H. Morgan, F.G.S., of Liverpool, recorded[5] the species in

[1] From Graig fawr, Prestatyn, Flintshire, and kindly sent to me for examination by Mr. G. H. Morton, F.G.S., Liverpool.

[2] *i.e.* converging towards the plane of symmetry external to the periphery.

[3] G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., 1887, Appendix 1, p. 182: Mem. Geol. Surv.

[4] J. H. Cumming, "Isle of Man," 1848, p. 357.

[5] Proc. Liverpool Nat. Field Club for 1894 (1895), p. 23.

his Presidential Address to the Liverpool Naturalists' Field Club, on "The Recent and Fossil Flora and Fauna of the country around Liverpool," and through his kindness the writer has been able to examine the specimen there referred to. It came from Graig fawr, Prestatyn, Flintshire.

Appended is a list of the species (with synonyms and references) belonging to the genus *Subclymenia*. So far as known, it is confined to the Carboniferous.

SUBCLYMENIA EVOLUTA, J. Phillips, sp.

1836. *Goniatites evolutus*, J. Phillips, "Geol. Yorkshire," pt. ii, p. 237, pl. xx, figs. 65–68. (Flasby, Yorkshire.)
1836. *Nautilus tetragonus* (pars), J. Phillips, *ibid.*, pt. ii, p. 233, pl. xvii, fig. 24 (right and left-hand figures); *not* pl. xxii, figs. 33, 34. (Northumberland ?)
1843. *Goniatites evolutus*, J. Morris, "Cat. Brit. Foss.," p. 179.
1843. *Nautilus tetragonus* (pars), J. Morris, *ibid.*, p. 183.
1848. *Goniatites evolutus*, J. H. Cumming, "Isle of Man," p. 357.
1850. *Subclymenia evoluta*, A. D'Orbigny, "Prod. de Paléont.," vol. i, p. 114.
1854. *Goniatites evolutus*, J. Morris, "Cat. Brit. Foss.," 2nd ed., p. 303.
1854. *Nautilus (Discites) tetragonus* (pars), J. Morris, *ibid.*, 2nd ed., p. 309.
1883. *Subclymenia evoluta*, A. Hyatt, Proc. Boston Soc. Nat. Hist., vol. xxii, p. 293.
1887. *Goniatites evolutus*, G. Sharman and E. T. Newton, "Geol. N. Derbyshire," 2nd ed., app. 1, p. 182: Mem. Geol. Surv. (Chrome Hill, Derbyshire.)
1888. *Goniatites evolutus*, R. Etheridge, "British Fossils," vol. i, Palæozoic, p. 311.
1891. *Discites Omalianus* (pars), A. H. Foord, "Cat. Foss. Ceph. British Museum," pt. ii, p. 87.
1893. *Subclymenia evoluta*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414.
1895. *Goniatites evolutus*, G. H. Morton, Proc. Liverpool Nat. Field Club for 1894, p. 23. (Graig fawr, Prestatyn, Flintshire.)

SUBCLYMENIA GIBBOSA, Hyatt.

1880. *Subclymenia evoluta* (pars), L.-G. de Koninck, "Faune Calc. Carb. de la Belgique," pt. ii, p. 83, pl. xlv, figs. 5, 6: Ann. Mus. Roy. d'Hist. nat. de Belgique, sér Paléont., vol. v (not of Phillips). Calcaire carbonifère (Assise vi): Visé, Belgium.
1893. *Subclymenia gibbosa*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414.

SUBCLYMENIA OCCULTA, Hyatt.

1893. *Subclymenia occulta*, A. Hyatt, 4th Ann. Rep. Geol. Surv. Texas for 1892, p. 414. Calcaire carbonifère: Visé, Belgium.

SUBCLYMENIA OMALIANA, De Koninck, sp.

1851. *Nautilus Omalianus*, L.-G. de Koninck, "Descr. Anim. Foss.," Suppl. p. 711, pl. lx, figs. 3*a–d*. Calcaire carbonifère: Visé, Belgium.
1880. *Subclymenia evoluta* (pars), L.-G. de Koninck, "Faune Calc. Carb. de la Belgique," pt. ii, p. 83 (excl. the figures): Ann. Mus. Roy. d'Hist. nat. de Belgique, sér Paléont., vol. v.
1891. *Discites Omalianus* (pars), A. H. Foord, "Cat. Foss. Ceph. Brit. Mus.," pt. ii, p. 87.
1893. *Subclymenia Omaliana*, A. Hyatt, 4th Ann. Rep. Geol. Surv Texas for 1892, p. 416.

SUBCLYMENIA WILLOCKII, Haughton, sp.

1859. *Nautilus Willockii*, S. Haughton, Nat. Hist. Review, vol. vi, p. 507, pl. xxi, figs. 1*a–b*. (Cleenish, Fermanagh, Ireland.)

Although only imperfectly known, this species most probably belongs to *Subclymenia*.

VI.—Notes on Jurassic Ammonites.

By S. S. Buckman, F.G.S.

Two valuable pamphlets on Jurassic Ammonites have lately appeared. One of these is entitled "Cephalopodes nouveaux ou peu connus des Étages jurassiques de Normandie, par Louis Brasil."[1] This author, who has paid very considerable and successful attention to the Jurassic rocks in the neighbourhood of Caen, describes and figures (there are four plates) nineteen new species of Ammonites belonging to fourteen genera, viz.: *Lytoceras, Phylloceras, Catulloceras, Zurcheria, Dorsetensia, Bajocia, Pœcilomorphus, Hammatoceras, Erycites, Oppelia, Cadomoceras, Strigoceras, Cosmoceras, Œcotyphius.* Of these genera one is new, namely, *Bajocia*, founded on an unique specimen; and it must be confessed that the example is sufficiently distinct in every way to warrant this treatment. Although the author does not say so, it is evident the genus belongs to the subfamily Sonniniæ; and M. Brasil practically admits as much when he states that it is very near to *Dorsetensia*. He further says that he considers it to be a branch from *Haplopleuroceras*, whose representatives have lost not only the two rows of spines, but even the keel and the furrows. We find ourselves unable to agree with this opinion, because the periphery is rounded and flattened; in our experience the keel and furrows do not disappear without leaving some trace of their former existence on the configuration of the periphery. We agree with the author that *Bajocia* is near to *Dorsetensia*, and we are inclined to think it is a late-surviving example of the stock whence *Dorsetensia* originated, and a "cousin" of *Zurcheria*.

Besides the new species, M. Brasil is able to give us descriptions, and in some cases figures, of previously described forms; and in all this work he adds to our knowledge of Jurassic Ammonites, and deserves our thanks.

We find that M. Brasil has carried into effect a suggestion which we made a few years ago. We wrote ("Bajocian of the Sherborne District": Q.J.G.S., vol. xlix, p. 483) concerning the use of the name *Humphriesianus* for chronological purposes—"The confusion concerning this specific name and the large number of species of *Stephanoceras* make this appellation very unsuitable. It would be desirable to apply the name of a species belonging to a less prolific genus." M. Brasil makes very similar remarks concerning the confusion, and then says — "It appears to us that *Dorsetensia Edouardiana* ought to replace *Ammonites Humphriesianus*." Whether this will free us from the confusion, or will only introduce another, remains to be seen. We remember that, unfortunately, our own identification of *D. Edouardiana* has been challenged, whether rightly we will not pretend to say, without an extended comparison of our specimens with the actual type, because it seems that the original figure is not altogether reliable.

In this matter of draughtmanship have arisen most of the troubles

[1] Extrait du Bulletin de la Société géologique de Normandie, tome xvi, 1892–3 (published 1896).

of identification. M. Brasil has attempted to diminish error by the application of photography to the production of his plates. Herein it seems to us that the results are not quite so successful as they should be, and as they can be made. From our own experience of photographing Ammonites we can tell him that orthochromatic plates destroy all those differences due to diverse colours of the matrix or test, and thus dark or light stains on the fossils do not give the false suggestion of furrow or rib. We give this hint because we are convinced that photography, rightly applied, is *the* medium for palæontological illustration.

The other pamphlet alluded to is the second part of that important work by Dr. J. F. Pompeckj, entitled "Beiträge zu einer Revision der Ammoniten des Schwäbischen Jura."[1] Two genera are dealt with—namely, *Lytoceras* and *Ectocentrites*. The author notices that from *Lytoceras*, as previously constituted, six already-named genera, of which *Ectocentrites* is one, may be sheared off; and then that *Lytoceras* is divisible into three groups—1, of *L. fimbriatum*; 2, of *L. Villæ*, Meneghini; 3, of *L. articulatum*, Sow. In these groups the author describes several new species, and gives important correction in regard to others; for instance, what we have long had in mind to do, the correction of the synonymy of *Lytoc. cornucopiæ*, Young and Bird—that this species=*Lytoc. Siemensi*, Denckmann, and is not *cornucopiæ*, Wright; and as we have said before this, not D'Orbigny's. For such work as this the author deserves our thanks; it is most necessary. Herein we may draw attention to one matter which has, in connection with other species, puzzled even English authors—that there were two editions of Young and Bird's work, one published in 1822, the other in 1828, *and that the contents of the plates differ considerably*.

In one matter we have to correct Dr. Pompeckj. He speaks of *Lytoc. confusum*, Buckman, as not figured, and that it may well be nothing else than *Lytoc. trapeza*, Quenst. But it is figured, namely, in 1883, in Proc. of Dorset Nat. Hist. Field Club, vol. iv, pl. iii, figs. 1, 2, along with ten other new species. It would, therefore, take precedence of *trapeza*, if they were the same: but they are not, as we have stated in the pages of this Journal (Vol. IX, p. 260, 1892). They lived, too, at different dates—*confusum* in the hemera *concavi*, *trapeza* two hemeræ later (Sonniniæ). We may remark that at one time the deposits of these dates were all called *Sowerbyi*-zone; but the separation of the *concavum*-zone from the *Sowerbyi*-zone has been pointed out some time.

VII.—On Plant Beds of Tertiary Age in British Columbia.

By Geoffrey F. Monckton, Esq.

THE following notes refer to the fossils found by me, during the last two years, in the Tertiary strata of Burrard Inlet, British Columbia, and to the enclosing rocks themselves. These fossils were derived from beds outcropping within four miles of the city of Vancouver. The strata consist of sandstones, mudstones, shales, and

[1] Stuttgart. E. Schweizerbart'sche Verlagshandlung, 1896, pp. 95–178, pls. viii–xii.

thin, irregular beds of lignite, of which last-named material a typical analysis by me gave—fixed carbon, 36·10; volatile combustible matter, 41·25; ash, 15·40; and hygroscopic water, 7·25 per cent. These lignite beds usually are only about an inch in thickness, but sometimes they run into pockets a foot or more in depth. There has been a considerable amount of money spent in putting down boreholes in this district in search of workable coal-seams, but, so far, without success; and the opinion of the writer is that no workable coal beds exist there, unless they occur in the Cretaceous beds, which are the coal-bearing deposits of Western North America, and probably underlie these strata. Early in 1894 I found the bed from which my earlier specimens were obtained. The lower part of this contains aquatic plants; above these are palm-leaves; and, again, above these salix, populus, and juglans (willows, poplars, and hickory). In the highest part of the deposit are palms and a few other leaves. The whole bed varies from four to eighteen inches in depth, and is underlain by a few inches of black shales, which contain many leaves that are for the most part very difficult to distinguish. This shale thins out in a few yards, and it would seem that the fossil bed runs out at the same point where the shale vanishes. I think that probably there existed, at the time when these fossils were deposited, a cove at this point, where the water was slack. The second bed which I worked in produces fewer fossils, but the veining is much more distinct. This deposit was only found in May, 1895. Where it was first opened the total thickness did not exceed one inch, which contained leaves of angiosperms, underlain by about one inch yielding fern-leaves. Underneath it was a bed of black shale two inches thick. Where it is now worked the upper part is at least six inches thick. It is curious to note in this deposit how at one end the hickory prevails; in the middle, poplars and willows; and at the other end, poplars alone: which would seem to point to the fact that these leaves were not carried any distance, but lie where they fell from trees overhanging the bank.

I might preface the description of my fossils with some remarks as to the supposed age of these rocks. To the southward is a region covered with strata which are of the same age, and are now generally supposed to be Eocene, and compared to the Upper Laramie. The Laramie formation is to be adjudged as belonging to the Eocene, if its age be determined by the fossil leaves which it contains. It is identified, however, by its saurian remains, and also by the occurrence of some mollusks with the Cretaceous. It passes down into the Cretaceous without any stratigraphical break, while the overlying Tertiary are, as a rule, unconformable to it. Heer classed it as Miocene, Lesquereux partly as Eocene and partly as Miocene, while Clarence King referred part of it to the Cretaceous. It has recently been found to underlie Miocene beds, which would seem to stamp the upper part as Eocene.

Some of the species found point to a considerably warmer climate than that which now prevails at Burrard Inlet, which resembles the south of England, although others are very similar to plants which grow there at the present time.

One of the most common forms found has been the leaf of a Sabal, which has been referred by Sir J. W. Dawson to *Sabal Campbellii.* The specimens submitted to him show about twelve parallel veins on each slope of the folds, at six inches from the base of the leaf. One fragment is apparently a portion of a leaf five feet in diameter. There are also fragments which indicate a pinnate palm-leaf referred to *Manicaria.*

Populus balsaminoides occurs very frequently. Although Sir J. W. Dawson has referred some leaves to this species, he points out that they do not possess the serrated edges peculiar to it. These leaves are often six inches across. Of willows, *Salix integra* and *Salix varians* are common; but the venation of these leaves is usually very indistinct, although one or two specimens which have been obtained show it very clearly.

Platanus is represented by a few large leaves. These are very common in the Laramie strata, which cover much of the interior of British Columbia. One specimen of *Æsculus* has been found by me, and Sir J. W. Dawson has named it *Æsculophyllum Hastingsense.* The specimen is not very distinctly defined. The bases of seven leaves which are articulated to a common petiole are shown.

In some places the leaves of the hickory occur in great profusion, and have been named *Juglans denticulata.* The same species occurs in the Eocene of Greenland. A fruit which was first discovered by Mr. Hill Tout, of Vancouver, and was afterwards found by the writer, has been named provisionally *Carex Burrardianus.* Leaves of the genus *Carex* have previously been found in this district. Several leaves referred to *Quercus* are found in the beds. A very large number of specimens of the fern *Lygodium neuropteroides* occurs, some layers being composed entirely of these. Among others, *Ficus Shastensis* (Lesq.), *F. Condorii* (Newberry), *Quercus Evansii* (Lesq.), *Sequoia spinosa* (Newberry), and *Dryophyllum*, are found. Impressions of a matted growth of aquatic plants occur at one point.

I had prepared a number of tracings from drawings of specimens in my collection to illustrate these notes.[1] The specimens are named by Sir J. W. Dawson, but some are not yet identified.

The strike of the beds from which the fossils were taken is very irregular, but is roughly S.W. and N.E., the dip being about 18° to the S.E., which would seem, so far as my explorations have yet gone, to bear some relation to basalt dikes, the trend of which is along the line of strike.

In conclusion, I may say that there has been but very little work done on these beds, the workers being very few in number; and we should be glad to have the co-operation of others. Some of my specimens have been described and figured by Sir William Dawson in a paper on collections of "Tertiary Plants from the vicinity of the City of Vancouver, B.C.": Trans. Roy. Soc. Canada (1895-6), vol. I, sec. iv, p. 137.

[1] These tracings (in the absence of the original specimens) were not deemed sufficient to enable the artist to prepare a plate by; they have therefore not been used to illustrate the paper.—Edit. Geol. Mag.

VIII.—On the Occurrence of the Genus *Listracanthus* in the English Coal-measures.

By Herbert Bolton, F.R.S.E.,
Assistant Keeper, Manchester Museum, Owens College.

DURING the last few months two spines, or Ichthyodorulites, belonging to the genus *Listracanthus*, have come under my observation. Since both are well-preserved specimens, and not hitherto recorded from the English Coal-measures, some information as to their appearance and stratigraphical position may be of interest.

The genus *Listracanthus* was formed by Newberry and Worthen[1] in 1870 to include small spines found in the Coal-measures of Illinois. These spines are small flattened structures, curved backwards, and with the sides ornamented by longitudinal ridges. The convex and concave margins are provided with acute spiny denticles.

Newberry and Worthen described only one species, *L. hystrix* (*tom. cit.*, p. 372, pl. ii, figs. 3, 3*a*), to which *L. Hildrethi* was subsequently added by Newberry[2] from the Coal-measures of Ohio, and *L. Beyrichi*[3] by A. von Könen from the Coal-measures of Herborn, Nassau. An undescribed species is also recorded by A. Smith Woodward[4] from the Calciferous Sandstone of East Kilbride, Lanarkshire; while others from the Upper Carboniferous Limestone Series of Belgium are noted by L. G. de Koninck.[5]

The larger of the two Lancashire specimens was found by me amongst the geological collections of the Royal Museum, Peel Park, Salford, when I was engaged upon their rearrangement. Although unlabelled, it fortunately happens that the spine lies upon the broken surface of an ironstone nodule, and is associated with *Goniatites Listeri*, *G. atratus*, *Aviculopecten papyraceus*, and numerous small ostracods. Ironstone nodules of this character are restricted in the Lancashire Coalfield to the roof of the Bullion or Upper Foot Mine of the Lower Coal-measures; hence the horizon of the specimen can be exactly determined. The second and smaller specimen is the property of Mr. Robert Cairns, of Ashton-under-Lyne, and was obtained by him from the marine band of the Middle Coal-measures in the River Tame at Dukinfield. It is enclosed in a nodule of earthy ironstone, and is unaccompanied by other fossils. I remember finding a third specimen ten years ago in the shales overlying the Bullion Coal of the Lower Coal-measures of Bacup, but it has since been lost.

Both the specimens now to be described differ from the three species hitherto defined, as well as from one another, but it is perhaps hardly justifiable to found a species upon the smaller specimen.

[1] "Pal. Illinois," vol. iv, 1870, p. 371.
[2] Rep. Geol. Surv. Ohio, vol. ii, pt. 2, 1875, p. 56, pl. lix, fig. 6.
[3] Neues Jahrb. 1879, p. 341, pl. vii, fig. 1.
[4] Catal. Foss. Fishes, B.M., pt. 2, 1891, p. 149.
[5] "Faune Calc. Carbf. Belg.," pt. 1, 1878, p. 75, pl. v, fig. 11.

Description of Specimens.

1. *Listracanthus spinatus*, sp.n.

Diagnosis.—Spine small, not exceeding 19 mm. in length, gently arched, sides flat, with seven longitudinal ridges, the convex and concave margins bearing acute spine-like denticles. The denticles of the convex margin few in number and placed at equal distances apart, these pointing a little forwards and upwards, and the angle which they make with the margin being not more than ten degrees. Only three denticles shown, but a fourth probably given off just above the broken upper edge. The first lateral ridge directly prolonged into the lowest denticle of the convex margin, the second ridge giving origin to the second and third denticles, and probably continuing upwards to a fourth (though a slight dislocation of the spine at this point prevents a clear determination). The denticles of the concave margin larger, stronger, and more numerous than those of the convex margin, and directed outwards at an angle fully double that of the latter. A cluster of five spines placed at the base, in fan-fashion, the margin spreading out between them like a web.

Listracanthus spinatus, sp.n. Lower Coal-measures, Lancashire.

Above the cluster are nine others at increasing distances apart. The lateral longitudinal ribs seven in number at the base, but only four continuing up to the broken apex. the remaining three running out into the denticles; all showing traces of slight nodular enlargements.

Observations. — The species thus described differs in several respects from all the known species, and is well characterized by the differences of the denticles of the concave and convex margins, the slight nodulation of the lateral longitudinal ridges, and the fan-like expansion of spines at the base of the concave margin.

Horizon.—Roof of Bullion Mine, Lower Coal-measures.

Locality.—Lancashire.

Type in the Royal Museum, Peel Park, Salford.

2. *Listracanthus*, sp. indet.

Description. — Spine small, not exceeding 11 mm. in length, arched, sides flat, with nine longitudinal ribs. Concave margin only bearing denticles, which are small, about twelve in number, and closely set. Convex margin entire.

Observations.—This specimen differs in several important features from *Listracanthus spinatus*. It is shorter, more arched, and broader in comparison to the length, whilst only the concave margin bears denticles. So little is known of the nature and position of the two spines, that it may possibly be that the differences between them are only due to the position they occupied upon the body, and not to specific difference. Against this view must be placed the fact that one spine belongs to the Lower and the other to the Middle Coal-measures.

Horizon and Locality.—Marine band, Middle Coal-measures, River Tame, Dukinfield.

In conclusion, I desire to record my indebtedness to Mr. A. Smith Woodward, who first recognized the specimens as belonging to the genus *Listracanthus.*

REVIEWS.

I.—The Scenery of Switzerland and the Causes to which it is due. By the Right Hon. Sir John Lubbock, Bart., M.P., F.R.S., D.C.L., LL.D., F.G.S. 8vo, pp. xxxvi and 474, with 154 illustrations in the text and one folding map of Switzerland. London: Macmillan and Co. (Limited), 1896.

THIS book, which was issued in July last, will have already found its way into many an Alpine tourist's knapsack, and been read with pleasure in railway-train, or steam-boat, and in many a Swiss hotel and chalêt, by mountain and lake.

Its author's varied writings are already agreeably known to and welcomed by many thousands of our fellow-countrymen, both here and in greater England beyond the seas.

Whatever subject Sir John Lubbock takes up, he has the facility to communicate the results of his studies, his readings, and his observations, in an agreeable form to the public at large, who are only too delighted to be told facts in natural history, geology, or physical geography in clear and simple language, so that the reader need not fear to be carried beyond his depth by a too learned treatise, or told mere second-hand twaddle by an incompetent but too officious guide.

Sir John Lubbock is no mere tyro as a travelling companion to the Swiss Alps. He tells us, that as long ago as 1861, he had the pleasure of spending a short summer holiday in Switzerland with Huxley and Tyndall, and that from that day to this many of his holidays have been spent in the Alps. "On them," he adds, "I have enjoyed many and many delightful days; to them I owe much health and happiness. . . . . My attention was from the first directed to the interesting problems presented by the physical geography of the country. I longed to know what forces had raised the mountains, had hollowed out the lakes, and directed the rivers."

The author read much of what has been written about them; but, like all students, he wanted some book which should give him a short, comprehensive statement of the views of the various great authorities who had devoted their lives to the unravelling of the vast problems of the structure of the Alps, which might be useful to those travelling in Switzerland; but no such handy book was available.

At last, after much hesitation, Sir John Lubbock resolved to write such a work as he had himself felt the need of in the past, and so set to work, aided by such valuable help as could be obtained from Professor Heim, Sir John Evans, and others, and by making careful studies of all the literature available, he has given to the inquiring Briton, who, bent on spending his summer holidays in a clamber over glaciers and snowfields to reach some lofty peak, is curious to know how the mountains were brought forth, and how the hills and the dry land were formed. For such this book will be a most acceptable offering; replete as it is with keys to unlock the many geological puzzles which the Alps afford. Nor need he be surprised to find that more than a hundred able and accomplished men of science in England, France, Germany, Austria, Switzerland, and Italy have laboured to provide the plans and explanations, the pith of which Sir John Lubbock has given us in a condensed form in the little book before us. In concluding his task, the author thus summarizes the causes which have led to the present scenery of Switzerland.

"In Permian times there were probably mountains where the Alps now rise, but this ancient range was gradually removed by denudation; moreover, the land sank, and during the Permian, Liassic, Jurassic, and Cretaceous periods, there was deep sea where the Alps now rise. There were certainly great changes of level, but they were all continental, and that is to say, they were approximately the same for the whole area; there was no compression and no folding.

"That the sea during this period must have covered the site of the present Alps, is proved (1) by the fact that we find no trace of its southern shores, no littoral deposits. If the Alps had then existed, pebbles, etc., from them must have been found in the Liassic, Jurassic, and the Cretaceous rocks. This is not the case: indeed, these rocks contain no pebbles of any kind, and the fossils in them are all indicative of deep water far away from land. There are no conglomerates or gravel beds between the Permian and the Upper Eocene. Again, (2) we find remains of the secondary strata protected in the troughs of the folds. These sedimentary deposits therefore extended completely over the site of the present mountains, and though no extensive remains of these deposits now occur in the Central Alps, this is because they have been entirely stripped away.

"The elevation of the country is due, not to upheaval from below, but to lateral pressure owing to the cooling and consequent contraction of the earth. It has been calculated that the strata between Basle and Milan, a distance of about 130 miles, would, if extended horizontally, occupy 200 miles. There has consequently been a shortening of no less than 70 miles.

"For some time the central ranges alone were above water, and the mountain torrents brought down gravel and boulders, forming the 'Nagelflue' of the Rigi and the central plains.

"The Alps, therefore, from a geological point of view, are very recent. Our Welsh hills, though comparatively speaking insignificant, are far more ancient. They had been mountains for ages and ages before the materials which now compose the Rigi or the Pilatus were deposited at the bottom of the sea. Indeed, we may say that it is because they are so old that they have been so much worn down; the Alps themselves are crumbling, and being washed away; and if no fresh elevation takes place, the time will come when they will be no loftier than Snowdon or Helvellyn.

"They have already undergone enormous denudation, and it has been shown that from the summit of Mont Blanc some 10,000 to 12,000 feet of strata have been already removed. The conglomerates of Central Switzerland, the gravels and sands of the Rhine and the Rhone, the Danube and the Po, the plains of Dobrudscha, of Lombardy, of South France, of Belgium and Holland, once formed the summits of Swiss mountains. This amount of denudation gives us, I will not say a measure, but at any rate a vivid idea of the immense time that must have elapsed since the Alps rose out of the sea.

"Denudation began as soon as the land rose above the sea; the main river valleys were excavated. Then came the period of cold known as the Ice Age or Glacial period.

"Round all the high mountains, and over many of them, are great fields of ice and snow, terminating in glaciers. These, however, are but the remnants of a much larger sea of ice which once covered almost the whole country. The glacier of the Rhone, for instance, descended the Valais, filled the Lake of Geneva, rose to what is now a height of 1350 metres on the Jura, and then dividing, sent one branch as far as Lyons, and a second along the Aar to Waldshut. The Glacial period, however, was not continuous, but interrupted by at least two periods of more genial climate. The mass of material brought down from the mountains partially filled the river valleys (which have not even yet been entirely re-excavated), formed great moraines, and is spread in thick but irregular masses over all the lower ground.

"The rivers of Switzerland run mainly in one of two directions—the first from south-west to north-east, or *vice versâ*, following the strike and original folds of the strata; and the second at right angles to it. Many, indeed most, of the principal rivers, take first the one and then the other direction in different parts of their course. In some cases the rivers cut through mountain ranges, as, for instance, the Rhone between Martigny and the Lake of Geneva. This probably indicates that the river is older than the mountain range, and cut through it as it rose.

"The river system of Switzerland was, however, at first very different from the present. The Vosges and the Black Forest were continuous, the subsidence which now separates them not having yet taken place, so that the Rhine Valley at Basle was not in existence.

"Nor had the gorges by which the Rhone finds its exit through the Vuache yet been formed, and the consequence was that the whole drainage of Switzerland north of the Alps found its way by the Danube to the Black Sea. For some time after the subsidence of the Basle Valley had taken place the upper waters of the Rhone still joined the Rhine, and ran over the plains of Germany to the North Sea; finally, however, it broke its way by Fort de L'Ecluse, and falling into the Saône runs into the Mediterranean. Another general change in the river system is that the crest of the Alps has retreated northwards. The southern slope being much steeper than that to the north, the Italian rivers have more power of erosion than their northern rivals, and are gradually eating their way back. The Upper Engadine is a conspicuous example.

"Many minor changes have taken place: partly (1) through recent changes of level, as, for instance, that which has diverted the Reuss from its old course by the Lake of Zug, and driven it round by Lucerne; partly (2) by rival rivers deepening and extending their valleys, and thus annexing territory which previously belonged to others; for instance, the Landquart has robbed the Landwasser of its head waters and carried off the Schlappina, the Vereina, and the Sardasca; partly (3) by dams due to river cones or glacial moraines, as, for instance, the Limmat, which was driven from the Glatthal and the Sihl from the Valley of the Lake of Zurich.

"The lakes which contribute so much to the beauty of the country fall into several different categories.

"1. Some are due to the inequalities in the glacial deposits; as the numerous small pieces of water in the curious district of the Pays de Dombes.

"2. Some are due to subsidence; strata, generally those of gypsum or salt, having been dissolved and removed; as, for instance, the lakes of Cadagno and Tremorgia.

"3. Some are dammed back by river cones, as the lakes of the Upper Engadine; or by moraines, as the lakes of Sempach, Baldeggar, and Hallwyl.

"4. The origin of the larger Swiss lakes has been the subject of much discussion. The opinion now prevalent among Swiss geologists is that they are mainly due to recent changes of level, and are in fact drowned river valleys.

"Even more striking than the exquisite beauty of the lakes is the grandeur of the history they unfold, and of the causes to which they are due; and, indeed, in contemplating the general scenery of Switzerland, we cannot but be profoundly impressed by the enormous magnitude of the changes, and the irresistible forces which have been brought into operation."

We have been tempted to quote perhaps too largely from this very interesting summary. To those who are attracted by this notice we would say, "Get the book and read it for yourselves." It is just of a handy size to put into one's haversack and take as a useful companion to Switzerland. The illustrations are very numerous, and many of them are excellent from a geologist's point of view.

II.—Essai de Paléontologie Philosophique. By Professor Albert Gaudry, Memb. Inst. France, For. Memb. Geol. Soc. London. Paris, 1896. (Dulau and Co., London.)

THIS volume forms a supplement to the distinguished author's well-known work "Enchainements du Monde Animal dans les Temps Géologiques": in it the facts and arguments brought forward in his previous volumes are correlated, and an attempt is made to give a general idea of the course followed in the evolution of the animal kingdom from the earliest times to the present day.

This progressive advance is compared by the author to the changes passed through in the development of an individual man, and in the successive chapters of his work he considers (1) the multiplication of beings, (2) their differentiation, (3) their increase in size in the course of geological time, (4) the progress of activity, (5) the progress of the perceptive faculties, (6) the progress of intelligence.

In the chapter dealing with the multiplication of animals, it is asserted that the number of organisms has increased successively from the Cambrian onwards, and that this increase was facilitated by the fact that the earlier forms were more strongly armoured than the later ones, and at the same time were less exposed to attack. That there has been an enormous increase in the forms of animal life is, of course, obvious, but that the fossils of the earlier rocks give any idea of the richness of the contemporary faunas is more than doubtful, since it is to the fact of their well-developed skeletons that these fossils owe their preservation, while doubtless innumerable forms must have existed in which the hard parts were little or not at all developed, and of these scarcely a trace remains. Again, if the earlier types were less exposed to attack, it is difficult to understand why in the greater number, according to the author, the means of defence should have been brought to so high a state of perfection.

In the chapter on the increase of size in animals, still pursuing the comparison with the life of the individual, it is stated that there has been a gradual advance in this respect from first to last. This, again, hardly seems borne out by the facts, for if we take almost any group of animals we find that though for a time the bulk may have increased, a maximum is arrived at, at different periods in the different classes, after which a diminution sets in. In the Amphibia, for example, this maximum was reached in the Trias, while the largest reptiles were Jurassic. The Mammalia, it is true, having been evolved later in time than any other group of the Vertebrata, may be said truly to have attained their maximum development to-day in the living Cetacea, hugest of all moving creatures that breathe, and it needs but small prophetic wisdom to see the rapid disappearance of these, and, indeed, of *all the larger mammals* within the next few years, annihilated everywhere by the advance of man the destroyer. Of the larger forms the horse, cow, and sheep will soon alone survive, and even the horse may succumb before the motor-car and the bicycle! In the invertebrates the same phenomenon may be observed; for instance, the gigantic *Pterygotus* of the Silurian and Devonian periods, is unsurpassed in bulk by any recent Crustacean. The later chapters dealing with the progress of the perceptive faculties and of intelligence will meet with fewer objections, but even here the generalizations will not always hold if an attempt be made to apply them to particular cases.

The pages on the utility of palæontology to the stratigraphers are perhaps the most interesting in the book, but it seems hard to think that it should be found necessary nowadays to employ elaborate arguments to prove the extreme value of fossils in stratigraphical work; but such is the case.

In conclusion, the writer passes beyond the realm of palæontology to the consideration of the origin of the higher faculties of man and of the prime cause of evolution, questions upon which the author's views may perhaps not be received altogether with general assent; but these need not be touched upon here.

On the whole this book is admirably and clearly written. There are many points of deep interest which are discussed in a lucid, if not alway convincing manner; and as an introduction to the outlines of palæontological history for general readers it is to be highly commended, especially as it is by one so distinguished and whose name is so widely known as an accomplished man of science and a most successful teacher. As in the previous volumes of the series, the illustrations and printing are most clear and excellent.

III.—Les Spirifères du Coblenzien Belge (Bull. Soc. Belge Geol., ix, pp. 131–240, pls. xi–xv, November 1895); and Catalogue Synonymique et critique des Spirifères du Devonien Inférieur (*tom. cit.*, pp. 260–288, February 1896). By Ferd. Béclard.

FOR over a dozen years Mr. Béclard has been studying the Spirifers of the Devonian—on the one hand, carefully revising the literature and comparing descriptions and figures with the specimens; on the other hand, making a scientific study of the specimens themselves with the aid of the abundant material in the Natural History Museum at Brussels, to which he is attached. The former branch of inquiry is soul-wearying, thanks to the vagaries of previous authors; the latter branch is not easy, owing to the remarkable extent of variation in this group, and the difficulty of obtaining specimens suitable for investigation. But both branches are absolutely necessary if the names finally attached to the specimens are to have greater value than mere dealers' labels or the haphazard shots of a schoolboy collector. In a great museum like that at Brussels, we expect that every label shall be the expression of a definite scientific opinion; for on the accessible collections of such a museum hundreds of students, geologists, and collectors depend, and rightly so, for the names of their own specimens. This fact is recognized by Dr. Dupont, and he has not grudged to Mr. Béclard the twelve years of silent but ultimately fruitful work.

Careful comparison of the Spirifers from the Coblenzian (Lower Devonian) of Belgium has convinced Mr. Béclard that though there may be scores of names in the books, and actually dozens of mutations, to which on occasion a subspecific name may legitimately be applied, yet that there are only eight distinct specific types, separated from one another without transitional forms. To these are applied the names *Spirifer primævus*, *S. hystericus*, *S. subcuspidatus*, *S. arduennensis*, *S. cultrijugatus*, *S. paradoxus*, *S. daleidensis*, and *S. Trigeri*. To these may be added *S. curvatus* and *S. speciosus*, which, however, only occur at the top of the Coblenzian, and are characteristic rather of the succeeding beds. The eight species all have pronounced lateral ribs, while, except in *S. paradoxus*, *S. daleidensis*, and *S. Trigeri*, the median fold is smooth. They also are uniformly ornamented with fine lamellæ of growth broken into papillæ.

The notes accumulated by Mr. Béclard in accomplishing this work, notes that naturally involve many species other than those occurring in Belgium, namely, all the Lower Devonian spirifers of the world, form the groundwork of his "Catalogue Synonymique," for which all students of Brachiopoda will feel profoundly grateful, while they will hope that the Brussels Museum will continue to produce work of this solid and enduring nature.

CORRESPONDENCE.

PROFESSOR BONNEY AND THE "PARALLEL ROADS."

Sir,—I had some other points in Professor Bonney's "Ice-Work" marked for comment; but the author's Note in your last issue suggests the question, *cui bono?*

I took the liberty of pointing out that, in certain instances, his statements were extremely partial and one-sided—more like the work of an advocate than of a judge. Such "criticism," he retorts, is a "typical specimen of forensic advocacy!" This is not generally considered a very satisfactory or dignified style of reply. To me, indeed, the charge may be rather complimentary; while it may be the very thing to be complained of in regard to him, who claimed to be a "judge," setting forth fairly the facts and arguments on both sides.

The Professor represented the "dispute" regarding these Parallel Roads as still active, and one on which "authorities" are divided. Now, when this has been shown to be incorrect, he says he is "not afraid of being in a minority" (a different matter altogether of which there was no mention formerly), having seen the fading of too many "Brocken spectres"!

May I ask where is the "Brocken spectre" in this instance? If there be one such apparition which the present generation of geologists has seen "fading," it is that of a "great submergence" during the Glacial epoch, which Professor Bonney now vainly attempts to restore or reproduce on the cloudy "screen."

I am content to leave the matter as it stands to the "jury," by whom all "advocacy," whether open and avowed from the "bar," or more covert and disguised from the "bench," will be weighed and tested; and who will not fail to note when good and sufficient evidence is set aside, and other evidence asked for, simply because that which is produced is not in accord with the opinions of the presiding judge!

I desire, however, to part from Dr. Bonney with the same expression of respect which I have long felt towards him. I sincerely trust that during his present tour in the Alps, he will not be tempted, by desire for singularity, to forsake the "trodden paths," and wander into others that have been disused for nearly thirty years.

Glasgow, 10*th August.* Dugald Bell.

THE

GEOLOGICAL MAGAZINE.

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No. X.—OCTOBER, 1896.

ORIGINAL ARTICLES.

I.—Preliminary Notice on Fossil Monkeys from Madagascar.

By Dr. C. I. Forsyth Major, C.M.Z.S.

DURING my excavations in the marshes of Sirabé (Vakinankaratra District, Central Madagascar), my assistant, Mr. A. Robert, came upon a small fragment of a right upper jaw of a mammal, containing the two anterior true molars, which presented the well-known pattern of the Old-World Cercopithecidæ. The presence of true monkeys, as contemporaries of the *Æpyornis*, in very recent deposits, appeared to be such an extraordinary fact that I anxiously looked forward for further and more conclusive evidence. This fortunately has since been forthcoming, by the subsequent discovery of more complete remains. Two of the most important pieces, viz. the anterior part of a skull, broken off behind the nasals and the molar series, and a left mandibular ramus, are here figured and briefly described.

Fig. 1.—Profile of the anterior part of a skull of *Nesopithecus Roberti*.

In the fragment of the skull the orbits are directed straight forward, and, although their hinder portion is broken, clearly show that they were separated from the temporal fossæ by a bony wall. The lachrymal foramen is situated within the margin of the orbit. The inner upper incisors are in contact in the middle line. The nasals are concave in profile, and the facial profile is steep.

The above characters, together with the pattern of the molars, are the very opposite of what we find in Lemuroidea, whilst they are as positively evidence that the fossil belongs to the Anthropoidea. The nasals are broad, and so is the whole of the interorbital region; its transversal diameter almost equalling that of the orbits, and therefore exceeding what obtains in the genera of Anthropoidea, which show the maximum of lateral extension of this region (*Mycetes*, *Hylobates*, *Homo*). This is about the only point in which the fossil approaches some of the Lemuroidea.

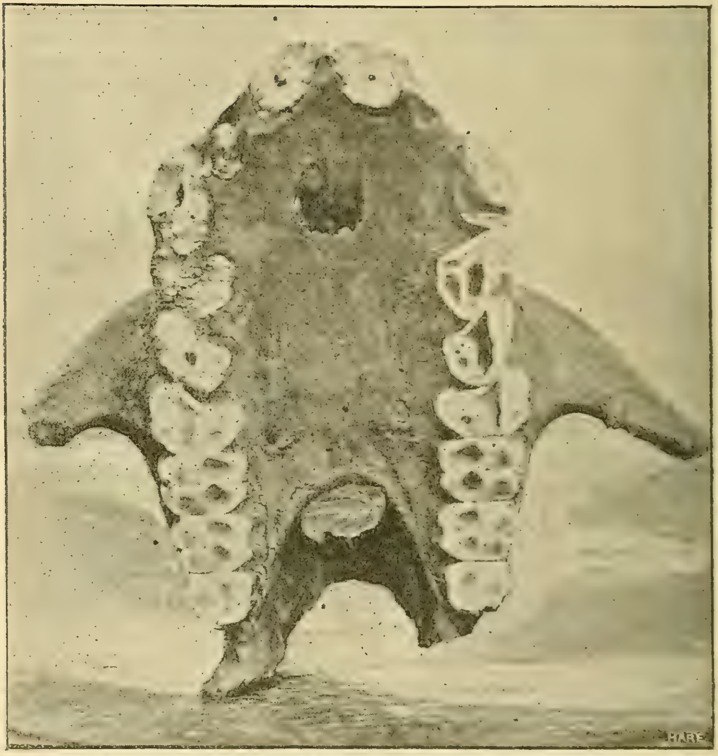


Fig. 2.—Palatal view of same skull of *Nesopithecus Roberti*.

The dental formula of the upper jaw is as follows: I 2, C 1, P 3, M 3. Only the molars, premolars, canine and the outer incisor of the left side are preserved, the other teeth being broken down to their sockets; those preserved are very much worn. The internal pair of upper incisors were strongly developed, the outer being much smaller. The incisors being inserted obliquely, there is left a triangular gap between them and the strong canine. This last is provided with an internal basal cingulum, terminating in a small posterior cusp. The two anterior premolars have their longest diameter parallel to the long axis of the skull, whilst the third is longest in a transverse direction. They overlap each other, the first two being inserted obliquely in their alveoli. All of them are provided with an internal cingulum. The three molars are each composed of four tubercles, the outer and inner pairs being placed opposite one another and connected together by transverse ridges. This is the pattern of the Cercopithecidæ; but, unlike the Old-World monkeys, the molars decrease in size from before backwards.

The left mandibular ramus of another specimen, with less worn teeth, seems referable to the same species. The incisors

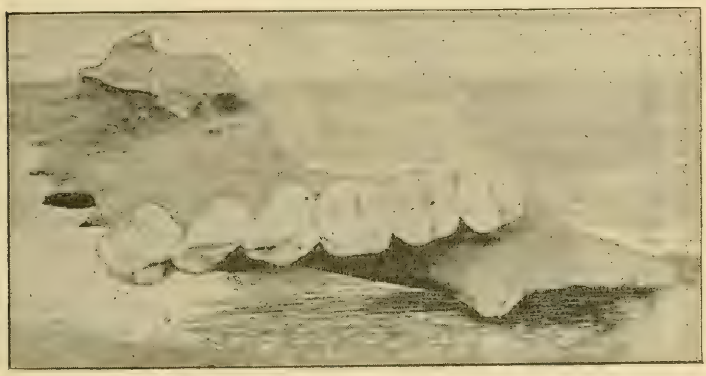


Fig. 3.—Left mandibular ramus of another specimen of *Nesopithecus Roberti.*

are wanting; but from the alveoli of both sides preserved, it is seen that they were four in all, and inserted obliquely. The remainder of the teeth of the left side are six in number: three are molars, their patterns being after the type of those in the upper jaw, and likewise decreasing in size from before backwards; no *talon* to the last inferior molar. Situated between the incisors and the molars are three teeth, viz. one less than in the upper jaw; and the question arises, whether the missing tooth is the canine or one of the premolars. The anterior of the three teeth in question is caniniform; but, in adapting the lower dental series to the upper one, it may be clearly seen that this caniniform tooth occupied the place behind the upper canine; so that, according to our received definitions, this tooth is not to be considered a canine, but a premolar. At any rate, whilst the dental formula of the upper teeth agrees with that of the Cebidæ, it is quite peculiar in the lower jaw; and whilst the pattern of the molars is that of the Cercopithecidæ, the premolars differ alike from Old and New World monkeys. The two posterior lower premolars overlap each other, as in the upper jaw, their longest diameter being oblique to the long axis of the skull; the anterior of the two has a longitudinal trenchant blade; the pattern of wear in the more bulky posterior one is somewhat like a cross.

These combined characters amply justify the establishment of a separate family of Anthropoidea for the Malagasy fossil, intermediate in some respects between the South American Cebidæ and the Old-World Cercopithecidæ, besides presenting characters of its own.

Fam. nov. Nesopithecidæ.

Gen. nov. *Nesopithecus Roberti.*

Measurements.

	mm.
Length of dental series from canine to last molar (upper jaw)	61
,, upper molar series	23
,, premolar series	27
,, p_1	9
,, p_2	11·5
,, p_3	12·5
Transverse diameter of p_1, at basis	12
Length of upper canine	11·5
,, palate, in middle line	56
Width of skull, between zygomata	about 95
,, ,, between outer margins of posterior-premolar (p_1)	48·5
,, ,, ,, ,, canines	45·5
,, palate between inner margins of canines	29·5
,, ,, ,, ,, anterior molar (m_1)	24
,, interorbital spatium	24
Transverse diameter of orbit	about 25
Width of nasals above	12·5
,, ,, below	20
Lower jaw:	
Length of dental series exclusive of incisors	55·5
,, molar series	26·5
,, premolar series	28·5
Width of p_1	11
,, p_2	9
,, p_3	11
Width of lower incisor series between margins of outer alveoli	17·5
Height of horizontal ramus beneath m_1	26

The present discovery suggests the following general conclusions, which I expect will be corroborated by further finds.

(1) We may look forward in Continental Africa likewise for the discovery of Tertiary monkeys, intermediate between Cebidæ and Cercopithecidæ.

(2) The recent African Cercopithecidæ are not invaders from the north-east, as has been supposed; on the contrary, most, if not all, of the Tertiary monkeys of Europe and Asia are derived from the Ethiopian region. The home of a part at least of the Anthropoidea seems to have been in the Southern Hemisphere. This assumption is corroborated by the two facts—that Anthropoidea make their appearance suddenly for the first time in the later Tertiary of Europe and Asia, and that they are entirely absent from the Tertiary of North America.

II.—The Geological Work of the Conway Spitzbergen Expedition.

By E. J. Garwood, M.A., F.G.S., and J. W. Gregory, D.Sc., F.G.S.

THE discovery by Keilhau in 1827 of Carboniferous fossils in Spitzbergen first called attention to the geological interest of this archipelago. The collections subsequently made by Robert during the voyage of the "Recherche" in 1838, by Loven in 1837, by Drasche in 1872, and by the series of Swedish expeditions under Baron A. E. von Nordenskiöld between 1858 and 1873, proved the occurrence of beds belonging to the Archean, Lower Palæozoic, Devonian, Carboniferous, Triassic, Jurassic, Cretaceous, and Miocene systems. The fossils collected by these explorers are now in the museums of Christiania, Paris, Stockholm, and Vienna; but up till the present the only collections in London are a few specimens of Devonian fish obtained by exchange, and of Carboniferous Brachiopods collected by Mr. Lamont. It was, therefore, part of the work of Sir Martin Conway's expedition to obtain a series of fossils to represent as fully as possible all the successive faunas and floras of this far northern archipelago. Previous work on the geology of Spitzbergen had, moreover, been carried out on the coast, and it was Sir Martin Conway's main object to explore the interior. These two considerations lessened the thoroughness of the geological study of the country and the extent of the collections, for we had to travel long distances to reach rocks of different systems, and transport of heavy geological specimens from the interior was difficult. Nevertheless, considerable collections were made, which, besides serving to represent the Spitzbergen fossils, will probably aid in the more exact correlation of the horizons from which they come, and throw light on the migrations of the faunas.

The expedition arrived in Advent Bay on the 19th of June, and finished landing the stores by the evening of the next day. Preparations were at once made for the march inland, Sir Martin Conway and Mr. Garwood leaving on the 21st to establish the first food depôt. From this point the inland party pushed up the valley that ascends from the head of Advent Bay; after three days' march we camped on a col leading into a corresponding valley that runs inland from Sassen Bay. During the descent into this valley we found a remarkable esker, which told the story of its formation. At this point the party had to halt, owing to the collapse of the sledges; while one of us returned to Advent Bay to repair them, the other made a collection from the Triassic rocks of the mountains beside the camp. Below the Trias were beds of Carboniferous limestone and chert; a stream had cut a deep gorge through these, and at its head plunged over a fine waterfall, which gave our resting-place the name of "Waterfall Camp." The sledges having returned, we resumed our journey to the east. At first our route lay along a valley cut through the Triassic rocks to the Carboniferous; occasional outcrops of the latter could be seen on the foot of the valley-walls. Most of the floor was occupied by recent alluvium, while a series of raised beaches containing shells of *Mya truncata* and *Saxicava arctica*, etc., formed terraces along the sides. Above the level of the marine terraces the valley contracted, and was blocked by a bar of moraine hills, 400 feet in height; in the hollows we often came upon beds of fossil ice, which added greatly to the difficulty of the traverse of these very irregular hills. After crossing the moraine, we had to leave the ponies and sledges and cross the glacier to the east coast, which we reached on July 16. We returned to Waterfall Camp by the same route; thence one of us walked back to Advent Bay overland, and the other along the coast, so that we were able to help in the geological examination of two east and west sections.

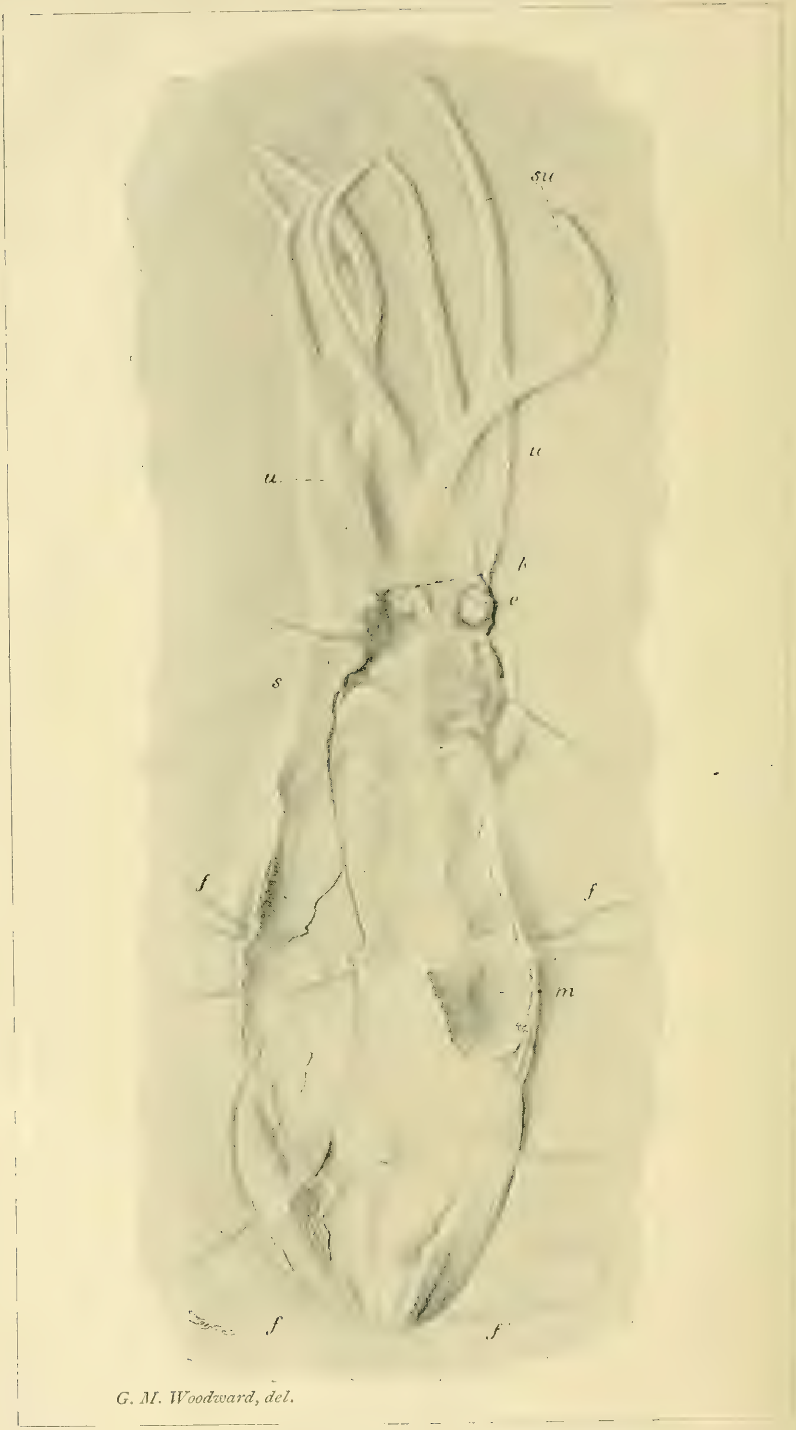
After meeting at Advent Bay we went with Mr. H. E. Conway, the artist of the expedition, to Green Harbour to collect fossil plants from the Tertiary beds there. Unfortunately the layer from which Baron Nordenskiöld made the collection in which Heer recognized over a hundred species, has been washed away by the sea. We obtained, however, a series of leaves of dicotyledons and of *Poacites*, and specimens of *Taxodium*, *Sequoia*, etc. Jurassic, Triassic, and Carboniferous rocks occur to the west of the Tertiary Plant-bed, and from these we also made collections.

After a few days' stay at this locality, Sir Martin Conway called for us in the "Expres," a small 13-ton steamer. In this vessel we sailed to the Seven Islands, through Hinlopen Straits, near to Prince Charles' Islands, and to the head of Wiide Bay. An attempt to circumnavigate Spitzbergen was frustrated by a belt of fast ice, which blocked up the passages into Stor Fiord, and formed a barrier across the broad Olga Strait. The excursion, however, gave us an opportunity for studying some fine sections in the Archean series of the Seven Islands, of the Devonian of Wiide Bay, and also of the Carboniferous and Tertiary rocks of Bel Sund, in which we spent a day during our return voyage.

One of us (E. J. G.) subsequently had the opportunity during the first ascent of Hornsund Tind, the highest mountain in Spitzbergen, of working out its geological structure.

It is too early to attempt any summary of the results of this journey, as many of the fossils are yet unpacked, and upon the examination of these the conclusions will depend. Sir Martin Conway made a careful map, on the scale of one inch to the mile, of the belt of country between Advent Bay and Agardh Bay, where we reached the east coast. We collected materials on which to prepare a geological edition of this map.

The stratigraphical sequence in Spitzbergen is remarkably complete, and its general characters are of great interest. The oldest beds are some schists, cut through and altered by some intrusive gneisses. These occur in the Seven Islands and in the north-west of Spitzbergen. Above these come the quartzites and schists of the Hecla Hook series; these are no doubt Lower Palæozoic, but fossils have not yet been found in them. The stratigraphical evidence proves them to be pre-Devonian. The series is named from their occurrence in the headland overlooking the bay in which Parry's ship, the "Hecla,"



Coccoteuthis hastiformis, Rüppell, sp.

Lower Kimeridgian (Lithographic Stone): Solenhofen, Bavaria.

spent the winter of 1826–7. Of the Devonian series we saw less than of the other formations, but obtained some fish-remains on the south-western shore of Wiide Bay. The Carboniferous system is one of the most extensively developed of any in Spitzbergen, and we obtained collections (mainly of Brachiopods) from various localities. The Carboniferous rocks are succeeded by those of the Trias, the two systems being sometimes separated by a slight unconformity. Another and greater break in the sequence occurs above the Trias, for the next fossiliferous beds apparently belong to the Upper Jurassic; fossils of this age occur in several localities, and they are succeeded by beds containing a species of *Aucella* very nearly allied, if not identical, with *A. concentrica*, Keys. After this comes another gap, including the upper part of the Cretaceous (if not the whole of that system) and the Lower Tertiary. There are no marine fossils later than the *Aucella* beds until we reach the Pleistocene raised beaches, with the exception of some unsatisfactory casts from beds associated with the Tertiary plant-beds.

The sequence of faunas in Spitzbergen is instructive, but the faunas themselves are thin. Species of certain classes, as of Brachiopods in the Carboniferous, and of Cephalopods in the Trias, may be numerous; but the classes represented are always very limited. The main lesson that the faunas teach seems to be that they always lived under unfavourable conditions. We had expected to find evidence of former climates not only much milder than the present, but even subtropical in warmth. In this we were unsuccessful; we found, on the contrary, beds of more than one period in the deposition of which ice must have taken part. We found boulders weighing three tons lying in beds of comparatively fine material; and it seems difficult to see what but ice could have transported them.

The ice of Spitzbergen consists of sea-ice, valley glaciers, and an ice-cap. The opportunity of the study of these three agents working side by side, was one of the greatest privileges we enjoyed during the expedition.

III.—On a Specimen of *Coccoteuthis hastiformis*, Rüppell, sp., from the Lithographic Stone, Solenhofen, Bavaria.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE XIV.)

The specimen which forms the subject of the present notice belongs to the genus which is termed by some authors *Trachyteuthis*, and by others *Coccoteuthis*. Both names were originally given to the internal shell of a *Sepia*-like Cephalopod; the former to examples from the Lithographic Stone (Lower Kimeridgian) of Bavaria, and the latter to a specimen from the Kimeridge Clay of Dorset. They are regarded as synonymous, but some authors use one and some the other.

The genus was first figured in 1755 by Knorr,[1] who mistook the

[1] "Sammlung von Merkwürdigkeiten der Natur und Alterthümern des Erdbodens, welche petrificirte Körper enthält," pt. i, pl. xxii, fig. 2.

fossil for a fish. Under the name *Sepia prisca*, König[1] figured an example in 1825, but gave no description of the specimen. Rüppell,[2] however, in 1829 figured and described as *Sepia hastiformis* an example from the Lithographic Stone (Lower Kimeridgian) of Mühlheim, near Solenhofen, Bavaria. Figures of these shells were subsequently given by Münster,[3] Férussac and D'Orbigny,[4] and Quenstedt,[5] all of whom referred them to the genus *Sepia*.

H. von Meyer, in a letter in the Neues Jahrbuch for 1846 (p. 598), suggested the name *Trachyteuthis* for some *Sepia*-like internal shells from the Lithographic Stone of Solenhofen, but did not fully describe the specimens which he referred to this genus until October, 1855. In the meantime (May, 1855), however, Professor Owen[6] figured and described from the Kimeridge Clay of Dorset a similar shell, to which he gave the name *Coccoteuthis latipinnis*. Since there is no doubt as to the generic identity of these fossils, it appears that the name *Coccoteuthis* should be preserved, for it was the first to be adequately described; we have accordingly used it in the present paper, following Dr. A. Wagner,[7] who after full consideration of this question adopts Owen's name for the genus. Dr. K. A. von Zittel, however, uses the name *Trachyteuthis* both in his "Handbuch der Palæontologie" (vol. ii, p. 516) and also in his more recent "Grundzüge der Palæontologie" (p. 446).

So far as we have been able to ascertain, there have been but few references to the soft parts of the animal associated with the shell of this genus. Férussac and D'Orbigny figure[8] an example of the genus under the name *Sepia hastiformis*, and indicate anterior to the shell what may possibly be some remains of the animal. F. A. Quenstedt, in his "Cephalopoden" (pl. xxxii, fig. 1), figures an example of *Saepia hastiformis* with the impression of the lateral expansion of the mantle, which he says shows distinctly the transverse muscular striation. The shell associated with this impression is 170 mm. long. The same author, in the third edition of his "Handbuch der Petrefactenkunde," p. 508, pl. xxxix, fig. 8, describes and figures from the Lithographic Stone of Solenhofen the head of a Cephalopod (showing eight arms and the "beaks"), which he refers to *Loliginites priscus* (=*Plesioteuthis prisca*); but there does not appear to be any reason why the head should be associated with this species. It agrees very well with the head of the specimen described below, which undoubtedly belongs to the genus *Coccoteuthis*.

[1] "Icones Fossilium Sectiles," 1825, pl. xvii, fig. 201.

[2] "Abbildung und Beschreibung einiger neuen oder wenig gekannten Versteinerungen aus der Kalkschieferformation von Solenhofen."

[3] G. Münster, "Beiträge zur Petrefactenkunde," Heft vii, 1846, pl. ix.

[4] "Hist. nat. des Céphalopodes acetabulifères," 1835–48, *Sepia*, pls. xiv–xvi.

[5] "Petrefactenkunde Deutschlands," vol. i (Cephalopoden), 1846–9, pls. xxxi, xxxii.

[6] Quart. Journ. Geol. Soc., vol. xi (1855), pp. 124–5, pl. vii.

[7] Abhandl. d. k. Akad. d. Wissensch., Berlin, math.-phys. Cl., vol. viii, p. 754 *et seq.*

[8] "Hist. nat. des Céphalopodes acetabulifères," 1835–48, *Sepia*, pl. xvi, fig. 1.

In his "Handbuch der Palæontologie" (vol. ii, p. 516, 1884), Zittel states that distinct impressions of the animal occurring in the Lithographic Stone show the hinder part of the body to have been broad and sack-shaped, with convex sides, and the head to have had eight, rather long, similar arms. In his "Grundzüge der Palæontologie" (p. 446, 1895), the same author remarks that impressions of the sack-shaped body and of the head are sometimes preserved in the Lithographic Stone of Bavaria.

The British Museum has lately acquired a splendidly-preserved example of this genus (see Pl. XIV) from the Lithographic Stone (Lower Kimeridgian) of Solenhofen, in which the body with its lateral expansions, and the head with its arms, are all in union with each other. The specimen is displayed on the surface of a small slab, 210 mm. long and 100 mm. wide, and presents a dorsal aspect of the animal. The total length of the specimen from the posterior extremity of the body to the anterior extremity of the arms is 180 mm.

The body is somewhat flask-shaped, rounded posteriorly, and slightly contracted anteriorly. Its length is 94 mm.; its greatest width (which is at about the middle of the body) 43 mm.; whilst at the anterior boundary of the mantle, which coincides with the anterior extremity of the shell (*s*), the body is not more than 32 mm. wide. Fragments of the mantle still adhere both on the right- and on the left-hand sides of the dorsal surface, and these exhibit very clearly the transverse striation not infrequently seen in the fossilized state, as e.g. in specimens of *Plesioteuthis prisca* from the Lithographic Stone, and also in *Geoteuthis brevipinnis* and *Belemnoteuthis antiqua* from the Oxford Clay of Wiltshire. A fragment (*m*) on the right-hand side of the dorsal surface extends from the lateral boundary of the body almost to the median line of this surface. Its lateral portion is of a very pale reddish-brown tint, but this colour becomes more intense towards the middle of the dorsal surface, where it is of a rich reddish-brown colour. This does not appear to be a stain, but is probably due to the original colour of the mantle. The lateral portion shows the usual transverse striation, but the median portion bears also longitudinal wrinkles.

The body was provided with lateral expansions or fins, as seen on both the right- and left-hand sides of the specimen. These seem to have been divided into a large anterior portion and a much smaller posterior part. That on the right-hand side is the more nearly complete; its posterior portion is trapezoidal in outline, antero-posteriorly it measures 9 mm., its width at the middle being 19 mm. Its posterior boundary (*f′*) is very slightly waved and nearly at right angles to the median line of the body. It arises from the body at about 3 mm. in advance of the posterior end; and at a distance of about 20·5 mm. from the boundary of the body it curves abruptly forward, and passes almost at right angles to its previous direction to meet the posterior boundary of the anterior larger portion of the lateral expansion. This posterior boundary of the anterior portion cannot be made out close to the general outline of the body, so that the anterior part appears to have been possibly for a width of about 5 mm. continuous with the posterior portion. This boundary curves gently outwards and upwards to the edge of the slab containing the fossil. The width of the expansion that is preserved is about 37 mm.; it is fairly smooth, with very obscure transverse striation, the rest of the surface of the slab being somewhat roughened and also of a lighter colour; its outer boundary was removed in reducing the specimen before it came into the National Collection. The anterior boundary (*f*) seems to be indicated by a faint line of colour arising from the margin of the body at a point 56·5 mm. from the posterior end; it curves outwards and rather abruptly forwards, and can be traced for about 17 mm. The antero-posterior length of this expansion at the margin of the body is 44 mm.

On the left-hand side of the specimen a portion of the lateral expansion is also shown, but unfortunately a much greater part than on the right-hand side has been removed in reducing the slab. The posterior portion has about the same antero-posterior dimension as on the other side, but appears to have been only about 12·5 mm. wide; its posterior boundary (*f′*), which is well preserved, is slightly curved and nearly at right angles to the median line of the body. On this side, too, the posterior boundary of the anterior larger portion cannot be traced to the margin of the body, and appears to support the idea that the two portions of the lateral expansion were continuous for a short distance from the margin of the body. The posterior boundary[1] of the larger portion curves like that on the opposite side of the body, but is intercepted by the edge of the slab at a width of about 16 mm. The anterior boundary (*f*) arises at about 57·5 mm. from the posterior extremity of the body, passes outwards and upwards to the edge of the slab at an angle of about 45° with the median line of the body.

Only portions of the internal shell are preserved, viz., the anterior portion, part of one of the sides, the greater part of one of the wing-like expansions, and the impression of the other expansion, but these are quite sufficient to indicate the complete outline of the shell. It is lanceolate-oval in form, 95 mm. long and 29 mm. in width, excluding the lateral expansions. The hinder three-sevenths (about 40 mm.) is provided with wing-like expansions; its greatest width, including these, is 41 mm. at about 28 mm. from the posterior extremity. There is no trace of the ink-bag. The head, with the arms, has a length of 85 mm. The greatest width of the head is 31 mm. On the right-hand side there is a mass of calcite, a portion of which possibly occupies what was the orbital cavity (*e*). About in the centre of the head there is a triangular indentation (*b*), having its apex directed forward and a little to the right side; this is without doubt the impression of one of the mandibles or "beaks."

Eight arms can be made out; they do not differ greatly in size. There appears to be no trace of the tentacular arms, but such may

[1] This is scarcely visible in the figure.

nevertheless have been present, for in the living *Sepia officinalis* "the tentacular arms remain contracted within the others when in repose."[1] The two dorsal arms are about 70 mm. long and 6 mm. wide at their base; for a short distance they taper rather rapidly, then much more gradually to their extremities. The next pair is a little longer and a little more robust. The third pair is about the same as the first, and the fourth or ventral pair a little shorter and less robust than the first. A marked irregularity in the outline of the inner surface of the arms is doubtless due to the presence of small acetabula or "suckers," but there are no indications of hooks. The first and second arms on either side seem to have been united for some short extent (perhaps one-third of their length) by a web-like membrane, which probably also connected some of the other arms, but this appears not to have united the bases of the two dorsal arms.

Dr. A. Wagner, in his memoir already alluded to, groups all the examples of *Coccoteuthis* which have been described from the Lithographic Stone into one species, viz. *C. hastiformis*, recognizing amongst them three varieties—(i) var. *minor*, (ii) var. *media*, and (iii) var. *maxima*. Fortunately in the specimen described above, the shell is preserved so that it can be readily compared with the species which have already been described. It is referable to Wagner's var. *minor*.

EXPLANATION OF PLATE XIV.

su. The first (dorsal) and second arms of the right side, showing acetabula or "suckers" on their inner surfaces.
u. Membrane uniting the bases of the first (dorsal) and second arms on either side.
b. Impression of beak or mandible.
e. Probable position of eye.
s. Anterior extremity of shell.
m. Portion of mantle, exhibiting wrinkles and traces of colour.
f. Anterior boundary of lateral fin on either side.
f′. Posterior boundary of same.

Slightly reduced from the original.

IV.—The Search for *Uintacrinus* in England and Westphalia.

By F. A. Bather, M.A.,
Assistant in the British Museum (Natural History).

It is just a score of years since the unstalked crinoid *Uintacrinus* was discovered, almost simultaneously, in the Niobrara Chalk of Kansas and the Lower Senonian of Westphalia. The American specimens were described by Grinnell and Meek, while the single European specimen was exhaustively discussed by Schlueter. Of recent years further specimens, in a better state of preservation, have been found in Kansas, and a slab purchased by the British Museum enabled me to make a more detailed study, the results of which were published in the Proceedings of the Zoological Society (vol. 1895, pp. 974–1004, pls. liv–lvi, April, 1896). But as to

[1] Tryon, "Manual of Conchology," vol. i, 1879, p. 58.

the occurrence of *Uintacrinus* in Europe, our knowledge at the beginning of 1896 remained as in 1876; not even from Recklinghausen, the original Westphalian locality, had another fragment been obtained. It may therefore be a surprise to many to learn that *Uintacrinus* is one of the commonest fossils of the *Marsupites* zone, not only in the Marlstone of Westphalia, but in the Chalk of our own island, and probably at the same horizon in a good many other countries.

It was in March last that Mr. C. D. Sherborn brought to me from Dr. A. W. Rowe, of Margate, a few scattered plates, supposed to belong to a small *Marsupites*. I saw at once that they belonged to *Uintacrinus*, though the species was uncertain; and having obtained two days' leave for the purpose, I set off for Margate, on Dr. Rowe's invitation, to examine his collection and to search the cliffs. Dr. Rowe has several fragments showing the plates in juxtaposition, and these fully confirmed my opinion. Moreover, a search, with the help of Mr. Sherborn, Dr. Rowe, and my wife, showed that along the cliffs east of Margate, next to columnals of *Bourgueticrinus*, cup-plates and brachials of *Uintacrinus* were the commonest fossils. We did not find it in the same places as *Marsupites* and *Echinocorys scutatus*, although Dr. Rowe says that he has found it in various localities west of Margate, associated with *Marsupites*. In any case it occurs at the horizon of *Actinocamax verus*.

Another diligent collector, Mr. C. Griffith, of Winchester College, showed me, last July, plates from the railway-cutting west of Grately station, near Andover, and from a pit one mile north-east of Wherwell railway station, which undoubtedly belonged to *Uintacrinus*. Among the associated fossils were said to be *Bourgueticrinus*, *Actinocamax verus*, *Micraster cor-anguinum*, and *Echinocorys*.

Clearly, then, *Uintacrinus* was common enough in England; but the fragments had, for the most part, been disdained by collectors, or relegated to "Marsupites?" Thus, in the Wetherell Collection at the British Museum there are *Uintacrinus* plates from the north of Kent, which had been labelled *Marsupites*, and which, when rapidly sorting the collection some eight years ago, I had set aside as belonging to an undetermined genus.

These discoveries suggested that *Uintacrinus* could not be so rare at Recklinghausen; so when the holidays came, off we went thither, visiting Bonn, Professor Schlueter, and the type-specimen on the way.

It is not easy to collect fossils at Recklinghausen. The rock is a glauconiferous sandstone, the grains of which are cemented by carbonate of lime, and coloured a greenish-gray by carbonate of iron. When freshly quarried it is a hard, massive stone; but exposure to the atmosphere rapidly dissolves the lime and decomposes the iron carbonate, leaving eventually a loose sand, coloured reddish-brown or yellow by iron peroxide. The rock is therefore useless for building purposes and for road-metal, and is not quarried in a regular manner, although there are a few pits in some unfossiliferous sand that seems to have arisen from the decomposition and perhaps partial erosion of the hard rock. Fortunately the soil requires occasional replenishing with lime, and this is supplied by scattering over the fields lumps of the fresh rock, such as may be obtainable from any casual openings. Such lumps and openings are the collector's only hope.

I reserve a statement of the various localities searched by us, and the fossils there found, for a future detailed description of the European specimens of *Uintacrinus*. The main result is that at Recklinghausen, as at Margate, *Uintacrinus* is, next to *Bourgueticrinus*, the commonest fossil. It occurs, associated with *Actinocamax verus* and *A. quadratus*; but, as at Margate, we found no *Marsupites*. The greater number of the remains consist of scattered cup-plates and brachials, differing only in colour from those so common in the Margate Chalk. This was all that I expected to find, so that I was all the more delighted when my wife discovered at the junction of the humus and the sand, in a small roadside cutting east of the railway station, a complete cup of *Uintacrinus*, less perfect than the type-specimen as regards the arms, but more perfect in its base and the important interbrachial areas. The specimen was extracted with great care, delicately laid in a round tin box, and packed in with fine dry sand. Thus it travelled safely until its loose substance could be hardened with water-glass.

The object of this note is to draw the attention of those who collect Upper Cretaceous fossils to this abundant species, which has been so strangely overlooked. If they have not already in their collections, they will doubtless find in the Lower Senonian of their neighbourhood, flattish, thin plates, usually of pentagonal or tetragonal outline, and marked on the inner surface with wide grooves radiating from the centre to the sides, not to the angles. Associated with these they will find brachials, often characterized by a diagonal fulcral ridge, as figured in the paper above referred to. I shall have pleasure in sending a copy of that paper to anyone who will look out for *Uintacrinus*, and will lend me the specimens he finds.

Possibly with this assistance many important questions may be solved. We want to know, first, if there are really two species of *Uintacrinus*, as has been supposed; and if both are represented in Europe; or if the European specimens belong to the American species: this can only be decided by the comparison of many specimens. Secondly, we have to determine the geological and geographical range of *Uintacrinus* in Europe: for this, details of its occurrence, and especially of the associated fossils, are desired. Does it really belong to the *Marsupites* zone? Thirdly, when this knowledge is obtained, we may be able to throw light on the correlation of the Cretaceous rocks in America and Europe, and to distinguish further between synchronism and homotaxis. Other questions there are of morphological and bionomic interest; but I hope enough has already been said to kindle in the breasts of geologists some enthusiasm for *Uintacrinus*.

V.—Recent Discoveries of Fossil Plants in Argentina. (Extract of a Letter from Dr. F. Kurtz, National Academy of Sciences, Cordoba, Argentine Republic.)

Communicated by W. T. Blanford.

[The following is an extract from a letter just received from Dr. Kurtz, who first discovered and described a Lower Gondwána (*Glossopteris*) flora in Argentina about two years ago. His paper was published in Spanish in the Revista del Museo de La Plata, vol. vi, and a translation in English was inserted by Mr. Griesbach, Director of the Geological Survey of India, in the Records of the Survey, vol. xxviii, 1895, pt. 3, p. 111. Shortly afterwards, Professor Zeiller added some very important and remarkable facts showing the occurrence of the same flora, associated with *Lepidodendron*, in Southern Brazil; and I wrote, at Mr. Griesbach's request, a brief comment on the data so far accumulated for the Records of the Geological Survey of India, in the May number of which, for the present year, my note was published. Dr. Kurtz's letter, containing several very interesting additions to our knowledge of the Argentine fossil floras, was written on the receipt of my paper, and as he has kindly allowed me to make the facts known, I have much pleasure in doing so, by permission of the Editor of the Geological Magazine.—W. T. B.]

THE most important addition to the fossil flora of the Bajo de Velis (which locality I visited from Dec., 1894, to March, 1895) is the discovery of *Rhipidopsis gingkoides*, Schmalh., and *R. densinervis*, Fstm., each represented by well-preserved leaves and numerous fruits. Both species are met with in the Damudas of India—*R. densinervis* in the Ráníganj (Kámthi group), *R. gingkoides* in the Barákar (Duranga Coalfield), the latter together with *Cyclopitys dichotoma*, Fstm. (this curious type was detected by my friend and colleague, Dr. Bodenbender, in the Sierra de Los Llanos, in the south of the province of La Rioja).

Schmalhausen described his *Rhipidopsis gingkoides* from deposits at the Petschora, which he considered to be of Jurassic age, but which will be more properly associated with the Permian, as already pointed out by Mr. C. Kosmovsky.[1] [I am almost convinced that the splendid *Zamiopteris glossopteroides*, Schmalh. (Mem. Ac. Sci. Petersbg., ser. vii, vol. xxvii, No. 4, pl. xiv, 1–3), from the Lower Tunguska, occurring there with *Nöggerathiopsis* (= *Rhiptozamites*, Schmalh.), is a true *Glossopteris*.] Besides the two species of *Rhipidopsis*, I found splendid and complete specimens of *Equisetites Morenianus*, Kurtz, proving this plant to belong to one of the larger species of *Equisetites* (the joints of the stem being 3 cm. long and nearly as broad).

During various expeditions to the Sierra de Los Llanos, Dr.

[1] C. Kosmovsky, "Quelques mots sur les couches à végétaux fossiles dans la Russie orientale et dans la Sibérie": Bull. Soc. Imp. Nat. de Moscou, 1891, No. 1, pp. 170–7.

Bodenbender collected the following fossil plants (besides some doubtful ones) :—

Neuropteridium validum, Fstm. (abundant).
Glossopteris communis, Fstm., or an allied form (the first *Glossopteris* in America ; rather common).
——— *retifera*, Fstm. ! (rare).
Phyllotheca, sp. (common).
Lepidodendron Pedroanum (Carruthers), Szajnocha.[1]
——— *Sternbergii*, Brong. (together with *Nöggerathiopsis Hislopi*, Fstm.).
Cyclopitys dichotoma, Fstm.

Near Carizal, in the Sierra Famatina, province of La Rioja, Bodenbender met with a splendid fern—*Sphenopteris*, sp. nov. (*ex aff. S. flexibilis*, Heer)—and *Phyllotheca*, sp.

Furthermore, at Trapiche, near Guandacol, in the same province, he detected a beautiful *Lepidodendron* (stem and leaves, but the leaf-scars unfortunately not well preserved), which I take to be *Lepidophloios laricinus*, Sternb. (also found in Rio Grande do Sul with *Gangamopteris cyclopteroides*, Fstm., var. *attenuata*, Fstm.), together with *Neuropteridium validum*, Fstm., the *Lepidophloios* occurring in strata *overlying* that containing *Neuropteridium*.

My friend Dr. Bodenbender regards all these deposits of Bajo de Velis, Pampa de Anzalan (= Sierra de Los Llanos), Sierra de La Rioja (Vilgo, Amanao, Saladillas), Carizal, and Trapiche,[2] as belonging to the same horizon, which he calls Permo-Carboniferous, only making a stratigraphical difference between Carizal with Trapiche on one side and all the other localities on the other side. This is a geological question with which I have not to deal, but, speaking in a purely botanical sense, I should discern at least two local horizons, the first represented by the Bajo de Velis alone, the other by the rest. The differences and similarities of these two groups are as follows :—

1. Common to both are *Neuropteridium validum* (very scarce in the Bajo de Velis, abundant in the Sierra de Los Llanos, scarce at Trapiche) and *Nöggerathiopsis Hislopi* (abundant in the Bajo de Velis, very common in the Sierra de Los Llanos).

2. At the Bajo de Velis alone were found : *Gangamopteris cyclopteroides* (not very frequently), *Equisetites Morenianus* (not very frequently), *Euryphyllum Whittyanum*, Fstm. (one leaf, which I described as a variety of *Nöggerathiopsis*, but which Zeiller, *l.c.*, thinks may be *Euryphyllum*), and the two *Rhipidopsis*. On the other hand, we know only from the Sierra de Los Llanos, etc., the two species of *Glossopteris*, the *Phyllothecas* (abundant), the *Lepidodendrons*, and the *Cyclopitys*. There remain the *Sphenopteris* and the

[1] The plant from Retavisto, in the province of San Juan, which Szajnocha (Sitzungsber. Ak. Wiss. Wien, Bd. C, Abth. i, p. 5) considered to be this species, belongs rather to a type of the Culm, perhaps to *L. Volkmanni*, Sternb. (R. Zeiller, Bull. Soc Geol. France, J. xxiii, 1895, p. 608.)

[2] He is rather inclined even to include Retavisto, which I take to be Lower Carboniferous (Culm).

Lepidophloios of the northern deposits, distinguished stratigraphically by Bodenbender (who will put forth his views in two memoirs—one in our Boletin, with a number of sections; the other in German accompanying a paper by Professor E. Kayser, describing the Devonian fossils collected by Bodenbender). The little diagram (Table A) at the end will perhaps explain the state of the flora better than my description.

From Cacheuta, in the province of Mendoza. we have received two beautiful collections of fossil plants made under the direction of Mr. E. Glaser, formerly Director of Petroleum Mines at that place. We had also smaller collections made by Dr. L. Brachebusch and by Dr. Bodenbender.

The principal species of this deposit are :—

Danœa, sp. nov. (a splendid fern).
Asplenium Whitbyense (Brong.), Heer (not rare).
Sphenopteris elongata, Carruthers (rather common).
Thinnfeldia odontopteroides (Morris), Fstm. (abundant).[1]
——— *lancifolia* (Morris), Szajn. (abundant).
Bravardia Mendozensis, Hanthal (perhaps the fruit-bearing state of a *Thinnfeldia*, the only indusia visible quite resembling those of *Aspidium*, sect. *Polystichum*).
Pecopteris tenuis, Schouw.
Oleandridium Mareyesiacum (Gein.), Kurtz (not rare).
——— sp. nov. (common).
Podozamites elongatus (Morris), Fstm., var. *latior*, Fstm. (common).
Zamites, sp. nov.
Sphenozamites, sp. nov.
Pterophyllum, sp. nov. (*ex aff. P. Carnalliani*, Göpp., rather common).
Baiera, sp. nov. (common).
Cardiopteris Juberi, Szajn., justly removed from this old Culm genus by Nathorst (*Ptilozamites*, Z. Nath.), proves to be nothing but a little curious form of *Thinnfeldia lancifolia*, Szajnocha. As you remarked in the "Records," the character of the Cacheuta flora is Australian and African, and has hardly anything in common with the higher Indian Gondwána floras.

The last discovery of fossil plants, made by Dr. Jose A. Salas, of Mendoza, a very zealous examiner of coal-mines in the Cordillera, furnished me with a small collection of types, derived from the mines of "Del Transito" on the Rio Atuel (southern part of the province of Mendoza), which prove the existence there of something like a Rajmahál flora. The plants I have been able to determine up to the present are as follows (in the same region were found Liassic animals) :—

Asplenium Whitbyense (Brong.), Heer.
Macroteniopteris, sp.

[1] The *Thinnfeldia odontopteroides* of the Upper Gondwánas is—as far as one may judge from the drawings in the Gondwána Flora (Pal. Ind.)—rather a doubtful form.

Oleandridium vittatum (Brong.), Schimper (?).
Pterophyllum princeps, Oldham & Morris (? *P. Morrisianum*, Oldh., if these two are distinct species!).
Pterophyllum Rajmahalense, Morris.
Palæozamia cf. *brevifolia*, Braun.
Ptilophyllum, sp.
Walchia, sp.

Finally, I should like to call your attention to the papers of my friend H. von Jhering (now Director of the Museum Paulista in São Paulo, Brazil) bearing upon the old Mesozoic relations of South America with New Zealand and Australia—"Die geographische Verbeitung der Flussmuscheln" (Das Ausland, 1890, Nos. 48 and 49) and "Ueber die alten Beziehungen zwischen Neuseeland und Sudamerika" (*ibid.*, 1891, No. 18)—if you are not already acquainted with them.

Table (A) referred to above (see p. 448).

Bajo de Velis.	Sierra de Los Llanos, Sierra de la Rioja (Vilgo, Amanao).
Neuropteridium validum, Fstm.	*Neuropteridium validum*, Fstm.
	Glossopteris communis, Fstm. (?).
	——— *retifera*, Fstm.
Gangamopteris cyclopteroides, Fstm.	
	Phyllotheca.
Equisetites Morenianus, Kurtz.	
	Lepidodendron Pedroanum, Szajn.
	——— *Sternbergi*, Brong.
Nöggerathiopsis Hislopi, Fstm.	*Nöggerathiopsis Hislopi*, Fstm.
? *Euryphyllum Whittianum*, Fstm. (?).	
Rhipidopsis gingkoides, Schmalh.	
——— *densinervis*, Fstm.	
	Cyclopitys dichotoma, Fstm.

Academia Nacional de Ciencias. Cordoba (Rep. Argent.), 5 Aug. 1896.

Dr. F. Kurtz.

VI.—The Chalky and other Post-Tertiary Clays of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

Among the so-called Glacial beds, none fills a larger place in geological literature than the Chalky Clay of Eastern England. I prefer to call it the Chalky Clay, as Searles Wood named it, rather than the Chalky Boulder-clay, because boulders in the true sense of the word, such as characterize the genuine Boulder-clays of North Britain, are infrequent in it. The term Chalky applied to this clay depends on the fact that it is more or less crowded with chalk rubble and chalk fragments of various sizes, and that it has also incorporated in it a considerable quantity of chalk dust, whence its colour and superficial appearance. These peculiarities, which mark it over a wide area from Yorkshire to Finchley, and from Southwold to Warwickshire, are, nevertheless, a secondary, and not a primary, feature of the clay, and have disguised and confused the problem of its explanation.

It has been noticed by several writers that, while there is a common appearance to this clay wherever found, due to the fact that it contains much débris of chalk strata, yet that in regard to its other contents, and notably its matrix, it varies in accordance with the composition of the beds over which it lies, that is, with the substratum. This fact has been frequently noticed, and was, so far as I know, first observed by the Rev. W. B. Clarke, who, writing as far back as 1837, says:—"The diluvial clay covers a great portion of Suffolk, Norfolk, Cambridgeshire, and Essex, and at Cromer rises to 400 feet; much of it is yellowish, but the greater part blue. In both cases it contains chalk pebbles, sometimes in layers, but generally dispersed. This at once distinguishes it from the London and Plastic Clays." Mr. Clarke then goes on to argue that "the yellow clay was derived from the plastic, and the blue, from its peculiar fossils, from the clay below the Chalk" (Geol. Transactions, ser. II, v, p. 365).

These observations of a very good geologist have been amply confirmed by later explorers. Thus Mr. Skertchly says, speaking of the Chalk, the Kimeridge and Oxford Clays:—"We find that the Boulder-clay lying upon these rocks partakes of their physical character. Thus, upon the Chalk the Boulder-clay is very chalky, and, indeed, in some places, as at Mareham le Fen in Lincolnshire, and Thetford in Norfolk, it is almost entirely made up of that substance; at the former place it is quarried and burnt for lime, and at the latter the presence of seams of clay and ice-scratched flints alone enables us to discriminate between it and the chalk beneath. The Kimmeridge Clay is darker than the Oxford Clay, and we accordingly find the Boulder-clay which reposes upon the former is darker than that which lies upon the latter. Where boulders are rare, it is sometimes very difficult to distinguish the Boulder-clay from the older rocks." ("Great Ice Age," new ed., p. 346.) "The Gault clay again takes the ground in but a small area in the Fens, but the Boulder-clay 'picks it out' as it were, and at Modney Bridge brickyard, near Hilgay, for example, I have known the glacial bed to be mistaken for Gault by persons quite familiar with the latter." "Similar remarks," says Mr. Skertchly, "apply to all other formations upon which I have mapped Boulder-clay. For example, the light-blue Upper Lias Clay of Leicestershire impresses its character upon the Boulder-clay which overlies it, and the other members of the Liassic group, where they are in force, behave in a similar manner. The Great Lincolnshire (Inferior) Oolite Limestone around Melton Mowbray yields so large a quantity of material to the Boulder-clay there, that I have been in doubt as to whether the deposit might not be faulted limestone. These peculiarities are at once and correctly expressed by the statement that the ingredients of the Boulder-clay are, for the most part, supplied by rocks, upon or near which it reposes. That this is actually the case, and not an accident of colour, is further attested by the included fossils; *Gryphæa dilatata* and *Belemnites Owenii*, for example, are abundant upon the Oxford Clay, and *Ostræa deltoidea* upon the Kimmeridge Clay." (Skertchly, communication to Geikie's "Great Ice Age," new ed., p. 346.)

It is curious that those writers who have been most ready to concede this change in the Chalky Clay, in accordance with its substratum, have not gone a step further, and also seen that the chalky character itself of the clay in certain districts is simply due to its being upon, or in close proximity to, the Chalk *in sitû*, and that there is no justification for constituting the Chalky Clay a separate horizon. It is because the Chalk occupies so much of the area, and is itself so easily disintegrated, that the name Chalky Clay, rather than Oolitic Clay or Liassic Clay, has been not improperly given to it.

That this feature of the Chalky Clay is due entirely to its lying upon or close to chalk, is also proved by another feature of its distribution, which is interesting for more than one reason, and which has not been sufficiently noticed. In the first place, the Chalky Clay is, so far as I know, largely confined to Eastern England, and is found nowhere else in the world, pointing to there not being the actual conditions elsewhere which prevail here. But this is not all. Mr. Searles Wood, jun., once published a little map roughly defining the area in which it occurs. A larger and more detailed map is appended to a manuscript memoir of his in the possession of the Geological Society, but it has only been since the detailed plotting and mapping of this area by the Geological Survey that it has been possible to define its frontiers, and it would be very useful to us all if the results thus obtained were set out on a map of moderate dimensions.

It will be seen that the distribution of the Chalky Clay, when thus viewed as a whole, is very remarkable. In the first place, it is entirely an inland deposit with duly circumscribed limits and boundaries. It really occurs in several detached masses—two of them in Lincolnshire, one in Yorkshire of no great importance, and a fourth covering more or less an area of several hundred square miles round the depression of the Fens.

In each case the area occupied by the Clay is an insular area, separated from the sea by other surface beds. At one point only—and this is clearly accidental, and due to the recent cutting back of the coast—does the Chalky Clay look down on the sea. In Lincolnshire it is only found to the west of the Lincolnshire Wolds; while in its great homeland further south it is separated from the sea on all sides by beds of Crag and of so-called contorted beds—Middle Glacial beds, etc. This is the case all round the coasts of Norfolk, Suffolk, and Essex, and in the low-lying northern frontier of the marshes and peat-lands of the Wash. To the south it thins out, and virtually ends with the hills bordering the Thames on the north. In the west its limits have not been quite defined, but it occurs abundantly in Leicestershire and Rutland, in Bedfordshire and Buckinghamshire, in Nottinghamshire, and parts of Staffordshire and Warwickshire; on all sides it is limited, however, by other beds, and forms a great concentric ribbon or ring round the Fen country.

The lesson I wish to deduce from these facts is, that the chalky nature of this clay in certain places is no criterion of a separate origin and a separate history for the deposit. It means no more than that the same clay, where it lies on or near chalk, is chalky; where it lies on or near Oolitic beds, is largely Oolitic; and where it lies on or near Liassic beds, is Liassic. Where, again, it is remote from chalk. chalk débris is necessarily not present in it, and yet the clays may be, and probably are, of the same age, produced by the same forces, and differentiated from each other only as the sandy deposits of one part of a bay are differentiated from the muddy deposits of another part of it;—the fact is that the Chalky Clay, which, in the eyes of so many geologists, forms a deposit which is treated as *sui generis*, and as marking a particular horizon, is nothing of the kind, but, as I believe, is merely a local form of other clays occurring in Eastern England, which do not contain chalk débris, but which resemble it in other respects, and which are, so far as we know, interlocked with it or mark the same horizon. This very fact, however, involves an issue of importance; for it may well be that where the chalk débris was not available for incorporation in the clay, the clay itself may be of precisely the same age, and be otherwise continuous with the Chalky Clay; and that instead of there being several superficial clays in Eastern England, whose various names, such as Stony Clay, or Hessle Clay, or Purple Clay, etc., suggest a varying origin, there may be only one such clay, marked in different areas by necessarily different characters, pointing, not to a different date, but to different ingredients, and perhaps a different provenance.

Two Boulder-clays have been described from Norfolk—the Upper or Chalky Boulder-clay and the stony loam or Lower Boulder-clay. The difficulty of separating the two may be judged from the following sentence of Mr. H. B. Woodward. He says:—"So little brick-earth is met with that for a long time I could not settle in my mind whether or not the Chalky Boulder-clay was distinct from the stony loam. The absence or rarity of this formation where the Lower Glacial brick-earth was well developed seemed to favour the notion. The apparent passage of stony loam into chalky loam at the brickyard in Long John's Road, also in the railway-cuttings north-west of Hapton; the difficulty in the parishes of Postwick, Brundall, and Plumstead of drawing a line between the Chalky Boulder-clay and the stony loam, where the two seem from their physical relations to merge one into the other, tended to support the supposition that they were but one formation." Mr. Woodward quotes the pits at Upton Hamlington and South Walsham as throwing some light on the subject

("Geol. of Norwich," p. 103). This light, it must be admitted, is a very small one, and he confesses that it illustrates the uncertainty of their development. Both beds contain chalk rubble; in some cases patches of very chalky clay appear in the stony loam; and towards Cromer, and further west, near Weybourn, these marly beds are worked for lime. Sometimes the beds in this stony loam are well stratified and laminated, and often inland, as well as on the coast, exhibit many and remarkable contortions. Hence the term contorted drift applied by Lyell. These contortions include masses or galls of sand and gravel.

One feature, supposed to distinguish the Chalky Clay from the stony loam, is the absence of shell fragments, but, as Mr. Woodward says—"It is by no means improbable that the stronger shells of the Crag period, such as *Cyprina Islandica*, might be caught up and preserved in it, as well as Liassic and other older fossils, or as the shells of the Kimeridge and Oxford Clays. And, indeed, shell fragments have been noticed by Messrs. Bennett, Blake, Skertchly, Reid. and myself, in the Boulder-clay at Flordon, and near Rockland St. Mary" (*id.*, p. 115). Mr. Woodward himself confesses that at Burlingham the Chalky Boulder-clay is much obscured by a loamy soil, so that it is difficult to distinguish it from the Lower Glacial brick-earth (*id.*, p. 119), which is surely an inversion of matters if the distinction is to be maintained.

Let us now turn elsewhere. The Lincolnshire Wolds, as is well known, separate the Chalky Clay of Lincolnshire from what I may call the maritime clays. Here, again, it is difficult to assign a different horizon to the two. It was remarked long ago that the clay in Lincolnshire is often without chalk where remote from the Chalk Wolds (Geol. Mem. N. Linc. and S. Yorkshire). While Mr. Jukes-Browne separates the Boulder-clays of South-west Lincolnshire into an older and younger Boulder-clay, he says some of his colleagues who had worked in that and adjoining areas regard the Boulder-clays as approximately of the same age (Mem. S.W. Linc., p. 74).

"In East Lincolnshire," says Mr. Jukês-Browne, "there are only three localities where the brown Boulder-clay comes in contact with the white Boulder-clay"; and he concludes, after examining them, that the appearances at those places are not against the supposition that the brown clays pass into the Chalky Clay. Mr. Bulman says the separation of the Chalky Clay and the Purple Clays of the Eastern Counties seems to have been made on arbitrary grounds. They do not occur in the same district, being separated by the Wolds. (Geol. Mag. 1891, p. 345.) Mr. Jukes-Browne similarly shows that the so-called Purple Clay and the Hessle Clay graduate into each other, and that there is no break between them (*id.*). Mr. D. Mackintosh speaks of the Purple Clay of East Yorkshire as horizontally continuous with the Chalky Clay of Lincolnshire (Q.J.G.S., vol. xxxvi, p. 187).

Young and Bird long ago discriminated the three Boulder-clays of Yorkshire, which are superficially marked by certain characters, but which they admit, as do more recent explorers, pass into each other. Thus they say of the most distinct of the three, the so-called basement clay—a bluish or blackish, tenacious clay, forming the lowest visible portion of the cliffs in Holderness and elsewhere:—"As the brown clay passes into the ash-coloured, so the latter passes into the blue clay, which often occurs in patches rather than a distinct bed. Indeed, all the three kinds of clay are often seen banded together in one mass, but we generally find the brown clay uppermost, the ash-coloured in the middle, and the blue, tenacious clay in the lowest place." (*Op. cit.*, pp. 17, 18.)

Mr. C. Reid, who is disposed to postulate two Boulder-clays in Holderness, separated by gravel, in some cases by fossiliferous gravel, says: "It is also interesting to find that this Boulder-clay" [underlying the fossiliferous gravel in one pit] "is, in its lithological character, quite indistinguishable from the newer chalky and purple Boulder-clay which overlies the gravel further east." This is in the valley of Croxton. He also mentions how, south of Laceby, "the gravels suddenly thin out and the two Boulder-clays come together."

At Grimsby the sections "showed two Boulder-clays, purple and chalky, and exactly alike, separated sometimes by a mere line of division, sometimes by gravelly sand, in which fragments of inter-Glacial shells were found. Though the sections were examined almost daily, not the slightest difference could be detected between the two Boulder-clays, either in their matrix or their included boulders." (C. Reid, Linc. and Yorks. Surv. Mem., pp. 169, 170.)

This will suffice to show that, essentially, the Boulder-clays of Eastern England are of one age, and graduate into each other. Their peculiarities are local, due to local causes, and mark only superficial *differentiæ*, and do not justify their being assigned to different periods. Their difference of contents depends very largely on their covering a different kind of substratum. The element and factor which unites them is the presence in them all of a certain number of foreign stones and débris, having, apparently, a common origin, and pointing to a common explanation.

Let us now turn to the contents of the clays, and especially of the Chalky Clay. The first ingredient of these clays which is noticeable is the clay itself, and I cannot help remarking that it is a pity the Geological Surveyors, in the various memoirs they have given us on the so-called Glacial beds, have not given us more analyses of the clays. One fact seems certain, namely, that the clayey matrix of these so-called Glacial clays is not an original product, but a derivative one. That is to say, it was in the state of clay before it was mixed with the ingredients which it now contains, and was directly derived from various Secondary and Tertiary clays already formed: the Speeton and other clays of Yorkshire supplied the main part of the Yorkshire so-called Boulder-clays; the Kimeridge and Oxford Clays, together with the variegated Reading and other Eocene beds of the Fen country, supplying the clays further south. It was because these clays are exposed in Eastern England, and not elsewhere, that we have the so-called Glacial beds so largely composed of clay there. The clayey matrix referred to was not only derivative, but it was derived from beds close by, and, so far as we know, was home-grown, and not imported from abroad.

As to the other ingredients of the so-called Glacial clays; these consist of two entirely different sets of materials—namely, the indigenous and home-grown on the one hand, and the foreigners or erratics on the other. It has been calculated by more than one observer that over 90 per cent. of the stones found in the Chalky Clay are of home growth; and it is probable that in all the clays of Eastern England generally referred to the so-called Glacial age, the proportion of home-grown boulders or stones is very largely indeed in excess of the strangers and foreigners.

The first and most important fact, therefore, to remember is that, over a very large area in Eastern England, the contents of the so-called Glacial clays, both the matrix and the stones in them, are of local origin and not imported. Most of the writers on these clays have been so impressed by the importance of these strangers which form barely a tithe of the contents of the clays, that they have neglected the more essential and more important lessons to be derived from an examination of the local and home-grown ingredients which they contain. I propose in this paper to entirely neglect the foreigners, and to converge attention upon the natives, reserving the discussion of the former for another occasion.

These natives consist of two entirely different classes. One class comprises more or less angular rubble, with its angles frequently blunted, and with the rude facets on its polygonal blocks often scratched; the other consisting of pebbles rolled perfectly smooth, and of various sizes, resembling sea- and river-shingle, these latter chiefly composed of flints and of quartzites, flints predominating greatly.

There can be no doubt whatever that these latter are the débris of marine and fluviatile shingles. It has apparently been argued by some that they were formed as pebbles during the so-called Glacial period. I believe this to be a complete mistake, and, so far as my own observations go—and I have worked pretty hard among them—they all seem to me to be derivative, and to be the débris of disintegrated Tertiary gravel and pebble beds. This view has been growing of late years.

Hutton, so far as I know, was the first to suggest that such gravels may have been the débris of the disintegration of older shingle beds. Thus he argues that these water-worn materials had their great roundness from the attrition caused by the waves of the sea upon some former coast, and that, after having been thus formed by *agitation on the shores, and transported into the deep*, this gravel contributed to the formation of Secondary strata, such as the pudding-stone he elsewhere described; and, lastly, that it was "from the decay and revolution of these Secondary strata, in the wasting operations of the surface, that have come those round siliceous bodies which could not be thus worn by travelling in the longest river." ("Theory of the Earth," vol. ii, p. 144, note.)

This view has been partially urged by Prestwich, and notably by Monckton, Herries, and the other younger geologists who have done so much to unravel the history of the Southern gravels. I would merely press their conclusions further, and affirm that all the rolled and rounded pebbles in the so-called Glacial clays and gravels are derivative, and have been derived from earlier Tertiary beds. I shall have more to say of them in a subsequent paper on the gravels and sands so frequently associated with the clays.

Turning from the polished pebbles to the angular and subangular rubble of home-made rocks, this consists of various kinds of Secondary strata, Lias, Oolite, and Chalk, distributed generally with a preponderance of Lias, Oolite, and Chalk fragments when the underlying beds correspond. These fragments, which have been partially shifted, and rolled and rubbed against each other, are, as I have tried to argue in two recent papers in the GEOLOGICAL MAGAZINE, the result entirely of the violent dislocation of the local Lias, Oolite, and Chalk solid beds, which has broken them up sometimes into great masses, and at others into mere road-metal. This disintegrated rubble was, in my view, ready made when the clay was compounded, and was in a large measure *in situ*; and the only alteration it underwent at the time when it was put into the portentous churn which turned out the chalky and other clays of Eastern England, was to have its angles blunted and its sides scratched and polished by being rolled and rubbed together. This seems as plain as plain can be if we are to explain the facts by inductive methods.

Whatever the forces or the machinery which mixed and distributed the so-called Boulder-clays of Eastern England, they had nothing to do with shaping the home-grown ingredients of the clays. These, with the exception of a little blunting of angles and polishing and some scratching, were already made, and are derivative. The process we have to analyze, therefore, is not complicated by questions as to the *modus operandi* by which the matrix of the clay itself and its contents were formed, but is limited to an explanation of how these ingredients were mixed and mingled together as we find them; and, secondly, how the product, when mixed, was distributed. What is most plain, *in limine*, is that, as the matrix of the clay and nine-tenths of its contents are local, it was fashioned on the spot, and was not imported. This follows from another fact. I have examined the coast of Norfolk and Suffolk with some care, and in those counties, as I have said, the Chalky Clay never reaches the sea, but occupies the projecting bluffs that form the highlands a few miles inland, while the country between them and the sea is occupied by the pebbly beds; the same is the case in Essex. This makes it clear that the Chalky Clay, which occupies the larger part of the interior of those counties, did not move westward from the seaboard, but came from the north or north-west, whence the chalk fragments and the clay itself were derived. This is again shown by the fact that this clay in Suffolk contains so many Liassic fossils. What is true of the eastern boundary of the Chalky Clay is true also of its southern, western, and northern boundaries. The same conclusion follows from the complete absence of any shells or other marine débris from the Chalky Clay, showing it to have been an inland product of the denudation of local beds; and the evidence seems clear that whatever mixed and distributed the clay, the work itself was done on the spot.

Let us now examine the clay a little more closely.

The local stony rubble in the so-called Glacial clays of Eastern England is dispersed irregularly throughout the matrix. As has been frequently noted, the *prevailing* rock fragments in any district depends upon the substratum, but in every district known to me the rocks of other districts are represented. This means that whatever force or engine mixed the clays as we find them, it must have been one that could take up fragments of rock from the north and east and west, and move them in directions opposite and contrary to each other. The great cauldron in which the clay was mingled must have been occupied by some very powerful mobile machinery, which did not move in direct lines, but could move in various directions, and thus bring together and mix together the débris from the four points of the compass in one common medley, and having done so, could distribute it in the fashion we see it distributed now. What force or machinery was competent to effect this extraordinary work?

A considerable number of geologists unhesitatingly attribute the formation and its distribution to ice, and, in fact, point to this clay and instance it as one of the most remarkable proofs of ice-action in this country. I absolutely traverse this position: not only does it seem to me that the Chalky Clay was not distributed by ice, but I would go further and say that I cannot understand how ice in any shape can have formed and distributed it; and it is a very remarkable fact that those who have chiefly championed the cause of ice in this particular instance, are those who have never seen ice at work at all in Nature, while those who have so seen and studied it are unanimous, or almost unanimously of opinion, that nowhere in Nature is ice-work of the kind postulated to be found now going on anywhere.

The champions of ice have invoked it in several forms. Some of them invoke a foreign ice-sheet coming partly from Durham and partly from Scandinavia. This is supposed to be necessitated as a postulate by the presence in these clays of the foreign stones whose provenance has been deduced from Durham and Scandinavia respectively. We shall have more to say to this when we consider the foreign stones. At present we are dealing with the local ones only, and their distribution. Suppose that we can postulate such a foreign ice-sheet coming down, say, in Lincolnshire and the Fenland and their borders, what is the work which it must have been capable of doing when it reached England in order to explain the Chalky Clay. This vast, almost rigid, mass of ice pressed on from behind, it is presumed, by some tremendous *vis a tergo*, and moving, if it moved like any ice known to us along definite lines of least resistance, must, when it reached England, have taken to sportively moving in all directions at once, not only towards its outward circumference sporadically, but also from its circumference inwards, in order to move the Oolitic and Lias fragments of Rutland, Northamptonshire, and Leicestershire, to the heights near Southwold, in Suffolk, the Red Chalk, carstone, and the limestones of Lincolnshire, far to the south of Cambridge, and the chalky fragments of the chalk exposures far to the west into middle England; and must have been capable of doing all these things at the same time, drawing in its scattered tribute to a common cauldron, and then distributing it, when mixed, as we see it distributed from Essex to Warwickshire. Have the fantastic attributes of man ever conceived a more preposterous mechanical process, and has science ever been burdened with such absurdities before?

Assuredly these facts make it impossible for those whose science is inductive to explain the mixing of the clays and their subsequent distribution by means of a foreign ice-sheet; and by foreign I mean here an ice-sheet, whencesoever derived, which has invaded Eastern England from the outside.

If we discard a foreign ice-sheet as the explanation of the Chalky Clay, shall we be any better off in making an appeal to a local glacier, or a series of local glaciers, as Searles Wood and others have done? In the first place, it must be remembered that such a local glacier does not in any way explain the crux of the position, namely, the presence of the foreign stones. Not only so, but if the area occupied by the Chalky Clay were occupied by local glaciers, how could it possibly be invaded by the foreigners at all? The presence of the local ice-sheet would form as complete a barrier to the introduction of foreign stones as a stone wall to the passage of the wind. This difficulty seems to have been entirely overlooked.

Let us pass on, however. The next difficulty is to understand how such *a local* ice-sheet or *local* glacier could be formed at all in the area in question when there are no mountains, and only low rolling downs. Glaciers, as we know them, gather on high ground, and descend into the valleys. If it were a local glacier which occupied the wolds of Lincolnshire, and thence distributed the products of its denuding agency, how comes it, again, that the débris of these chalk hills should be so different on the east side of them to what it is on the west? and how are we to account for the absence of chalk fragments in the beds to the east of these ridges? but apart from this, how are we to postulate glaciers as existing on lands so slightly elevated as are these wolds? Where is the gathering-ground for such glaciers to be found here? The same argument applies to the wolds of Norfolk or Yorkshire. If they were covered with local glaciers, how comes it that this ice shed such very different materials from their eastern and western flanks respectively? But suppose we got our local glaciers, each one crowning a different set of wolds, and moving outwards, how can we possibly explain the collecting of stones from the east and the west, and the north, from areas entirely outside these local glaciers and their influence, and their distributing the mixed products far and wide right over the very areas supposed to have been occupied by the local glaciers ?

Again, if the country were more or less blanketed by ice, either by a foreign ice-sheet or local glaciers, whence could the stones have been derived at all ? There are no high mountains in Eastern England whose peaks would have projected above the ice, and been broken and weathered off to supply materials in this fashion. If the ice produced the disintegration, it must have been by digging up and excavating its own bed, and not in the fashion in which moraines are formed. Now this process of excavating a bed of rock underneath a moving mass of very heavy ice is not only mechanically incredible, but it is quite unsupported by any facts known to me, and is quite repudiated by Professor Bonney and others whose experience of ice is very much greater and more intimate than mine; and here we have to do, not with a local phenomenon occupying a few square yards or acres, but with a stupendous one involving the digging out and removing of wide stretches of rock, not in the form of mud or powder, but in some cases of great lumps and blocks of chalk and oolitic rock, over a wide area. Whether the ice postulated be foreign ice or native ice, it is equally impossible to understand how it could work in this fashion.

If we turn to the stones themselves, we shall have our view confirmed. True glacier-rubbed stones acquire a very curious contour, that is, so far as I know, never present in these chalk lumps of the Chalky Clay. In the case of all soft stones like chalk, they are rubbed down on two sides into flat cakes, so as to have two parallel faces, which are much scratched and furrowed, having, in fact, been used by the glacier as the "skid" of a coach is used. These are the real products of ice rubbing on soft stones, as known to myself in glacier districts, but such stones are markedly absent here. The stones in the Chalky Clay, etc., are as polygonal as those made by the stone-breakers on the highway, differing from such stones only in the fact that they range in size from dust up to masses many scores of feet long, and also in having their surface smoothed and their angles blunted. These are in no sense glacier stones. It is true that occasionally some are found which are scored and scratched, but those who appeal to these sporadic stones forget that whatever drove the clay along, if the movement were quick and two stones rubbed against each other, scratches or marks of rubbing must have ensued in such soft materials as chalk. Those who have examined the débris of such catastrophes as the Holmforth flood, etc., have noticed how invariably some of the stones are scored and scratched. It has been said that such stones are very scarce in shingles made by seas and rivers. Of course they are, because these shingles are formed of smoothed hard stones, like flint and chert and quartzite, which cannot scratch each other easily, but only rub each other down. Where a number of angular stones, such as ballast, lie on a beach, and are examined after a gale, scratches and groovings can always be found. Professor Hughes, in an admirable paper published by the Cambridge Philosophical Society, has shown to how many adventitious causes such scratches can be traced; and "it is a long way to Loch Awe" when we invoke an ice-sheet or local icebergs to account for a few scratches on soft chalk stones, which are themselves otherwise absolutely different to true glacier stones, and have been clearly rolled and had their angles blunted by some other cause than ice. If the smaller lumps are difficult to explain by glacier action, *a fortiori*, as I have before argued, are the large masses, such as those in the contorted drift near Cromer, at Ely, in Rutlandshire, and the great masses of oolite in Lincolnshire, not only detached from their matrix but underlain by other so-called glacial deposits, and this, according to the land-ice hypothesis, all done under the tremendous pressure of such a heavy foot as its own gravid mass. It must be remembered also that among these very large transported rocks are, in some cases, great lumps of clay and of stratified sand, which have been moved *en masse*, and if moved under an ice-sheet must have been pounded and kneaded into a mere medley, and not had their lines of stratification intact. In these cases, at all events, the portage of the soft boulders must have been under the heavy foot of the ice, and not on its back.

Let us turn to another argument. In all glaciers known to me, the glacier products are distributed in a certain definite way, which at every point is different to that of the clays of Eastern England. Instead of being deposited in enormously thick masses near the focus of distribution, and gradually thinning out, glaciers deposit their greatest burdens at their furthest point in the form of mounds and ramparts and moraines. To a glacier it is indifferent whether a stone is big or small; big and little travel together, nor do we find the whole country, irrespective of its contour, as we do in this case, mantled and covered with continuous sheets of clay, which differs in texture and in aspect from all moraine matter known to me.

It was apparently the absence of anything like moraines which so impressed the late Professor Carvill Lewis, one of the most aggressive champions of glacial action, that he absolutely repudiated the presence of traces of ice in any form in East Anglia. If the ice here were an ice-sheet, we may well ask where is its great terminal moraine? and, if it were in the form of local glaciers, where are their lateral and terminal moraines?—where are the mounds and heaps of heterogeneous moraine stuff invariably present where glaciers have been at work?

Again, how are we to explain by ice the distribution of this clay in many places over perfectly horizontal layers of finely laminated sand and gravel, with the laminæ intact and undisturbed, as if the clay had been simply laid down on the sands by some gentle fingered agency? This is quite inconsistent with a moving mass of hard heavy ice, which would have kneaded and pounded the materials into a mass of what the American farmers call "muck."

Moreover, according to any rational mechanical theory, how can we account for the portage over wide areas of clay, scores of feet thick, under an ice-foot at all? How is it to seize it and move it *en masse* in the way required? It would surely slip over itself at once if the attempt were made to push it by means of a stupendously weighted and heavy ice-foot.

All these difficulties present themselves if we treat the glaciers as ordinary glaciers, such as we know them, moving down an ordinary set of hills, from the highlands to the lowlands. *A fortiori* do the difficulties become intensified when the particular contour of the country is considered. It must be remembered that the clayey matrix of the great mass of these clays only exists in the lowest hollows, where the denudation has been greatest. It is thence that the Kimeridge and Oxford Clays must have come to form the mass of the Chalky Clay, and been thence distributed in various directions. It is in the low grounds of the Fen country where the churning and mixing of the materials must have been carried out, and it is thence the clay must afterwards have been sporadically spread out and scattered. How are we by any stretch of the imagination to realize an ice-sheet, formed in the deep hollow of the Fenlands, collecting together from the four winds of heaven materials for the clay, working and mixing them up in the deepest part of the area where it occurs, and then distributing it in various directions, *always* moving uphill from the trough on to the plateau? The kind of reasoning involved is assuredly going back to the dark ages of science, and getting away from induction altogether.

It does not seem possible to me that those who have postulated these local glaciers have ever really measured or thought out the conditions under which they would work at all. Mr. Jukes-Browne has stated some of the insurmountable difficulties in an excellent manner. Thus he says, writing of the Lincolnshire beds :—"The Boulder-clay is not disposed in the manner of moraines, but was clearly spread out as a universal mantle over the whole surface of the country. The ice which produced it certainly could not have been generated on the ridge itself, nor on any of the neighbouring hill ridges, and yet the materials of which the clay consists, and nearly all the stones it contains, are essentially local products derived from the rocks in the immediate neighbourhood. It is obvious that the chalk fragments must have been brought from the north-east, the Carboniferous rocks can only have come from the north or north-west, and the marlstone blocks travelled in all probability from west or south-west of the places where they are now found. . . . . When we consider the remarkable distribution of the stones and boulders in the clay of this area, the greater proportion of chalk detritus on the eastern slopes, and of Jurassic detritus on the western slopes, the fact that enormous masses of marlstone occur many miles to the eastward of the only place whence they can have been derived, the position of the large boulder of Cornbrash, near Ingoldsby, and the occurrence of Lower

Lias Limestone at Croxton, 300 feet above its level, the steep slopes of the Oolitic escarpment up which the ice must have passed, the difficulties in the way of applying the prevalent land-ice hypothesis become considerable." (Mem. S.W. Leicestershire, Sheet 70, pp. 82, 83.) I agree with every word of this, except the word 'considerable,' for which I should have substituted 'insurmountable.'

Land-ice in any form, therefore, seems quite incompetent to account for the Chalky Clay, nor can we invoke it without shutting our eyes to innumerable difficulties which at once arise. Some geologists have therefore had recourse to floating-ice, in the form of icebergs, or to coast-ice. This seems even a more desperate appeal. It first necessitates our conceding a general submergence of the country where the Boulder-clay is found, that is, as far as the Thames in the south and Warwickshire in the west. Granting this, how are we to solve by this agency any of the critical difficulties of the Chalky Clay; its existence in Lincolnshire to the west only of the Wolds; its existence everywhere in great insular areas separated from the sea; the complete absence of marine shells or débris from every place where it has been examined? How by such means as icebergs or shore-ice can we explain the covering of hundreds of miles of country with continuous blankets of chalky clay, not deposited in local heaps and masses but in sheets irrespective of the contour of the country, and in some cases deposited in very deep beds indeed, and most conspicuously on the higher grounds rather than the valleys? How could such agencies collect together oolitic blocks from Leicestershire and pieces of hard chalk from Norfolk, and mix them with the Oxford or Kimeridge Clays of the Fenland, or of the valley of the Ancholme, and then spread them out, as we find them spread out, from Suffolk in the east, into the Central Midlands?

Mr. Skertchly has stated the case against icebergs with singular force. "Icebergs," he says, "are the wrecks of land-ice, and the rocky material they carry is derived from the gathering-grounds of the parent ice; hence, if the Boulder-clay be iceberg drift, its components must be those of *the distant gathering-grounds*, and not those of the rocks it falls upon as the berg melts away." He goes on to say that as the chief ingredient in the clay is chalk, as it is found 300 feet above the present sea-level, not only must the gathering-ground have been on chalk but there must have been a submergence of at least 500 feet. This would convert the chalk area into a number of small islands, where it is not possible to understand glaciers gathering at all. Again, all the argillaceous matrix of the Chalky Clay is derived from the Fenland and the valley of the River Ancholme, and all the formations whence it could be derived would be under water. A more powerful argument remains in the fact that, if the clay be of iceberg origin, it can have no relation to the rocks on which it rests, except by accident; but the Chalky Clay does possess such a connection, and the icebergs must have had a selective affinity in shedding their burdens, by virtue of which they preferred to drop Kimeridge

Clay débris upon Kimeridge Clay and Oxford Clay detritus upon Oxford Clay. The clay is dark-blue on Kimeridge Clay, and light upon the light-blue Oxford Clay, besides which the fossils in the clay show a large percentage of Kimeridge Clay species where that rock lies below, and of Oxford Clay fossils where that is the subjacent bed. Not only so, but we find that the Kimeridge Chalky Clay invades the outcrop of the Oxford Chalky Clay, and the latter does not come on until the Oxford Clay has fairly taken the ground. In like manner the Boulder-clay is much more chalky on the Chalk than elsewhere, and this feature it maintains over the narrow Greensand outcrop, on to the Kimeridge Clay, as at Mareham, where chalky Boulder-clay is burned for lime. It is quite impossible, as Skertchly says, that icebergs should have dropped their burdens so geologically. ("Geology of the Fenland," pp. 215, 216.) The iceberg theory has, so far as I know, no friends left. I have already, in another paper, criticized the shore-ice theory, of which Mr. M. Reade has been the champion. He has invoked it to explain the portage of the vast blocks which so often occur in the Chalky Clay; but he would hardly attribute to coast-ice the collecting of the materials of the Chalky Clay, the mingling of them into the present medley, and the distribution of the mixture far and wide over one-third of England.

Whichever way the problem is approached, the intervention of ice as a *causa causans* seems impossible. It was appealed to in reality to explain phenomena whose explanation is to be sought for in very different causes—(1) the scratching of certain chalk masses, a result which must have followed from any theory of the distribution of the Chalk involving its portage from one place to another, which we all concede; (2) the presence in the eastern drifts of vast continuous masses of chalk, etc., which, as we have seen, is due to an entirely different cause; and, lastly, the presence of the foreign boulders. This last fact I hope to discuss on another occasion, when I should like to correlate with the clays we have been discussing the gravels and so-called Middle Sands of Eastern England, in which these foreign stones also occur. In the meantime the view I would press is, that these clays present no single feature consistent with their having been deposited by ice, nor do I know of any reason which is sound for invoking ice to explain them. The view is held by others besides myself, on other grounds. Thus, Mr. (now Professor) Seeley says:—"I have not found in this locality a vestige of iceberg action. Of glacier action the deposits of the Fenlands offer no traces, unless the fragments of northern rocks be held to prove that one great glacier stretched from the Tweed to the Thames, of which there may be as much likelihood as that the ice of the Caucasus excavated the Black Sea." (GEOL. MAG., 1866, Vol. III. p. 496.) Mr. Jukes-Browne's opinion I have already quoted, but the most unexpected and trenchant view of all is that of the late Professor Carvill Lewis, who was one of the archpriests of Ultra-Glacialism, and who in regard to East Anglia emphatically took the same side.

REVIEWS.

Crystallography for Beginners, with an Appendix on the Use of the Blowpipe and the Determination of Common Minerals (after the Method of Dr. Albin Weisbach). By C. J. Woodward, B.Sc. Pp. 164, 4 Plates, and 75 Woodcut Illustrations. (London: Simpkin, Marshall, Hamilton, Kent and Co., 1896.)

THIS work consists of two parts, really independent of each other: the one treats of Crystallography (100 pages); the other (termed merely an Appendix, though extending to more than half the length of the first) consists almost entirely of tables relating to the determination of the more common minerals. The author has avoided technicalities of expression as far as is possible, and has aimed throughout at extreme simplicity of literary style, as will be clear from one of the opening sentences of the First Lesson: "Put into a pipkin, or an earthenware basin, about half a pint of water, and add two to three ounces of the blue vitriol, and heat to near boiling." In spite of the difficulty inseparable from a subject which involves the geometry of solid bodies, the meaning of the author is always evident to the thoughtful reader. In a brief introduction Mr. Woodward first explains the method of preparing pasteboard models for the illustration of the lessons, and supplies two plates of "nets" to be used for this purpose. He then treats successively of the constancy of the angles of crystals, the idea of symmetry, the systems of crystallization, the notation of forms, the drawing of crystals, and the stereographic projection of poles. The discussion of the physical characters of crystals extends over only 15 pages, and is followed by a brief account of mero-symmetry. At the end of each of the nine lessons is given a series of questions for the mental exercise of the student, and the whole is illustrated with numerous diagrams. Although some inaccuracies of statement are obvious to the critical eye, they are not of a character to interfere with the general usefulness of the book. The Appendix, as is stated by the author, is virtually an extract from the more complete tables published by Professor Weisbach, of Freiberg, and will be of service to the mineralogical beginner. Sets of six illustrative specimens and some pieces of simple apparatus have been prepared for issue to students using the book.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science. Address to the Geological Section by Professor J. E. Marr, M.A., F.R.S., Sec.G.S., President of the Section, Liverpool, September 17, 1896.

THE feelings of one who, being but little versed in the economic applications of his science, is called upon to address a meeting of the Association held in a large industrial centre, might, under ordinary circumstances, be of no very pleasant character; but I take courage when I remember that those connected with my native county, in which we are now gathered, have taken prominent part in advancing branches of our science which are not directly concerned with industrial affairs. I am reminded, for instance, that one amongst you, himself a busy professional man, has in his book on "The Origin of Mountain Ranges" given to the world a theoretical work of the highest value; that, on the opposite side of the county, those who are responsible for the formation and management of that excellent educational institution, the Ancoats Museum, have wisely recognized the value of some knowledge of geology as a means of quickening our appreciation of the beauties of Nature; and that one who has done solid service to geology by his teachings, who has kept before us the relationship of our science to that which is beautiful—I refer to the distinguished author of "Modern Painters"—has chosen the northern part of the county for his home, and has illustrated his teaching afresh by reference to the rocks of the lovely district around him. Nor can I help referring to one who has recently passed away—the late Sir Joseph Prestwich—the last link between the pioneers of our science and the geologists of the present day, who, though born in London, was of Lancashire family, and whom we may surely therefore claim as one of Lancashire's worthies. With these evidences of the catholicity of taste on the part of geologists connected with the county, I feel free to choose my own subject for this address, and, my time being occupied to a large extent with academic work, I may be pardoned for treating that subject in academic fashion. As I have paid considerable attention to the branch of the science which bears the somewhat uncouth designation of stratigraphical geology, I propose to take the present state of our knowledge of this branch as my theme.

Of the four great divisions of geology, petrology may be claimed as being largely of German origin, the great impetus to its study having been given by Werner and his teachings. Palæontology may be as justly claimed by the French nation, Cuvier having been to so great an extent responsible for placing it upon a scientific basis. Physical geology we may partly regard as our own, the principles laid down by Hutton and supported by Playfair having received illustration from a host of British writers, amongst whom may be mentioned Jukes, Ramsay, and the brothers Geikie; but the grand principles of physical geology have been so largely illustrated by the magnificent and simple features displayed on the other side of the Atlantic, that we may well refer to our American brethren as leaders in this branch of study. The fourth branch, stratigraphical geology, is essentially British as regards origin, and, as everyone is aware, its scientific principles were established by William Smith, who was not only the father of English geology, but of stratigraphical geology in general.

Few will deny that stratigraphical geology is the highest branch of the science, for, as has been well said, it "gathers up the sum of all that is made known by the other departments of the science, and makes it subservient to the interpretation of the geological history of the earth." The object of the stratigraphical geologist is to obtain information concerning all physical, climatic, and biological events which have occurred during each period of the past, and to arrange them in chronological order, so as to write a connected history of the earth. If all of this information were at our disposal, we could write a complete earth-history, and the task of the geologist would be ended. As it is, we have barely crossed the threshold of discovery, and the "imperfection of the geological record," like the "glorious uncertainty" of our national game, gives geology one of its great charms. Before passing on to consider more particularly the present state of the subject of our study, a few remarks upon this imperfection of the geological record may not be out of place, seeing that the term has been used by so many modern writers, and its exact signification occasionally misunderstood. The imperfection of the palæontological record is usually understood by the term when used, and it will be considered here as an illustration of the incompleteness of our knowledge of earth-history; but it must be remembered that the imperfection of the physical record is equally striking, as will be insisted on more fully in the sequel.

Specially prominent amongst the points upon which we are ignorant stands the nature of the pre-Cambrian faunas. The extraordinary complexity of the earliest known Cambrian fauna has long been a matter for surprise, and the recent discoveries in connection with the *Olenellus* fauna do not diminish the feeling.[1] After commenting upon the varied nature of the earliest known fauna, the late Professor Huxley, in his Address to the Geological Society in 1862, stated that "any admissible hypothesis of progressive modification must be compatible with persistence without progression, through indefinite periods. . . . . Should such an hypothesis eventually be proved to be true, ... the conclusion will inevitably present itself, that the Palæozoic, Mesozoic, and Cainozoic faunæ and floræ, taken together, bear somewhat the same proportion to the whole series of living beings which have occupied this globe, as the existing fauna and flora do to them." Whether or not this estimate is correct, all geologists will agree that a vast period of time must have elapsed before the Cambrian period, and yet our ignorance of faunas existing prior to the time when the *Olenellus* fauna occupied the Cambrian seas is almost complete. True, many pre-Cambrian fossils have been described at various times, but, in the opinion of many competent judges, the organic nature of each one of these requires confirmation. I need not, however, enlarge upon this matter, for I am glad to say we have amongst us a geologist who will at a later stage read a paper before this Section upon the subject of pre-Cambrian fossils, and there is no one better able, owing to his intimate acquaintance with the actual relics, to present fairly and impartially the arguments which have been advanced in favour of the organic origin of the objects which have been appealed to as evidences of organisms of pre-Cambrian age than our revered co-worker from Canada, Sir J. W. Dawson. We may look forward with confidence to the future discovery of many faunas older than those of which we now possess certain knowledge, but until these are discovered the palæontological record must be admitted to be in a remarkably incomplete condition. In the meantime, a study of the recent advance of our knowledge of early life is significant of the mode in which still earlier faunas will probably be brought to light In 1845 Dr. E. Emmons described a fossil, now known to be an *Olenellus*, though at that time the earliest fauna was supposed to be one containing a much later group of organisms, and it was not until Nathorst and Brögger established the position of the *Olenellus* zone that the existence of a fauna earlier than that of which *Paradoxides* was a member was admitted; and, indeed, the *Paradoxides* fauna itself was proved to be earlier than that containing *Olenus*, long after these two genera had been made familiar to palæontologists, the Swedish palæontologist, Angelin, having referred the *Paradoxides* fauna to a period earlier than that of the one with *Olenus*. It is quite possible, therefore, that fossils are actually preserved in our museums at the present moment which have been extracted from rocks deposited before the period of

[1] Dr. C. D. Walcott, in his monograph on "The Fauna of the Lower Cambrian or *Olenellus* Zone" (Washington, 1890), records the following great groups as represented in the *Olenellus* beds of America: Spongiæ, Hydrozoa, Actinozoa, Echinodermata, Annelida? (trails, burrows, and tracks), Brachiopoda, Lamellibranchiata, Gasteropoda, Pteropoda, Crustacea, and Trilobita. Others are known as occurring in beds of the same age in the Old World.

formation of the *Olenellus* beds, though their age has not been determined. The *Olenellus* horizon now furnishes us with a datum-line from which we can work backwards, and it is quite possible that the *Neobolus* beds of the Salt Range,[1] which underlie beds holding *Olenellus*, really do contain, as has been maintained, a fauna of date anterior to the formation of the *Olenellus* beds; and the same may be the case with the beds containing the *Protolenus* fauna in Canada,[2] for this fauna is very different from any known in the *Olenellus* beds, or at a higher horizon, though Mr. G. F. Matthew, to whom geologists owe a great debt for his admirable descriptions of the early fossils of the Canadian rocks speaks very cautiously of the age of the beds containing *Protolenus* and its associates. Notwithstanding our ignorance of pre-Cambrian faunas, valuable work has recently been done in proving the existence of important groups of stratified rocks deposited previously to the formation of the beds containing the earliest known Cambrian fossils; I may refer especially to the proofs of the pre-Cambrian age of the Torridon Sandstone of North-west Scotland lately furnished by the officers of the Geological Survey, and their discovery that the maximum thickness of these strata is over 10,000 feet.[3] Amongst the sediments of this important system, more than one fauna may be discovered, even if most of the strata were accumulated with rapidity, and all geologists must hope that the officers of the Survey—who, following Nicol, Lapworth, and others, have done so much to elucidate the geological structure of the Scottish Highlands—may obtain the legitimate reward of their labours, and definitely prove the occurrence of rich faunas of pre-Cambrian age in the rocks of that region.

But although we may look forward hopefully to the time when we may lessen the imperfection of the records of early life upon the globe, even the most hopeful cannot expect that record to be rendered perfect, or that it will make any near approach to perfection. The posterior segments of the remarkable trilobite *Mesonacis Vermontana* are of a much more delicate character than the anterior ones, and the resemblance of the spine on the fifteenth "body-segment" of this species to the terminal spine of *Olenellus* proper, suggests that in the latter subgenus posterior segments of a purely membranous character may have existed, devoid of hard parts. If this be so, the entire outer covering of the trilobites, at a period not very remote from the end of pre-Cambrian times, may have been membranous, and the same thing may have occurred with the structures analogous to the hard parts of organisms of other groups. Indeed, with our present views as to development, we can scarcely suppose that organisms acquired hard parts at a very early period of their existence, and fauna after fauna may have occupied the globe, and disappeared, leaving no trace of its existence, in which case we are not likely ever to obtain definite knowledge of the characters of our earliest faunas, and the biologist must not look to the geologist for direct information concerning the dawn of life upon the earth.

Proceeding now to a consideration of the faunas of the rocks formed after pre-Cambrian times, a rough test of the imperfection of the record may be made by examining the gaps which occur in the vertical distribution of forms of life. If our knowledge of ancient faunas were very incomplete, we ought to meet with many cases of recurrence of forms after their apparent disappearance from intervening strata of considerable thickness, and many such cases have actually been described by that eminent

[1] See F. Noetling, "On the Cambrian Formation of the Eastern Salt Range": Records Geol. Survey India, vol. xxvii, p. 71.

[2] G. F. Matthew, "The *Protolenus* Fauna": Trans. New York Acad. of Science, 1895, vol. xiv, p. 101.

[3] Sir A. Geikie, "Annual Report of the Geological Survey [United Kingdom] . . . for the year ending December 31, 1893." London, 1894.

palæontologist, M. Barrande, amongst the Palæozoic rocks of Bohemia, though even these are gradually being reduced in number owing to recent discoveries; indeed, in the case of the marine faunas, marked cases of recurrence are comparatively rare, and the occurrence of each form is generally fairly unbroken from its first appearance to its final extinction, thus showing that the imperfection of the record is by no means so marked as might be supposed. Fresh-water and terrestrial forms naturally furnish a large percentage of cases of recurrence, owing to the comparative rarity with which deposits containing such organisms are preserved amongst the strata.

A brief consideration of the main reasons for the present imperfection of our knowledge of the faunas of rocks formed subsequently to pre-Cambrian times may be useful, and suggestive of lines along which future work may be carried out. That detailed work in tracts of country which are yet unexplored, or have been but imperfectly examined by the geologist, will add largely to our stock of information, needs only to be mentioned; the probable importance of work of this kind in the future may be inferred from a consideration of the great increase of our knowledge of the Permo-Carboniferous faunas, as the result of recent labours in remote regions. It is specially desirable that the ancient faunas and floras of tropical regions should be more fully made known, as a study of these will probably throw considerable light upon the influence of climate upon the geographical distribution of organisms in past times. The old floras and faunas of Arctic regions are becoming fairly well known, thanks to the zeal with which the Arctic regions have been explored. But, confining our attention to the geology of our own country, much remains to be done even here, and local observers especially have opportunities of adding largely to our stock of knowledge, a task they have performed so well in the past. To give examples of the value of such work, our knowledge of the fauna of the Cambrian rocks of Britain is largely due to the present President of the Geological Society, when resident at St. David's, whilst the magnificent fauna of the Wenlock Limestone would have been far less perfectly known than it is if it were not for the collections of men like the late Colonel Fletcher and the late Dr. Grindrod. Again, the existence of the rich fauna of the Cambridge Greensand would have been unsuspected, had not the bed known by that name been worked for the phosphatic nodules which it contains.

It is very desirable that large collections of varieties of species should be made, for in this matter the record is very imperfect. There has been, and, I fear, is still, a tendency to reject specimens when their characters do not conform with those given in specific descriptions, and thus much valuable material is lost. Local observers should be specially careful to search for varieties, which may be very abundant in places where the conditions were favourable for their production, though rare or unknown elsewhere. Thus, I find the late Mr. W. Keeping remarking that "it is noteworthy that at Upware, and, indeed, all other places known to me, the species of Brachiopoda [of the Neocomian beds] maintain much more distinctness and isolation from one another than at Brickhill."[1] The latter place appears to be one where conditions were exceptionally favourable in Neocomian times for the production of intermediate forms.

A mere knowledge of varieties is, however, of no great use to the collector without a general acquaintance with the morphology of the organisms whose remains he extracts from the earth's strata, and one who has this can do signal service to the science. It is specially important that local observers should be willing to devote themselves to the study of particular groups of organisms, and to collect large suites of specimens

[1] W. Keeping, Sedgwick Essay: "The Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill." Cambridge, 1883.

of the group they have chosen for study. With a group like the graptolites, for instance, the specimens which are apparently best preserved are often of little value from a morphological point of view, and fragments frequently furnish more information than more complete specimens. These fragments seldom find their way to our museums, and accordingly we may examine a large suite of graptolites in those museums without finding any examples showing particular structures of importance, such as the sac-like bodies carried by many of these creatures. As an illustration of the value of work done by one who has made a special study of a particular group of organisms, I may refer to the remarkable success achieved by the late Mr. Norman Glass in developing the calcareous supports of the brachial processes of Brachiopods. Work of this character will greatly reduce the imperfection of the record from the biologists' point of view.

The importance of detailed work leads one to comment upon the general methods of research which have been largely adopted in the case of the stratified rocks. The principle that strata are identifiable by their included organisms is the basis of modern work, as it was of that which was achieved by the father of English Geology, and the identification of strata in this manner has of recent years been carried out in very great detail, notwithstanding the attempt on the part of some well-known writers to show that correlation of strata in great detail is impossible. The objection to this detailed work is mainly founded upon the fact that it must take time for an organism or group of organisms to migrate from one area to another, and therefore it was stated that they cannot have lived contemporaneously in two remote areas. But the force of this objection is practically done away with if it can be shown that the time taken for migration is exceedingly short as compared with the time of duration of an organism or group of organisms upon the earth, and this has been shown in the only possible way—namely, by accumulating a very great amount of evidence as the result of observation. The eminent writers referred to above, who were not trained geologists, never properly grasped the vast periods of time which must have elapsed during the occurrence of the events which it is the geologist's province to study. An historian would speak of events which began at noon on a certain day and ended at midnight at the close of that day as contemporaneous with events which commenced and ended five minutes later, and this is quite on a par with what the geologist does when correlating strata. Nevertheless, there are many people who still view the task of correlating minute subdivisions of stratified systems with one another, with a certain amount of suspicion, if not with positive antipathy; but the work must be done for all that. Brilliant generalizations are attractive as well as valuable, but the steady accumulation of facts is as necessary for the advancement of the science as it was in the days when the Geological Society was founded, and its members applied themselves "to multiply and record observations, and patiently to await the result at some future period." I have already suggested a resemblance between geology and cricket, and I may be permitted to point out that just as in the game the free-hitter wins the applause, though the patient "stone-waller" often wins the match, so, in the science, the man apt at brilliant generalizations gains the approval of the general public, but the patient recorder of apparently insignificant details adds matter of permanent value to the stores of our knowledge. In the case of stratigraphical geology, if we were compelled to be content with correlation of systems only, and were unable to ascertain which of the smaller series and stages were contemporaneous, but could only speak of these as "homotaxial," we should be in much the same position as the would-be antiquary who was content to consider objects fashioned by the Romans as contemporaneous with those of mediæval times. Under such circumstances geology would indeed be an uncertain science, and we should labour in the field knowing that a satisfactory earth-history would never be written. Let us hope that a brighter future is in store for us, and let me urge my countrymen to continue to study the minute subdivisions of the strata, lest they be left behind by the geologists of other countries, to whom the necessity for this kind of study is apparent, and who are carrying it on with great success.

The value of detailed work on the part of the stratigraphical geologist is best grasped if we consider the recent advance that has been made in our science owing to the more or less exhaustive survey of the strata of various areas, and the application of the results obtained to the elucidation of the earth's history. A review of this nature will enable us not only to see what has been done, but also to detect lines of inquiry which it will be useful to pursue in the future ; but it is obvious that the subject is so wide that little more can be attempted than to touch lightly upon some of the more prominent questions. A work might well be written treating of the matters which I propose to notice. We have all read our "Principles of Geology," or "The Modern Changes of the Earth and its inhabitants considered as illustrative of Geology," to quote the alternative title ; some day we may have a book written about the ancient changes of the earth and its inhabitants considered as illustrative of geography.

Commencing with a glance at the light thrown on inorganic changes by a detailed examination of the strata, I may briefly allude to advances which have recently been made in the study of denudation. The minor faults, which can only be detected when the small subdivisions of rock-groups are followed out carefully on the ground, have been shown to be of great importance in defining the direction in which the agents of denudation have operated, as demonstrated by Professor W. C. Brögger, for instance, in the case of the Christiania Fjord[1] ; and I have recently endeavoured to prove that certain valleys in the English Lake District have been determined by shattered belts of country, the existence of which is shown by following thin bands of strata along their outcrop. The importance of the study of the strata in connection with the genesis and subsequent changes of river-systems is admirably brought out in Professor W. M. Davis's paper on "The Development of certain English Rivers,"[2] a paper which should be read by all physical geologists ; it is, indeed, a starting-point for kindred work which remains especially for local observers to accomplish. Study of this kind not only adds to our knowledge of the work of geological agencies, but helps to diminish the imperfection of the record, for the nature of river-systems, when rightly understood, enables us to detect the former presence of deposits over areas from which they have long since been removed by denudation.

An intimate acquaintance with the lithological characters of the strata of a district affords valuable information in connection with the subject of glacial denudation. The direction of glacial transport over the British Isles has been largely inferred from a study of the distribution of boulders of igneous rock, whilst those of sedimentary rock have been less carefully observed. The importance of the latter is well shown by the work which has been done in Northern Europe in tracing the Scandinavian boulders to their sources, a task which could not have been performed successfully if the Scandinavian strata had not been studied in great detail.[3] I shall

[1] W. C. Brögger, Nyt. Mag. for Naturvidensk., vol. xxx (1886), p. 79.

[2] W. M. Davis, Geograph. Journ., vol. v (1895), p. 127.

[3] It is desirable that the boulders of sedimentary rock imbedded in the drifts of East Anglia should be carefully examined, and fossils collected from them. The calcareous strata associated with the Alum Shales of Scandinavia and the strata of the *Orthoceras* Limestone of that region may be expected to be represented amongst the boulders.

presently have more to say with regard to work connected with the lithological characters of the sediments. Whilst mentioning glacial denudation, let me allude to a piece of work which should be done in great detail, though it is not, strictly speaking, connected with stratigraphy, namely, the mapping of the rocks around asserted "rock-basins." I can find no actual proof of the occurrence of such basins in Britain, and it is very desirable that the solid rocks and the drift should be carefully inserted on large-scale maps, not only all around the shores of several lakes, but also between the lakes and the sea, in order to ascertain whether the lakes are really held in rock-basins. Until this work is done, however probable the occurrence of rock-basins in Britain may be considered to be, their actual existence cannot be accepted as proved.

When referring to the subject of denudation, mention was made a moment ago of the study of the lithological character of the sediments. Admirable work in this direction was carried out years ago by one who may be said to have largely changed the direction of advance of geology in this country owing to his researches "On the Microscopical Structure of Crystals, indicating the Origin of Minerals and Rocks." I refer, of course, to Dr. H. C. Sorby. But since our attention has been so largely directed to petrology, the study of the igneous and metamorphic rocks has been most zealously pursued, whilst that of the sediments has been singularly little heeded, with few exceptions, prominent amongst which is the work of Mr. Maynard Hutchings, the results of which have been recently published in the GEOLOGICAL MAGAZINE, though we must all hope that the details which have hitherto been supplied to us, valuable as they are, are only a foretaste of what is to follow from the pen of this able observer. Descriptions of the lithological changes which occur in a vertical series of sediments, as well as of those which are observed when any particular band is traced laterally, will no doubt throw light upon a number of interesting questions.

Careful work amongst the ancient sediments, especially those which are of organic origin, has strikingly illustrated the general identity of characters, and therefore of methods of formation, of deposits laid down on the sea-floors of past times and those which are at present in course of construction. Globigerine-oozes have been detected at various horizons and in many countries. Professor H. Alleyne Nicholson[1] has described a pteropod-ooze of Devonian age in the Hamilton Limestone of Canada, which is largely composed of the tests of *Styliola*; and to Dr. G. J. Hinde we owe the discovery of a large number of radiolarian cherts of Palæozoic and Neozoic ages in various parts of the globe. The extreme thinness of many argillaceous deposits, which are represented elsewhere by hundreds of feet of strata, suggests that some of them, at any rate, may be analogous to the deep-sea clays of modern oceans, though in the case of deposits of this nature we must depend to a large extent upon negative evidence. The uniformity of character of thin marine deposits over wide areas is in itself evidence of their formation at some distance from the land; but although the proofs of origin of ancient sediments far from coast-lines may be looked upon as permanently established, the evidence for their deposition at great depths below the ocean's surface might be advantageously increased in the case of many of them. The fairly modern sediments, containing genera which are still in existence, are more likely to furnish satisfactory proofs of a deep-sea origin than are more ancient deposits. Thus the existence of *Archæopneustes* and *Cystechinus* in the oceanic series of Barbadoes, as described by Dr. J. W. Gregory, furnishes strong proofs of the deep-sea character of the deposits; whilst the only actual argument in favour of the deep-sea character of certain Palæozoic sediments has been put forward by

[1] Nicholson and Lydekker, "Manual of Palæontology," chap. ii.

Professor Suess, who notes the similarity of certain structures of creatures in ancient rocks to those possessed by modern deep-sea crustacea, especially the co-existence of trilobites which are blind with those which have enormously developed eyes.

A question which has been very prominently brought to the fore in recent years is that of the mode of formation of certain coral-reefs. The theory of Charles Darwin, lately so widely accepted as an explanation of the mode of formation of barrier-reefs and atolls, has been, as is well known, criticized by Dr. Murray, with the result that a large number of valuable observations have been recently made on modern reefs, especially by biologists, as a contribution to the study of reef formation. Nor have geologists been inactive. Dr. E. Mojsisovics and Professor Dupont, to mention two prominent observers, have described knoll-like masses of limestone more or less analogous, as regards structure, to modern coral-reefs. They consider that these have been formed by corals, and, indeed, Dupont maintains that the atoll-shape is still recognizable in ancient Devonian coral-reefs in Belgium.[1] I would observe that all cases of "knoll-reefs" of this character have been described in districts which furnish proofs of having been subjected to considerable orogenic disturbance, subsequent to the formation of the rocks composing the knoll-shaped masses, whilst in areas which have not been affected by violent earth foldings, the reef-building corals, so far as I have been able to ascertain, give rise to sheet-like masses, such as should be produced according to Dr. Murray's theory. I would mention especially the reefs of the Corallian rocks of England, and also some admirable examples seen amongst the Carboniferous Limestone strata of the great western escarpment of the Pennine Chain which faces the Eden Valley in the neighbourhood of Melmerby in Cumberland. Considering the number of dissected coral-reefs which exist amongst the strata of the earth's crust, and the striking way in which their structure is often displayed, it is rather remarkable that comparatively little attention has been paid to them by geologists in general, when the subject has been so prominently brought before the scientific world, for we must surely admit that we are much more likely to gain important information, shedding light upon the methods of reef-formation, by a study of such dissected reefs, than by making a few boreholes on some special coral island. I would specially recommend geologists to make a detailed study of the British coral-reefs of Silurian, Devonian, Carboniferous, and Jurassic ages.

Turning now to organic deposits of vegetable origin, we must, as a result of detailed work, be prepared to admit the inapplicability of any one theory of the formation of coal-seams. The "growth-in-place" theory may be considered fairly well established for some coals, such as the spore-coals, whilst the "drift" theory furnishes an equally satisfactory explanation of the formation of cannel-coal. It is now clear that the application of the general term *coal* to a number of materials of diverse nature, and probably of diverse origin, was largely responsible for the dragging-out of a controversy in which the champions of either side endeavoured to explain the origin of all coal in one particular way.

The stratigraphical geologist, attempting to restore the physical geography of former periods, naturally pays much attention to the positions of ancient coast-lines; indeed, all teachers find it impossible to give an intelligible account of the stratified rocks without some reference to the distribution of land and sea at the time of their formation. The general position of land-masses at various times has been ascertained in

[1] Similar knoll-like masses have been described in this country by Mr. R. H. Tiddeman, as occurring in the Craven district of Yorkshire, but he does not attribute their formation to coral-growth to any great extent.

several parts of the world, but much more information must be gathered together before our restorations of ancient sea-margins approximate to the truth. The Carboniferous rocks of Britain have been specially studied with reference to the distribution of land and water during the period of their accumulation, and yet we find that owing to the erroneous identification of certain rocks of Devonshire as grits or sandstones, which Dr. Hinde has shown to be radiolarian cherts, land was supposed to lie at no great distance south of this region in Lower Carboniferous times, whereas the probabilities are in favour of the existence of an open ocean at a considerable distance from any land in that direction. This case furnishes us with an excellent warning against generalization upon insufficient data.

As a result of detailed study of the strata, the effects of earth-movements have been largely made known to us, especially of those comparatively local disturbances spoken of as orogenic which are mainly connected with mountain-building, whilst information concerning the more widely-spread epeirogenic movements is also furnished by a study of the stratified rocks. The structure of the Alps, of the North-West Highlands of Scotland, and of the uplifted tracks of North America is now familiar to geologists, whilst the study of comparatively recent sediments has proved the existence of widespread and extensive movements in times which are geologically modern; for instance, the deep-water deposits of late Tertiary age found in the West Indies indicate the occurrence of considerable uplift in that region. But a great amount of work yet remains to be done in this connection, especially concerning horizontal distortion of masses of the earth's crust, owing to more rapid horizontal advance of one portion than of another, during periods of movement. Not until we gather together a large amount of information derived from actual inspection of the rocks shall we be able to frame satisfactory theories of earth-movement, and in the meantime we are largely dependent upon the speculations of the physicist, often founded upon very imperfect data, on which is built an imposing superstructure of mathematical reasoning. We have been told that our continents and ocean-basins have been to a great extent permanent as regards position through long geological ages; we now reply by pointing to deep-sea sediments of nearly all geological periods, which have been uplifted from the ocean-abysses to form portions of our continents; and as the result of study of the distribution of fossil organisms, we can point almost as confidently to the sites of old continents now sunk down into the ocean depths. It seems clear that our knowledge of the causes of earth-movements is still in its infancy, and that we must be content to wait awhile, until we have further information at our disposal.

Recent work has proved the intimate connection betwixt earth-movement and the emission and intrusion of igneous rocks, and the study of igneous rocks has advanced beyond the petrographical stage; the rocks are now made to contribute their share towards the history of different geological periods. The part which volcanic action has played in the actual formation of the earth's crust is well exemplified in Sir Archibald Geikie's Presidential Addresses to the Geological Society, wherein he treats of the former volcanic history of the British Isles.[1] The way in which extruded material contributes to the formation of sedimentary masses has, perhaps, not been fully grasped by many writers, who frequently seem to assume that deposition is a measure of denudation, and *vice versâ*, whereas deposition is only a measure of denudation, and of the material which has been ejected in a fragmental condition from the earth's interior, which in some places forms a very considerable percentage of the total amount of sediment.

[1] Sir A. Geikie, Quart. Journ. Geol. Soc., vols. xlvii and xlviii.

The intruded rocks also throw much light on past earth-history, and I cannot give a better illustration of the valuable information which they may furnish to the stratigraphical geologist, when rightly studied, than by referring to the excellent and suggestive work by my colleague, Mr. Alfred Harker, on the Bala Volcanic Rocks of Carnarvonshire.[1]

Perhaps the most striking instance of the effect which detailed stratigraphical work has produced on geological thought is supplied by the study of the crystalline schists. Our knowledge of the great bulk of the rocks which enter into the formation of a schistose complex is not very great, but the mode of production of many of them is now well known, and the crude speculations of some of the early geologists are now making way for theories founded on careful and minute observations in the field as well as in the laboratory. Recent work amongst the crystalline schists shows, furthermore, how careful we should be not to assume that because we have got at the truth we have therefore ascertained the whole truth. We all remember how potent a factor dynamic metamorphism was supposed to be, owing to discoveries made in the greatly disturbed rocks of Scotland and Switzerland ; and the action of heat was almost ignored by some writers, except as a minor factor, in the production of metamorphic change. The latest studies amongst the foliated rocks tend to show that heat does play a most important part in the manufacture of schists. The detailed work of Mr. George Barrow, in North-east Forfarshire,[2] has already thrown a flood of light upon the origin of certain schists, and their connection with igneous rocks, and geologists will look forward with eagerness to further studies of the puzzling Highland rocks by this keen observer.

The subject of former climatic conditions is one in which the geologist has very largely depended upon followers of other branches of science for light, and yet it is one peculiarly within the domain of the stratigraphical geologist ; and information which has already been furnished concerning former climatic conditions, as the result of careful study of the strata, is probably only an earnest of what is to follow when the specialist in climatology pays attention to the records of the rocks, and avoids the theories elaborated in the student's sanctum. The recognition of an Ice Age in Pleistocene times at once proved the fallacy of the supposition that there has been a gradual fall in temperature throughout geological ages without any subsequent rise, and accordingly most theories which have been put forward to account for former climatic change have been advanced with special reference to the Glacial period or periods, although there are many other interesting matters connected with climate with which the geologist has to deal. Nevertheless, the occurrence of Glacial periods is a matter of very great interest, and one which has deservedly received much attention, though the extremely plausible hypothesis of Croll, and the clear manner in which it has been presented to general readers, tended to throw other views into the shade, until quite recently, when this hypothesis has been controverted from the point of view of the physicist. In the meantime considerable advance has been made in our actual knowledge, and this year, probably for the first time, and as the result of the masterly *résumé* of Professor Edgworth David,[3] the bulk of British geologists is prepared to admit that there has been more than one Glacial period, and that the evidence of glacial conditions in the southern hemisphere in Permo-Carboniferous times is established. Croll's hypothesis of course requires the recurrence of Glacial periods, but leaving out of account arguments not of a geological character, which have been advanced against

[1] Alfred Harker, Sedgwick Essay for 1888 (Camb. Univ. Press, 1889).
[2] G. Barrow, Quart. Journ. Geol. Soc., vol. xlix (1893), p. 330.
[3] T. W. E. David, "Evidences of Glacial Action in Australia in Permo-Carboniferous Time": Quart. Journ. Geol. Soc., vol. lii, p. 289.

this hypothesis, the objection raised by Messrs. Gray and Kendall,[1] that in the case of the Pleistocene Ice Age "the cold conditions came on with extreme slowness, the refrigerations being progressive from the Eocene period to the climax," seems to me to be a fatal one. At the same time, rather than asking with the above writers "the aid of astronomers and physicists in the solution of this problem," I would direct the attention of stratigraphical geologists to it, believing that, by steady accumulation of facts, they are more likely than anyone else to furnish the true clue to the solution of the glacial problem.

I have elsewhere called attention to marked changes in the faunas of the sedimentary rocks when passing from lower to higher levels, without the evidence of any apparent physical break, or any apparent change in the physical conditions, so far as can be judged from the lithological characters of the strata, and have suggested that such sudden faunistic variations may be due to climate. I refer to the matter as one which may well occupy the attention of local observers.

One of the most interesting points connected with climatic conditions is that of the former general lateral distribution of organisms, and its dependence upon the distribution of climatic zones. The well-known work of the late Dr. Neumayr[2] has, in the opinion of many geologists, established the existence of climatic zones whose boundaries ran practically parallel with the equator in Jurassic and Cretaceous times, and the possible existence of similar climatic zones in Palæozoic times has been elsewhere suggested; but it is very desirable that much more work should be done on this subject, and it can only be carried out by paying close attention to the vertical and lateral distribution of organisms in the stratified rocks.

So far we have chiefly considered the importance of stratigraphical geology in connection with the inorganic side of nature. We now come to the bearing of detailed stratigraphical work upon questions concerning the life of the globe, and here the evidence furnished by the geologist particularly appeals to the general educated public as well as to students of other sciences.

Attention has just been directed to the probable importance of former climatic changes in determining the distribution of organisms; but the whole subject of the geographical distribution of organisms during former geological periods, though it has already received a considerable amount of attention, will doubtless have much further light thrown upon it as the result of careful observations carried out amongst the stratified rocks.

So long ago as 1853, Pictet laid it down as a palæontological law that "the geographical distribution of species found in the strata was more extended than the range of species of existing faunas." One would naturally expect that at a time when the diversity of animal organization was not so great as it now is, the species, having fewer enemies with which to cope, and on the whole not too complex organizations to be affected by outward circumstances, would spread further laterally than they now do; but as we know that in earliest Cambrian times the diversity of organization was very considerable, it is doubtful whether any appreciable difference would be exerted upon lateral distribution then and now, owing to this cause. At the time at which Pictet wrote, the rich fauna of the deeper parts of the oceans, with its many widely distributed forms of life, was unknown, and the range in space of early organisms must have then struck everyone who thought upon the subject

[1] J. W. Gray and P. F. Kendall, "The Cause of an Ice Age": Brit. Assoc. Rep. (1892), p. 708.

[2] M. Neumayr, "Ueber klimatische Zonen während der Jura- und Kreidezeit": Denkschr. der math.-naturwissen. Classe der k. k. Akad. der Wissenschaften, vol. xlvii. Vienna, 1883.

as being greater than that of the shallow-water organisms of existing seas, which were alone known. It is by no means clear, however, with our present knowledge, that Pictet's supposed law holds good, and it will require a considerable amount of work before it can be shown to be even apparently true. Our lists of the fossils of different areas are not sufficiently complete to allow us to generalize with safety, but a comparison of the faunas of Australia and Britain indicates a larger percentage of forms common to the two areas, as we examine higher groups of the geological column. If this indication be fully borne out by further work, it will not prove the actual truth of the law, for the apparent wider distribution of ancient forms of life might be due to the greater probability of elevation of ancient deep-sea sediments than of more modern ones which have not been subjected to so many elevatory movements. Still, if the law be apparently true, it is a matter of some importance to geologists; and I have touched upon the subject here in order once again to emphasize the possibility of correlating comparatively small thicknesses of strata in distant regions by their included organisms.

Mention of Pictet's laws, one of which states that fossil animals were constructed upon the same plan as existing ones, leads me to remark upon the frequent assumption that certain fossils are closely related to living groups, when the resemblance between the hard parts of the living and extinct forms are only of the most general character. There is a natural tendency to compare a fossil with its nearest living ally, but the comparison has probably been often pushed too far, with the result that biologists have frequently been led to look for the ancestors of one living group exclusively amongst forms of life which are closely related to those of another living group. The result of detailed work is to bring out more and more prominently the very important differences between some ancient forms and any living creature, and to throw doubts on certain comparisons; thus I find several of the well-known fossils of the Old Red Sandstone, formerly referred without hesitation to the fishes, are now doubtfully placed in that class.

The importance of detailed observation in the field is becoming every day more apparent, and the specialist who remains in his museum examining the collections amassed by the labours of others, and never notes the mode of occurrence of fossils in the strata, will perhaps soon be extinct, himself an illustration of the principle of the survival of the fittest. In the first place, such a worker can never grasp the true significance of the changes wrought on fossil relics after they have become entombed in the strata, especially amongst those rocks which have been subjected to profound earth-movements; and it is to be feared that many "species" are still retained in our fossil lists whose supposed specific characters are due to distortion by pressure. But a point of greater importance is, that one who confines his attention to museums cannot, unless the information supplied to him be very full, distinguish the differences between fossils which are variations from a contemporaneous dominant form, such as "sports," and those which have been termed "mutations," which existed at a later period than the forms which they resemble. The value of the latter to those who are attempting to work out phylogenies is obvious, and their nature can only be determined as the result of very laborious and accurate field-work; but such labour in such a cause is well worth performing. The student of phylogeny has had sufficient warning of the dangers which beset his path, from an inspection of the various phylogenetic trees, constructed mainly after study of existing beings only, so

"... like the borealis race,
That flit ere you can point their place":

but recent researches amongst various groups of fossil organisms have further illustrated the danger of theorizing upon insufficient data, especially suggestive being the discovery of closely similar forms which were formerly considered to be much more nearly related than now proves to be the case. Thus Dr. Mojsisovics [1] has shown that Ammonites once referred to the same species are specifically distinct, though their hard parts have acquired similar structures, sometimes contemporaneously, sometimes at different times; and Mr. S. S. Buckman [2] has observed the same thing, which he speaks of as "heterogenetic homœomorphy" in the case of certain brachiopods; whilst Professor H. A. Nicholson and I [3] have given reasons for supposing that such heterogenetic homœomorphy, in the case of the graptolites, has sometimes caused the inclusion in one genus of forms which have arisen from two distinct genera. As the result of careful work, dangers of the nature here suggested will be avoided, and our chances of indicating lines of descent correctly will be much increased. It must be remembered that, however plausible the lines of descent indicated by students of recent forms may be, the actual links in the chains can only be discovered by examination of the rocks, and it is greatly to be desired that more of our geologists, who have had a thorough training in the field, should receive in addition one as thorough in the zoological laboratory. Shall I be forgiven if I venture on the opinion that a certain suspicion which some of my zoological fellow-countrymen have of geological methods, is due to their comparative ignorance of palæontology, and that it is as important for them to obtain some knowledge of the principles of geology as it is for the stratigraphical palæontologist to study the soft parts of creatures whose relatives he finds in the stratified rocks?

The main lines along which the organisms of some of the larger groups have been developed, have already been indicated by several palæontologists, and detailed work has been carried out in several cases. As examples, let me allude to the trilobites, of which a satisfactory natural classification was outlined by the great Barrande in those volumes of his monumental work which deal with the fossils of this order, whilst further indication of their natural inter-relationships has been furnished by Messrs. C. D. Walcott, G. F. Matthew, and others; to the graptolites, whose relationships have been largely worked out by Professor C. Lapworth, *facile princeps* amongst students of the Graptolitoidea, to whom we look for a full account of the phylogeny of the group; to the brachiopods, which have been so ably treated by Dr. C. E. Beecher,[4] largely from a study of recent forms, but also after careful study of those preserved in the fossil state; and to the echinoids and lamellibranchs, whose history is being extensively elucidated by Dr. R. T. Jackson,[5] by methods somewhat similar to those pursued by Dr. Beecher. I might give other instances,[6] but have chosen some striking ones, four of which especially illustrate the great advances which are being made in the study of the palæontology of the invertebrates by our American brethren.

[1] E. Mojsisovics, Abhandl. der k. k. geol. Reichsanst., vol. vi (1893).

[2] S. S. Buckman, Quart. Journ. Geol. Soc., vol. li (1895), p. 456.

[3] H. A. Nicholson and J. E. Marr, Geol. Mag., Dec. 4, Vol. II (1895), p. 531.

[4] C. E. Beecher, "Development of the Brachiopoda": Amer. Journ. Sci., ser. iii, vol. xli (1891), p. 343, and vol. xliv (1892), p. 133.

[5] R. T. Jackson, "Phylogeny of the Pelecypoda," Mem. Boston Soc. Nat. Hist., vol. iv (1890), p. 277; and "Studies of Palæechinoidea," Bull. Geol. Soc. Amer., vol. vii (1896), p. 171.

[6] *E.g.* the following papers treating of the Cephalopoda: A. Hyatt, "Genesis of the Arietidæ," Smithsonian Contributions, vol. xxvi (1889); M. Neumayr, Jura-Studien I, "Ueber Phylloceraten," Jahrb. der k. k. Geol. Reichsanst., vol. xxi (1871), p. 297; L. Würtenberger, "Studien über die Stammesgeschichte der Ammoniten," Leipzig, 1880; S. S. Buckman, "A Monograph of the Inferior Oolite Ammonites of the British Islands," 1887, Monogr. Palæontographical Soc.

I have occupied the main part of my address with reasons for the need of conducting stratigraphical work with minute accuracy. Many of you may suppose that the necessity for working in this way is so obvious that it is a work of supererogation to insist upon it at great length; but experience has taught me that many geologists consider that close attention to details is apt to deter workers from arriving at important generalizations, in the present state of our science. A review of the past history of the science shows that William Smith, and those who followed after him, obtained their most important results by steady application to details, and subsequent generalization, whilst the work of those who theorize on insufficient data is apt to be of little avail, though often demanding attention on account of its very daring, and because of the power of some writers to place erroneous views in an attractive light, just as

> " . . . . the sun can fling
> Colours as bright on exhalations bred
> By weedy pool or pestilential swamp,
> As on the rivulet, sparkling where it runs,
> Or the pellucid lake."

Nor is there any reason to suppose that it will be otherwise in the future, and I am not one of those who consider that the brilliant discoveries were the exclusive reward of the pioneers in our science, and that labourers of the present day must be contented with the gleanings of their harvest; on the contrary, the discoveries which await the geologist will probably be as striking as are those which he has made in the past. The onward march of science is a rhythmic movement, with now a period of steady labour, anon a more rapid advance in our knowledge. It would perhaps be going too far to say that, so far as our science is concerned, we are living in a period rather of the former than of the latter character, though no great geological discovery has recently affected human thought in the way in which it was affected by the proofs of the antiquity of man, and by the publication of "The Origin of Species." If, however, we are to some extent gathering materials, rather than drawing far-reaching conclusions from them, I believe this is largely due to the great expansion which our science has undergone in recent years. It has been said that geology is "not so much one science, as the application of all the physical sciences to the examination and description of the structure of the earth, the investigation of the agencies concerned in the production of that structure, and the history of their action"; and the application of other sciences to the elucidation of the history of our globe has been so greatly extended of recent years, that we are apt to lose sight of the fact that geology is in itself a science, and that it is the special province of the geologist to get his facts at first hand from examination of the earth. The spectroscope and the telescope tell the geologist much; but his proper instrument is the hammer, and the motto of every geologist should be that which has been adopted for the Geological Congress—"*Mente et malleo.*"

At the risk of being compared to a child playing with edge tools, I cannot help referring to the bearing of modern stratigraphical research on the suggested replacement of a school of uniformitarianism by one of evolution. The distinguished advocate of Evolutionism, who addressed the Geological Society in 1869 upon the modern schools of geological thought, spoke of the school of evolution as though it were midway between those of uniformitarianism and catastrophism, as indeed it is logically, though, considering the tenets of the upholders of catastrophism, as opposed to those of uniformitarianism, at the time of that address, there is no doubt that evolutionism was rather a modification of the uniformitarianism of the period than intermediate between it and catastrophism, which was then practically extinct, at any rate in Britain. One of my predecessors in this chair, speaking upon this subject, says that "the good old British ship 'Uniformity,' built by Hutton and refitted by Lyell, has won so many glorious victories in the past, and appears still to be in such excellent fighting trim, that I see no reason why she should haul down her colours, either to 'catastrophe' or 'evolution.'" It may be so; but I doubt the expediency of nailing those colours to the mast. That Lyell, in his great work, proved that the agents now in operation, working with the same activity as that which they exhibit at the present day, *might* produce the phenomena exhibited by the stratified rocks, seems to be generally admitted, but that is not the same thing as proving that they *did* so produce them. Such proof can only be acquired by that detailed examination of the strata which I have advocated in this address, and at the time that the last edition of the "Principles" appeared, our knowledge of the strata was far less complete than it has subsequently become. It appears to me that we should keep our eyes open to the possibility of many phenomena presented by rocks, even newer than the Archæan rocks, having been produced under different conditions from those now prevalent. The depths and salinity of the oceans, the heights and extent of continents, the conditions of volcanic action, and many other things, may have been markedly different from what they are at present, and it is surely unphilosophical to assume conditions to have been generally similar to those of the present day, on the slender data at our disposal. Lastly, uniformitarianism, in its strictest sense, is opposed to rhythmic recurrence of events. "Rhythm is the rule with nature; she abhors uniformity more than she does a vacuum," wrote Professor Tyndall, many years ago, and the remark is worth noting by geologists. Why have we no undoubted signs of Glacial epochs amongst the strata from early Cambrian times to the Great Ice-period, except in Permo-Carboniferous times? Is there not an apparent, if not a real, absence of manifestation of volcanic activity over wide areas of the earth in Mesozoic times? Were not Devonian, Permo-Triassic, and Miocene times periods of mountain-building over exceptionally wide areas, whilst the intervening periods were rather marked by quiet depression and sedimentation? A study of the evidence available in connection with questions like these suggests rhythmic recurrence. Without any desire to advocate hasty departure from our present methods of research, I think it should be clearly recognized that evolution may have been an important factor in changing the conditions even of those times of which the geologist has more direct knowledge. In this, as in many other questions, it is best to preserve an open mind; indeed, I think that geologists will do well to rest satisfied without an explanation to many problems, amongst them the one just referred to; and that working hypotheses, though useful, are better retained in the manuscript notebooks of the workers than published in the Transactions of learned societies, whence they filter out into popular works, to the great delight of a sceptical public should they happen to be overthrown.

May I trespass upon your patience for one moment longer? As a teacher of geology, with many years' experience in and out of a large University, I have come to the conclusion that geology is becoming more generally recognized as a valuable instrument of education. The memory, the reasoning faculties, and the powers of observation are alike quickened. The work in the open air, which is inseparable from a right understanding of the science, keeps the body in healthy condition. But over and above these benefits, the communing with nature, often in her most impressive moods, and the insignificance of events in a man's lifetime, as compared with the ceaseless changes through the long æons which have gone before, so influence man's moral nature, that they drive out his meaner thoughts and make him "live in charity with all men."

OBITUARY.

ALEXANDER HENRY GREEN, M.A., F.R.S., F.G.S.

BORN OCTOBER 10, 1832. DIED AUGUST 19, 1896.

WITH deep regret we have to record the death of our friend and brother geologist Professor Alexander Henry Green, M.A., F.R.S. He was the son of the Rev. Thomas Sheldon Green, who was for many years Master of the Ashby Grammar School and a classical scholar of some repute. A. H. Green was born at Maidstone, October 10, 1832, and educated at his father's school, Ashby-de-la-Zouche, and at Gonville and Caius College, Cambridge. He was Sixth Wrangler in 1855, and was elected Fellow of his College the same year. In 1861 he was appointed an Assistant on the Geological Survey of England and Wales, and in 1867 he attained the rank of Geologist. During the time he was connected with the Survey, he examined considerable areas of the Jurassic and Cretaceous rocks in the Midland counties, and of the Carboniferous rocks in Derbyshire, Yorkshire, and other northern counties. Many Survey memoirs were written wholly or in part by Mr. Green, among which are the "Geology of Banbury" (1864), and the geological descriptions of the country around Stockport (1866), Tadcaster (1879), Dewsbury (1871), Barnsley (1878), and Wakefield (1879). The memoir on the geology of North Derbyshire, of which the first edition was published in 1869 and the second in 1887, was written chiefly by Mr. Green. His most important Survey work is the "Geology of the Yorkshire Coalfield" (1878).

Mr. Green retired from the Geological Survey in 1874 on his appointment to the Professorship of Geology in the Yorkshire College at Leeds, to which was added, in 1885, the Professorship of Mathematics in the same College. But he completed some official Survey work after the time of his appointment at Leeds.

In 1876 he published a Manual of Physical Geology, a work which has taken a leading place as a textbook for students and teachers in this branch of the science; a third edition was issued in 1883.

For several years Professor Green held the Lectureship on Geology at the School of Military Engineering at Chatham. In the year 1886 he was elected a Fellow of the Royal Society; and in 1888 he was appointed Professor of Geology at Oxford, as successor to the late Sir Joseph Prestwich. In 1890 Professor Green filled the office of President of Section C (Geology) at the British Association, Leeds, and delivered the customary address. He served on the Council of the Royal Society 1894–5, and also for some years on that of the Geological Society of London, to which he had been elected in 1862. Professor Green filled the offices of Examiner to the University of London and Assistant Examiner to the Science and Art Department; he was also Examiner in Geology to the University of Durham, and latterly for the Home and Indian Civil Service.

His death took place, from paralysis, on Wednesday, August 19, 1896, at his residence Boar's Hill, near Oxford.

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ORIGINAL ARTICLES.

I.—On some Crush-Conglomerates in Anglesey.[1]

By Sir Archibald Geikie, D.Sc., LL.D., F.R.S.,
Director-General of the Geological Survey.

THE important observations made by Mr. Lamplugh among the "crush-conglomerates" of the Isle of Man suggest that the phenomena described by him may have a much wider range than had previously been supposed. Ever since I had the opportunity of going over his Manx evidence with him, I have suspected that some of the fragmental rocks which I myself have regarded as volcanic agglomerates might prove to be due, not to volcanic explosions, but to the same kind of underground movements which have undoubtedly given rise to the enormous masses of "crush-conglomerate" in the Isle of Man. The breccias of Anglesey seemed to me likely on renewed examination to prove to belong to the latter series. Accordingly I recently took occasion to revisit these rocks, both in the centre and along the north coast of the island. The result was entirely confirmatory of my suspicions. The breccias in question are, I now feel convinced, true crush-conglomerates.

The amount of mechanical deformation which these rocks have undergone is one of their most obvious characteristics. On the supposition of their volcanic origin it was quite conceivable that coarse agglomerates and volcanic breccias might undergo crushing, together with the sedimentary series to which they belonged, so that this evidence of deformation formed in itself no proof that they were not of pyroclastic derivation. But more detailed investigation, in the light of the Manx examples, brings to view proofs that this conglomeratic structure has been produced by the breaking up of stratified rocks *in situ*. At Llangefni, for example, the strata affected appear to have been originally shales or mudstones (with possibly some fine felsitic tuffs), alternating with bands of hard siliceous grit. They have been crumpled up and crushed into fragments which have been driven past each other along the planes

[1] Read before the British Association at Liverpool.

of movement. Every stage may be traced, from a long piece of one of the grit bands down to mere rounded and isolated pebbles of the same material. The grits, being much more resisting, have withstood the deformation better than the argillaceous strata, which have been crushed into a kind of lustrous slate, or phyllite. Everywhere the signs of movement or "flow-structure" meet the eye. It is not that the rocks have been merely crushed to fragments. The differential movements which produced the ruptures also made the materials to flow onwards, the dislocated bands of grit being reduced to separate blocks and pebbles, entirely surrounded in the moving matrix of finer shaly paste.

The "agglomerates" on the coast near Cemmaes, so singularly deceptive as to be easily mistaken for volcanic necks, prove to be capable of a like interpretation. The huge blocks of limestone, there to be seen isolated among fragmentary grits and slates, are referable to the disruption of some of the limestone bands which occur abundantly in the neighbourhood. A gradation may be traced from the slates and grits outside the areas of more severe dislocation into the intensely crushed and sheared "agglomerate." The dykes which cut through these rocks, and increase the likeness to true volcanic vents, are later than the period of crushing and may be traced in the surrounding slates and grits.

But though the volcanic nature of the rocks believed to be agglomerates must be abandoned, the question of the original formation of the strata which have been so greatly ruptured remains quite distinct. I agree with Mr. Blake in regarding these strata as largely composed of volcanic detritus. The breccias and fine tuffs which alternate with and overlie the Lower Silurian black shales, can be traced upward into the mass of the Amlwch slates, which are full of volcanic dust. The evidence for the existence of Lower Silurian volcanoes in the north of Anglesey remains quite valid and ample, though we must abandon the volcanic origin of the "agglomerates," which seemed to form part of that evidence. The production of the crush-conglomerates has involved the volcanic as well as the non-volcanic parts of the series in the same destruction.

II.—Notes on the Superficial Deposits of North Shropshire.[1]

By C. Callaway, D.Sc., F.G.S.

In studying the rocks of Shropshire, I have paid some attention to the superficial deposits that lie irregularly scattered over the solid strata in the northern half of the county. They had previously been noticed by Miss C. Eyton, in her little book "On the Geology of North Shropshire," while special areas occupied by them have been described by Mr. G. Maw, Mr. C. J. Woodward, and Mr. A. C. Nicholson. Nevertheless, it seemed to me that it

[1] A brief abstract of this paper was read before the British Association, Liverpool, 1896.

would be useful to present a summary of my own observations on the district in question, at the same time incorporating in my notes the most important results of the work of preceding geologists.

I do not propose to enter into the controversy now proceeding between the advocates respectively of land-ice and floating-ice, except in so far as the war has been carried into Shropshire. The facts that I have collected appear to me most consistent with the theory that, in some part of the Glacial Epoch, the Salopian area was submerged to a depth of at least 1100 feet; that during the submergence sandy and shingly deposits were laid down, the materials of which were largely derived from the north; that the marine origin of these beds is demonstrated by an abundant molluscan fauna; and that these deposits were overlain by erratics and boulder-clay, let fall by floating-ice as the floes or bergs melted or capsized. I have not found a single fact inconsistent with this hypothesis, and I have not found a single fact clearly pointing to the former existence in the Salopian area of a great glacier. It is quite possible that, on the flanks of some of the hill-ranges, there accumulated the slight beginnings of glaciers, which carried débris from the higher ground to lower levels; but if such land-ice existed its effects were not very marked.

First, as to the submergence. The deposits with marine shells, found at Gloppa by Mr. A. C. Nicholson, are now well known. They are at 1100 feet above sea-level. They are not to be distinguished from shore deposits now forming at many parts of our coast. The shells they contain are often entire, but they are more frequently broken, as in ordinary littoral sands. The natural interpretation of these facts is, that Gloppa was visited by the sea some time in the Glacial Epoch. That a sheet of ice once scooped up gravels and shells from the bottom of the Irish Sea, and pushed or dragged them to the top of the hills above Oswestry, is a hypothesis that commends itself rather to the intoxication of the theorizer than to the sobriety of the inductive reasoner.

The sands at Ketley, near Wellington, display facts still more hostile to the land-ice theory. The lower part of the section consists of evenly-bedded sands, often clearly ripple-marked. The rippled seams occur one above another to a thickness of some yards, unmistakably indicating a continuance of littoral conditions.

Sand and gravel, usually containing marine shells, are found scattered over the surface of a large part of North Shropshire. At Wollerton, near Hodnet, a gravel-pit displays twenty feet of pebbly beds, with horizontal seams of red sand. *Turritella* and other molluscs are fairly abundant. Besides the ordinary northern erratics, the beds contain large pieces of Lias clay, with *Gryphæa*, *Pecten*, and *Belemnites*. Flints are abundant. In one of them I found a *Rhynchonella*. The Lias specimens are probably derived from the Prees outlier. The flints have been referred to an Irish origin, but of this there is no proof.

At Shrewsbury a large pit on the Severn displays marine sands and gravels of a normal type. They rest on Permian, and are overlain by Boulder-clay. A mile or so north of Shrewsbury, near Almond Park, the shingle is very coarse, rounded fragments up to one foot in diameter being common. Flints are not so abundant as they are further east, which is difficult to account for if they were derived from Antrim.

A good exposure of gravel is seen near Welshampton, not far from the northern border of the county, and is overlain by clay with boulders; but it is needless to multiply descriptions of sections which present so many features in common.

I may remark in passing that I have never found clay under the sands and gravels of Shropshire. Wherever the two formations are seen together, the clay is always uppermost. Strictly speaking, the latter ought not to be described as a clay at all. I have selected specimens of the stiffest material, and triturated them with water in a tall narrow glass, with the result that at least two-thirds of this so-called clay is seen to consist of sand.

I have already thrown doubt upon the alleged derivation of the Chalk flints from Antrim, and should be disposed to refer them to an eastern source. This suggestion receives confirmation from an interesting discovery made some years ago in Wellington. Gravels were being excavated within 100 yards of my house, when the workmen found at a few feet below the surface a perfect specimen of *Waldheimia obovata*. This is a well-known Cornbrash fossil, and must have been conveyed by currents from the south or east.

There is one fact which seems to me absolutely fatal to the views of the advocates of the action of land-ice in Shropshire, and that is the entire absence of the rounding and smoothing ordinarily produced in glaciated districts. I have been working for over twenty years in the county, yet I have never found a *roche moutonnée*. Glacial sands and gravels are found up to nearly the summit of Grinshill Hill, and a boulder of Eskdale granite can be seen on the Longmynd Hills at a height of 1050 feet. The glacier that deposited this boulder, as the land-ice advocates believe, must therefore have entirely submerged Grinshill Hill; yet that elevation is strikingly conspicuous for its angularity. If it be thought that the water-stones of the Keuper were not hard enough to retain a rounded contour, what is to be said for Lilleshall Hill? It stands but slightly above the plain of North Shropshire, and its summit is composed of an extremely hard and flinty felspathic ash; yet the surmounting crags are exceptionally rough and angular. But the time would fail me to tell of Charlton Hill, of Primrose Hill, of the lower slopes of the Caer Caradoc chain and the Longmynd, and of countless crags and elevations which would certainly have retained hundreds of proofs of glaciation had an ice-sheet ever passed over them.

III.—Notes on the Ancient Rocks of Charnwood Forest.[1]

By W. W. Watts, M.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

During the re-survey of sheet 155 of the Geological Survey map by Mr. C. Fox Strangways, the writer was instructed to study the ancient rocks where they crop up inside the boundaries of the Trias. The ancient rocks of Charnwood Forest appear in isolated spots, sometimes of considerable size, through the Trias of the Midland Plain. The oldest rock in contact with them is the Carboniferous Limestone of Grace Dieu, which is dolomitized. Evidence as to their exact age cannot, therefore, be obtained from superposition.

They clearly existed as islands in the Triassic and Carboniferous sea, and most probably stood up as mountains on the land in Old Red Sandstone times. The Trias runs up into the hollows and valleys of the old rocks, and from the small amount of débris which extends beyond the margins of the masses it is obvious that the smaller of these, at any rate, have been uncovered at a time geologically very recent. Their features are not those of the present day, but date back partly to the subaerial denudation of Old Red Sandstone and probably earlier times, and partly to the aqueous denudation of Carboniferous and Triassic times. This is the reason for the peculiar character of the surface features presented by the old rock; escarpments are practically absent, hard beds are cut off abruptly, the rocks strike across the ridges, and the landscape generally is not of the usual subaerial character. Present-day denudation, by clearing out the Triassic débris, has done little more than expose to-day a pre-Triassic landscape.

The ancient rocks themselves may be classified as follows, in descending order:—

Swithland and Groby slates Conglomerate and quartzite Purple and green beds	The Brand Series.
The olive hornstones of Bradgate The Woodhouse beds Slate agglomerate of Roecliffe Hornstones of Beacon Hill Felsitic agglomerate	The Maplewell Series.
Rocks of Blackbrook	The Blackbrook Series.

This general succession corresponds with that made out by Messrs. Hill and Bonney, with whose observations the author is in substantial agreement.

These divisions sweep round the semi-dome which is exposed; it is elongated from north-west to south-east, and broken by several longitudinal faults in the same direction. Probably there are some cross faults as well.

The succession is most easily made out in the eastern side of the

[1] An abstract was read before the British Association, Liverpool, Sept. 1896.

anticline, but even here the details are very much complicated, and it is not possible to trace some of the beds for any considerable distance, although the general succession seems quite clear. As Messrs. Bonney and Hill pointed out, the two agglomerates form a most useful index and one which can be traced for a great part of the way round the Forest. The same may be said of the Beacon Hill beds and of the Brand Series.

The bulk of the rocks are made of volcanic ingredients, even the fine hornstones and slates being made of volcanic dust often interleaved with tuffs and breccias. When the lower part of the Maplewell Series is traced round to the north-west it becomes coarser, and eventually passes into a mass of very coarse agglomerates, in which the succession is not easy to unravel, while it is much confused by faulting and the intrusion of igneous rocks; possibly also by the outflow of lava.

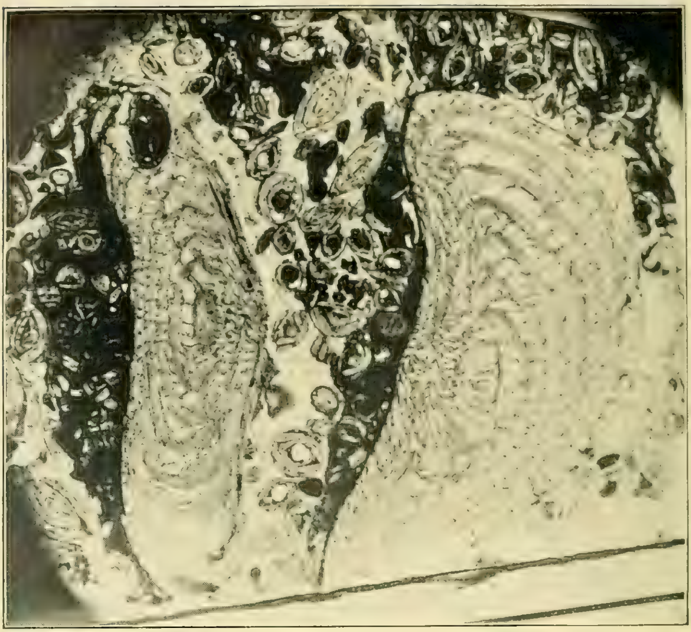
Bardon Hill presents exceptional difficulties. While the chief rocks are like those of Grace Dieu, Cademan, and Whitwick, it lies altogether out of the line of these rocks and must owe its position to faulting. The agglomerates are also associated with a mass of porphyroid like that which occurs in a normal position at Peldar Tor and High Sharpley. At Bardon this rock appears to be intrusive into the agglomerates, and a similar explanation may have to be adopted for Sharpley, Peldar, and Ratchet. Many difficulties would still have to be met, not the least of which is the occurrence of boulders of Peldar rock in some of the agglomerates. A possible explanation of this is found at High Sharpley, where porphyroid, which is now acknowledged to be either an intrusion or a lava, is nodular in structure; it has been subsequently sheared so as to put on the aspect of an agglomerate.

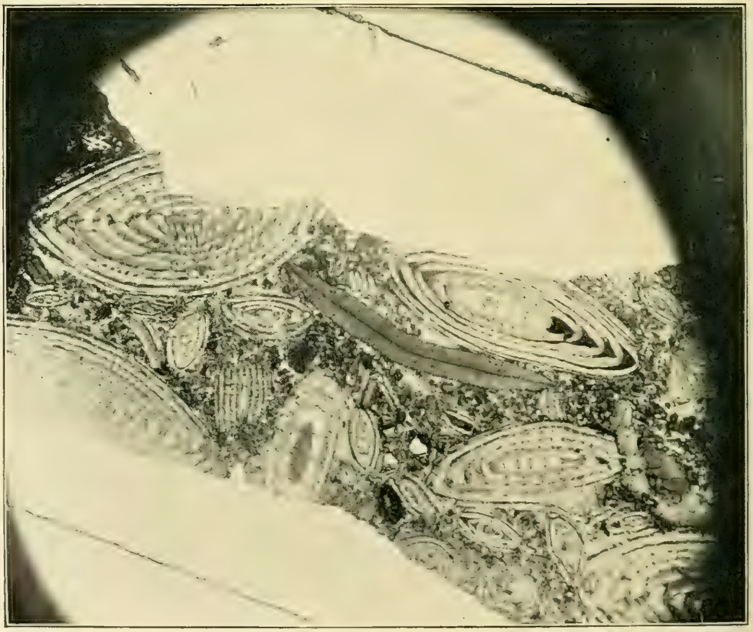
The porphyroids would appear to have been the first rock intruded before much movement had taken place in the rocks; they are sheared, cleaved, and crushed along the north-west and south-east lines.

Syenite was next intruded, generally along the main movement planes such as faults and the junction of the Brand Series with the Maplewell Series. It has been somewhat crushed by the movement, and its main divisional planes agree with the cleavage and faulting directions in the country.

A still later intrusion appears to be the Mount Sorrel Granite, which does not penetrate into the Forest proper, while it is in contact with rocks whose relation to the rest of the Forest has not been ascertained with certainty. It is the only igneous rock which effects any considerable amount of metamorphism in the clastic rocks with which it is in contact.

As to the age of the rocks, we have little to guide us. They are unlikely to be later than Cambrian; they are not at all like the fossiliferous Cambrian rocks of Nuneaton, they do not contain Cambrian fossils, nor do the Nuneaton diorites penetrate them. On the other hand, the movement by which they were affected came from the direction S.W. to N.E., whilst Lower Silurian and Cambrian





Sections of Nummulitic Limestone from Gaza-land, South-East Africa.

rocks are generally, except at Nuneaton, affected by forces which acted at right angles to this.

Professor Lapworth, when with me in Charnwood, succeeded in finding a worn burrow in the slates low down in the Brand Series, and Mr. Rhodes has since obtained one or two additional examples; these are the first undoubted fossils found in the Forest.

IV.—Note on the occurrence of Nummulitic Limestone in South-Eastern Africa.

By R. Bullen Newton, F.G.S.

(PLATE XV.)

THE object of this communication is to place upon record the existence of Nummulitic rocks in South-Eastern Africa; the result of an examination of specimens brought me by their discoverer, Mr. David Draper, F.G.S., of Johannesburg, the enterprising Secretary of the Geological Society of South Africa.

The specimens, comprising two pieces of limestone, were obtained *in sitû* from a spot about 100 miles westward of the mouth of the Busi River in Gaza-land. One is of a light-greyish colour, the other pink or flesh-tinted, and both are crowded with foraminiferal tests in a good state of preservation. Some of the organisms are exhibited in relief on the weathered surfaces, either as sections or exteriors, though for structural details it was necessary to prepare microscopical slides. When these were completed I was able to determine the presence of two rather important species, viz. *Nummulites perforata* and *Nummulites Biaritzensis*, both of which occur in abundance in Madagascar, India, and other localities.

Professor Rupert Jones, F.R.S., who most kindly undertook to examine the sections, not only confirmed my identifications, but was likewise able to point out some other forms, such as *Nummulites Guettardi*, *N. planulata*, and varieties of *Orbitoides papyraceus*. Professor Jones was inclined to regard the *N. perforata* as more closely allied to *N. Ghizensis* of the Pyramids, but as *Orbitoides* is absent in the Egyptian limestone he felt satisfied as to the correctness of the former name. Most of the species referred to are found in the light-coloured rock, the pink material yielding the forms of *N. Biaritzensis* and *Orbitoides*. Both large and small examples of *N. perforata* are present, the former measuring in their longest diameter 15 millimetres, and having an extremely small nucleus; the latter being only three or four millimetres across and possessing very large initial chambers. This difference in the same species forms a good illustration of the phenomenon usually alluded to as dimorphism.

Mr. Draper informs me that there is a large development of this limestone, and although at present without any accurate details of the beds, he hopes soon to return to this part of Africa, when he intends to re-examine the rocks and to construct a map of the district.

A short time since I called attention to the discovery of Upper Cretaceous strata at Sofala, proved by the occurrence there of *Alectryonia ungulata*;[1] now we have by this new evidence distinct information of the presence of Lower Tertiary deposits, probably capping the Cretaceous formation, in almost the same area of South-Eastern Africa.

The figures accompanying this notice on Plate XV are reproduced from photographs of the sections, whilst the specimens themselves have been kindly presented by Mr. Draper to the Geological Department of the British Museum.

EXPLANATION OF PLATE XV.

Figs. 1 and 2.—Photo-process-reproductions of two thin slices of Nummulitic Limestone (Eocene) prepared by Mr. Frederick Chapman, from hand-specimens obtained by Mr. David Draper, F.G.S., 100 miles to the west of the mouth of the Busi River, in Gaza-land, S.E. Africa, exhibiting sections of the tests of—

Nummulites perforata, De Montf. (Fig. 1.)
,, *Guettardi*, D'Arch.
,, *planulata*, Lamk.
,, *Biaritzensis*, D'Arch. (Fig. 2.)
Orbitoides papyraceus, var., Boubée.

The specimens seen in the sections are magnified four diameters.

V.—Oscillations in the Level of the Land as shown by the Buried River-Valleys and Later Deposits in the Neighbourhood of Liverpool.[2]

By T. Mellard Reade, F.G.S.,
President of the Liverpool Geological Society.

The geology of the neighbourhood of Liverpool is not on a superficial view very attractive. Nevertheless, to those interested in physical geology it presents some phenomena worthy of careful study.

Treating the subject on Lyellian principles, and proceeding from the latest to the earliest, from the known to the unknown, we have on the coasts of Lancashire and Cheshire an extensive fringe of blown sand. In Lancashire it covers about 22 square miles. In this blown sand I have shown from time to time that many geological phenomena may be studied, some of these being only in miniature. For instance, after a wet season succeeded by wind all the features of cross-bedding as exhibited in the Triassic rocks are beautifully developed in the sand cliffs after they have been cut into by a high tide. Again, sometimes after winter's rain the water, banking up inland against the barriers of sandhills, breaks its bonds

[1] Journal of Conchology, 1896, vol. viii, p. 136.
[2] An abstract read before Section C, Liverpool Meeting of the British Association, 1896.

after reaching a certain level and cuts out miniature river cliffs and terraces and alluvial fans and bottoms.[1] Many other interesting phenomena may be studied which I have no time to deal with here.

The blown sand over its larger area rests upon peat which, appearing on the shore at Alt Mouth, Lancashire, and Dove Point, Cheshire, in turn rests upon Scrobicularia Clays (the Formby and Leasowe Marine beds of my classification[2]). I have found *Scrobicularia in situ* in the erect position in which they lived in blue clay immediately underlying the peat at both places. I also found, by excavating through the peat at the Alt Mouth, a bed of cockles and other common marine shells at a depth of seven feet. Sewer excavations made under my directions at Birkdale and Hightown proved the continuity of the peat under the sandhills and its connection with the inland peat mosses. In the shore peat are the stools of trees, which are, I am satisfied with most other observers, in the position in which they grew. At the Alt Mouth they were very plentiful twenty years ago, and even so far back as 1796 there is an engraving in the *Gentleman's Magazine*, quite identifiable, exhibiting "Remains of a large Forest near Liverpool." Latterly the peat and trees have been to a great extent swept away by the encroaching tide. Oak was the most abundant, mixed with a great quantity of birch and some Scotch firs. Elytra of beetles are to be found in the peat and many bones of a small species of horse, antlers and bones of the red deer, skull of a *Bos longifrons*, etc. Similar mammalian remains are also found in the underlying blue clays and silts.

These clays and silts—the deposit getting siltier towards the base—in turn rest upon an eroded surface of Boulder-clay, which in certain rare cases has another layer of peat (Lower Peat bed) resting upon it. There is no doubt that the surface of the Boulder-clay represents a land-surface with quite as much certainty as does the Upper Peat, and one that is cut into channels by post-Glacial streams and filled up by post-Glacial deposits.

Underlying all these post-Glacial deposits come the Low-Level Marine Boulder-clays and Sands of Lancashire and Cheshire, which in turn repose upon the Trias, either the Bunter or the Keuper, which may be well studied in quarries about Liverpool. The Low-Level Marine Boulder-clays may be seen in the cliffs of Dawpool on the Dee and in numerous brickworks about Liverpool. The clay is usually of a brown or reddish-brown colour, and mechanical analyses through sieves show various quantities of sand and gravel mixed with clay and flour of rock. Many of the sand-grains are most highly polished and rounded, as also is some of the fine gravel. Mixed with the clay are the remains of numerous shells, of which I have myself collected 44 species, many being of a Northern facies.[3] The clay also contains Foraminifera, and in some places

[1] Science Gossip, 1881, pp. 198–206.

[2] "Post-Glacial Geology of Lancashire and Cheshire": Proceedings of the Liverpool Geological Society, 1871–2.

[3] Q.J.G.S. 1874.

in great abundance. At Cook's Lane, Great Crosby, 3 lbs. of clay yielded to Mr. Joseph Wright 900 of one species, viz. *Nonionina depressula*,[1] and the clay in the cuttings of the Seacombe Branch of the Wirral Railway yielded them plentifully.[2] All these clays contain boulders in varying proportions, mostly of Lake District Silurians, andesitic lava and ash, Eskdale granite and Buttermere granophyre, together with much Carboniferous Limestone and some flints. These are usually planed and striated, often intensely so. Very large erratics of similar rocks are also met with. One now in Sefton Park, dug out of the foundations of a school at Edgehill, of andesitic ash, weighs about six tons. One boulder of Carboniferous Limestone which I got in a brick-pit at New Ferry is bored with *Saxicava*, many of the valves being still in the holes *in situ*. It is also striated. Intercalated in the Boulder-clay are beds of sand and gravel, of which, perhaps, the best-known example is at Blackpool, where the Boulder-clays and sands as proved by boring are nearly 200 feet thick and rest on the Keuper Marls. In connection with the intercalated sand-seams are sometimes to be seen indications of shore action, as in the cuttings of the Wirral Railway before mentioned. Here a sand-bed of a few feet thick is intercalated in the clays and covers a large area. It is full of clay spheres and spheroids, evidently boulders of the Boulder-clay rolled on the beach of sand and sand-coated. Experiments made by Mr. T. W. Davies, F.G.S., show that it was impossible to coat a ball of the clay by rolling it in sand under water, but rolled in damp sand it quickly took up a shield of sand and shell fragments; hence we both of us inferred that the sand-bed represented an ancient shore.

The Boulder-clay, as already observed, rests in this neighbourhood upon the Trias, either Keuper or Bunter, and if the rock be of a nature fit to receive striæ they are usually found upon it, being generally in a north-westerly direction, though they frequently cross each other at an angle even in the same example, and at Millers Bridge I found cross striæ approaching a right angle. If the rock be soft it usually either grinds into sand or sand and rubble. I have never succeeded in finding a boulder lying upon the rock of which it could be said the striæ were due to it, but this may arise from the difficulty of making the observations. The surface of the Triassic rocks under the Boulder-clay without doubt represents a land-surface still older than the land-surface at the top of the Boulder-clay or that of the peat and forest bed. The evidence of this is the subaerial erosion which has shaped its orographic forms and the river-channels now filled up with Boulder-clay which ramify below the present surface. Such a pre-Glacial valley was proved to exist in the Mersey filled with Boulder-clay, which was predicted by me in 1873, and proved by the Mersey Tunnel twelve years afterwards. If the clay and sand deposits were

[1] "Foraminiferal Boulder-clay, Great Crosby": Proceedings of Liverpool Geological Society, Session 1895–6.

[2] Proceedings of Liverpool Geological Society, Session 1894–5.

stripped from the Triassic rocks, we should behold a landscape of a much more varied character than that which we now see.

If, as I have endeavoured to show, the geological facts related prove the existence of *three land-surfaces*, the first in time being pre-Glacial or, at all events, pre-Boulder-clay, and cut in the Triassic rocks, the second post-Glacial, represented by the buried eroded surface of the Boulder-clay, and the third indicated by the peat and forest beds, it is evident that there have occurred a good many variations in the relative levels of land and water. In the first or pre-Boulder-clay period, taking into consideration the known depth of many buried valleys, it is highly probable that this was a Continental period, with all the British Islands, united, and the various rivers converging into one large river traversing the basin now occupied by the Irish Sea, and delivering its waters into the Atlantic through the Straits of Galloway, where there is a "broad ditch" 600 feet below the general level of the bottom. The land then sank beneath the waves, and the marine Boulder-clay was deposited.

Certain supporters of land-ice as against every other cause maintain that there was no alteration of the relative level of land and sea at this time, but that the low-level marine boulder-clays and sands and the high-level sands and gravel are simply sea-bottom swept on to the land by an ice-sheet advancing from Scotland over the Irish Sea bed. Suppose we grant this contention, which 25 years' observations has led me to reject, the pre-Boulder-clay valleys running down to a level far below low-water remain unaccounted for, and it is necessary still to postulate a pre-Boulder-clay elevation of the land to account for these river-channels eroded in the Triassic rocks. If we admit this reasoning, and I see no escape from it, the *a priori* assumption against the probability of a movement of submergence during the Glacial Period, of which, I maintain, the whole of the marine glacial deposits up to 1400 feet are indicative, is knocked off its feet. The first period of oscillation, then, is represented by a high-level land-surface, followed by a subsidence of a river-valley system below the waves, and, I maintain, by a still further depression of 1400 feet during the deposit of the low-level marine boulder-clays and high-level sands and gravels containing marine shells.

The second period of oscillation represents an emergence of the sunken land from its extreme depression to a level above the sea considerably greater than we see now. In a minor manner stream and river valleys were cut in the Boulder-clay similar to those of the previous period. In the third and last period of oscillation a depression of the land again occurred to the 25-feet contour, and the post-Glacial silts and Scrobicularia clays were laid down upon the eroded surface of the Boulder-clay with its minor valley system.

Again a reverse movement took place, the land being elevated above its present level, allowing the growth of forest trees now swept by the tide, and finally these were submerged by the last downward movement of the land.

That this in outline is what geological history tells has happened in the neighbourhood of Liverpool, I have no manner of doubt. Similar movements of the land, not necessarily in this order or of the same frequency, are registered all round the coasts of England and Wales, Scotland and Ireland, as shown by dock or other excavations where the submarine geology can be explored.

Whether my hearers agree with me or not in the details of these land movements, he would be a bold man who would deny that they have occurred on a large scale during the periods named. Admitting the fact, the interesting question remains, what is the cause of these frequent oscillations of level. One favourite explanation at the present time is that it is the effect of isostacy, of a loading and unloading of the earth's crust by sedimentation and denudation. Let us examine this: the glacial deposits cannot average so much as 200, probably not 100, feet in thickness; the effect of such a loading would be inappreciable on the earth's crust, whatever view we take of the constitution of the earth's interior. If the addition of the glacial deposits cannot affect the foundations of the earth, still less can their partial denudation create a rise of land. The same reasoning applies with greater force to the post-Glacial deposits, as they are neither so extensive nor so massive. Alterations of the sea-level seem to me out of court, simply because such fluctuations must arise from gravitation to land masses, thus creating a greater difficulty to account for a lesser one, as the land masses have to be moved first before the water of the sea can follow.

Mr. Shone has suggested that the subsidence of the peat and forest beds has been due to subterranean erosion, but they occur at too regular levels and in too many places to render this a feasible explanation. Ice in the Glacial Period accumulating in great thicknesses on the land has been appealed to as a cause of submersion, and its melting of emergence. This is a more plausible suggestion, because there is nothing to bind us in our idea of the load, which we can pile up in imagination to any extent, but unfortunately it does not explain post-Glacial movements which are demonstrated to have taken place, not only by the facts I have laid before you, but by the shore terraces found in various places around our Islands.

It appears, then, that these pulsations of the land are not due to external causes, but to causes hidden from us in the earth's interior.

VI.—On the occurrence of Corundum produced by Contact-metamorphism on Dartmoor.[1]

By Professor K. Busz.

SOME three years ago, when travelling in Devonshire, I had the opportunity of visiting some places on Dartmoor, and of collecting on the border of the Dartmoor Granite some specimens of rocks, which on closer examination seemed to be of general

[1] An abstract of this paper was read before the British Association, Liverpool, September, 1896.

interest. Although I have not finished the examination of these, yet I have made some remarkable observations, which I should like to describe to the readers of this Magazine.

It is well known that the Dartmoor Granite is the largest of the numerous granite exposures of Devon and Cornwall. As to its origin and age, there have been brought forward very many different views and theories. Whatever these may be, it is, I suppose, generally understood that this granite-mass is of post-Carboniferous age. The Devonian, as well as the Carboniferous strata and their interbedded contemporaneous igneous rocks, have undergone great alteration at their zone of contact with the granite.

The place I visited, where these alterations are well exposed, is near South Brent, on the south end of the Dartmoor Granite, where a little stream, the Avon River, cuts right through the contact-zone.

The rocks affected by the contact-metamorphism are of different characters. I found Devonian clay-slate altered into chiastolite-slate and spotted mica-slate, while small seams of interbedded limestone have given rise to the formation of garnet and other minerals.

I may mention here that I found close to South Brent on the right side of the Avon River one of these limestone-layers, of about two yards' width, almost entirely changed into garnet. This garnet, grossularia (calcium-iron-garnet), is of a light-brown colour, and either shows the very well-developed form of the dodecahedron or occurs in granular masses with no distinct crystallographic form; it shows a very strong, anomalous, double refraction, and also very distinctly the partitioning into sectors described by Professor Klein. The crystals are sometimes imbedded in a saccaroid-grained white mineral, which chemical analysis proved to be the lime-felspar anorthite. Besides these, malacolite and axinite occur abundantly in this locality.

It may perhaps be of interest to mention that I have found Cassiterite to be present in some of the andalusite-bearing schists. It occurs not only imbedded in the long-shaped crystals of andalusite but also in the groundmass of the rock, and exhibits well-defined crystalline forms, which very often show the well-known twinning.

By the aid of hydrofluoric and hydrochloric acid I succeeded in isolating these crystals for chemical analysis.

All these alterations of the schists surrounding the granite, which we may call exomorphous contact-metamorphism, are of course very common, and can be observed more or less intensely developed in every granite-mass. Not so common, but, on the contrary, rather rarely observed, is endomorphous contact-metamorphism, and it is the latter to which I desire to draw the attention of your readers.

In the above-mentioned locality I found in close contact with clay-slate a felsitic porphyry, which, in a light grey-coloured groundmass, contained a few small but rather well-defined crystals of plagioclase. One specimen which I was able to collect consists, one half of this felsitic porphyry, the other half of clay-slate altered into black hornfels. The latter is very much broken, and the irregular-shaped pieces are surrounded by felsitic matter. The microscopic examination showed that the felsite contained a great number of very small colourless crystals, which sometimes show distinct hexagonal outlines and contain minute black inclosures. These crystals accumulate round the pieces of clay-slate, and decrease in number the further away from the slate one examines the slice. I have for some time been very much puzzled as to what this mineral could be. By dissolving a portion of the rock in hydrofluoric and hydrochloric acid a white powder remained, which under microscopic examination proved to consist solely of the crystals in question. By analyzing these I found nothing but alumina and very small traces of iron-oxide, probably due to the minute black inclosures, which I suppose to be magnetite.

I then tried to determine the hardness. I put a little of the powder between two cleavage-flakes of topaz, which after a little rubbing soon lost their lustre and became perfectly dull. There can be no doubt, therefore, that the mineral in question is corundum; and also, considering the manner in which it occurs, that it is not an original constituent of the felsitic porphyry.

My belief in regard to the origin of this corundum is this, that the eruptive rock, when the eruption took place, partly dissolved and absorbed the broken pieces of the clay-slate, and that afterwards in this felsitic matter, which was then supersaturated with alumina, the crystallization of the corundum took place on cooling.

We are aware of the fact that corundum as a product of contact-metamorphism is very rare, and has, indeed, only lately been described in one or two cases, which, however, are quite different from the occurrence on Dartmoor. I therefore thought it would be of some interest to record this discovery, all the more as it is, so far as I know, the first instance of the occurrence of corundum in this way in the British Islands.

VII.—On the occurrence of Sillimanite Gneisses in Central Anglesey.[1]

By Edward Greenly, F.G.S.

In the course of some traverses of the central region of Anglesey recently made, preparatory to mapping it out in detail, I observed a few facts which, in spite of the evident complexity of the structures, can, I think, be safely described before completion of the map, and are of some interest in connection with other recent researches in gneissose areas.

The region in question (see descriptions by Sir A. C. Ramsay, Dr. Callaway, the Rev. J. F. Blake, Sir A. Geikie, and others) extends across the island in a north-easterly direction from Llanfaelog to near Llanerchymedd.

To the south-west of the Holyhead Road granite appears to occupy the greater part of the surface, but to the north-east a complex system

[1] An abstract of this paper was read before the British Association, Liverpool, September, 1896.

of gneissose rocks is associated with the granite. Some of these, as about Craig yr Allor, are banded hornblendic gneisses and foliated diorites, whose strong resemblance to much of the Archæan gneiss of the North-west Highlands of Scotland has been pointed out by Sir A. Geikie.

But in the neighbourhood of the Holyhead Road the coarse granites can be seen in contact with quartzose and micaceous schists. The junctions are very clearly intrusive, the granite often passing quite abruptly across the foliation planes of the schists, and containing many included fragments of them. More frequently, however, the relations are those of sills, the granite lying between parallel folia, or passing across them at very gentle angles. Moreover, the schists contain, close to their junction with the granite, thin seams of quartz, which are full of fine needles of sillimanite, forming thoroughly characteristic "Faserkiesel." The granite shows no sign of chilled edges, being, so far as I have yet observed, quite as coarse at the junction as elsewhere. The phenomena are, in fact, very closely allied to those described by Mr. Barrow in the S.E. Highlands of Scotland, and also in a paper by Mr. J. Horne and myself, read before the Geological Society of London, on June 10 last, on "Foliated Granites and their Relation to Crystalline Schists in Eastern Sutherland." Fine granulitic quartzose schists, containing idiomorphic magnetite, also occur.

Although sillimanite occurs in certain seams in the schists close to the Holyhead Road, it does not appear to be abundant; and the crystalline texture of the schists is, on the whole, rather fine. But a little distance along the strike, to the north-east, the whole series of phenomena become much more pronounced. Coarse, wavy gneisses appear in which sillimanite is abundantly developed, knots and irregular seams of hard, pale sea-green "Faserkiesel," full of fine, lustrous needles, being conspicuous on their rugged, weathered surfaces. Innumerable granite bands and lenticles are interfelted with these gneisses, exactly as in Eastern Sutherland,[1] and synthetic gneisses of the same type occur all along the strike to the neighbourhood of Llanerchymedd. The beautiful biotite gneisses of the inlier at Tafarn-y-botel (whose resemblance to rocks of the Scottish Highlands has been noticed by Mr. Blake) are almost identical in character with those of Kinbrace, in Sutherland, a region of excessive metamorphism and intimate granitic injection. Sillimanite is of frequent occurrence, being sometimes included in the micas, which are large and well developed. The thin granitic seams contain large and beautifully striated oligoclase.

The whole series of phenomena closely correspond with those of Eastern Sutherland, and I have little doubt that they are of essentially the same nature. Certain rock types occur, however, which have not yet been observed in the latter country.

[1] In the recognition of these peculiar modes of granitic injection will, I think, be found a reconciliation of the conflicting views that have been held as to the intrusive or "interbedded" character of the granite. I should like also to draw attention to the very vivid and faithful description of these phenomena by Sir A. C. Ramsay ("Geol. North Wales," ed. 2, p. 243).

The progress of the mapping (a small part only of which is completed) will, I hope, throw light upon the relations of this highly crystalline series to the schists of undoubtedly clastic origin which occur in the island, as well as to those basic gneisses of Hebridean or Lewisian aspect which appear to form part of the same foliated complex.

VIII.—Recent Borings in the Red Marl, near Liverpool.[1]

By G. H. Morton, F.G.S.

Boring in the Red Marl near Altcar, North of Liverpool.

During the years 1890–2 an important boring was made in the Red Marl, rather under a mile NNE. of Altcar and nearly two miles east from Formby station. Previous to 1890, the formation was supposed not to exceed 400 feet in thickness, the amount proved at Birkdale many years ago. The following is a section of the strata passed through, condensed from details for which I am indebted to Mr. E. Fidler, who was connected with the undertaking :—

	Ft.	in.
Peat	5	0
Loam and sand	28	6
Boulder-clay	16	0
Sand and marl	8	6
Red Marl	971	0
Keuper Sandstone...	62	0
	1,091	0

The diamond boring machine was used, and the diameter of the borehole was thirteen inches near the surface, seven and six inches through most of the Red Marl, and five inches in the Keuper Sandstone. The dip of the strata was supposed to be a few degrees to the north-east, as determined by the cores brought up. The marl separated with thin laminæ, and the surfaces were often covered with pseudomorphic crystals of chloride of sodium from an eighth to an inch across, and they were most numerous in the middle and lowest beds. There were many seams of gypsum, which varied in thickness from a quarter of an inch to three or four inches, and a few diagonal cracks filled with the same mineral traversed the beds, and often contained fragments of marl and presented a brecciated appearance. The surfaces of the cores of gypsum exhibited pseudomorphs like those on the marl. Most of the marl was red, but sometimes a greenish grey, and the lower beds contained the tracks of annelids, which have been found on the same horizon in several other places in Lancashire and Cheshire. The Keuper Sandstone below the Red Marl was red and grey in colour, and there was an abrupt change from one formation to the other without any transitional strata between.

The object of the boring was to find brine or rock-salt, but it was unsuccessful, and the attempt was made in consequence of a

[1] An abstract read before the British Association, Liverpool, September, 1896.

tradition that prevails in the neighbourhood that salt water occurs below the surface. Mr. J. Dickinson, F.G.S., in his Parliamentary Report on "The Salt Districts," refers to a brine spring mentioned by Dr. Browning; and Baines, in his "History of Lancashire," states that it "contained as much salt as that at Northwich." Mr. Fidler informed me that though salt water has been frequently found near the surface in various places in the district, fresh water was found on penetrating to a greater depth.

I am inclined to think that the salt water found about the surface of the country is in consequence of frequent floods from the sea in former years, and the deposit of spray during storms. The wind carries the fine spray for many miles inland, and a film of salt has been found coating windows at a distance of twenty or thirty miles from the sea after storms, so that it is certain to impart a saltness to the soil over the land along the coast.

Boring in the Red Marl at Ford on the West of Bidston Hill.

Another boring in the Red Marl has been in progress during the last two years on the east bank of the Fender, a brook running from south to north into the Birket and finally into Wallasey Pool. The object of the boring was to obtain an additional supply of water for Birkenhead, and I am indebted to Mr. W. A. Richardson, C.E., for the following section of the strata passed through:—

	Feet.
Surface-soil	1
Boulder-clay	45
Sand and gravel	16
Red Marl	454
Keuper Sandstone	244
Fault rock	7
Upper Soft Sandstone of the Bunter...	133
	900

The boring was made with a revolving iron disc with steel chisels, two feet in diameter, suspended by a flat rope, but the cores brought up were only four inches across, most of the rocks having been broken into fragments, sand and clay. The cores showed that the strata were horizontal. The Red Marl was found to be much harder than usual, and principally composed of tough argillaceous sandstones and shales nearly all of a red colour. Very little gypsum was found, and the entire absence of pseudomorphic crystals was remarkable. It seems probable that the deposit was formed in deeper water than the Red Marl at Altcar.

At Greasby, a village two miles west of the boring, there are some beds about two inches thick containing small ramifying tube-like cavities from $\frac{1}{40}$ to $\frac{1}{60}$ of an inch in diameter. They have been supposed to be at the base of the Red Marl, but were found at several horizons in the boring, and evidently do not indicate the base, so that the beds at Greasby may be considerably above it. The Red Marl ended at the depth of 516 feet below the surface, so that deducting 62 feet for the superficial deposits the thickness is 454 feet, being about double the amount it was expected to be. There was an abrupt change from the Red Marl into the underlying Keuper Sandstone, which was penetrated to the depth of 244 feet, when a fault was crossed and the Upper Soft Sandstone of the Bunter proved to the depth of 133 feet.

The Geological Survey Map of the district (Sheet 79, N.E.) distinguishes the Red Marl from the "Waterstones" at the base over the centre of Wirral, but it does not seem possible to have made such a distinction in South-West Lancashire, where both are included in the Red Marl. At Ford most of the marl is of an arenaceous character, while on the east of Liverpool the beds are softer and include more shale and clay. It seems, however, that the Keuper Sandstone in Wirral is of less thickness than it is under Liverpool, and that the upper beds there are represented by the "Waterstones."

IX.—The Great Submergence: an Interpretation of the Clava Section, near Inverness, Scotland.[1]

By John Smith, Monkredding.

THE interesting section at Clava, near Inverness, was first examined geologically by Mr. James Fraser, C.E.; and his remarks on it were published in the Transactions of the Geological Society of Edinburgh, vol. iv, part 2, and in the Transactions of the Inverness Field Club, vol. ii.

As this section contains a thick bed of shelly clay situated at a height of 503½ feet above sea-level, it has become, owing to its uniqueness[2] in Scotland, of the very greatest interest to geologists, so much so that it has been examined and reported on by a committee appointed for the purpose. The finding of the majority of the committee has been that the shelly clay is in position, as it was deposited on a sea-bottom. The minority (Mr. D. Bell and Mr. P. F. Kendall) think that the shells were carried uphill by ice from Loch Ness, then an arm of the sea. I throw in my lot with the majority, and shall give my reasons for doing so.

At the invitation of Mr. Bell I had an opportunity of examining the section, and spent part of a day there when the Committee made one of their visits to Clava. This was at the time when the large pit was dug, and there was an excellent opportunity of inspecting the section, and especially the shelly clay.

The section at the main pit, as published by the Committee, is as follows, the lower part having been ascertained by boring:—

	Feet.
1. Surface-soil and sandy boulder-clay	43
2. Fine sand (stratified, yellowish-brown)	20
3. Shelly blue clay with stones in lower part	16
4. Coarse gravel and sand	15
5. Brown clay and stones	21½
Solid rock, Old Red grit.	

[1] Read to the Geological Society of Glasgow, February 13, 1896.

[2] Since this was written I have discovered in Ayrshire very numerous exposures of shelly clay at various levels, from a little above high-water mark to 1061 feet above sea-level.

A few sentences may here be given from the report of the Committee—

"The highest part of the shelly clay in the 'main pit' is 503½ feet above sea-level. The deposit is 16 feet thick in that section, and appears to be continuous for a distance of at least 190 yards in a well-nigh horizontal position." . . . . "It contains a small proportion of stones usually well-rounded and chiefly near the base." . . . . "The shells are chiefly shallow-water species; some might have lived at a depth varying from 15 to 20 fathoms[1] . . . but the majority are littoral forms." . . . . "The shells on the whole are remarkably well preserved, many retaining their epidermis. They are neither rubbed nor striated." . . . . "The pressure of the ice that formed the overlying 43 feet of Boulder-clay would be sufficient to account for the crushing of certain shells, the compression of the annelid tubes, and the production of the system of cracks in the clay."

These quotations agree perfectly with what I myself observed at the Clava pit. I will now first attempt to show, having regard to the facts of the case, that it is physically impossible that the shelly clay with stones, or even the shells, can have been transported uphill by ice.

Stones may be carried long distances by ice, even uphill, without being striated, but they must fall on the surface of a glacier. The moment a stone reaches the bottom of the ice it will begin to be striated. The shelly clay cannot possibly have fallen on the surface of the ice, neither could it have been carried up *under* it without many of the shells (if not all, in this case) having been striated. *Now, not a fragment of a striated shell has been found in the shelly clay.*

Neither are the stones in the shelly clay striated. This point I can myself attest, as I superintended the washing of the stones from which the percentages were taken, and only *three* of them showed *faint* striations, two of the stones having been obtained when I was present. A stone striated on *one* side had the mark of attachment of a *Balanus*. It cannot therefore possibly have been striated *after* the *Balanus* had grown on it. It was more likely to have been a scratched stone washed out of the Lower Boulder-clay

[1] In the body of the report it is stated that some of the species still live at 100 fathoms.

I asked Mr. J. T. Marshall, of Torquay, one of the authorities on recent shells, to give me the depths at which some of the species found in the Clava section still live, and he has furnished me with the following information:—

Astarte compressa	3 to	2000	fathoms.
,, sulcata	3	400	,,
Leda pernula	5	210	,,
,, tenuis (pygmæa)	0	240	,,
Nucula tenuis	3	365	,,
Tellina calcarea	0	128	,,
Natica Grœnlandica	2	1290	,,
Pleurotoma turricula	10	150	,,
,, Trevelyana	6	189	,,
Trochus Grœnlandicus	0	150	,,
Trophon clathratus	3	530	,,

during the subsidence, from which the striæ had not been wholly removed by subsequent attrition.

As no one holds the opinion that the shelly clay was transported *en masse*, this point need not be discussed. I merely remark that we see how Carboniferous shale which had been torn up by a glacier may be drawn out into a *long thin band* before it travels many yards. This would be the fate of any shelly clay adhering to the bottom of a glacier.

Mr. Bell, in his paper published in the Geological Magazine in July, August, and September, 1895 (pp. 321, 348, and 402), offers the following explanation of the mode of formation of the shelly till. He says: "We have said that, if transported by the ice, it does not 'necessarily follow' that the whole of this deposit was conveyed simultaneously, or *en masse*. Briefly, our idea is that it may have been conveyed very gradually, and deposited in an *extra-glacial* lake, formed at this point along the side of the ice-sheet, into which part of the materials being carried by the latter (fine mud, rounded stones, shells, etc.) dropped and were accumulated."

I have already stated that it is physically impossible that part of a sea-bottom could be taken up and carried forward by ice (in the Clava case the marine material would require to have travelled over "hill and dale" some ten miles) without the shells being striated. We have plenty of shelly tills that have been dragged a bit by land-ice, but in them the shells (nearly always fragments) are mostly striated. Two stones from the shelly clay had several *Balani* attached to them, and three others had marks of the bases of *Balani* still upon them. Some of the shells of *Astarte* had both valves *in position*, but crushed.

But for argument's sake let us suppose that the ice has delivered its burden at Mr. Bell's hypothetical lake some 500 feet above the present sea-level, or some 400 feet above the then sea-level, for Mr. Bell's hypothesis demands a small subsidence. In the first place, the stones (now in the shelly till) would require to have had their striæ removed, which could only have been done by being rolled in water. (They are all well-rounded stones, and could not have fallen *as splinters* from a cliff upon the top of a glacier.) Now the Clava shelly clay says—"No, this cannot have been the case. *I am a mud; there were no currents flowing where I was laid down*; there is not a single line of stratification in me." In the second place, there would be water flowing through this hypothetical lake which would cause the deposits to be stratified. And there would be the further impossibility of substituting *complete* for broken and scratched shells.

It is clear, then, that this deposit (the shelly clay) could not possibly be formed in this way; it is a deep-water deposit formed in the sea where there were no *bottom* currents. Had it been formed in an upland tarn it ought to have contained abundance of vegetable matter, fresh-water mollusca, fresh-water diatoms, fresh-water Ostracoda, etc.; *but there is not a vestige of anything organic in it that is not marine.*

The fossils from the shelly clay may be tabulated as follows:—

	Species.	
Mollusca	24	
Decapoda	2	
Cirripedia	1	
Ostracoda	24	
Annelida	1	
Foraminifera	36	
Total	88	All *marine* species.

I will now give my own interpretation of the Clava section, commencing with the lowest bed.

Bed No. 5 is described as "brown clay and stones," and is probably the Lower Boulder-clay, but as it is only known from boring, nothing further need be said about it.

Bed No. 4 is composed of coarse gravel and sand. I shall call it the basal gravel of the Interglacial Period, and explain my reason for this. When a country is sinking below the sea, the shore waves constantly agitate the material they come in contact with, washing out the mud and forming gravels and sands. These may in time form what are known as *basal conglomerates*, from being found at the bases of the great formations. This bed, then, I take to have been formed by the waves when the land was sinking. It may originally have contained abundance of shells, etc., but in such loose material fossils are seldom preserved.

On the top of it comes the *shelly clay*, 16 feet in thickness, with stones up to six inches in diameter, mostly in the lower part. It has no stratification, no bedding-planes; the stones cannot, then, have been rolled into it by bottom currents.[1] If they had been so derived it would have been a *gravel* bed instead of a mud bed with stones; currents strong enough to have rolled along stones from two to six inches in diameter would have swept away all the muddy material.

The shelly clay has been formed in deep water by *surface currents* carrying muddy water, and thin shore-ice carrying mud, sand, stones, and littoral species of shells. It also contains ten species of shells that may have lived at a depth of 150 fathoms; and as many of those which have lived at moderate depths may have been cast ashore and caught up by the shore-ice which carried the stones, there is no difficulty, in this view, of seeing how shells which lived at different horizons may have been commingled in the Clava shelly clay.

The next bed is composed of fine stratified sand, with some very small stones. It is 20 feet in thickness, and is yellowish-brown in

[1] At a depth of $3\frac{1}{2}$ feet in the clay a horizontal line was observed, and at 6 or 7 feet streaks or thin layers of sand and gravel were seen, but these do not at all affect the argument. There was also a transition bed of 2 feet in thickness at the bottom of the shelly clay, with a well-defined bedding-plane between it and the gravel bed below, the 2 feet bed being mixed with fine gravel.

colour. It has been formed by bottom currents, and has every appearance of a sand that was at one time filled with shells which have been dissolved away by acidulated water. It is, in fact, what is known as a "rotten sand."

At page 14 of the report it is stated that spines of *Echinus* and *Spatangus* were obtained in No. 6 bore at a depth of 21 to 24 feet, in hard-bound sand. This may have been the same bed as the above.

The top bed is *sandy* Boulder-clay and stones, of the great thickness of 43 feet, and I take it to be a ground moraine[1] of the second glaciation.[2]

I have now only to add that when the glacial deposits (drift formation) receive a closer examination than has hitherto been given to them, many more proofs of their marine origin will, I think, be forthcoming. The most accessible exposures are the scaurs of drift along the stream courses, and I seldom return from a day's examination of them without finding additional proofs of the *whole drift formation* having been deposited in the sea.

X.—Notes on the Globigerina Limestones of the Maltese Islands.

By John H. Cooke, F.G.S.

THE Globigerina Limestones of the Maltese Islands consist of a series of beds of varying character, the upper portions of which belong to the Lower Langhian, while the lower are referred to the Upper Aquitanian. The formation extends throughout both islands, but in the north-western and western portions it is masked by overlying beds of clays, greensands, and limestones, of Tortonian and of Helvetian age.

The Maltese Langhian may be divided, lithologically, into two well-marked sub-series—the upper, which includes the "Marls and Clays," and extends from the base of the Greensands to the top of the Globigerina Limestones; and the lower portion, which includes the beds A to F of the "Globigerina" series. Palæontologically both divisions agree closely, and contain such characteristic Langhian forms as *Aturia aturii* and *Pecten denudatus.* The palæontological analogies of the two groups are shown in the synoptical table of fossils at the end of this paper. The total thickness of the formation ranges from 150 feet to 250 feet.

Regarded vertically the following tabular summary gives the serial order and the thicknesses of the subdivisions.

[1] From what I have since seen in Ayrshire I have been obliged to abandon the idea that the Boulder-clays are *ground moraines* pure and simple. I think there is ample proof that they are *marine deposits.* In places where they have been *dragged* a bit by the last glacier-ice they become ground moraines.

[2] It is not here argued, of course, that during the period between the two Boulder-clays the country was entirely free from ice.

THE GLOBIGERINA LIMESTONES.

Sub-division.	Lithology.	Thickness	Series.	Equivalents in Vienna Basin.
A	A ferruginous, argillaceous freestone.	15 to 30 ft.	Langhian.	Horner Schichten
B	First seam of phosphatic nodules.	1 foot.		
C	A fine-grained, bluish freestone.	30 to 50 ft.		
D	Second seam of phosphatic nodules, with smaller seams above and below locally developed.	1 to 2 ft.		
E	Fine-grained limestone, with several bands of phosphatic nodules locally developed.	35 to 50 ft.		
F	A massive, compact limestone, with chert nodules.	30 to 50 ft.		
G	Third nodule seam.	1 to 2 ft.	Aquitanian.	Solszka-Schichten
H	A variously textured limestone, with phosphatic nodules sparsely distributed.	50 to 80 ft.		
I	Fourth seam of phosphatic nodules.	2 to 4 ft.		

Bed A.—The "Marls and Clays" that overlie this formation graduate downwards into a close-textured, fine-grained freestone, the upper portion of which contains from 25 to 30 per cent. of alumina, but towards the lower part this percentage decreases until the ratio of alumina to calcium carbonate is as 1 to 9. The bed is variously coloured, the upper layers being generally of a bluish-grey, and the lower part of a light-yellow or yellowish-ashen colour. Iron pyrites abound, and it is to the decomposition of these that the tinctorial variations are due. Organic remains are plentiful, but as a rule they are so pseudomorphed with either peroxide or phosphate of iron, as to be barely recognizable. The carbonate of lime, of which the shells were originally composed, has been wholly or partially replaced by carbonate of iron, and this, by subsequent oxidation, has been converted into a hydrous peroxide. The pyritized condition of the fossils is a feature of this bed. The most prevalent and characteristic forms are *Aturia aturii*, *Pecten Koheni*, *Pecten denudatus*, *Chenopus pes-pelicani*, *Dolichotoma cataphracta*, *Nuculana fragilis*, and *Marginella Deshayesi*. Many forms of the Gorgonidæ,[1] e.g. *Isis Peloritana*, *I. Melitensis*, and *I. compressa*; the claws and carapaces of *Cancer macrocephalus*; and the tests of pteropods, chiefly *Vaginella* and *Hyalæ*, invested in thin metallic-iron coverings, are also numerous.

The *Scalariæ*,[2] which make their first appearance in division F, and are continued in the successive beds up to the "Marls and Clays," are here represented by the minute form *S. Melitensis*, Fuchs.

[1] For the determination of the Gorgonidæ I am indebted to Professor Angelli, Università di Roma.

[2] Mr. G. F. Harris, F.G.S., kindly determined the *Scalariæ*

Of the Echinodermata, *Echinocyamus Studeri*, *Echinolampas Manzoni*, *Hemiaster vadosus*, *Sarsella anteroalto*, and *Schizaster Parkinsoni*, are found here and in the underlying divisions B, C, and D.

At this horizon lignite is of common occurrence. Mr. N. Tagliaferro described a piece, in the pages of the *Mediterranean Naturalist* for June, 1893, that measured 11 ins. × 4 ins. × 1 in., and which a microscopical examination showed to be the outer layer of a tree-trunk.

Division B: the first nodule seam.—A seam of phosphatic nodules forms the base of the limestones of division A. The cliff exposures along the southern shores of Malta show this seam to average about 9 inches in thickness, and the nodules are small and sparsely distributed. But in the hill escarpments of Emtarfa, Wardia, Boschetto, and Hempsia it averages 15 inches, and the nodules are large, numerous, and compactly cemented together in a phosphatic paste. Most of the nodules and the fossils found with them are of a jet-black colour, and they have a high, metallic lustre. In composition they vary from the nodules contained in the underlying seams, being composed for the most part of phosphate of iron. Of the fossil organisms the corals are a noteworthy feature. The following species occur in abundance: *Trochocyathus laterocristatus*, *T. pyramidatus*, *Flabellum avicula*, and *F. intermedium*. All of these species have a considerable vertical range, being also found in the Tongrian of Dego, the Helvetian of Torino, of Belforte, and of Val Salice, the Tortonian of Tortona and of Stazzano, and in the Pliocene of Zinola. In the Maltese Islands they occur in the subdivisions A to I.

Division C.—This bed consists of a variously textured rock, having a reddish-yellow colour. The upper portion is coarse and susceptible to weather influences; but it merges imperceptibly into a fine-grained, compact limestone, massive and homogeneous, and with a total absence of the tendency to cleave which characterizes the coarser variety. Small concretionary masses of hæmatite and chert frequently occur, and when the rock is cut through they appear on the slabs as black or red blotches which are known locally as *suaba* or finger-marks. Thin layers of phosphatic nodules are locally developed at Fom-ir-Rieh, but they seldom extend far. The fauna of the bed is similar to that of B and D; but several fossils of note occur in it that are deserving of mention. A portion of a carapace of turtle, *Tryonx Melitensis*, Lyd., was obtained by Mr. G. Gollcher; a fragment of the symphysial part of the slender mandible of ?*Ichthyosaurus gaudensis*, Hulke, was exhumed at Marsa Forno; the greater portion of the jaws of *Tomistoma champsoides* and the remains of numerous crocodilians and whales have been obtained from this horizon by Adams and others.

The Brachiopoda are here well represented by *Terebratula caput-serpentis*, *T. minor*, and *T. Cortæ* var. *parumlobata*, De Greg.

Division D: the second nodule seam.—This bed consists of an aggregation of irregularly-shaped nodules, intermixed with enormous quantities of the phosphatized remains of molluscs, echinoderms, crustaceans, corallines, fish, and cetaceans. It has an average thickness of about 18 inches, and it is very uniform in its general physical and chemical aspects. The interstitial cement contains about 2 per cent. of phosphoric anhydride, all of which is found in combination with iron, alumina, or lime. These nodules contain a much higher percentage of alumina and of iron than do the nodules of seam iv.

The following analysis shows the composition of the nodules of this seam :—

Carbonate of lime ($CaCO_3$)	40·24
Sulphate of lime ($CaSO_4$)	1·55
Phosphate of lime ($Ca_3\ 2PO_4$)	39·52
Phosphates of iron and alumina...	6·50
Residue...	12·00
	99·81

The interstitial cement is of a very soft nature and readily disintegrates. The nodules and fossils therefore drop out in considerable quantities along the bases of the valley escarpments, and, becoming incorporated with the soil, they render it highly fertile and productive. Many of the fossils are of a jet-black colour, due to the substitution of the pre-existing phosphate of lime for phosphate of iron by the decomposition of bicarbonate of iron.[1] *Pecten denudatus*, *P. Pandora*, and *P. varians* occur ; *Scalaria retusa* is common ; but *S. Ducei* is rare. Among the echinoderms *Brissopis crescenticus*, *Schizaster Parkinsoni*, and *Brissus latus* are common. Pteropods and large-sized Foraminifera, chiefly *Cristellaria* and *Nodosaria*, are enormously prevalent, as well as the teeth of Telostean and other fish, and the rib-bones and vertebræ of Cetaceans.

Division E.—This bed is fully developed in nearly every portion of the two islands, and it is, therefore, the most conspicuous stratigraphical member of the series. In colour it varies from blue to a pale ashen-gray, and it has an average thickness of about 40 feet. It is traversed at different levels by two thin seams of phosphatic nodules ; but though of frequent occurrence they are only locally developed. They commence and break off very abruptly. At Maddalena, near the northern extremity of the Great Fault, three of these seams are shown, the uppermost of which is very pockety and disappears in an easterly direction, while to the westward it thins out and breaks off abruptly. The remaining two may be traced for 50 yards to the east, when they, too, break off abruptly. Thin mounted sections of the rock show them to be made up almost entirely of the tests of minute foraminifera, among which *Globigerinæ* predominate. The corals and the *Scalariæ* now become very rare ; and pelagic mollusca and other forms characteristic of deep waters take their place. *Terebratula sinuosa*, *Balantium*, and *Vaginella depressa* occur at this horizon. I obtained two specimens of *Aturia aturii* (British Museum Collection) from the middle of

[1] Bicarbonate of iron would be formed by the reaction of iron-oxide, and carbonic-oxide derived from decaying organic matter.

this bed; but below this, *Aturia* does not seem to occur, its place being taken by a large nautiliform cephalopod, many casts of which may be seen in the Valetta Museum.

Division F.—The rock of this division is a yellowish, soft-textured limestone, homogeneous and fine-grained, and composed for the most part of minute, thin-shelled tests of foraminifera. The formation extends throughout the islands, but it varies in thickness from 50 feet in the western parts of Gozo to 30 feet in eastern Malta. A characteristic feature of the bed is the quantity of siliceous concretions which occur in the lower parts of the formation. These concretions have already been described.[1] The upper portion of this bed is not prolific in fossils, but in the lower part, and especially in and around the pockets of phosphatic nodules, numbers are to be found in a good state of preservation. The mollusca are numerously represented: *Pecten denudatus*, *P. spinulosus*, *P. cristatus*, *Conus dubius*, *C. Russigeri*, and casts of *Arca* are very common. Of the corals, the eight species that occur in the overlying beds are also found here.

The remains of cetaceans and sharks are common, and it was from this horizon that the teeth and vertebræ of *Phoca rugosidens*[2] were obtained. It is noteworthy that no *Scalariæ* have been found below this bed. *Cirsotrema retusa*, *C. Ducei*, and *C. pumiceum* were found above the third nodule seam, but they were rare. Another interesting fossil which seems to make its first appearance here is the pteropod *Cavolina Cookei*, Simonelli.[3] Its vertical range is very limited, as it appears to be strictly confined to this horizon. The pockety phosphatic seams at Kala and Xeuchia in Gozo yield it in comparative abundance. During the construction of the new dock at Burmola, numerous ribs, vertebræ, and teeth of reptiles having crocodilian affinities were discovered in this bed. A portion of a skull of *Tomistoma champsoides* with teeth *in sitû* and with two vertebræ imbedded by the side of it were obtained from the lower portion of the bed by the Dock engineer, and were presented by him to the Valetta University. Several large pieces of amber, of a dirty brown colour and semi-opaque, were found imbedded in the rock at the same place.

Division G: the third nödule seam.—This layer of phosphatic nodules forms a well-marked horizon in the strata of Malta and Gozo. The nodules are small, and they have a greenish lustre due to the presence of glauconite and phosphate of iron. In chemical composition they vary considerably, those portions of the seam being the richest in phosphoric acid which are the more compact and fossiliferous. The following analysis made by Mr. J. P. Walton, A.R.S.M., represents the average composition of the bed:—

[1] Cooke, J. H., "On the Flint and Chert of the Globigerina Limestones of the Maltese Islands": Geol. Mag., Dec. III, Vol. X, 1893, p. 157.

[2] *Ibid.*, "On the occurrence of *Phoca rugosidens*, Owen, in Maltese Strata": Geol. Mag., Dec. IV, Vol. II, May, 1895, p. 215.

[3] Simonelli, V., "Sopra un nuovo pteropod del miocene di Malta": Bol. del. R. Com. Geol. d'Italia, June, 1894.

Carbonate of lime	51·70
Phosphate of lime	41·46
Peroxide of iron	1·82
Insoluble siliceous matter	3·55
Moisture, etc.	1·47
	100·00

This seam is specially interesting, as it seems to mark the line of demarcation between the Langhian and the Aquitanian series. It is not so fossiliferous as the other phosphate seams. *Pecten denudatus* and *Aturia aturii*, which are so characteristic of and prevalent in the overlying beds, are neither found here nor in any of the strata beneath. Teeth and bones of *Phoca rugosidens*, Owen, were obtained from this horizon in the neighbourhood of Marsa Forno, Gozo. *Pentacrinus Gastaldi, Scalpellum Melitensis, Trochocyathus latero-cristatus, T. pyramidatus, T. vericostatus,* several species of *Flabellum*, and *Stephanocyathus*,[1] are very abundant.

Division H.—This bed of limestone constitutes a considerable bulk of the series that represent the Maltese Aquitanian. It varies from 50 to 80 feet in thickness, and it crops out in every valley and cliff in the two islands. The general character of the bed is that of a yellowish-grey limestone. Sections of the rock under the microscope show it to be made up almost entirely of the calcareous skeletons of foraminifera, among which those of the Globigerinæ, Textulariæ, Uvigerinæ, and Orbulinæ are the most numerous. Minute grains of glauconite, granules of oxide of iron, and curiously-formed nodular masses of manganese having radiating arms of the same mineral, are also abundant.

Coccoliths and rhabdoliths are also present, and like those contained in the *Pietra Leccese* and in the Sicilian rocks (Ragusa) they are of forms similar to those that have been collected in the Adriatic in depths of from 500 to 700 fathoms and described by Schmidt.[2] This limestone is remarkable for the change in the fauna which manifests itself. *Scutella striatula, Thecidium Adamsi, Heterostegina Stricklandi, Cidaris Scillæ,* and *Echinolampas posterolatus,* occur sparingly; but they have not been found in any of the overlying beds. Towards the base of this bed, as well as in phosphate seam iv and in the transition bed at Ricasoli, they are very abundant. A considerable number of fish-remains have been obtained from this horizon in the quarries at Luca. During the governorship of Sir William Reid many of them were figured; but the illustrations were not sufficiently accurate to render them of much scientific value. These illustrations, as well as the original fossils, are now in the Valetta Museum, but the latter are in a very indifferent condition. Spratt[3] has recorded the occurrence in this bed of a fossil turtle; and at St. Julians and Dingli the teeth and

[1] I am indebted to Professor Angelli, of Rome, for the determination of the corals.
[2] Capellini, G., "Della Pietra Leccese e di Alcuni suoi Fossili," Bologna.
[3] Spratt, T., "On the Geology of Malta," Valetta, 1854.

vertebræ of *Stereodon Melitensis*, a fish having sauroid dentition, were found.[1] Leith Adams obtained ear-bones, caudal vertebræ, and a penultimate molar of *Halitherium*[2]; and in the Valetta Museum are several large vertebræ of *Zeuglodon* that, judging from the limestone matrix on them, were also obtained from this bed.

Division I: the fourth nodule seam.—The fourth or lowest seam of phosphatic nodules averages three feet in thickness, and ranges from two to four feet. The nodules are irregular in shape, and generally present an exceedingly wrinkled and coriaceous appearance. Nearly all of them contain one or more fossil organisms, around which the phosphate of lime has segregated; and in many cases they consist almost entirely of the shells of foraminifera. Phosphatized remains of molluscs, corals, and echinoderms, the teeth and vertebræ of sharks, bones of whales, and immense quantities of casts and pseudomorphed tests of pteropods, *Vaginella* and *Hyalea*, enter largely into the composition of the seam. Alluding to the origin of these nodules, Dr. John Murray[3] points out that they are precisely similar to the phosphatic nodules that were dredged from modern sea-beds during the voyage of the "Challenger," and he is of opinion that these nodules, like their modern prototypes, were formed *in sitû* at the bottom of the Oligocene sea. A sample of rock from this seam was sent to Professor J. F. Blake for analysis and report. The following was the result:—

Sulphate of lime	1·97
Carbonate of lime	51·12
Phosphate of lime	31·66
Alumina	10·55
Silica	3·83
Moisture	·87
	100·00

Conclusion.—The foregoing details afford evidences as to the nature of the bathymetric conditions that prevailed when these strata were deposited. These conditions have already been indicated by Dr. John Murray[4] and Dr. J. W. Gregory,[5] and I shall therefore now confine myself to a brief summary of the conclusions which the details in this paper seem to corroborate.

The Globigerina Limestones of the Maltese Islands are broadly divisible into three sections—

I. The lowest beds, comprising the subdivision *I* and the lower

[1] Cooke, J. H., "Notes on *Stereodon Melitensis*, Owen": Geol. Mag., Dec. III, Vol. VIII, December, 1891, p. 546.

[2] Adams, A. L., "On the Discovery of the Remains of *Halitherium*": Q.J.G.S., vol. xxii, p. 595.

[3] Murray, Dr. J., "The Maltese Islands, with special reference to their Geological Structure": Scot. Geog. Mag., vol. vi, p. 449.

[4] *Vide ante.*

[5] Gregory, J. W., "The Maltese Echinoidea, etc.": Trans. Roy. Soc. Edin., vol. xxxvi, p. 585.

portion of *H*, have a composition of from 70 to 90 per cent. of calcium carbonate, and are made up for the most part of shallow-water organisms. These limestones, together with the underlying transition bed and the upper portion of the Lower Coralline Limestone, were laid down on a sinking sea-floor and in about 300 fathoms of water.

II. The subdivisions *D*, *E*, *F*, *G*, and the upper portion of *H*, are composed of from 80 to 90 per cent. of calcium carbonate, the greater portion of which consists of Globigerina and other pelagic organisms. These were probably deposited in about 1000 fathoms.

III. The subdivisions *A*, *B*, and *C* contain from 50 to 70 per cent. of lime. These, together with the overlying "Marls," are considered by Dr. John Murray to have been laid down on a rising sea-floor and to have been within the influence of river waters and their detrital products. They were probably laid down in about 300 fathoms.

The following is a list of the fossils of the formation, about one-half of which are new to the palæontology of the Maltese Miocene, and many are new to science.

Palæontology.—The figures 1, 2, 3 placed after the names of the fossils indicate the occurrence of the fossils in the three sections referred to in the conclusion.

MAMMALIA:

Carnivora—	*Sirenia*[1]—	*Cetacea*—
Phoca rugosidens, Owen, 1, 2.	? Halicore, 1, 3.	Zeuglodon, 3.
	Halitherium, 1, 2, 3.	Delphinus, 1, 2, 3.
P. Scillæ, Capellini, 1.	? Manatus, 1, 2, 3.	Cetacea (gen. ?), 1, 2, 3.

REPTILIA—

? Ichthyosaurus gaudensis, Hulke, 3.
Tomistoma champsoides, Lyd., 1, 3.
Crocodilus gaudensis, Hulke, 1, 3.
Tryonx Melitensis, Lyd., 3.

PISCES—

Stereodon Melitensis, Owen, 1, 2.
Notidanus primigenius, L. Ag., 1, 2, 3.
Platax Woodwardi, L. Ag., 1.
Oxyrhina xiphodon, L. Ag., 1, 2, 3.
O. hastilis, L. Ag., 1, 2, 3.
Carcharodon megalodon, L. Ag., 1, 2, 3.
Carcharias, 1, 2, 3.
Holocentrum Melitense, A. S. Woodw.
Odontaspis Hopei, L. Ag., 1, 2, 3.
Sphærodus, 3.
Sphenodus, 3.
Hemipristis serra, L. Ag., 1, 2, 3.
H. paucidens, P. Gerv., 2, 3.
Lamnidæ, 1, 2, 3.
Diodon Scillæ, L. Ag., 2.
Ætobates, 3.
Chrysophrys, 1, 2, 3.
Scyliidæ, 1, 2, 3.

MOLLUSCA: (1) *Cephalopoda*—Aturia aturii, Basterot, 3. Nautilus, sp. ? 2, 3.

(2) *Pteropoda*—

Vaginella depressa, Daudin, 1, 2, 3.
Cavolina Cookei, Simonelli, 2.
Hyalea taurinensis, Sism., 1.
H., sp., 1, 2, 3.

(3) *Gasteropoda*—

Conus Melitensis, De Greg., 2, 3.
C. Mercati, Brocchi, 2, 3.
C. dubius, Gulia, 1, 3.
C. Melitosiculus, De Greg., 3.
C. Ruschi, Michelotti, 1, 2, 3.
Conus Russigeri, Haues, 1, 2, 3.
C. betulinoides, Lamarck, 1, 2, 3.
C. (casts indet.), 3.
Dolichotoma cataphracta, Brocc., 3.
D. ramosa, Brocc., 3.

[1] Most probably all the Sirenian remains found in Malta are referable to the genus *Halitherium*.—EDIT. GEOL. MAG.

Cirsotrema Swanni, Adams, 3.
C. scaberrima, Mich., 2, 3.
C. Melitensis, Fuchs, 3.
C. Ducei, Wright, 1, 3.
C. crassicostatum, Deshayes, 2.
—— *var.*, 3.
C. retusa, 2, 3.
C. pumiceum, Brocc., 2.
C. taurovaricosum, Sacco, 2.
Cirsotrema (sp. indet.), 3.
Cypræa amygdalum, Brocc., 1.
C. fabagina, Lam., 2, 3.
Turritella inequiculpta, Seg., 3.
T., sp., 2, 3.
Natica pratensis, Raqa., 2.
N. hortensis, Bayan, 1.
Oliva (casts), 1, 2, 3.
Trochus patulus, Brocc., 1.
T. (casts), 1, 2, 3.
Voluta ficularia, Lam., 2.
Cassidaria fasciata, Borson, 3.
C. echinophora, Lam., 3.
—— *var.*, 3.
Cassis Neumayri, Hörnes, 2.
Patella Melitensis, De Greg., 3.
Fissurella, sp., 3.
Erato lævis, Don, 3.
Actæon pinguis, d'Orb., 3.
Solarium simplex, Brong., 2, 3.
Chenopus pes-pelicani, Phil., 3.
Acera (casts), 1, 2, 3.
Xenophora incertissima, De Greg., 3.

(4) *Lamellibranchiata*—

Pecten Melitensis, De Greg., 3.
P. Cookei, De Greg., 2, 3.
P. scabrellus (Lam.), Desh., 3.
—— *var.* arcæopsis, De Greg., 3.
—— *var.* gibbosulus, De Greg., 3.
—— *var.* parti-imbricatus, De Greg., 3.
—— *var.* post-scabriusculus, De Greg., 3.
P., sp. (?), De Greg., 3.
P. Haveri, Mich., *var.* Koheni, Fuchs, 3.
P. denudatus, Reuss, 2, 3.
P. Pandora, 3.
P. Reussi, Hörnes, 3.
P. varians, 3
P. dubius, Wood, 3.
P. spinulosus, 2.
Pecten cristatus, 2.
P. Koheni, Fuchs, 3.
Ostrea cochleare, Poli, 3.
O. mutabilis, Desh., 3.
O. tenuiplicata, Seg.. 2.
O. teriodentata, De Greg., 3.
O. perminuta, De Greg., 3.
Lucina sinuosa, Don, 3.
Cardita tornanæta, Bast., 3.
Pholas (casts), 1, 3.
Nuculana pellucidiformis, Hörnes, 3.
N. nitida, Brocc., 2.
N. fragilis, Chemn., 3.
Nucula Mayeri, Hörnes, 3.
Lima, sp., 2, 3.
Arca (casts), 1, 2, 3.
Isocardia (casts), 1, 2, 3.
Astarte (casts), 1, 3.

Brachiopoda—

Terebratula caput-serpentis, 1, 2.
T. Cortæ, Seguenza, 3.
—— *var.* parumlobata, De Greg., 3.
Terebratula minor, 1, 2.
T. sinuosa, 3.
Thecidium Adamsi, McDonald, 1.

Bryozoa—Idmonea, 3.

Crustacea: *Decapoda*—Cancer macrocheilus, Mantell, 3. Cancer, sp., 1, 3.

Cirripedia—

Scalpellum venustum, De Greg., 1.
S. Melitense, De Greg., 1, 2, 3.
S. magnum, Darw., *var.* angustum, De Greg., 1.
—— *var.* equisignatum, De Greg., 1.
—— *var.* radiatum, De Greg., 1.
Scalpellum magnum, Darw., *var.* ornatum, De Greg., 1.
S., sp., 1.
S., sp., 1.
Cirripede, nov. sp.

Echinoidea—

Cidaris Scillæ, Wright, 1.
C. avenionensis, Desml., 3.
Echinus Hungaricus, Laube.
Echinocyamus Studeri, Sism., 2, 3.
Breynella Vassalli, Wright, 3.
Studeria Spratti, Wright, 3.
Echinolampas Manzoni, Greg., 2, 3.
E. posterolatus, Greg., 1.

Hemiaster Cotteaui, Wright, 3.
H. Scillæ, Wr., 1, 2, 3.
H. vadosus, Greg., 1, 2, 3.
Pericosmus latus, Agassiz, 2.
P. coranguinum, Greg., 3.
Schizaster Parkinsoni, Defr., 1, 2, 3.
S. Desori, Wr., 2, 3.
Metalia Melitensis, Greg., 2.
Brissopis crescenticus, Wr., 3.
Spatangus pustulosus, Wr., 3.
Euspatangus De Konincki, Wr., 3.
Sarsella Duncani, Greg., 2, 3.
S. anterolata, Greg., 2, 3.
Pygorhynchus Spratti, Wr., 2.
Scutella striatula, Greg., 1.
Brissus latus, 3.

Crinoidea—Pentacrinus Gastaldi, Mich., 1, 2.

Alcyonaria: *Gorgonidæ*—

Isis Peloritana, Seg., 1, 3.
I. compressa, Seg., 3.
Isis Melitensis, Seg., 3.
—— *var.* antiqua, Seg., 3.

Actinozoa—

Ceratrochus typus, Seg., 2, 3.
Cœnocyathus Adamsi, Duncan, 3.
Stephanocyathus, sp., 1, 2, 3.
Caryophyllia, 1, 3.
Trochocyathus latero-cristatus, Edw. & H., 1, 2, 3.
T. pyramidatus, Mich., 1, 3.
Trochocyathus vericostatus, Mich., 1, 3.
T., sp., 3.
Flabellum extensum, Mich., 1, 2, 3.
F. Melitensis, De Greg., 1.
F. avicula, Mich., 1, 2, 3.
F. intermedium, Mich., 1, 3.
F. fæcundum, Mich., 1, 3.

Spongida—Cliona (perforating shells of Lamellibranchs).

Foraminifera—In addition to the 54 species recorded by Dr. John Murray, I have collected—

Nodosaria soluta, Reuss, 2, 3.
N. consobrina, d'Orb., 3.
Textularia carinata, d'Orb., 3.
Cristellaria cassis, F. & M., 3.
C. radiata, Born., 2, 3.
Cristellaria variabilis, Reuss, 3.
Marginulina Bœhmi, Reuss, 1, 2.
Frondicularia interrupta, Karrer, 3.
Miliolina agglutinans, d'Orb., 3.
Heterostegina Stricklandi, Adams, 1.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science. Sixty-sixth Annual Meeting, held at Liverpool, September 16–28, 1896.

I.—List of Papers read in Section (C), Geology.

J. E. Marr, Esq., M.A., F.R.S., Sec. Geol. Soc., President.

President's Address (see October Number, p. 464).
Prof. W. Boyd-Dawkins.—On the Geology of the Isle of Man.
H. C. Beasley.—Observations on some Footprints from the Trias in the Neighbourhood of Liverpool.
G. H. Morton—Recent Borings in the Red Marl near Liverpool (see p. 496).
G. H. Morton—Erosion of the Sea-coast of Wirral (see p. 516).
T. Mellard Reade—Oscillations in the Level of the Land as shown by the Buried River-Valleys and Later Deposits in the Neighbourhood of Liverpool (see p. 488).
A. Bell.—Tertiary Deposits in North Manxland.

E. Greenly.—On the occurrence of Sillimanite Gneisses in Central Anglesey (see p. 494).

E. Greenly—On the Quartzite Lenticles in the Schists of S.E. Anglesey.

Sir W. Dawson.—Pre-Cambrian Fossils—especially in Canada (see p. 513).

G. F. Matthew—Some Features of the early Cambrian Faunas.

Report of the Committee on Zones in British Carboniferous Rocks.

G. H. Morton.—The Range of Species in the Carboniferous Limestone of North Wales.

J. L. Lobley—On the Source of Lava.

J. L. Lobley.—On the Post-Cambrian Shrinkage of the Globe.

P. F. Kendall.—Cause of the Bathymetric Limit of Pteropod Ooze.

P. F. Kendall.—On the Conditions under which the Upper Chalk was deposited.

J. Johnston-Lavis.—The Highwood Mountains of Montana and Magmatic Differentiation. A Criticism.

G. B. Wethered.—The Depths of the Sea in Past Epochs.

Vaughan Cornish.—Rippling of Sand by Water and Wind (see p. 521).

Prof. J. Walther.—Are there Fossil Deserts?

W. W. Watts.—Notes on the Geology of Charnwood Forest (see p. 485).

F. T. Howard and *E. W. Small.*—The Geology of Skomer Island.

H. B. Woodward.—Notes on Sections along the London Extension of the Manchester, Sheffield, and Lincoln Railway between Rugby and Aylesbury.

Report of the Committee on Stonesfield Slate (see p. 517).

Report of the Committee on Coral-Reef Structure.

Report of the Geological Photographic Committee.

Report of the Hoxne Excavation Committee.

John Smith.—On the Discovery of Marine Shells in the Drift Series at High Levels in Ayrshire.

Dr. C. Callaway.—Notes on the Superficial Deposits of North Shropshire (see p. 482).

J. Lomas and *P. F. Kendall.*—Glacial Phenomena of Vale of Clwyd.

P. F. Kendall.—Post-Pliocene Changes of Physical Geography.

Report of the Erratic Blocks Committee.

Prof. E. Hull.—Another Possible Cause of the Glacial Epoch (see p. 514).

Report of the Committee on the High-level Shell-bearing Deposits at Clava.

Report of the Singapore Caves Committee.

Report of the Calf-Hole Cave Committee.

Report of the Committee on the High-level Flint Drift at Ightham.

Report of the *Cetiosaurus* Committee.

Report of the Eurypterid Committee.

Report of the Committee on the Fossil Phyllopoda.

Report of the Committee on Life-zones in Carboniferous Rocks (see p. 519).

A. C. Seward—A New Cycad, from Portland (see p. 518).

A. C. Seward—A Large Specimen of *Lyginodendron* (see p. 518).

Report of the Committee on the Registration of Type Specimens.

Montagu Browne.—The Rhætic Bone-beds of Aust Cliff and the Rock-bed above it.

Prof. H. G. Seeley.—On the Skull of the South African Fossil Reptile *Diademodon.*

Prof. H. G. Seeley.—Two examples of Current Bedding in Clay.

Sir Archibald Geikie.—On some Crush-Conglomerates in Anglesey (see p. 481).

Prof. J. Milne.—Report of the Seismological Committee.

A. C. Seward.—Note on some Fossil Plants from South Africa (see p. 519).

Prof. K. Busz.—On the occurrence of Corundum produced by Contact-metamorphism (see p. 492).

Report of the Moreseat Committee.

ABSTRACTS OF PAPERS READ AT THE BRITISH ASSOCIATION MEETING, LIVERPOOL, SEPTEMBER, 1896.

II.—PRE-CAMBRIAN FOSSILS. By Sir W. DAWSON, LL.D., F.R.S.

THE author stated that it was his object merely to introduce the specimens he proposed to exhibit by a few remarks rendered necessary by the present confusion in the classification of pre-Cambrian rocks. He would take those of Canada and Newfoundland as at present best known, and locally connected with the specimens in question.

He referred first to the "*Olenellus* Zone," and its equivalent in New Brunswick, the "*Protolenus* Fauna" of Matthew, as at present constituting the base of the Cambrian, and terminating downward in barren sandstone. This Lower Cambrian had in North America, according to Walcott, afforded 165 species, including all the leading types of the marine invertebrates.

Below the *Olenellus* Zone, Matthew had found in New Brunswick a thick series of red and greenish slates, with conglomerate at the base. It has afforded no Trilobites, but contains a few fossils referable with some doubt to Worms, Mollusks, Ostracods, Brachiopods, Cytideans, and Protozoa. It is regarded as equivalent to the Signal Hill and Random Sound Series of Murray and Howley in Newfoundland, and to the Keweenian, and the Chuar and Colorado Cañon Series of Walcott in the west. The latter contains laminated forms apparently similar to Cryptozoon of the Cambrian and Archæozoon of the Upper Laurentian.

The Etcheminian rests unconformably on the Huronian, a system for the most part of coarse clastic rocks with some igneous beds, but including slates, iron-ores, and limestones, which contain worm-burrows, sponge-spicules, and laminated forms comparable with Cryptozoon and Eozoon. The Huronian, first defined by Logan and Murray in the Georgian Bay of Lake Huron, has been recognized in many localities, both in the west and east of Canada and the United States; but designated by other local names, and by some writers is included, with the Etcheminian and sometimes with part of the Laurentian, in the scarcely-defined "Algonkian" group of the United States Geological Survey.

Below the Huronian is the Upper Laurentian or Grenville system, consisting of gneisses and schists (some of which, as Adams has shown, have the chemical composition of Palæozoic slates), along with iron-ore, graphite, and apatite, and great bands of limestone, the whole evidently representing a long period of marine deposition, in an ocean whose bed was broken up and in part elevated before the production of the littoral clastics of the Huronian age. It is in one of the limestones of this system that, along with other possible fossils, the forms known as *Eozoon Canadense* have been found. The author did not propose to describe these remains, but merely to exhibit some microphotographs and slices illustrating their structure, referring to previous publications for details as to their characters and mode of occurrence.

Below the Grenvillian is the great thickness of orthoclase gneiss of various textures, and alternating with bands of hornblende schist, constituting the Ottawa gneiss or Lower Laurentian of the Geological Survey. No limestones or indications of fossil remains have yet been found in this fundamental gneiss, which may be a truly primitive rock produced by aqueo-igneous or "crenitic" action, before the commencement of regular sedimentation.

The author proposed, with Matthew, to regard the Etcheminian series and its equivalents as pre-Cambrian, but still Palæozoic; and, as suggested by himself many years ago, to classify the Huronian and Grenvillian as *Eozoic*, leaving the term Archæan to be applied to the Lower Laurentian gneiss, until it also shall have afforded some indications of the presence of life.

He insisted on the duty of palæontologists to give more attention to the pre-Cambrian rocks, in the hope of discovering connecting links with the Cambrian, and of finding the oceanic members of the Huronian, and less metamorphosed equivalents of the Upper Laurentian, and so of reaching backward to the actual beginning of life on our planet, should this prove to be attainable.

III.—Another Possible Cause of the Glacial Epoch. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

The author gave an account of the results arrived at by Professor J. W. Spencer, Ph.D., in his memoir on "The Reconstruction of the Antillæan Continent" (Bull. Geol. Soc. America, January, 1895), from observations laid down on the Admiralty charts of the east coast of North America and the shores of the West Indian Islands and Gulf of Mexico. He shows that the "continental shelf" lying between the coast and the 100-fathom line is succeeded by a second and deeper plateau, called by Professor A. Agassiz "the Blake plateau," the average depth of which may be taken at 2,700 feet, separated from the continental shelf by a steep descent, and in its turn bounded by a second steep descent leading down to the abysmal depths of the Atlantic Ocean at 12,000 or 13,000 feet below the surface. A careful investigation of the soundings shows that these plateaux are traversed by channels, sometimes of great depth and with precipitous sides, leading down from the *embouchures* of the existing rivers which open out on the coast, and connected with the outer margins of the plateaux by wide embayments. The form of these channels would in some cases entitle them to be called "cañons" or "fjords"; and as Professor Spencer truly considers that such channels could only be formed by river erosion, he concludes that the whole eastern coast and the West Indian Isles were elevated to the extent of the outer embayments where they open out on the floor of the ocean. Such an elevation of 12,000 feet or so would have connected North and South America along the line of the Antilles, constituting a single continent, and are termed "stupendous changes of level" of the Pleistocene epoch.[1]

The author of this paper proceeds to discuss some of the climatic conditions which would result from such changes, and supposes that the elevation of the Antillæan continent would have shut out the northern branch of the great equatorial current, known as the Gulf Stream, from the Caribbean Sea and the Gulf of Mexico, causing it to enter the North Atlantic directly; and he comes to the conclusion that the Atlantic current would have crossed the 40th parallel with a surface temperature of only 74° F. instead of 84° F., as is the case at the present day. The author then discusses the question to what extent such a lowering of the temperature of the present Gulf Stream would have affected the climate of the regions bordering the North Atlantic, and considers that this effect may be approximately arrived at by transferring the climatic conditions of the isotherm of annual mean temperature of 32° F. (the freezing-point of water) to those of the 42° F. of the present day, resulting in subglacial conditions along the line of this isotherm.[2]

Proceeding next to examine the effects of the elevation of the American continent to the extent required by Professor Spencer's conclusions, the author considers it as extremely probable that the cold produced by this physical change, added to that due to the lowering of the temperature of the Atlantic current, would result in bringing about the conditions of the Glacial epoch; and as similar elevation of land has been determined in the case of the platform of the British Isles and North-Western Europe—though to a much smaller extent than in the case of the American continent—the increased cold due to this cause, added to that due to the diminished temperature of the Atlantic current, would have been, if not a *vera causa* of the Glacial epoch of Europe, a most material cause in bringing about the climatic conditions of that epoch.

[1] For those who are unable to obtain Professor Spencer's original memoir, the review thereof by Mr. A. J. Jukes-Browne, F.G.S., in the Geological Magazine for April, 1895 (p. 173), will probably suffice.

[2] The isotherm of 42° passes by the north coast of the British Isles.

IV.—Erosion of the Sea-coast of Wirral. By G. H. Morton, F.G.S.

THE oldest maps of the coast of Wirral, the north-western extremity of Cheshire, afford very little information on the exact outline of the coast in former years. It was not until the publication of the 6-inch map of the Ordnance Survey in 1880, that it became possible to make exact observations on the erosion of the coast. The late Sir James Picton, F.S.A., in 1846, was the first to direct attention to the waste of the land, but he had not made any personal investigation, and more recent writers on the subject have confined themselves to showing the incorrectness of some of his statements, rather than making original observations. The object of this paper is to record the result of close attention given to the subject for many years.

Half a mile south-west of the Leasowe Embankment, and about 100 yards from Seabank Cottages, there is an old weather-beaten brick and stone house, known as the "Warren," and evidently the oldest in the neighbourhood. According to the 6-inch Ordnance Map, the distance between the house and the sea was about 130 yards when the country was surveyed in 1871, but I found it to be 70 yards in 1890, 55 yards in March 1894, and only 45 yards in May 1896, and the residents have shown me the position of several high sand-hills that once formed part of the lost land.

In an affidavit, filed in a recent case concerning the extension of the Embankment, George Banks states that he had been born and had lived in the house ever since. It was only 60 yards from high-water mark at spring tides in 1892, "whereas when he first remembered it, the house stood at least 350 yards from high-water mark at spring tides, and the land washed away included some sand-hills 30 and 40 feet, and one 50 or 60 feet in height."

The greatest erosion by the sea along the coast has taken place at Dove Point, about 350 yards to the south-west of the house. In 1862 there were two "perches" constructed of timber, one being 10 yards from the edge of the sand-hills, which were then about 12 feet high, and the other 150 yards behind, near the boundary of the enclosed land. The seaward perch is shown in the frontispiece of the "Geology around Liverpool." On January 20, 1863, this perch had become close to the edge of the cliff and fell down on the shore, its original position being indicated by several masses of masonry and large stones which had formed the foundation of the structure. The perch was re-erected on the sand-hills, and is shown on the 6-inch map, but it was afterwards removed, with the one behind, to the north-east of the "Warren," so that neither of them is now in the place shown on the map. The foundation stones still lie on the shore in their original position. In consequence of the continual erosion by the sea the stones have gradually become further from the coast-line, and in September, 1894, the distance was 144 yards, showing the erosion of the coast from 1863 to 1894 to have been between 4 and 5 yards per annum. In May, 1896, the distance had been increased to 152 yards, proving an erosion of 8 yards in 20 months, but as they included two winters the loss would be about 4 yards per annum.

South of Dove Point the erosion gradually decreases, but 50 yards of the sand-hills have been washed away on the north-east of Sandhey, though not in recent years, as there is now a fringe of grass growing in the denuded bay for about 100 yards, when it gradually dies away. The grounds along the sea-front at Sandhey are protected by an embankment and groins, which arrest the encroachment of the sea. Beyond, in front of Hoylake, there is no erosion, and the Red Stones at Hilbre Point protect the land from the sea.

V.—Stonesfield Slate.—Third and Final Report of the Committee, consisting of H. B. Woodward (Chairman), E. A. Walford, F.G.S. (Secretary), Professor A. H. Green, Dr. H. Woodward, and J. Windoes, appointed to open further sections in the neighbourhood of Stonesfield in order to show the relationship of the Stonesfield Slate to the underlying and overlying strata. (Drawn up by Edwin A. Walford, F.G.S., Secretary.)

The succession from the Great Oolite through the Stonesfield Slate into the Inferior Oolite, as shown in the sections made by your Committee, may be thus summarized :—

		Ft.	in.
Great Oolite	Limestone with corals		
	Limestone and marls with *Ostrea* (oyster beds) ...	17	3
	Slate beds (Stonesfield Slate)	5	3
Fullonian	Fawn-coloured limestone with lignite and carbonaceous markings (Chipping Norton Limestone) ... ... about	18	0
Inferior Oolite Series	Sandy limestones with some marl beds; lower limestone with vertical plant-markings (Lower Estuarine Series)	11	0
	Clypeus-grit: zone of *Ammonites Parkinsoni* ...	13	0

(About 12 feet of Inferior Oolite strata can be made out below.)

The faulted state of the bank prevents exact measurement of the series now assumed to be Fullonian. These beds had previously been classed with the Inferior Oolite. Notwithstanding the great care taken in making a practically vertical section, a series of Great Oolite beds was found at a much lower level than the Slate. The error was indicated in the Second Report, and the greater part of beds Nos. 18 to 26 has to be excised from the list.

The additions to our knowledge consist mainly in the discovery of the strata with vertical plant-markings (evidently the equivalent of the Lower Estuarine Series of the Northamptonshire Inferior Oolite), and in the particulars given of the thickness of the higher beds of the Inferior Oolite and the Fullonian strata. Fawler, two miles distant, has been supposed to mark the virtual disappearance of the Inferior Oolite. Sir Joseph Prestwich, however, had grouped with the Inferior Oolite certain beds (14 feet 6 inches thick) which had been proved in the boring at Wytham, near Oxford;[1] and Mr. H. B. Woodward has classed with the Inferior Oolite Series 30 feet of strata proved in a boring at Witney.[2] These correlations were inferential, but the facts now brought forward give them support.

VI.—A New Cycad from the Isle of Portland. By A. C. Seward, M.A., F.G.S.

Dr. WOODWARD lately obtained an exceedingly fine specimen of a cycadean stem from the Purbeck Beds of Portland, which is now in the fossil plant gallery of the British Museum. The stem, which is probably the largest known, has a height of 1 m. 18·5 cm., and measures 1 m. 7 cm. in girth at the broadest part. A striking feature of the specimen is the conical apical bud enclosed by tapered bud-scales, bearing numerous ramental outgrowths on the exposed surface. The surface of the stem presents the appearance of a prominent reticulum of projecting ridges, of which the meshes were originally occupied by the persistent petiole bases. The substance of the leaf-stalks has for the most part disappeared, while the inter-petiolar ramental tissue has been mineralized and so preserved as a projecting framework. In structure the ramenta are practically identical with those of *Bennettites*, as described by Carruthers and other writers. The petiole bases also agree very closely with those of *Bennettites*, consisting of a mass of parenchymatous tissue traversed by numerous vascular bundles and secretory canals, with a distinct band of cork at the periphery. No trace of any inflorescence has been found. It is proposed to name the plant *Cycadeoidea gigantea*.

VII.—Note on a Large Specimen of *Lyginodendron*. By A. C. Seward, M.A., F.G.S.

The specimens on which this description is based are in the Botanical Department of the British Museum and in the recently acquired Williamson Collection. The block, from which several sections have been prepared, is a striking example of the preservation of the minute structure of a Coal-measure plant on a large scale; it consists of a mass of wood at least 6 cm. thick in a radial direction, and a pith about 3 cm. in diameter, but without any trace of cortical tissue. Sections obtained from this block, and included in the Williamson Collection, were described at some length in the recently published memoir by Williamson and Scott on *Lyginodendron* and *Heterangium*. The examination of additional specimens has led to a somewhat fuller diagnosis of the structure and a more detailed comparison with *Lyginodendron Oldhamium* and other plants. The main mass of the wood possesses a structure practically identical with that of *Lyginodendron Oldhamium* and recent cycadean stems; internal to the centrifugally developed

[1] Geol. Mag. 1876, p. 238.
[2] "Jurassic Rocks of Britain," vol. v, 1895, p. 42.

secondary wood there is a fairly complete and narrow ring of centripetally developed xylem. In the pith there are numerous secretory canals and nests of dark-coloured sclerous cells. No definite traces of primary xylem like that of *Lyginodendron Oldhamium* have been detected. As a matter of convenience the specimen may be designated *Lyginodendron robustum.*

VIII.—Note on some Fossil Plants from South Africa. By A. C. Seward, M.A., F.G.S.

THE author has recently had an opportunity, through the kindness of Mr. David Draper, F.G.S., of examining a collection of fossil plants from a locality a short distance south of Johannesburg. The collection forwarded to England by Mr. Draper includes examples of *Glossopteris*, *Vertebraria*, and other genera, associated with specimens of *Lepidophloios*. The occurrence of Lepidodendrons in strata containing typical members of the *Glossopteris* flora is extremely important from the point of view of the geological and geographical distribution of fossil plants, and specially interesting in connection with a similar association lately recorded by Professor Zeiller in Brazilian plant-bearing beds. In South Africa, as in South America, we have evidence of the existence of a plant genus characteristic of the Upper Palæozoic flora of the northern hemisphere, in the same region with the Permo-Carboniferous *Glossopteris* flora.

IX.—Life-zones in the British Carboniferous Rocks.—Report of the Committee, consisting of J. E. Marr, F.R.S. (Chairman), E. J. Garwood, F.G.S. (Secretary), and A. H. Foord, F.G.S., appointed to study the Life-zones in the British Carboniferous Rocks. (Drawn up by J. E. Marr.)

IN a paper read before the British Association at Ipswich in 1895, two of us called attention to the work of Dr. Waagen on the Upper Palæozoic rocks of the Salt Range, and gave reasons for supposing that the Carboniferous rocks of Britain might be divided into zones.[1] In that paper it was suggested "that a committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists to whom these fossils may be submitted." This committee was appointed, and the members thereof beg leave to submit their report.

The Committee believes that the following districts would furnish good results, and recommends that those whose names are appended to the various districts be asked to take charge of their particular districts and to endeavour to carry out therein the objects of the Committee—

[1] See Rep. Brit. Assoc. 1895, p. 696.

England and Wales: Northumberland and the Border, Professor G. A. Lebour; Northern part of Pennine Chain and adjoining regions, Messrs. Garwood and Marr; Southern part of ditto and adjoining regions, Mr. P. F. Kendall and Dr. Wheelton Hind; North Wales, Mr. G. H. Morton; South Wales, Mr. A. Strahan; Devon, etc., Mr. Howard Fox and Dr. G. J. Hinde.

Isle of Man: Mr. G. W. Lamplugh.

Scotland: Mr. B. N. Peach.

Ireland: Mr. A. H. Foord.

The Committee recommends that the following directions for working be communicated to the various workers:—

1. When possible, a typical measured section should be given of each locality examined, with notes of as many confirmatory sections as possible.

2. Any specimen not actually found *in situ* to be labelled to that effect, with the exact conditions under which it was found noted.

3. All specimens should be labelled with the local name of the bed, giving as many additional details as possible, and in all cases the exact locality, which should further be noted on a large scale-map.

4. All specimens should be labelled *when found.*

5. So far as possible, workers are recommended to collect from one bed at a time, and to pack the specimens from each bed in a separate parcel before commencing to collect from another bed.

6. Attention should be paid to apparently identical forms separated by many feet or yards of deposit, as the forms may be *mutations*; large suites of such specimens should be collected; indeed—

7. As large a number of specimens as possible should be obtained of each species in every bed examined.

8. Absence of fossils in any bed should be noted whenever possible.

9. Attempts should be made to record the relative abundance of fossils, which may be roughly done by recording those which are very rare (*v. r.*), rare (*r.*), common (*c.*), and very common (*v. c.*).

10. In case of beds being obviously rich in micro-organisms, large pieces should be collected for future examination.

11. Considering the importance which cherts have assumed, it is very desirable to collect specimens of cherts.

Specimens may be kept by the discoverers or forwarded to the Secretary of the Committee (E. J. Garwood, Dryden Chambers, 119, Oxford Street, London, W.), on loan or for retention.

The Committee recommends that the names of those whom they have mentioned as likely to undertake the charge of districts be added to the Committee, and that the following palæontologists be asked to co-operate with the other members, and to identify such fossils as may be submitted to them, their names being also added (when not previously mentioned) to those of the Committee: Dr. G. J. Hinde (radiolaria and sponges), Professor H. A. Nicholson (corals), Mr. J. W. Kirkby (entomostraca), Dr. H. Woodward (other crustacea), Mr. F. A. Bather (echinoderms and brachiopods), Dr. Wheelton Hind and Mr. E. J. Garwood (lamellibranchs and gasteropods), Messrs. G. C. Crick and A. H. Foord (cephalopods), and Mr. R. Kidston (plants).

The Committee recommends that a grant be applied for, in order to pay for the services of collectors, who are to be under the direction of the Secretary of the Committee.

X.—The Rippling of Sand by Water and by Wind. By Vaughan Cornish.

REGULAR ripple-mark is produced in various ways in *rolling* sand. The billows formed by deposition of flying or floating sand are considered in another paper (Section E—Geography). The author distinguishes three principal kinds of rippled sand, viz.:

1. The Ripple-mark of Sea.
2. The Ripple-mark of Streams.
3. The Ripple-mark of Dunes.

In (1) symmetrical, knife-edged ridges are built up, owing, as is well known, to the complete reversal of the current at short intervals, which results in an effective co-operation of the direct current with the vortex formed in the lee of projections on the rough surface of the sand. This mechanism in the vertical plans raises the ridges, and, in plan, extends them laterally, so that the mottled surface of the initial stage is changed into long lines of parallel ridge and furrow.

If the direction of the waves changes, another set of ridges is formed, and this produces polygonal figures. These have an even number of sides, and the sides are arranged in opposing pairs. This serves to discriminate polygonal forms due to fossil ripple-mark from Hitchcock's supposed fossil tadpole-nests.

2. The symmetrical, rounded, ripple-mark of the sandy bottom of a stream is formed by the alternate acceleration and retardation of current which occurs wherever the surface of the water is corrugated by a train of standing waves. This form has been called Ripple Drift. The ridges only travel when the whole train of water-waves travels; when the train of waves arises from a *fixed* obstacle the sand ridges are stationary.

3. The ripple-mark of dunes is produced when sand-grains roll before the wind. These ripples are not symmetrical, but they preserve their sectional shape during their growth, the height and length increasing in the same proportion. They grow laterally in the same way as (1). They are produced by the steadiest natural wind, and even by a steady artificial blast, the resistance offered by the sand-grains being sufficient to produce in yielding air a periodic motion such as must be independently produced in water for the formation of the ripple-mark of sea or stream.

Flying-sand falling upon the surface of a sand-dune blurs the pattern of the ripples, but if the shower be not too thick the grains are soon sorted into position as they roll.

REVIEWS.

I.—Reminiscences of a Yorkshire Naturalist. By the late William Crawford Williamson, LL.D., F.R.S., Professor of Botany in Owens College, Manchester. Edited by his Wife. 8vo, pp. xii and 228. (London: George Redway, 1896.)

THIS little volume contains a record of the principal events in the life of the author, written by himself, and tenderly edited by Mrs. Williamson after his death.

It falls to the lot of but few amongst us to have the events of our lives set down in a book, and it may very well be doubted if such records, save in a few exceptional instances, are worth the expenditure of ink and paper. Professor Williamson may be looked upon as one of these exceptional instances; indeed, it would be extraordinary if, having attained his 79th year in the present century, and witnessed some of the greatest changes brought about by scientific discovery and invention, he should have failed to record many matters of vital interest to the *fin du siècle* world of which he saw the earlier days.

Born of humble parents, and by nature a delicate boy, young Williamson's early schooldays were interrupted by long enforced holidays spent delightfully upon a farm in Yorkshire. At other times he went birds'-nesting or collecting insects, or he watched an uncle who executed work with a lapidary's wheel, cutting agates and other stones obtained along the coast. Later on he assisted his father in his duties as Curator of the Scarborough Museum, and made the acquaintance of that grand old man William Smith, the "father of English Geology," and also of his nephew, Professor Phillips, whose "Geology of the Yorkshire Coast" was young Williamson's first introduction to a scientific work on the geology of the country around his boyhood's home. At the age of fifteen Williamson was sent to school at Bourbourg, in France; to accomplish which he incurred many trials, and his parents considerable additional expense: when he left he had learned little more of colloquial French than he had brought with him, and gained no compensating advantages. Returning to London in 1832, his father directed him to call upon Sir Roderick Murchison, by whom he was well received, and breakfasted with that great man and Lady Murchison, who was most kind to the country lad.

After "doing the sights of London" he returned home, and was forthwith apprenticed to a general practitioner in Scarborough, and became in process of time what is nowadays termed in joke a "pill-box." He only remained with Mr. Weddell, of Scarborough, three years, when, in September, 1835, he was permitted to resign his articles, and was appointed Curator to the Museum of the Manchester Natural History Society, a post which he held until he was twenty-two years of age.

In 1838 young Williamson earnestly desired to qualify himself as a medical man; but for this purpose his medical studies, so long neglected for Natural History work, must be taken up in earnest.

The question was, how could the necessary funds be raised. He had prepared a series of six lectures on Geology with appropriate diagrams and specimens; with these he visited the chief towns of Lancashire and Yorkshire, and thus earned sufficient to cover his fees at the medical school in Manchester, and to pay for his board and pocket-money. In September, 1840, he set out for London, and entered as a student at University College. In 1841, his examination passed, we find young Williamson a full-fledged practitioner, with a brass-plate on the door of his house, at the corner of Wilton Street and Oxford Road, Manchester.

It was a hard, uphill climb for the young surgeon; indeed, at first it seemed to be a case of "*facilis descensus Averni*"; an old medical friend remarking sagely to the young one: "You will have for some time to go much oftener down steps than up steps. Never mind! win the good opinion of washerwomen and such like, and in time you will hear of their recommendations of you to the wealthier families by whom they are employed." "I followed his advice," says Williamson, "and found it succeeded as predicted."

But one may well ask, where does the title of a "Yorkshire Naturalist" come in? To understand this, it is necessary to read the book. The fact is, he had only been apprenticed to Mr. Weddell in Scarborough two years when he began to publish his observations as a naturalist in the "Magazine of Natural History," the first paper being "On a Rare British Species of *Mytilus*," and the second "On the Distribution of Organic Remains in the Lias Series of Yorkshire," etc. (Proc. Geol. Soc., vol. ii, 1833–8). Then, a "Description of a Tumulus opened at Gristhorpe," 1834, followed by "Illustrations and Descriptions for the Fossil Flora of Great Britain," by Lindley and Hutton, 1835, whom he assisted with notes and drawings. Also on the "Distribution of Organic Remains in the Oolite of Yorkshire," 1836. These papers, commenced at the age of 18, and continued with greater knowledge in later years, only ended in 1895, the year of his death, when they numbered 145, including nineteen important memoirs on the structure of fossil plants read before the Royal Society of London and published in the Philosophical Transactions, 1870–93. The fact of his having held the Chair of Professor of Botany in the Owens College, Manchester, for forty-one years, speaks volumes for his indomitable energy and ability; and when one considers that he carried on an extensive private medical practice in Manchester at the same time, one is the more impressed by his power of work. That he should have found time in the midst of all his other labours to cut, grind down, mount, and prepare a large proportion of the sections of fossil plants from the Coal-measures which he described in his numerous papers, seems almost incredible; but his whole life was occupied with his pursuits, and he had no idle time, and certainly during his long life he never wasted any.

Besides the narrative of actual work performed by Professor Williamson—which, as a public lecturer alone, would have satisfied the craving for occupation of any ordinary strong man!—we have the sketch of his work in Owens College from 1851 to 1892; his pursuit of medicine as a practitioner in Manchester; his fossil botanical studies, resulting in the fine series of monographs on the microscopic structure of the plants of the Carboniferous period; the outcome of the examination of the hundreds of slides prepared with his own hands; his microscopic investigation of the bones, teeth, and scales of fishes; and on Foraminifera and other lowly organisms: these are only a small part of the records of his busy life. That he should have been elected to the Royal Society in 1854, been a Royal Medallist in 1874, an LL.D. and an honorary member of many learned societies, seems but fitting and just. Of his social and family records much is told in this volume, and we learn of all those with whom Williamson became acquainted in his long life. Some of these notes are of much interest, but others are only valuable to those of his own immediate household. His name will survive for long in scientific circles as a palæobotanist, and his Scarborough and Manchester friends will no doubt keep his memory green. Beneath the surface of this long and busy life, we may read this lesson—that success can only be attained by patient study, diligence, and self-denial; these Williamson practised, and, combined with an ardent love of natural history, made the curious and inquiring child the father of the earnest man of science and the Yorkshire Naturalist.

II.—Dr. G. Agamennone on Earthquakes in the South-East of Europe.

(1) Liste des tremblements de terre qui ont eu lieu dans l'Empire Ottoman pendant l'année 1894.

(2) Bulletin météorologique et séismique de l'Observatoire Impériale de Constantinople. Partie Séismique. I Année (1895).

(3) L'activité sismique en Orient, et en particulier dans l'Empire Ottoman pendant l'année 1895.

(4) Tremblement de terre de Paramythia (Epire) de la nuit du 13–14 mai 1895. (Boll. Soc. Sismol. Ital., i, 1895, pp. 121–130.)

(5) Vitesse de propagation du tremblement de terre de Paramythia (Epire) dans la nuit du 13–14 mai 1895. (Boll. Soc. Sismol. Ital., ii, 1896, pp. 3–14.)

The organization of earthquake-studies in the Balkan peninsula has advanced remarkably during the last few years. The number of self-recording instruments erected is still small, but as in each country the Meteorological Office undertook the seismological work, the existing network of stations was immediately available. In Servia and, strange to say, in Austria-Hungary, no regular provision seems to be made for the collection of earthquake observations; but Dr. Hepites in Roumania, M. Watzoff in Bulgaria, and Dr. Papavasiliou in Greece, are doing very valuable work in this direction.

In Turkey, the foundation of the geodynamic section of the meteorological observatory was due to the interest excited by the Constantinople earthquakes of July, 1894. The authorities were fortunate enough to secure the services as Director of Dr. G. Agamennone, whose excellent work as assistant in the Meteorological and Geodynamic Office of Rome is widely known among seismologists. The success achieved by him in one year proves that something good can even yet come out of the Ottoman Empire.

The first of the above-mentioned papers is a catalogue of forty-nine shocks felt in Turkey alone in 1894. This includes the Constantinople earthquake and many of its after-shocks. In the following year, Dr. Agamennone commenced the publication of monthly *Bulletins*, and at the same time widened the area of investigation so as to embrace all the countries bordering the eastern end of the Mediterranean. The third paper, published in the *Bulletins* for December, 1895, and January, 1896, contains a summary of the results for 1895. Instead of the 49 shocks chronicled in the previous year, we have no fewer than 400 observed in Turkey, 236 in Greece, 55 in Bulgaria, and 62 in the remainder of the region, making a total of 753, or about two a day. The majority of these are connected with several well-marked earthquake-centres, of which Dr. Agamennone discriminates thirty-one as having been in action in 1895. The Constantinople centre has sunk into relative unimportance, only ten shocks being known to have their origins in the neighbourhood of that city.

One of the most important earthquakes in 1895 was that felt at and near Paramythia during the night of May 13–14. Its intensity was between the degrees ix and x of the Rossi-Forel scale. At least seventy persons were killed, and more than 500 houses were destroyed, within an area of about 150 square miles. The shock was felt at Zante, about 110 miles from the epicentre, and was registered at several observatories in Italy, and also at Nicolaiew, in the south of Russia. From the times obtained at these places and near the epicentre, Dr. Agamennone estimates that the early tremors travelled at about 1·21 miles a second, and the larger pulsations at about 0·88 miles a second. C. Davison.

CORRESPONDENCE.

THE PENEPLAIN OF THE SCOTCH HIGHLANDS.

Sir,—Your Magazine for last March contains an article by Messrs. Macnair and Reid that touches on a chapter in Scotch geology and geography which has interested me for some time past; but, unhappily, the few words of discussion that I contributed to the problem in a footnote to an article on a very different subject[1] seem to have been misunderstood by the above-named authors.

The problems discussed by Messrs. Macnair and Reid include a consideration of the geographical conditions obtaining in Scotland

[1] "The Development of certain English Rivers": London Geogr. Journ. 1895, p. 139.

during Old Red Sandstone time. Among these conditions, the form of the floor of ancient rocks on which the Old Red lies unconformably may be regarded as of prime importance.

The problem to which my attention had been attracted is the date and process of origin of the now uplifted peneplain in which the Scotch glens of to-day are carved. Judging by analogy with other peneplains, that of the Scotch Highlands can hardly have been longer exposed to dissection than since the latter part of Mesozoic time; indeed, Tertiary time alone may have been sufficient for the excavation of the narrow glens in the hard rocks of the Highlands, as well as for the more general denudation of the weaker rocks of the Lowlands. It is, therefore, not unreasonable, in my view of the matter, to regard the broad denudation by which the Highland peneplain itself was formed as having been completed in Cretaceous, or, at earliest, in Jurassic time. Whether this denudation was accomplished by marine or by subaerial agencies, or by the co-operation of both, I see no means of deciding definitely; but, for various general reasons, I incline to ascribe it chiefly to subaerial agencies.

Now, the reason that my brief footnote afforded material for quotation by Messrs. Macnair and Reid is, that I referred therein to the views of Sir A. Geikie concerning the date of the Highland peneplain, from which I took the liberty of dissenting; but I am at a loss to understand why a quotation from my footnote should be cited as "a very good example of the misconception and general indefiniteness which accompany Sir A. Geikie's description." If the brief note be misconceived and generally indefinite, the blame should fall on no one but myself.

In continuation, Messrs. Macnair and Reid seem to infuse their own views into my words when they say—"Professor Davis speaks of Devonian seas having cut down the Highlands to their base-level." On the contrary, I said that "Devonian erosion consumed a great volume of the contorted and overthrust rocks of the Highlands." Whether this erosion was marine or subaerial, is a difficult matter to decide, and I did not undertake to decide it. That the erosion of that time reduced the Highlands to base-level, was regarded as probable, but was not directly asserted.

Moreover, my use of the terms "Devonian" and "Old Red" was as synonyms—not for a moment as names of different times or of successive formations. Furthermore, I said nothing to justify the statement that "Professor Davis speaks . . . as if there were two distinct sets of rocks in Scotland, one marine . . . the other fresh-water." The question of the marine or lacustrine deposition of the Old Red (Devonian) was not raised in my note. On the other hand, I cannot justly take shelter under the statement of Messrs. Macnair and Reid that any error in my note "is quite excusable in one who has never studied the rocks of our country, but only read of them in the 'Scenery of Scotland,'" for my reading extends much further; and while I have not "studied" the rocks on the ground, I have at least seen some of them, and in most enjoyable company, from the Buried pre-Torridonian mountains on the shore of Loch Maree to the Carboniferous rocks of the Lowlands. But from these personal matters, let me turn again to the problem of the Highland peneplain.

It seems to me beyond dispute that a great denudation (whether marine or subaerial is here irrelevant) preceded the deposition of the Old Red (Devonian), because its lowest strata are strongly unconformable on their foundation. The place where the detritus furnished by this denudation was deposited is unknown; but this does not weaken the evidence of the denudation. The precise date of the denudation is not defined; it certainly preceded the deposition of the Old Red, but its chief accomplishment may have been at a considerably earlier date; indeed, after the greater part of the denudation had been effected, there may have been some deformation; and upon this deformed denuded surface, the Old Red deposition may have been begun. This can only be told by piecing together such fragments of the Old Red floor as are now in sight, restoring them to the position that they had at the beginning of Old Red deposition by allowing for the dip that the Old Red strata have since then gained, and then judging as well as may be whether the restored floor has the form of a surface of denudation or of deformation. Likely enough, this problem is not definitely soluble; but as far as I have read, the facts fully support the general statement that "a vast denudation was accomplished in earlier times than the Old Red Sandstone period." The contention that there was no such vast denudation does not seem to me well grounded. On the other hand, it seems equally indefensible to maintain that the surface produced by the very ancient pre-Old Red denudation is essentially identical with the once continuous peneplain of the Highland ridge-tops. Whatever even floor was produced before the beginning of Old Red deposition, it must be altogether lost to our sight by the significant deformation and the extensive denudation which have taken place since.

At the close of the Old Red period, some old-land areas may have remained above water (marine or lacustrine is immaterial in this connection). Around any such areas stretched the horizontal Old Red strata. But that condition is not presented to us; for the Old Red strata were at some later time more or less tilted, especially around the Grampians; and in this disturbance the foundation rocks must have shared with their cover. It is true that in certain districts the Old Reds have been little disturbed; but the dips that I have seen in the neighbourhood of Moray Firth are quite sufficient to have required a significant disturbance in the old-land floor, as well as in the Old Red cover. Hence it seems impossible to make the peneplain that is indicated by the existing ridge-tops of the Highlands agree with either the pre-Old Red floor, or with the old-land areas that may have remained above water at the end of Old Red deposition. Just what view Messrs. Macnair and Reid hold on this question I do not gather from their essay; but my reasons for differing from Sir A. Geikie do not seem to me to exhibit misconception or general indefiniteness.

Whatever peneplain is recognizable in the sky-line of the

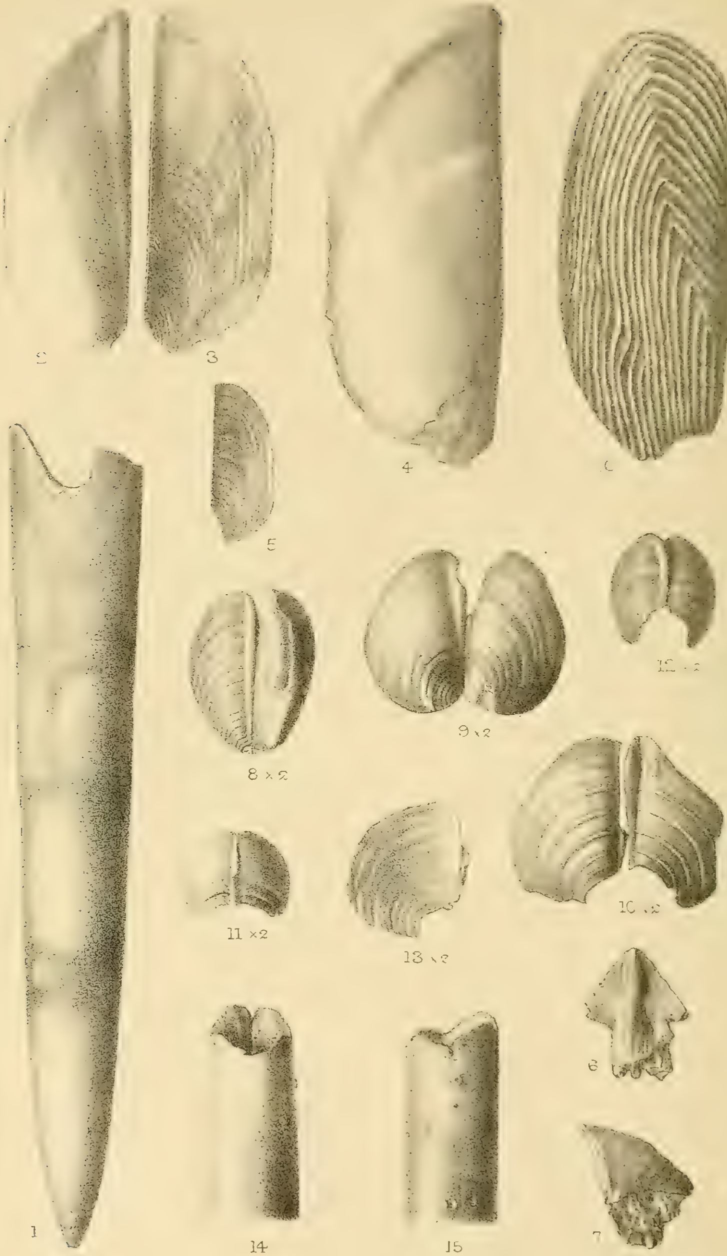
Highlands, I believe it to have been produced after the post-Old Red deformation of the region; probably long afterwards. In some places it may by accident agree with the Old Red floor; but as a whole it must differ from that floor, because the floor was generally deformed after the Old Red strata were laid on it. Such coincidence is against all probabilities. It is altogether unlikely that a peneplain of so ancient a date as Middle Palæozoic time should have stood nearly level and close to sea-level until so comparatively late a date as just before the uplift that allowed the erosion of the glens.

It may be noted that the peneplain of the Highlands is of more imperfect form, of more difficult recognition, and hence attended with more uncertainty in explanation, than various other uplifted and dissected peneplains that I have seen: for example, that of the Ardennes and Hunsrück, or that of southern New England, or of western Pennsylvania and Virginia. The Scotch example must have been a rugged one at the best. Local study may perhaps identify certain peneplain areas that were well developed by the denudation that formed them when the region stood lower, and that are not yet altogether obliterated by the denudation that has been initiated since the region has risen to about its present height. The record of such a study I would gladly see. At the same time it might be possible to infer by what sort of uplift the peneplain gained its present order of altitude; whether by an arching, such as Hayes and Campbell have described for the uplifted peneplain of the southern Appalachians (Nat. Geogr. Mag., Washington, vi, 1894, p. 63), or otherwise. It is perhaps to Scotch geographers rather than to Scotch geologists that one must look for a solution of this long-postponed problem; but the solution will be welcome whencesoever it comes.

HARVARD UNIVERSITY, *September*, 1896. W. M. DAVIS.

THE PARALLEL ROADS OF GLEN ROY.

SIR,—If the "parallel roads" are marine raised beaches, they were accumulated between daily tide-marks, and as such are sure to differ in character from beaches accumulated at more or less fixed levels. Secondly, if the beaches were marine and rocky, one or other form of *Littorina* could scarcely be absent, and *Littorinas* are practically indestructible. In the loose sand of one at least of the Devonshire raised beaches, these shells occur in perfect preservation; *Littorina obtusata* is also said to occur in the deposits on Moel Tryfaen. If, then, the beach-deposits of the parallel roads of Glen Roy still survive, and no trace of *Littorina* can be found in them, the fact is hard to explain in such a sheltered valley, on the hypothesis that the accumulations are of marine origin. If, in addition to the absence of *Littorina* the beaches show no signs of being accumulated between tide-marks, the difficulty of accepting their marine origin will be greater still. The best evidence of a raised-beach platform is its sloping towards the water as part of an old tidal strand. Can such inclined planes be detected in the case of the parallel roads of Glen Roy? A. R. HUNT.



G.M. Woodward del et lith. West, Newman imp.

Upper Chalk Belemnites.
to illustrate Dr H. P. Blackmore's paper.

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ORIGINAL ARTICLES.

I.—Some Notes on the Aptychi from the Upper Chalk.

By H. P. Blackmore, M.D., F.G.S.

(PLATE XVI.)

In 1853–6, when Mr. Sharpe published his monograph on the Cretaceous Cephalopoda of England, the various species were roughly placed according to the divisions of the Chalk formation as described by Conybeare and Philips. This, unfortunately, led to many mistakes: amongst others, Mr. Sharpe described *Belemnitella mucronata* as occurring "everywhere in the Upper Chalk of the South of England," whilst *Belemnitella quadrata* is only noticed as occurring in the Middle Chalk of Kent, Surrey, and Sussex; the fact being that *Belemnitella quadrata* is not found in the Middle Chalk, and *Belemnitella mucronata* is restricted to the highest zone of the Upper Chalk.

A careful study of the various Chalk beds by Barrois, Whitaker, Price, Evans, and others has resulted in establishing the fact that the Upper Chalk, which to the casual observer looks all alike, can be easily subdivided into various zones, each zone being characterized by the presence of certain typical fossils, amongst which the Belemnites play an important part. In the upper beds are found *Belemnitella mucronata*; these are immediately followed by others containing *B. quadrata*, and in the lower third of this zone is a small band which contains *B. lanceolata*; whilst still further down in the Marsupite zone is found the small *B. vera*.

UPPER CHALK ZONES IN THE NEIGHBOURHOOD OF SALISBURY.

1	100 feet	*Belemnitella mucronata* zone
2	150 feet	*Belemnitella quadrata* zone *Belemnitella lanceolata* band
3	200 feet	Marsupite zone with *Belemnitella vera*

In the neighbourhood of Salisbury, the zone of *Belemnitella quadrata* is largely developed, as well as the smaller, more limited bed which contains *Belemnitella lanceolata*: a carefully-collected series of fossils from these two zones soon brought out the fact that *Aptychus leptophyllus* and *Belemnitella lanceolata* always occurred together, and that *Aptychus Portlockii* and *Belemnitella quadrata* were similarly associated. A further study of the specimens themselves revealed what this probably meant, viz., that these two Aptychi were the forward extension of the phragmocone, called by Huxley the pro-ostracum, of *Belemnitella lanceolata* and *Belemnitella quadrata* respectively. Let us now examine more closely and see whether the facts bear out this interpretation, and, for the sake of convenience, begin with *Aptychus leptophyllus*, as related to *Belemnitella lanceolata*.

If a specimen of the latter, sufficiently well preserved to show the form of the alveolar opening of the guard, be carefully examined, it will be noticed that the lateral curve of the anterior edge exactly fits the posterior end of *Aptychus leptophyllus*; and further, that these corresponding edges are similarly ended by roughened margins (Figs. 1 and 2); also, on the inner surface of the outer margin of the proximal end is a well-marked curved line (more apparent in some specimens than others), evidently caused by a fold of membrane which attached this part of the shell to the latero-dorsal end of the alveolus. The semi-crystalline structure and mineral condition of *Aptychus leptophyllus* are identical with the alveolar lining of *B. lanceolata*, both differing from the structure of the guard, corresponding in this respect with the analogous structure of the conotheca of *Belemnites paxillosus*, *B. inornatus*, and *B. ellipticus*, from the Lias and Oolite; furthermore, the singular and characteristic curves on the surface of the conotheca of the first of these species closely resemble the well-marked curved lines of growth seen on the inner concave surface of *Aptychus leptophyllus*. The outer surface of the proximal end of most of the aptychi shows distinct marks of lamination, indicating the secretion of successive layers of shell, deposited by the membrane as the animal increased in age.

This is an important point to notice, as it clearly proves that the shell grew from this end of the aptychus, and not from the straight lateral edge, as would have been the case if these aptychi represented the opercula of Ammonites. The well-marked curved lines of growth on the inner concave surface, as well as the direction of the few radiating longitudinal lines, also prove the same point.

The outer surface of the aptychi is smooth, convex, and thickened towards the outer edge, which in a side view presents a double curve; the distal end is terminated by a thickened, rounded, smooth ridge. The straight inner side is very thin, sharply curved inwards at its margin; some specimens from the Salisbury chalk-pits show the two halves united along this margin, one lapping over the other, the junction forming a straight groove which was probably a continuation of the ventral sulcus or the siphuncle.

The alveolar end of the guard of *B. lanceolata* is generally much paler in colour than the rest of the guard; but at about a quarter of an inch from the free margin there is a well-marked stain of darker colour which follows the contour of the alveolar margin; this is so constantly present in well-preserved specimens that it is probably due to, or marks a point of attachment of, the membrane which united the pro-ostracum to the phragmocone. This darker marking can also be observed along the outer and upper curved margin of the aptychus.

The roughened termination of the thin alveolar margin, and corresponding irregularity of the proximal end of the aptychus, have been already noticed; from this it would appear there was no fixed shelly attachment of the pro-ostracum to the phragmocone; the union was one of membrane only, which would have allowed a considerable amount of movement to this portion of the shell of the Belemnite. This is also probably the reason why the aptychi in the Chalk are not found attached to the guard; the membranes would speedily decompose after death, and in decaying become separated from the heavier guard, which from its shape and weight would naturally sink to the bottom of the ocean, whilst the membranes containing the head, arms, and pro-ostracum would float away and be deposited probably far away from the guard.

One other point is worthy of note, viz. what one might term the suitability in point of size and shape. Fig. 4 represents the largest and Fig. 5 the smallest specimen found: both can be readily fitted to appropriate guards from the same bed of Chalk; whereas they would be utterly out of proportion as opercula of the huge *Ammonites leptophyllus*, which is also found in this locality, but in a much lower zone.

In the Marsupite zone of this neighbourhood Mr. Jebbett has, however, met with a fragment of a very different and much thicker, coarser aptychus, with numerous prominent points which project nearly an eighth of an inch from the external convex surface. My thanks are due to Mr. G. C. Crick for drawing my attention to several nearly perfect specimens from Charlton and Bromley, in Kent (Nos. 46,770, 48,741, 70,391), in the Natural History Museum, Cromwell Road, in every respect corresponding with a broken specimen from Salisbury. These aptychi are very different from those already described in this paper, and, from their size and the fact of their occurring in the Marsupite zone, they may be fairly assigned to *Ammonites leptophyllus*; certainly they could not belong to any Belemnite.

In the same zone of Chalk in which is found *B. lanceolata* and its pro-ostracum, have been discovered specimens of rhyncholites, which there is good reason for considering the beak of this Belemnite; no Ammonite or Nautilus being known in this zone at this locality. Two views of the upper mandible of a large Salisbury specimen are given in Pl. XVI, Figs. 6, 7.

Belemnitella quadrata differs in so many respects from *B. lanceolata* and *B. mucronata*, both in the shape and proportion of the alveolar cavity, as well as in the size and granular surface of the guard, that one is not surprised to find how widely the small aptychi which

Mr. Sharpe described in the Memoir of the Palæontological Society under the name of *Aptychus Portlockii*, differ from the pro-ostracum of *B. lanceolata*. There is, however, to be noticed the same appropriate correspondence in regard to size, between these small aptychi and the small contracted alveolar opening of *B. quadrata*; the largest specimen measuring in length 18 mm. and the smallest only 7 mm. The straight inner edge is very different from that of *Apt. leptophyllus*, being bent into an angular process which laps over the similar projection of the other shell—generally the left laps over the right—and when thus united they form on the inside a groove which corresponds with the internal groove previously described in the pro-ostracum of *B. lanceolata*. (See Figs. 10–12.)

There is no evidence how these small pro-ostraca were attached; but probably the attachment was loosely by membrane, not so near the guard as in *B. lanceolata*, and hence were even more easily detached and separated from the guard after the death of the Belemnite.

No trace of mandibles has been hitherto found associated with *B. quadrata*; the beak was possibly horny and not of the same composition as the guard or pro-ostracum, hence it was not preserved, and has left no trace behind.

After having established the fact of the relationship of *B. lanceolata* and *B. quadrata* to the two aptychi found with them, attention was paid to the higher zone of the Chalk, and here it was discovered that *Aptychus rugosus* was associated with *B. mucronata*. As the guard and alveolar cavity of this species bear a close resemblance to the same parts of *B. lanceolata*, so *Aptychus rugosus* in many ways—in outline, general form, and relative size—resembles *Apt. leptophyllus*. There is the same thin, straight inner edge curved to lap over the margin of its fellow shell, and the curved lines on the inner concave surface are nearly identical. Externally, as the specific name indicates, the surface is marked with a series of roughened ridges, arranged in irregular parallel lines, which somewhat follow the outline of the upper and outer sides of the shell; these tuberculated ridges do not extend to the outside, which is terminated by a thin, flat, bevelled edge. The peculiar sculpturing of the external surface is probably due to the impression made by the roughened membrane which originally covered this extension of the phragmocone, and bears a close resemblance to the granular surface, so often seen on the guard of *B. quadrata*, and also very marked in the upper part of the guard of a large specimen of *B. mucronata*, from Westphalia, in the Natural History Museum, Cromwell Road, which is undoubtedly secreted by the membrane covering it.

Briefly, therefore, it appears that—

(1) *Aptychus rugosus* is the pro-ostracum of *Belemnitella mucronata*.

(2) *Aptychus leptophyllus* is the same part of *Belemnitella lanceolata*.

(3) *Aptychus Portlockii* is the pro-ostracum of *Belemnitella quadrata*.

(4) The large, coarsely punctate aptychus from the Marsupite zone is the true *Aptychus* of *Ammonites leptophyllus*.

It is consequently proposed that in future, as far as the first three are concerned, the term aptychus be omitted, the fossils being named after the several Belemnites of which they form a part.

EXPLANATION OF PLATE XVI.

1. Lateral view of guard of *Belemnitella lanceolata*, showing curve of alveolar margin, and the dark stain parallel to it.
2. External view of *Aptychus leptophyllus*, showing the smooth thickened ridge on upper and outer edge, and also laminated lower edge.
3. Internal view of same, showing the curved lines of growth, and curved line produced by membrane on the lower outer edge.
4. External view of largest specimen of *Apt. leptophyllus.*
5. Internal view of smallest specimen of *Apt. leptophyllus.*
6. Front view of *Rhyncholite*, the upper mandible of *Bel. lanceolata.*
7. Lateral view of the same.
8. External view of *Aptychus Portlockii*—the right perfect half, the left broken on inner edge.
9. External view of an example of *Apt. Portlockii*; the surface is nearly smooth, showing but few lines of growth.
10. External view of a specimen of *Apt. Portlockii*, slightly broken on inner and lower edges; lines of growth strongly marked.

11, 12. Two small examples of *Apt. Portlockii*, the two halves united on the inner margin at an angle which corresponds with that of the alveolar cavity of *Belemnitella quadrata.*

13. Internal view of right side of *Apt. Portlockii*, showing regular lines of growth.
14. Dorsal view of a part of guard of *Bel. quadrata*, showing the form of alveolar cavity and the curve of alveolar edges.
15. Lateral view of the same.
16. External view of a large specimen of *Aptychus rugosus* from the Upper Chalk, Norwich.

All the illustrations of *Bel. quadrata* and *Apt. Portlockii* are magnified two diameters, save Figs. 14 and 15, which, like the other figures, are of the natural size. The specimens are in the author's cabinet, Vale House, Salisbury.

II.—The so-called Middle Sands and Glacial Gravels of Eastern England.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

In a previous paper I have discussed the post-Tertiary Clays of Eastern England.[1] In that paper I endeavoured to show that these clays, varying as they do in texture, composition, and contents, mark a varying geographical distribution and substratum rather than a succession of changes in time; that, so far as we can tell, they are for the most part on the same horizon, and interlock with each other, with occasional local overlaps; while they are united by one common element, namely, the presence of certain foreign boulders of the same general type in them all.

These clays are closely associated with largely developed beds of sand and gravel, which present similar problems for solution, and to some hitherto neglected features of which I should like to call attention. Before turning to these sands, etc., I would, however, add one or two additional facts and quotations in reference to the clays in support of my former conclusion. In Norfolk an attempt has been made to separate the so-called glacial clays

[1] Geol. Mag., October, 1896, p. 449.

into a Lower Clay, consisting of a brown stony loam, and an Upper or Chalky Clay, overlain by sands and gravels; but the sections from which this attempted division has been deduced are very uncertain and doubtful in their testimony, and the best authority known to me on the surface beds of East Anglia, Mr. Horace Woodward, says of them: "Most of these sections show in the same pit the sand tapering away, and then the two Boulder Clays come together, and their separation is not a happy task." Again, he says that in many places the Lower and Upper Boulder-clay are identical in character. He further says that, while in East Norfolk the brown clay maintains its character of a brown stony loam, further west "the lower glacial clays become so like the Chalky Boulder-clay that, from the evidence of pit-sections, they cannot be separated one from the other." (Woodward's Geology, p. 507, and "Geology of Country round Fakenham, etc.," p. 19.) This geographical distribution of the two clays is at once explained when we map out the beds underlying the Drift in Norfolk, and find that in the eastern part of the county the Chalk is still covered and protected by Crag beds, and was not, therefore, accessible when the Drift was formed, while in West Norfolk the Crag is denuded, as are the other Tertiary beds, and the Chalk itself is exposed. This accounts for the chalky débris in the one clay and its absence in the other. Carvell Williams, in describing the surface beds of Lincolnshire, says: "Near Weston, three miles west of Louth, are good exposures of Hessle Clay banked against the Chalky Boulder-clay"; and he adds the pertinent question—"Does not the brown clay pass into the chalky clay?" Again, he describes at Bricket Wood, in Hertfordshire, a clay as precisely intermediate between the Hessle Clay and the great Chalky Boulder-clay, and adds, "It is clearly both." Again, Jukes-Browne wrote a well-known memoir proving the connection of the Lincolnshire clays with the Hessle clays of Yorkshire (Q.J.G.S. 1879, p. 397).

Let us now pass on. With the post-Tertiary clays, as I have said, are associated large beds of sand sometimes having a gravelly texture, and containing seams of gravel and of laminated brick-earth. These sands agree with the clays in containing the same kind of erratics, and are treated by the orthodox geologists, who champion an Ice Age, as glacial deposits.

As is well known, efforts were made long ago by Binney and Hull, working on different lines and coming to different conclusions, to arrange the so-called glacial beds of Lancashire into three series. Binney divided them into two sandy beds separated by a clay; while Hull, whose division has been more popular, into two clays separated by sands and sandy gravels.

To these sands and sandy gravels of Hull's arrangement was given the name of Middle Sands, because they were supposed to come between the two clays. This tripartite division has caused much heartburning among geologists, who have found it impossible to apply it to the great mass of the beds found outside of Lancashire, or even within that county, and especially has the difficulty been felt in Eastern England, where no sophistication of the evidence enables us to apply such a division or any other yet suggested, and no one has been more emphatic in pointing this out than Mr. Horace Woodward. Speaking of the quadripartite division of Messrs. Wood and Harmer, he says (in reference to the area around Fakenham): "I have been at a loss to find the persistence of any of the above four divisions." The beds have "frequent and often very abrupt changes in lithological characters," etc., etc.

Every geologist known to me of any repute, and working in Eastern England, now repudiates the notion that it is possible to apply any of the plausible divisions which have been suggested to the surface beds of Eastern England; while most of them would agree with Professor Judd in his remarks on Leicestershire, Rutland, etc., that the sands and gravels pass horizontally into boulder-clay, and reject any classification of the beds based upon the alternation of clay with sand. The fact is, not only do the clays and sands run into each other and interlock, but the clays frequently contain pockets and lenticular masses of sand, in many cases of laminated sands with shells, while the sands contain similar patches of boulder-clay, showing they were contemporary or virtually so. Although the tripartite division has not been adopted, the term Middle Sands still figures largely in the literature of these deposits, and occupies a notable place in the index to the Quarterly Journal of the Geological Society.

The geologists of the Survey now generally separate the so-called glacial beds of Eastern England into two series, contrasted sharply by their matrix and texture, namely, the boulder-clays and the sands, etc. While the clays are treated as the remnant of some entirely hypothetical *moraine profonde*, the sands, which are often stratified and current-bedded, and which cannot therefore be attributed to this fantastic product of Cloudland, are assigned to the action of water. By some this water is supposed to have flowed from the glaciers or ice-sheets in the form of subglacial streams, and by others, who still maintain a tripartite or multiple division, to mark Interglacial climates.

First, a word or two on a critical difficulty for the Glacialists, suggested by the existence of sands and clays in separate and intercalated layers. Every true glacier moraine known to me consists of a perfectly heterogeneous mass of clay, sand, and stones, or of sand and stones mixed in the greatest confusion and quite unsorted. A glacier, or any great mass of solid ice, is incapable, by any known process, of sifting and separating the ingredients in its moraines into sands and clays. Whatever virtues we attribute to ground moraines, we cannot well suppose that the glacier could separate them into the two great constituents of the so-called glacial beds. If the sands and the clays were once mixed in a common mass of so-called "glacier muck," they must have been sifted by something, and that something is shown by the laminæ and current-bedding of the sands to have been water and not ice. Water is, in fact, invoked to account for the sands by the ultra-Glacialists, but, if water arranged and deposited the sands, whence did it derive them? If it washed them out of the heterogeneous "muck" which formed the moraine, then the clays, no less than the sands, must have been in suspension in the water, and been deposited by it, and if deposited slowly they ought to show, which they do not, lines of continuous stratification. If they came from some other source than this, whence could they have come when the country was, according to hypothesis, either blanketed by ice or covered with the moraine stuff of the glaciers or ice-sheets. The dilemma seems complete. I have put it before, in my "Glacial Nightmare." Of course, I have received no answer. The creed of the Glacialists could not live an hour if its advocates did not persistently hide their heads in the sand, like ostriches, to avoid the most commonplace and every-day evidence. But let that pass.

To a large number of geologists, these so-called Middle or Glacial Sands of Eastern England still index a supposed Interglacial, mild period. It was, in fact, upon the evidence of these very sands that Searles Wood first based his postulate of mild periods in Glacial times. It was supposed to be evidenced by the presence of marine shells in these sands, which could not have lived when the North Sea was choked with its portentous ice burden; and Searles Wood's conclusion is still quoted in some quarters. But the whole induction was really based on a complete mistake of observation. The shells contained in these sands did not live contemporaneously with the deposit of the sands at all. My friend Mr. Horace B. Woodward has shown very conclusively that all the shells and fragments of shells found in the so-called Middle Sands of East Anglia are derivative, and all of those which were formerly supposed to especially distinguish a mild, Interglacial age are really Crag shells, and derived from rearranged Crag beds. This view is now shared by Mr. Clement Reid, who formerly opposed it.

I would carry Mr. Horace Woodward's induction much further. It seems to me that, so far as we have evidence, it extends to making, not only the East Anglian, but all the shelly deposits of Eastern England, which have been treated as original deposits of the Glacial Age, derivative.

I cannot see how it is possible to separate the isolated shelly beds at March, in Cambridgeshire, from the shell beds of East Anglia, with which they agree so much in texture and contents; while, if we turn to the Yorkshire beds the evidence of their derivative and pre-Glacial character is very marked. These shells occur in the so-called Basement Clay at Bridlington, very often with their valves united, in "transported masses of olive-grey sand and clay." Other similar shells occur at Dimlington in pockets of transported sand which still preserve their lamination, as was observed long ago by Sir Charles Lyell and Professor Hughes, and broken shells also occur there in the clay. Mr. Clement Reid and Mr. Lamplugh have shown that these shells occur, not *in situ*, but as transported boulders.

The beds in question were formerly boldly called Crag, a name which ought never to have been dropped, for, so far as can be judged, they are the Yorkshire representatives of the Upper Crag beds in Norfolk, in which, as is well known, Arctic shells occur. It is noteworthy that the beds at Bridlington contain vertebrate remains from the Crag, Eocene, and older beds (Woodward's Geology, p. 499).

It would also seem that the shell beds at Kelsey Hill, near Hull, which are overlain by Boulder-clay at Speeton, where they occur below the Lower Purple Clay, and at Aby, near Claythorpe, in Lincolnshire, are also of late Crag age. I find that after I had written this Mr. Carvell Williams had suggested the same conclusion; and if it be sustained it enables us to solve a considerable difficulty, namely, how to account for the Norwich Crag having been such a local deposit as it has been hitherto deemed to be. It enables us to connect the East Anglian Crag, as Mr. Carvell Williams has done, with the fragments of Crag beds which have occurred on the coast of Scotland in Aberdeenshire and Nairnshire. We must remember that as we get further north we must expect the shells during the period of the Norwich Crag, as in our own time, to show a more and more Arctic facies. I am not sure, in fact, whether all the drift shells on the British coasts which have been treated as glacial are not derivative, and ought not really to be classed as equivalents of the later Crag shells of Norfolk.

With the disappearance of these shells from the category of true glacial débris, and with the proof that they are derivative, disappears the postulate of an Interglacial climate in so far as it has been based on the shelly sands of Eastern England. It also opens the way for an explanation of these sands very different to that usually adopted.

As I have said before, the opinion is now pretty general that all the clayey matrix of the so-called glacial clays of Eastern England is a derivative product, and that it is not, in fact, a clay ground down from argillaceous rocks *de novo* by whatever distributed and arranged the so-called glacial beds, but that it was ready-made clay when that instrument began its work. It was taken up ready-made from the various beds of clay exposed to its influence — in some places from the Kimeridge and Oxford Clays, in others probably from London Clay and the clays of the Plastic Series, and in others, again, from the so-called Chillesford Clays of the Crag deposits.

Everyone who has written in any detail on the subject, seems to allow that the clay which forms the magma or body of the Boulder-clays was derived from pre-existing beds of clay. This conclusion is, in my view, equally true of the so-called sands and sandy gravels. *The sands associated with the Boulder-clays of Eastern England are, so far as I know, all derivative also*, and were ready-made as sands when the instrument which laid down the so-called glacial beds began to operate. For the most part they are *rearranged Crag sands*. In part, also, they are probably rearranged sands of the Bagshot and Reading Series; these recent beds having, doubtless, before the denudation of the Fens occupied a much larger area in Eastern England than they do now.

In a very great number of cases where they have been mapped as glacial sands by the Geological Surveyors, I believe it has been through a mistaken notion that Crag sands or Bagshot sands must necessarily contain Crag or Bagshot shells, whereas a very large portion of those sands is barren, and they only become fossiliferous in places. In the Memoirs of the Survey for East Anglia, there are continual laments about the difficulty of separating the so-called Middle Sands or glacial sands from the sand beds of the Norwich Crag. Mr. H. B. Woodward, for instance, says in his memoir on the country round Norwich, in many places there is considerable difficulty in drawing a definite line between the glacial sands and the Norwich Crag where they do not contain foreign stones (*op. cit.*, p. 104). The explanation of the difficulty seems simple enough. There is no difference, except of arrangement, between these sands. The same sands, when they occur in horizontal or undisturbed beds, are rightly treated as Tertiary sands; when they have become contorted and dislocated, or mixed with foreign stones, they are classed as glacial sands, the fact being that they are then merely Tertiary sands *remaniés*. The so-called contorted drift is probably nothing more than a series of alternating Crag sands and laminated clays which have been twisted and contorted and subjected to violent alteration, and in some cases mixed with some erratic boulders. This mixing and tossing about constitute the sole testimony they offer to their not being true and normal beds of Crag, etc. The so-called Middle Sands or glacial sands of Eastern England have their equivalents on the other side of the North Sea,[1] where they are developed on a great scale, and may be studied in a much more effective and simple way, since they are not associated there with the clays which form such a prominent feature of our own surface beds. In Holland, from Brabant to the Helder, the surface beds which are classed as glacial, lie immediately on Crag beds, which are there developed on a great scale, while there are no beds of Secondary clay or chalk exposed which could supply the ingredients for making boulder-clays like our Chalky Clay, etc. These so-called glacial beds in Holland, therefore, consist merely of sands and pebbly gravels corresponding to the Middle Sands which we have been discussing, and consist there, as they do here, of rearranged Crag beds, with a certain mixture of erratic boulders, and nothing more. The matrix of the beds is of home origin, and simply testifies to the Crag sands and gravels having been taken up by some mighty engine, which has rearranged and tossed them about, just as our Secondary and Tertiary clays and sands have been taken up and similarly rearranged. Nor is there a tittle of evidence in these Dutch beds, other than the supposed ice-borne character of the erratics contained in them, to suggest ice-portage or an Ice Age.

To return to England—what the instrument was which tossed the sands and gravels about, formed the contorted drift, and generally rearranged them in this fashion, I hope to discuss on another

[1] My friend Mr. Harmer's paper on the Dutch surface beds had not been published when I wrote this, or I should have referred to it.

occasion. At present it will suffice to draw the same negative conclusion from the sands that we have already drawn in regard to the clays.

In my former paper I examined every feature of these clays in succession, and endeavoured to show that in no single one do these clays support the notion that they were formed or distributed by ice; but, on the contrary, when critically examined, their texture, contents, mode of occurrence, etc., are absolutely inconsistent with ice in any form having had to do with them.

If this be so with the clays, *a fortiori* is it so with the so-called Middle Sands. These sands are stratified, laminated, and false-bedded; they present all the features of subaqueous deposition and arrangement, and it is universally concluded that they were, in fact, deposited by water. The champions of the Ice Age save their consistency, as I have said, by postulating that the sands were either distributed and laid down by subglacial streams or during an Interglacial, temperate period. I have already discussed the latter issue. In regard to the former let me add one further argument. These sands and sandy gravels are distributed in a most erratic fashion—sometimes, but rarely, in the valleys, sometimes capping the hills, sometimes on the slopes. How subglacial streams could run about the country, irrespective of its drainage and surface contour, uphill and downhill, and deposit these beds as we find them, passes all belief. The fact is, that directly the Glacialist has secured his ice-sheet, and covered the land with it, he considers that he is entitled to postulate any kind of mechanical absurdity as having occurred under its shelter—to believe in the moving about under a portentous weight of hundreds of feet thick of slippery clay, and sliding pebbles, and disintegrated sands, as of ice, ground moraine; the running about of water up and down the country, contrary to and in spite of gravity. These are samples of what is commonly supposed to have occurred in the far-off days when ice was everywhere. In fact, with the intervention of these entirely imaginary ice-sheets we are naturally transported to an entirely imaginary world, and entirely imaginary operations of Nature.

While the ultra-Glacialists admit the deposition of the so-called Middle Sands by water, there is one feature developed locally in them which many of the prophets of ice attribute directly to ice-action in the form of floating bergs, or of the melting of subterranean ice, namely, the contortions which occur in the so-called contorted drift, and the curves and twists of the laminar beds of sand, etc. Upon these I must add a few words. I have spent many scores of days on the coasts and in the sand and chalk pits of East Anglia, and have drawn a good many sections there. Many a time have I wondered how it was possible for any human being who realizes what a grounded berg is like, and the kind of mechanical work it can do, to suppose that it could possibly fashion the *long-continuous, beautifully modelled curves* into which the sandy laminæ have been arranged, many of them extending for hundreds of yards without any breach in the continuity of their graceful lines, in many cases twisted into various serpentiform curves, which are often reversed. How a solid, heavy mass of ice, pounding down upon soft débris, marked by delicate lines and laminæ, or pushing over it, could avoid pounding it into what the Americans call "muck," or could in any way arrange the curved laminæ of the contorted drift as we see it in the cliffs of Norfolk, is a stupendous mystery to myself and perhaps to many other people. How it would be possible, again, to either create or maintain such curves and lines by the collapse of portions of soft beds in consequence of the local melting of buried layers of ice, as some others have argued, is equally confusing. The unsophisticated student who has drunk at these orthodox geological wells should suspend his judgment on these conclusions until he has actually seen the gigantic swirls and figures of ∫ curves, which are so frequent in the Cromer cliffs, or mapped out carefully a series of the layers all arranged in concentric curves round some lenticular or other nucleus, of which examples occur at every few yards in the cliffs. The fact is, such reasoning as I am criticizing is the despairing death-song of Uniformity as understood by some of Lyell's scholars.

Not less impossible to attribute to ice-action, as we have shown in previous papers, is the presence in some of these contorted beds of great masses, not only of solid chalk, but of loose and soft materials, of pockets of sand or lumps of shale, which have been taken up and redeposited with their fine laminæ undisturbed, and the shells in them unbroken and transferred as boulders into the beds in question. That grounded bergs or coast-ice should have performed this kind of work, is as credible to some of us as that Nasmyth's hammer should have come down on a raspberry sandwich and left the indigestible layers intact. I claim to have shown that in no single respect do the so-called Middle Sands, so far as I know them, either testify to the action of ice in any form or to the existence of glacial conditions when they were deposited, nor to the existence of Interglacial periods: conclusions which I share in, as far as East Anglia is concerned, with one of the ablest and most experienced prophets of Neo-Glacialism, Mr. Carvell Lewis.

Having dealt with the post-Tertiary clays and sands, we still have to consider another set of beds, associated with them in Eastern England and marked, like them, by the presence of foreign stones. These are the beds of gravel and shingle (for the most part clean-washed), and consisting, with the exception of the comparatively small proportion of erratics they contain, of smooth flint and quartzite pebbles of a lenticular or flat, oval shape, and occurring in many cases as caps to the hills or on their flanks. Many of these were formerly treated as gravels formed in subglacial streams or by interglacial rivers.

The opinion has been gradually gaining ground lately, however, owing to the admirable work of Prestwich, Searles Wood, Monckton, and others, that the pebbles in these shingle and gravel beds were all formed and smoothed as we find them long before the so-called

Glacial Age. With the contour of the country as we know it there are no rivers in Eastern England which either make or can make gravel or shingle, nor do we see whence the original stones could have been derived under present conditions for fashioning the pebbles. These pebbles are precisely like in form and in character to the pebbles occurring in the Bagshot and Reading beds. Where they occur in East Anglia, etc., in regular beds and undisturbed layers, as they do at Southwold and in other places, it seems to me that they actually represent Tertiary horizons. Where they occur mixed with foreign stones and disturbed, they form another instance to be added to those already quoted of Tertiary beds which have been *remanié* and redistributed by the same force and at the same time as the various Boulder-clays were distributed. Let us now sum up some conclusions—

1. A general and most important result from these arguments and facts, if they are sound, is, that whatever it was that mixed and distributed the soft surface beds of Eastern England, the Boulder-clays, so-called Middle Sands, and the gravels, *it had no part in manufacturing the ingredients out of which those beds were fashioned.* These ingredients, in so far as they were local, were already fashioned and ready to its hands. The clays were already there in the form of clay; the chalky, Oolitic, and Liassic rubble was there in the form of rubble; the polished flint and quartzite pebbles were there in the form and shape we now find them; and the shells were also there, having lived in the Crag seas.

2. What the instrument alone did which formed these beds as we know them, was to bring with it a certain number of foreign stones and to mix them with the ingredients already on the ground, and then to distribute the product as we find it distributed.

3. There is no evidence in these beds to justify our postulating a long process and a prolonged period as necessary for this work, such as the fashionable school of geologists postulate, who profess to account, not only for this mixture and distribution, but for the manufacture of the ingredients, by invoking the long-continued action of ice during an Ice Age. On the contrary, there is every ground for believing the process to have been rapid, and, if not sudden, to have been continuous and not intermittent.

4. There is no ground, so far as these beds or their contents are concerned, for invoking the intervention of ice in any form in their mixture and distribution, but every feature which marks them is at issue with their having been the handiwork of ice. The term glacial, therefore, applied to the clays, sands, and gravels in question, is inapplicable. It is quite time that the authors of this literature should put on their armour and sharpen their weapons, and instead of repeating the *obiter dicta* of their wildest prophets, should condescend to examine the facts and arguments which have been quoted against them and to reply to their critics.

III.—The Present Aspects of Glacial Geology.[1]

By T. Mellard Reade, C.E., F.G.S.

SINCE I joined this Society I have devoted special attention to Glacial Geology, commencing with an investigation of the Pleistocene deposits in the neighbourhood of Liverpool, and gradually extending my observations to adjacent areas, and finally generally to England, Wales, Scotland, and Ireland. I have therefore thought that the "Present Aspects of Glacial Geology" would form a fitting subject for my closing Presidential Address.

My first published papers deal mostly with the Low-level Boulder-clays and Sands, of which we possess an excellent development in Lancashire and Cheshire. Latterly I have extended my studies to the High-level Shelly Sands and Gravels, and Boulder-clays. These observations are noted in papers which have appeared in the Proceedings of the Geological Society of London, our own and the Proceedings of other societies, and in the Geological and kindred Magazines; consequently, though the work has been continuous and connected, it cannot be studied as a whole without considerable labour, which few would care to enter upon.

The object of my present address is to compress the leading facts into a convenient compass, and to bring out the salient results and conclusions as they bear upon the present position of the Glacial question.

The whole of the Lancashire and Cheshire plain, from the sea-level up to about 400 feet, and in places 600 feet, is covered by a continuous mantle of Boulder-clay and sands, broken only by areas where the Triassic or Carboniferous rocks protrude through it, either from the absence of original deposition or from after-denudation. This series of deposits I have called the Low-level Marine Boulder-clays and Sands. These clays, as a rule, contain distributed through them, in a greater or less degree, fragments of shells and some perfect ones. I myself have recorded forty-four species.[2] The majority of the shells are of species that now live in the adjoining seas, mixed with a few others of a more northern type, such as *Astarte borealis*, which may be considered the typical Boulder-clay shell of our neighbourhood. Occasional examples of more southern forms occur, such as *Venus Chione*. The *facies* of the shells does not lead one to think that they lived in water of a very low temperature. An examination of the Boulder-clays from several localities, notably from the cutting of the Seacombe Branch of the Wirral Railway, and from Cook's Lane, Great Crosby,[3] show that they sometimes contain, and probably more frequently than is known, a profusion of Foraminifera, which tell a story not very different to the molluscan remains.

On the other hand, throughout these clays, which are commonly

[1] Presidential Address to the Liverpool Geological Society, 1896–7, by T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

[2] Q.J.G.S. 1874.

[3] Proc. Liverpool Geol. Soc. 1894–5 and 1895–6.

used for brickmaking, there occurs a great variety of boulders and pebbles, of which those from the English Lake District predominate, consisting of Silurian grits and ashy rocks and lavas from the Volcanic Series, which, if not individually identifiable, are certainly so in the mass. The rocks individually identifiable are, firstly. Eskdale Granite and, secondly. Buttermere and Ennerdale Granophyre. Mixed with these are Carboniferous rocks and, in a lesser degree, Triassic sandstones and shales, the Keuper Marls being identifiable by the casts of crystals of chloride of sodium seen on their surface. Granites from the South of Scotland, and also Silurian greywackes, may be distinguished.[1] These rocks, with the exception of the granites, are almost invariably striated, and often intensely so, especially the Silurian grits. The Carboniferous limestones are sometimes drilled with holes by boring molluscs, and in one case I found a boulder well striated on one side, and bored at the top and sides with *Saxicava* with the valves perfect and still remaining in the burrows. From the sand washed out of some of the holes I obtained the fry of *Saxicava* and of *Mactra*.[2]

I have shown[3] that though consisting of Boulder-clay and sands, the character of the drift differs in various localities, being related to the nature of the rocks in the river-basins in which it occurs: in one, clay predominates; in another, sand. The sand may lie at the base, in the middle, or on the top, or in all these positions at once. In some places the basal clay is fuller of stones, mostly rounded pebbles, and is of a sandier and harder nature, so as in some few cases, as at Dawpool, on the River Dee, to stand vertically. There are also divisions in the clay in places like unconformity, but probably due to contemporaneous erosion.

A microscopic examination of the various samples of clay shows that the percentage of sand is commonly much greater than one would expect it to be.[4] The sand-grains, as a rule, are much worn and rounded, and no doubt they have commenced as rounded grains, in many cases being derived from the Trias, but they are often much more polished than any grains I have taken direct from Triassic sandstone, being perfectly smooth and transparent. Also, there are to be seen very minute polished pebbles of hard drift rocks. The shell fragments often, but not always, show signs of much attrition. These deposits rest upon a floor of Triassic or, in some cases, Carboniferous or Permian rocks, which have a system of valleys not always corresponding with the present orographic system.

The Drift has by filling up the valleys sometimes changed the pre-Glacial course of the rivers, so that in the case of the Mersey it now runs in the rock-channel at Runcorn Gap, instead of along the deeper rocky valley buried below the town of Widnes. The pre-Glacial scenery was deeper-cut and bolder than the usually soft

[1] Q.J.G.S. 1884.

[2] Nature, vol. xl, p. 246.

[3] Q.J.G.S. 1883, vol. xxxix, pp. 83–132.

[4] See Davies and Reade, Proc. Liverpool Geol. Soc. 1894–5. Reade, "Drift Beds of Moel Tryfaen": *ibid.*, 1892–3; etc.

outlines of the Boulder-clay country. There is also evidence from the depth of these buried valleys that the pre-Glacial and, perhaps, early Glacial land stood much higher with respect to the sea-level than at present.

When the Boulder-clay, and in some cases the sand, is cleared from the surface of the rock, when this is of hard compact stone, striæ are pretty sure to be found, having usually a north-westerly trend, but with considerable variation and, in most cases, divergent, or even in some cross, striations. At Little Crosby the surface of the rocks was so ice-dressed that the mason who erected the village cross thought it unnecessary to chisel the top surface, upon which at the present moment deep and fine ice striæ are to be observed.[1] Extending our observations beyond the immediate neighbourhood of Liverpool, we find along the Welsh coast as far as Nevin, in Carnarvonshire, a similar assemblage of rocks and shells occurring in the Low-level Boulder-clays and Sands, intermixed to a greater extent with local rocks. These deposits show in some cases decided evidences of stratification. In addition to local differences in the clays the Welsh Low-level Marine Boulder-clays rest generally on another clay, which I call "till," which is distinguished by its assumption of the colour of the local rocks from which it is derived and on which it rests, and the absence of shells and far-travelled erratics.

This deposit bears a relation to the orography of the country, and is present in greatest force in the hilly and mountainous districts, where it can be traced in stream courses far up the valleys. The boulders are of rocks belonging to the immediate watershed, and are found both rounded and striated, angular and subangular. In the case of the larger valleys like the Vale of Clwyd, the marine drift penetrates further inland, but even at Rhuddlan it is seen to rest on a more local clay.[2] These marine deposits are in some cases continuously connected with the High-level Shelly Drifts, which occur at from 1,000 to 1,200 feet, as in the range of hills extending from Minera to Llangollen.[3] This connection may be traced from Ruabon up to the High-level sands just mentioned; also up the course of the River Alyn from its mouth to its source, and again down the continuing Vale of Afon Chwiter by Caerwys to the Vale of Clwyd. In this connection it has been necessary here to mention the continuity of the Low-level and High-level Drifts, though I shall have to recur again to the latter.

To the eastward the Marine Boulder-clays are traceable to Macclesfield, where they occur at a level of about 600 feet in what are known as the Cemetery beds, and an outlying and well-known deposit of shelly sand and gravel is found near the "Setter Dog" at a level of about 1,200 feet.[4]

[1] I had the pleasure of showing this to several well-known geologists during an excursion of Section C of the British Association—Liverpool meeting, 1896.

[2] See "Geology of the Vale of Clwyd" (McKenny Hughes: Proceedings of Chester Society of Natural Science, No. 3. Also, "Drifts of the Vale of Clwyd": Q.J.G.S. 1887, p. 80.

[3] Mackintosh, Q.J.G.S., vol. xxxviii, p. 184.

[4] Prestwich, R. D. Darbishire, GEOL. MAG. 1865, p. 293.

Tracing the extension of the Low-level Marine Boulder-clays and Sands northwards, we find them typically developed at Blackpool in the well-known cliff section first described by Mr. Binney. They can be seen along the coast of Morecambe Bay by Grange, at Rampside opposite Walney Island, and very greatly developed from Ravenglass to St. Bees Head. All the low-level adjoining country inland is occupied with them, and this marine drift, in which shells can be found, is extensive and widespread.

Turning now to Scotland, we are taught by the very excellent work of Mr. John Smith, of Kilwinning,[1] that a large part of Ayrshire is covered with similar shelly Boulder-clays, and he has traced them up in continuous sections from the sea-level to a height of 1,061 feet at Dippal. These deposits I have myself examined with him, and was much struck by their continuity and regular stratification, no less than with the wonderful preservation of the shell fragments and shells, both often possessing their epidermis unabraded. These beds constitute a really massive formation, often presenting sections 80 feet high through the lateral denudation of the River Ayr. The Boulder-clay in which they are preserved is tough and dry below the weathered surface, so that the shells may by a little trouble be got out of the solid clay; in fact, Mr. Smith informs me that in all his fifty recorded localities he has obtained his specimens in this way. Though rubbed, polished, and striated shells occur in places, the shells as a rule are much better preserved than with us. The boulders in the Drift consist to the greater extent of local rocks of the respective watersheds, mixed with some Highland schists. In the valley of the Girvan Water, Loch Doon, granite blocks up to a large size are common, and they also extend further south.[2]

The area worked by Mr. Smith covers tens of square miles, and I have no doubt that the deposits south of his recorded examples are largely of the same nature. In proof of this I may mention that I discovered shelly Boulder-clay containing Loch Doon granite boulders and striated grits in a small exposure in the banks of Byne Hill Burn, about two miles south of Girvan, and 120 feet above the sea-level. The clay was identical in character with that at Muirkirk which I examined with Mr. Smith, and the shells preserved their epidermis. Mr. J. W. Davies, F.G.S., and I afterwards found fragments of shells at several places in the drift cliffs between Bennan Head and Girvan; also, at a level of 280 feet we found some shell fragments and a small *Turritella* in the drift of Byne Hill Burn, south of the place where the shelly Boulder-clay occurs. This is rather remarkable, as Mr. Smith tells me he has found no *Turritell* in any of his Boulder-clay localities in Ayrshire.

From my observations I am satisfied that here we have an

[1] "On the Discovery of Marine Shells in the Drift Series at High Levels in Ayrshire": British Association, Section C, Liverpool Meeting, 1896.

[2] The Baron's Stone of Killochan is a well-known example, and, according to Geikie, contains 480 cube feet.

area of shelly marine Boulder-clay, with sand and gravel beds of great combined thickness, extending from sea-level to 1,061 feet, with a possible higher development of several hundred feet, and in no sense can these high-level drifts be called "sporadic" deposits. They are one and the same thing with the Low-level Boulder-clay and Sands, with the stratification more highly developed.

These Ayrshire high-level shells have, in the majority of cases, been taken, not from sand and gravel beds, but from the Boulder-clay, and in that respect they are most important and unique. In the first discovered and classical example of Moel Tryfaen the shells are found in sands and gravels at a maximum level of 1,400 feet[1]; at Moel-y-Crio,[2] Flintshire, in sands and gravels at 982 feet; on the range of hills from Minera to Llangollen, first discovered by Mr. Daniel Mackintosh, from 1,000 to 1,200 feet; also in sands and gravels at Gloppa, near Oswestry, at 1,100 to 1,200 feet, described by Mr. Nicholson[3]; in stratified beds of sand and gravel, about 100 feet thick; at the "Setter Dog" before mentioned, near Macclesfield, discovered by Prestwich, also in sands and gravels, at a level of about 1,200 feet. In fact, before Mr. Smith's discoveries in Ayrshire, the whole of the known shelly drifts were classified as High-level Shelly Sands and Gravels.[4] Curiously enough, in the sister island the High-level Shelly Drifts discovered by the Rev. Maxwell Close were in gravelly sand, the preponderating rock being Carboniferous Limestone. Here, however, these drifts can be traced continuously up the valleys from sea-level to their highest development on the Three Rock Mountain.[5]

There are also to be found in many localities shelly drifts at intermediate levels, and sometimes well developed. Dr. Charles Callaway has lately described those of Shropshire, in a paper read before the British Association, Liverpool Meeting,[6] in which he arrives at pretty much the same conclusions with regard to them that I do myself.

Before the Ayrshire deposits were discovered, it seemed somewhat of a mystery why the High-level Shelly Drifts should be so commonly sands and gravels, for these materials are obviously less calculated to preserve the marine calcareous exuviæ than clay. In the case of the Dublin and Wicklow High-level Drifts, this may be accounted for by the enormous quantity of limestone gravel

[1] These deposits have been often visited and described, but the most detailed account of them will be found in the Proceedings of the Liverpool Geological Society, Session 1892–3.

[2] Memoirs of Geol. Survey—Mold, Flint, and Ruthin, p. 139.

[3] Q.J.G.S. 1892.

[4] Marine shells are recorded from Bacup, Lancashire, 800 feet above sea-level, which appear to have come from Boulder-clay.—H. Bolton, Trans. Manchester Geol. Soc., vol. xxi, pp. 574–6. See also Roeder, *ibid.*, 607–19.

[5] "Dublin and Wicklow Shelly Drift": Proc. Liverpool Geol. Soc., Session 1893–4. Mr. Joseph Wright, F.G.S., records the occurrence of marine Boulder-clay in Divis, co. Antrim, at between 1,300 and 1,400 feet.—Proc. Belfast Nat. Field Club, 1894–5 (2), iv, pp. 215–6.

[6] "Notes on the Superficial Deposits of North Shropshire": GEOL. MAGAZINE, November, 1896, p. 482.

present. The water percolating through this calcareous deposit would no doubt soon get charged with lime, so that the acids would be neutralized and incapable of acting upon the shells. Be this as it may, I observed in many places delicate shells in all stages of decomposition, and so friable that under ordinary subsoil conditions I have no doubt they would have long ago disappeared in solution and left no trace behind. In the deposits at Gloppa and Tryfaen the shells and shell fragments are of a much stronger type, and appear to have become in many cases partially hardened and fossilized, as, indeed, is often the case with our Low-level Boulder-clay shells. On Tryfaen also there formerly existed a protective covering of Boulder-clay lying on the sands and gravels.

The subject I have ventured to deal with in this address is a very wide one; it has been studied by many minds in many countries, and after fifty years of work perhaps there is less theoretical agreement now than there was in the beginning, although I think I see signs that a development of the older ideas is gaining ground.[1] I venture to think that the questions that have arisen, and which will arise in the future, are essentially of a character in which inductive methods are required for their solution. Whichever view is taken, whatever theory propounded, there are many facts known to working geologists which do not range themselves under any one hypothesis. Of late years there has been a tendency to aim at almost mathematical precision in the explanation of laws which are supposed to govern these Ice-Age phenomena. To my mind, the facts which I have been collecting for the last quarter of a century, having seen the whole of the leading examples of High-level Shelly Drifts in Great Britain and Ireland, as well as made a detailed study of the most prominent of them, together with the Low-level Shelly Boulder-clays and Sands over large areas, as also the essentially glacial and land-ice phenomena of the Welsh and Cumbrian Mountains, lead me to think that the precise, deductive, and dogmatic method so much in vogue is ill adapted to evolve truth from these varied and often, apparently, contradictory facts. For my own part I feel that I have gained by my observation and studies a certain little space of sure ground on which to place my lever, but I confess with sorrow that there are many points on which my judgment is less sure than it was in the first few years of study.

Let us first deal with what appears to be the axiom of a certain class of glacialists, for it is interesting to observe that even those who favour the land-ice as opposed to subaqueous theories differ considerably among themselves. This axiom is, that all the shells and shell fragments found in either the Low-level or High-level Drifts are "boulders," that is, they have been removed from their original habitat and carried to the places where they are found, whether at high or low levels, whether on the coast or far inland; furthermore, the carrying agent or pushing agent, as the case may

[1] Professor Bonney has lately given an excellent résumé of the whole subject in his interesting book, "Ice-Work, Present and Past."

be, was land-ice. In proof of this, the fragmentary character of the shells, their worn appearance, and the occasional striæ found upon them, are adduced.

I am far from alleging that the fragmentary character of the shells presents no difficulty, for I distinctly pointed it out in my earlier writings. But do not the opponents of the marine origin of the Shelly Drift, however, make too much of it? Anyone who will take the trouble to examine a gravelly beach at the present day will find a preponderantly large assortment of shell fragments as compared with perfect valves; he will also find them much worn and rounded at the edges, and seldom will he see any epidermis preserved. Dredgings of the sea-bottom also often bring up remains of broken and rounded shells, so that if, in addition to the ordinary agencies of waves and tides shore-ice were introduced, the pounding of this mill would, as Sir Wm. Dawson informs me is at present the case in the St. Lawrence, work destruction even on the living shells.[1]

I have pointed out that in our Low-level Boulder-clays of the north-west of England the fragments as a rule are minute enough to be carried about by marine currents, in which case they may be looked upon as "boulders" without the intervention of land-ice. Perfect valves are, however, found, and *Turritellæ* are very frequently perfect; also small Gasteropods, such as *Trophon truncatus* and *Fusus*, are in perfect preservation. At Gloppa, as Mr. Nicholson's collection shows, there are many very perfect specimens and a wide range of species. I have, however, pointed out again and again that *negative* evidence is pretty sure in the end to prove fallacious. In *Natural Science*[2] (1893) I urged that the High-level Shelly Drifts, so far from being "sporadic" examples, which some had contended, were simply limited by the difficulty of observation, the known sections having only been exposed by artificial excavations, which are not often required in these out-of-the-way localities. I was not, however, prepared for such a tremendous demonstration of the possibility of natural sections exposing shelly drift having been overlooked by geologists as those in Ayrshire appear to have been. It is a striking demonstration of the truth that things that are not expected to be found are not looked for. The striæ on the rocks of Ayrshire work out in a north-westerly direction from Loch Doon, turning more to the westward as they

[1] Since this was written I have had the pleasure of reading Sir Wm. Dawson's "Canadian Ice Age" (Montreal, 1893), which renders clear many phenomena I have observed in Britain on which I could previously only surmise.

[2] The following is the substance of what I said:—"In working out this objection the supporters of the Irish Sea Glacier unconsciously minimise the quantity of High-level Shelly Drift; there is much more in existence than they have persuaded themselves to believe. There is no occasion for me to name the localities over again, as I have stated them at the commencement of this paper. Again, it can hardly be expected that all High-level deposits laid down by the sea should contain shells, and further it is unphilosophical to assume that all High-level drifts have been discovered. Their discovery has generally been in the nature of an accident. I fear the advocates of the Irish Sea Glacier are continually forgetting how difficult it is to prove a negative, and unfortunately the arguments are too frequently of the negative kind."—*Natural Science*, vol. iii, p. 430, 1893.

approach the Clyde.[1] The distribution of Loch Doon granite follows much the same direction; hence it was inferred that the body of the drift travelled outwards from the land and consequently could not be sea-borne.[2] This, together with the very few recorded examples of shelly drift in the South of Scotland, the highest being that of Airdrie,[3] and the previously expressed opinions that the Scotch "Till" was the result of land-ice stifled observation.[4] It was only by the acumen and industry of Mr. John Smith, of Kilwinning, within the last year that these enormous stratified beds at levels up to 1,061 feet have been proved to contain in the Boulder-clay beds, shells often well preserved with the epidermis intact: a discovery of the utmost importance, to be welcomed as throwing much light upon some obscure points.

We naturally ask ourselves why are the High-level shelly beds in Ayrshire constituted of Boulder-clay, while those of England, Wales, and Ireland are of sand and gravel? After carefully examining all the leading examples, the natural explanation that presents itself to me is a very simple one, viz. the form of the ground where they occur.

In England and Wales the High-level Shelly Drifts are on the summits of hills or ranges where there is either little material for the manufacture of clay, or the orographic position renders it unsuitable for the deposition of fine muds. In Ireland the presence of limestone gravel in large volumes tells the same story, but in Ayrshire the High-level Shelly Boulder-clays near Muirkirk occur in a wide embayment or plateau, surrounded by higher land in which the deposit of fine material derived largely from the Carboniferous rocks might readily take place. There are together with local rocks Highland schists found in the Drift, and these may most readily be accounted for by floating-ice. The very considerable difficulty in assenting to the necessary convolutions and diverse tracks of an ice-sheet or sheets, varied in direction and volume from time to time to

[1] See Memoirs of the Geological Survey of Scotland, Explanation of Sheet 7, p. 14.

[2] In the "Scenery of Scotland" (second edition), by Sir A. Geikie, a Drift map is published in which the only shelly drift shown between the Clyde and the Irish Sea is in the extreme south-west corner of Scotland. It is evident from this that the important shelly drifts of Ayrshire were unknown at the time of publication.

[3] Mr. Dugald Bell, previous to the discoveries of Mr. Smith in Ayrshire, threw such doubts upon the recorded instances of the occurrence of shells in the Drift of the South of Scotland that the stock example of Chapelhall, near Airdrie, which was supposed to prove a submergence of about 500 feet, was omitted in the last edition of Dr. James Geikie's well-known "Ice Age." A committee with Mr. Dugald Bell as a member re-examined the locality, with a result entirely *negative*. This is only another instance of the futility of *negative* evidence, for, as we see, not long afterwards evidence of the most conclusive sort of the presence of sea-shells in natural sections open to the world were found in Ayrshire up to double the height. See "The Great Ice Age and Submergence," by Dugald Bell, Geol. Mag., Dec. IV, Vol II, p. 322.

[4] In a paper read before the Geological Society of Glasgow, April, 1880, and published in its Transactions, vol. vi, pt. 2, pp. 264–276, I stated my opinion that the Scotch Till and the Low-level Marine Boulder-clay of Lancashire are continuous, and that some of the unfossiliferous Scotch Till had probably been formed under glaciers where they debouched into the sea. This is rendered far more probable now that we know that the mud of the Scotch Boulder-clay is marine.

meet the exigencies of the latest discoveries, are immeasurably increased when we attempt to explain these Muirkirk shelly deposits on that system. The great bulk of materials enclosed in the Drift of Ayrshire has worked outwards and downwards, as might be expected in a world governed by gravitation. This, I conceive, is the true explanation, taken together with the wider area on which denuding agents could work, of the presence of Boulder-clay covering the country in large sheets at low levels.

Those who from their studies of glacial phenomena have been led to look upon land-ice as the almost exclusive agent in the manufacture and distribution of glacial deposits, ask those who are in favour of the sea origin of a large portion of these deposits to point out in all beds classed as marine, marine exuviæ, and if they cannot do so, consider it fatal to the submergence theory.

Is not this an extravagant demand to make, for it is really only under exceptional conditions that such organic remains are preserved? Destruction was everywhere going on from the time of the existence of these molluscs in the icy and stone-laden seas to that in which they have been exposed to destruction and dissolution by percolating acidulated waters when these beds became exposed to subaerial influences. We have seen that where the matrix in which these organic remains are entombed is of a non-porous and dry character, like much of the Boulder-clay of Ayrshire, the remains are preserved even to the epidermis. There is also the example of Clava in Nairn, which the Committee of the British Association appointed to investigate pronounced to be a shell-bed *in sitû*, resting upon 36 feet of coarse gravel and sand, and overlaid by 63 feet of Boulder-clay and sands, showing a submergence of the land to the extent of 500 feet.

Again, if we look broadly at the distribution of these shelly deposits, we find that they occur all round our maritime coasts in Lancashire, Cheshire, and Wales, in Cumberland and Westmoreland, Wigtownshire and Ayrshire, and along the eastern coasts of Ireland. The same is to be said of the eastern coasts of England and Scotland. Is it probable that land-ice would so universally work from the sea towards the land? Are we to explain the presence of sea-shells imbedded in Boulder-clay up to 1,061 feet in Ayrshire, 25 miles distant from the coast in a bee-line, by a great glacier proceeding from the Atlantic, crossing Cantire and the Firth of Clyde, and working 25 miles inland, when the travel of the material, excepting as regards some Highland schists, has been in the opposite direction? [1] I confess that my education in the principles of Hutton and Lyell, and my own natural mode of thought, make me averse to such drafts upon our scientific imagination, when there is a simple and direct explanation close at hand. It was well observed by Playfair, some 90 years ago, that "a theory that explains everything explains nothing." [2] May we not

[1] See Memoir of Geol. Survey, Scotland, Explanation of Sheet 7.
[2] "Illustrations of the Huttonian Theory."

apply this excellent saying to the exaggerated form in which land-ice theories are often presented to us?

The phenomena of the Glacial Period in Britain contain some of the most interesting problems it has yet been the lot of geologists to attempt to solve. It therefore behoves us to approach the subject in a spirit of humility. That such varied explanations have been proffered from time to time, that most contradictory conclusions should be drawn from well-ascertained and generally acknowledged facts, is curious and somewhat depressing. There is, however, this reflection to comfort us: however strange, however contradictory, however devoid of common-sense the various explanations and theories of the Glacial Period appear to the various observers and reasoners upon them, the total effect is, like that of the hypothetical Ice-Sheet, a push forward. Without opposition, observation stagnates, so that the first effect of enthusiasm, even if directed in lines that afterwards prove to be mistaken, is to advance the science we love so well. Even if a theory be utterly false, it may prove of great educational value, for, until every possible line of reasoning has been traversed, secure ground cannot be reached.

IV.—On Quartzite Lenticles in the Schists of South-Eastern Anglesey.[1]

By Edward Greenly, F.G.S.

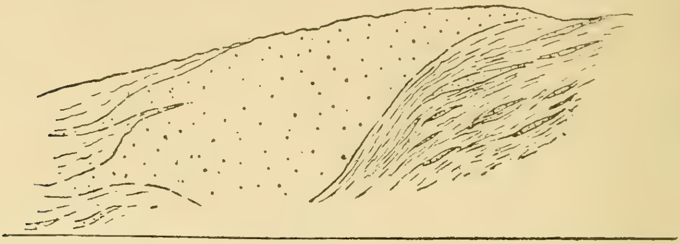
THE prevailing type of schist in the south-east of Anglesey, for some miles to the north and north-west of Beaumaris, is a wavily foliated, pale-green, chloritic rock,[2] the quartz in which, though more abundant than appears at first glance, is in a very fine state of subdivision. In a common variety, especially prevalent about Llanddona, quartz forms nearly the whole of the rock, but it is still in very compact seams, separated by partings of chlorite or mica.

In none of these rock-types can original clastic grains be detected by the naked eye or with the hand-lens; but areas occur in which they contain great numbers of lenticles of quartz, imbedded in a finely foliated matrix of much finer quartz and chlorite. Many of these lenticles have the aspect and fracture of vein-quartz; but a large number, and in some areas almost all, are fragments of true granular quartzite, composed of clastic grains often well rounded. The whole rock, indeed, might be termed a "quartzite-augen-gneiss." With a few exceptions, these fragments range in size from a quarter of an inch to three feet across, but they are apt to be elongated, the axes being often as 8 : 2 : 1. Very frequently they are ellipsoidal rather than lenticular, the bounding curves being continuous all round.

[1] An abstract of this paper was read before the British Association, Liverpool, September, 1896.

[2] There are other green schists in the same area, which are probably of igneous or pyroclastic origin.

Round about them the foliated matrix sweeps in graceful curves, its folia being sometimes truncated against the sides of the lenticle at a low angle. There is abundant quartz-veining within the body of the quartzite, locally obliterating the original clastic texture; and near the margin the quartz-grains are apt to be flattened, a faintly schistose texture being set up in the mass.



Lenticle of quartzite, $3\frac{1}{2}$ feet in length, in pale-green schist, containing many small lenticles. Llansadwrn.

Viewed as a whole, the structures reminded me strongly of those in the mylonites at the Moine thrust in the North-West Highlands of Scotland, except that the lenticular fragments in the latter are generally (so far as I have myself seen) portions of coarse felspathic, gneissoid, or granitoid rocks. But a mylonite, in which the fragments were of rather coarse gritty sediment, would, if a certain degree of crystallization were set up in the matrix, be indistinguishable from these schists.

On reading the paper by my old colleague Mr. Lamplugh (Q.J.G.S., vol. li, 1895) on the "Crush-Conglomerates" of the Isle of Man, it appeared to me that these might yield further light still upon the subject. By his kindness I have been able to study the Manx phenomena in several of the most typical localities, and I have but little doubt that these East Anglesey schists are essentially "crush-conglomerates" whose matrix (containing originally a good deal of iron and magnesia) has become crystalline.[1] Even in the rounding and elongation of the fragments they resemble the crush-rocks of Ramsey and Sulby Glen.[2]

In the district at present mapped, I have failed to trace these rocks into any unbroken sedimentary series. But that the lenticles are of truly cataclastic origin, and not sheared and flattened boulders in a now schistose conglomerate, is, I think, practically certain, from the occurrence among them of four masses of much larger size. These are the quartz-rocks of Pen-y-parc, near Beaumaris, which

[1] An explanation, practically the same, was applied by Sir A. Geikie and Mr. Peach to some rocks of doubtful age in the neighbourhood of Llangefni, Anglesey. (Geikie, Pres. Address Geol. Soc. 1891, p. 130.)

[2] I have since seen the breaking up of a banded slate into rounded fragments, on a small scale, though very markedly, at Llyn Padarn, Llanberis. Mr. Lamplugh, however, lays stress, and I think justly, not so much on the bare occurrence of the phenomenon as on its great scale and extent, in the Isle of Man.

have been described by Professor Bonney and the Rev. J. F. Blake. The mass which has been quarried is a lenticle of which about 175 × 75 ft. are clearly exposed. Its truly sedimentary character has been described by Professor Bonney. Its greatest length is probably not less than 700 ft.; and there are in addition three smaller lenticles a little further east, whose longer axes are from 100 to 200 ft.

These great masses of quartzite can only have been portions of a once continuous bed or beds,[1] from which they have been torn out and carried away, as have been the innumerable masses of the Cambrian quartzites in the North-West Highlands, of somewhat similar form, which are piled up on the minor thrust-planes of that region. Judging also from what we see in the Isle of Man, these beds were probably the more massive members of an alternating series of grits and shales, the thin and flaggy bands of grit having furnished the material of the smaller lenticles.

The complexity of structure consequent upon such movements is admirably illustrated by the two regions just quoted; especially where, as in the Isle of Man, movement has recurred at a later period, superinducing new structures, and to some extent effacing the records of the earlier episodes.

To what extent this may have happened in Anglesey it is at present impossible to say; but it seems probable that the movements which have affected the schistose rocks of that island were of a very high degree of intensity; and the structural relations of the rock-masses may therefore be expected to be in a corresponding degree complex and deceptive.

V.—On the Exmoor Earthquake of January 23, 1894, and on its Relation to the Northern Boundary Fault of the Morte Slates.

By Charles Davison, Sc.D., F.G.S.;

King Edward's High School, Birmingham.

A SLIGHT earthquake of intensity IV, according to the Rossi-Forel scale, was felt in and near Exmoor at about 9 a.m. on January 23, 1894. Its interest lies, not so much in the seismic phenomena presented by it, as in its connection with the northern boundary fault of the Morte Slates.

In studying this earthquake, I have been able to avail myself of 56 records from 48 different places, as well as of 13 other records from 13 places where, so far as known, it was not perceived. The names of the observers and others to whom I am indebted for

[1] The appearances of irregular or intrusive junction figured by Professor Blake are deceptive, being due to the form of the present outcrop. Such discordance as exists is not more than that which sometimes occurs at the margins of smaller lenticles, and may be expected in any highly disturbed region. The relations of this mass of quartzite do not, I think, necessitate our referring its origin to causes acting locally or sporadically.

information are given below,[1] but my thanks are specially due to the Rev. W. Hook of Porlock, Mr. A. L. Ford of Lynton, and Mr. J. H. Barrow of Challacombe, for several additional records which they were kind enough to send me.

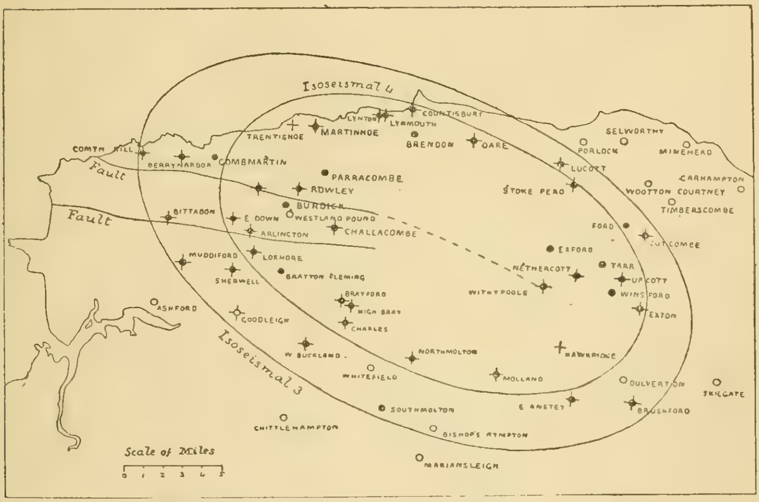
It is possible that there may have been two preparatory shocks. I have only received one record of each, and, in accordance with the usual rule, their occurrence should not be regarded as quite certain, though they are probably of seismic origin: (1) January 22, about 10 p.m., at Arlington, a slight shock, with a noise like underground thunder; (2) January 23, about 8.40 a.m., at Berrynarbor, a series of small waves, duration one second, intensity III, preceded slightly and accompanied by a noise like that of a heavy cart rumbling by, the shock and noise being less intense than those of the principal earthquake at 9 a.m. Both places lie near the north-west end of the disturbed area of the latter, Arlington being close to the southern boundary fault of the Morte Slates, and Berrynarbor about half a mile north of the northern fault.

Nature of the Earthquake.—Detailed accounts of the shock are few in number, and, as will be seen from the map, observations of any kind are wanting in the epicentral district. As a rule, the shock consisted of a tremulous motion, which gradually increased in intensity and then died away. This was the case even at Berrynarbor and Brushford, which are near opposite ends of the disturbed area. At East Anstey, the shock began with a tremulous motion for about three seconds, after which came two prominent vibrations, and then a series of gradually decreasing vibrations for about four seconds. From Eastdowne there comes a somewhat similar observation, a tremulous motion gradually increasing in intensity and then as gradually dying away, and in the middle two distinct

[1] Authorities.—Arlington, Rev. T. de L. Sprye; Ashford, Mr. H. C. Fletcher; Berrynarbor, Rev. R. Churchill; Bishop's Nympton, Rev. E. A. Lester; Bittadon, Rev. E. Braund; Bratton Fleming, Mr. J. H. Barrow; Brayford, Mr. J. Carter; Brendon, Mr. A. L. Ford; Brushford, Rev. C. S. Barber; Burdick, Mr. W. R. Smyth; Carhampton, Rev. W. P. Michell; Challacombe, Mr. J. H. Barrow, Mr. J. Carter; Charles, Mr. J. Carter; Chittlehampton, Mr. H. E. Seymour; Combmartin, Rev. H. C. Jenoure; Comyn Hill, Miss M. Slesser, Mr. J. G. Wood; Countisbury, Rev. H. F. Ramsay; Cutcombe, Rev. J. J. Large; Dulverton, Rev. R. J. Collyns; East Anstey, Rev. J. Owen; Eastdowne, Rev. R. H. Giles; Exford, Mr. A. L. Ford, Rev. J. J. Large, Rev. J. Owen; Exton, Rev. F. K. Warren; Ford, Rev. E. P. Stanley; Goodleigh, Mr. G. Mugford; Hawkridge, Mrs. Thomas; High Bray, Mr. J. Carter, Rev. C. P. Whitaker; Kentisbury, Rev. H. C. Jenoure; Loxhore, Rev. G. O. Ramsay; Lucott, Rev. W. Hook; Lynmouth, Mr. E. B. Jeune; Lynton, Rev. W. E. Cox, Mr. A. L. Ford; Mariansleigh, Rev. A. Winnifrith; Martinhoe, Rev. R. W. Oldham; Minehead, Rev. A. H. Luttrell; Molland, Mr. S. J. Case; Muddiford, Mr. T. R. de Suerin; Nethercott, Rev. W. P. Anderson; Northmolton, Dr. Spicer, Rev. A. Winnifrith; Oare, Rev. H. F. Ramsay; Parracombe, Mr. J. H. Barrow; Porlock, Rev. W. Hook; Selworthy, Rev. F. Hancock; Skilgate, Rev. C. A. B. Harris; Southmolton, Mr. J. H. Barrow, Mr. A. L. Ford, Rev. J. Owen; Stoke Pero, Rev. W. Hook; Tarr, Rev. W. P. Anderson; Timberscombe, Rev. R. J. Crosswell; Trentishoe, Mr. J. H. Barrow; Upcott, Rev. W. P. Anderson, Mr. Tapp; West Buckland, Dr. Spicer; Westlandpound, Mr. W. R. Smyth; Winsford, Rev. W. P. Anderson, Rev. J. J. Large, Mr. A. Tudhall; Withypool, Mr. A. Tudhall; Wootton Courtenay, Mr. E. Brazier.

instantaneous bumps; a sound, as of a heavy cart-load of iron crossing a wooden floor, grew and died away with the trembling, encountering, as it were, two large stones on the way at the instants when the bumps were felt. At Challacombe two distinct rumbles were heard by one observer, without any interval between, each increasing in intensity and then dying away, the first and louder lasting three or four seconds, the second rather less. Lastly, at Molland two rumbles (like distant thunder or firing of artillery) were heard, but in this case there was an interval of a few seconds between them, and it was during this interval that the only perceptible movement was felt.

Disturbed Area and Isoseismal Lines.—The two curves on the map represent the isoseismals of intensities IV and III respectively, the latter forming the boundary of the disturbed area. The isoseismal III is $29\frac{3}{4}$ miles long, $16\frac{1}{2}$ miles broad, and contains 389 square miles. The length of the isoseismal IV is $22\frac{3}{4}$ miles, its breadth $12\frac{1}{4}$ miles, and the area included within it 228 square miles. Both curves are elongated ellipses, and their longer axes are parallel, being directed W. 22° N. and E. 22° S. If the earthquake were due to fault-slipping, this must, therefore, be the direction of the fault-line in the neighbourhood of the epicentre.



Map of the Exmoor Earthquake of Jan. 23, 1894.[1]

The distance between the two isoseismals being $1\frac{1}{4}$ miles on the north side of the longer axis, and 3 miles on the south, it follows

[1] The places where the shock was felt are shown by small black discs; a cross drawn through the disc means that the sound was also heard; a cross alone, that the sound was heard, no reference in the account being made to any perceptible vibration; a small circle marks the places where the earthquake was not observed; and a cross drawn through a circle, a place where the sound was heard, but no shock was felt.

that the originating fault must hade to the south. Moreover, the centre of the isoseismal IV lying half a mile south-west of Simonsbath (or about $5\frac{3}{4}$ miles west of Exford), the fault-line must pass a little to the north of this point, and thus its position is approximately determined.

Origin of the Earthquake.—The geology of the district has been studied recently by Dr. Hicks, though the complete results of his work are not yet published.[1] On the map are shown by continuous lines the north and south boundaries of the Morte Slates, so far as they are given in the papers referred to. The discovery of organic remains in these slates has led Dr. Hicks to regard them as the oldest rocks of the district, the fossils in some of the beds indicating "an horizon low down in the Silurian (Upper Silurian of Survey)," while the rocks on either side, though belonging to varying horizons, are assigned by him to the Devonian period. "A great thrust fault extends continuously along the northern boundary of the Morte Slates, from the coast near Ilfracombe to the Exe Valley. On the south side there is evidence generally also of a well-marked fault." Both the faults hade towards the south.

Unfortunately, Dr. Hicks' map does not show the course of these faults more than about two miles east of Challacombe, so that they stop short of the epicentral area of the Exmoor earthquake. It is evident, however, from its final trend, that the northern boundary fault occupies very nearly the position required by the seismic evidence. The dotted line on the earthquake map is drawn so as to continue the line of fault in a direction parallel to the axis of the disturbed area, and the true position of the fault-line will, I believe, be found to be either along this line or, more probably, a little to the north of it.

If the two preliminary tremors referred to above were of seismic origin, the first movement seems to have been a slip along the southern boundary fault in the neighbourhood of Arlington. This was apparently followed, after less than eleven hours, by a slip along the northern fault, somewhere near Berrynarbor, and about twenty minutes later by the more marked but interrupted slip which gave rise to the double series of vibrations of the earthquake here described. That the length of fault over which the latter slip occurred was considerable, is evident from the form and dimensions of the isoseismal lines; possibly it may have been as much as nine or ten miles. Whether the rocks on the north or south side of the fault were displaced, is not quite clear; but, if we may rely on the evidence of the two preparatory shocks, the more probable alternative is, that the Morte Slates over a length of several miles were forced bodily forward along the thrust-plane.

[1] "On the Morte Slates, and Associated Beds, in North Devon and West Somerset," Part I: Quart. Journ. Geol. Soc., lii, 1896, pp. 254-72. "The Palæozoic Rocks of West Somerset and North Devon": Proc. Geol. Assoc., xiv, 1896, pp. 357–70.

NOTICES OF MEMOIRS

Explanation of the Plan adopted for Preparing an "Index Generum et Specierum Animalium." By C. Davies Sherborn, F.Z.S.[1]

THE following description of the work of preparing an Index to the generic and specific names of animals, both recent and fossil, which was commenced by the author in July, 1890, has been prepared for the Society, at the request of Sir William Flower, Mr. Sclater, and Dr. Henry Woodward.

The difficulty of finding accurate and reliable lists of the species of any particular genus was pointed out by Darwin years ago, and impressed itself so strongly on that naturalist that he personally endowed the undertaking which we know as the "Index Kewensis," recently brought to so successful a conclusion by Benjamin Daydon Jackson. In this book of reference there are some 600,000 generic and specific names of flowering plants. The botanist has now a key to the literature of Phanerogams for 150 years within covers, and all difficulty in keeping pace with present and future descriptions of new phanerogamic plants has been removed.

It is quite otherwise with zoological generic and specific names. Agassiz, Marshall, Scudder, and others have partially catalogued the genera; Waterhouse has listed the genera of birds; H. G. Bronn, John Morris, and, more recently, R. Etheridge, have provided lists of fossil species. But no one book including references to all names that have been given to fossil and recent animals has yet been attempted. The vastness of the record is appalling, but given time all difficulties disappear.

The work now commenced by the German Zoological Society, which was described before this Society at a recent meeting, and known as "Das Tierreich," will be familiar to all present; and it has been suggested that a brief account of the "Index Generum et Specierum Animalium" should be put on record in the same manner.

In May, 1890, a letter appeared in *Nature* and in *La Feuille des Jeunes Naturalistes*, from the author, setting forth a scheme for the compilation of such a work, and inviting suggestions for improved details or other matter. Beyond friends interested at the British Museum, those who offered valuable suggestions were David Sharp, Alfred Newton, Sven Lovén, and Victor Carus. It was, therefore, obvious that the details were satisfactory to those interested, and work was commenced on July 1, 1890.

Since that date recording has steadily progressed (circumstances have restricted the time at disposal to an amount equivalent to three years), and a total of 130,000 slips have been stored away in the alphabetical order of genera. Notices of the progress of the work have appeared in *Nature*, vol. xliv, p. 207 (1891), and *Natural Science*, vol. iii, p. 379 (1893), and the manuscript has frequently

[1] Proceedings Zool. Society, 1896, p. 610.

been referred to by those in need of information at the British Museum and elsewhere.

The following is a reprint of the original set of rules:—

(1) The earliest reference is to date from the twelfth edition of Linnæus, 1766.

(2) The last reference to close with December 31, 1899.

(3) The names of genera and species to be given in one alphabetical sequence, and accompanied by a reference to the original source.

(4) The names of species of each genus to be also quoted in alphabetical order under that genus.

(5) No attempt at synonymy to be given; but, to assist reference, the various genera in which a species has from time to time been placed to be indicated under that species.

(6) Pre-Linnæan names to be quoted as founded by the author first using them after 1766: e.g. *Echinocorys*, Leske, 1778 (*ex* Klein, 1734). Should a pre-Linnæan species or genus have been renamed after 1766, before the post-Linnæan use of that pre-Linnæan name, the new name is to stand. [References will be given to Artedi, Brisson, and Scopoli, in accordance with British Association rules.]

As soon as the work commenced it was found advisable to adopt the tenth edition of the "Systema" as a starting-point, instead of the twelfth. The reasons for this adoption need not be discussed here; the use of the tenth edition is fast becoming universal. This alteration caused a slight modification of several of the proposed rules. At the same time a reference is also given to the twelfth edition of the "Systema," as it will be convenient to many people and will not increase the number of slips in any appreciable degree.

Each genus-name and each species-name is recorded on a separate slip, the original reference being quoted; and every time a species-name is transferred to a new genus a separate slip is used, the quotation including a reference back to the original genus in which the species was first placed.

Each slip is made out in duplicate—one set being sorted up in alphabetical order of genera; and a second set being kept tied up as an index of the contents of the particular book quoted.

References are taken from one book at a time—*i.e.* a book is gone through from cover to cover—every genus and species, and every change of genus, being systematically recorded; thus completely disposing of that particular book, and ensuring the almost absolute certainty of every reference being taken. This system proves far more exact than the recording of any special group of animals at one time. It further permits of the printing from type of a reference to that particular book on each slip, and thus ensures the absolute accuracy of the reference with the sole exception of the page. The entries are made in black-lead pencil and black or blue carbon paper —both methods having proved to be quite indelible.

A particular paper has been chosen, known as "white rope," which presents the requisite stiffness for an edge-on arrangement of slips, the toughness necessary for constant handling, a surface equally convenient for pencil and carbon paper, and a cheapness of 1*s.* 2*d.* per 1000 slips. The size of slip employed is 127 × 63 mm. (5 × 2½ inches).

Nomina nuda are distinguished by the letters [*n. n.*].

Nomina nuda accompanied by figures by the letters [*n. et f.*].

In those cases where an author has described and figured a species some time after printing his *nomen nudum*, a reference is also given to the *nomen nudum*, when possible.

Particular attention has been paid to the date of publication of books, periodicals, and serials. This is a part of the work which demands considerable time and patience, but the results obtained fully justify the labour. The more important results as to dates already arrived at and published are:—

Pallas, P. S., Icones Insect. (See Annals Mag., ser. 6, vii, p. 236, 1891.)

Pallas, P. S., Nov. spec. Glir. (See Annals Mag., ser. 6, vii, p. 236, 1891.)

Schreber, J. C. D., Säugthiere. (See Proc. Zool. Soc. 1891, p. 587.)

Sowerby, Genera Recent Shells. (See Annals Mag., ser. 6, xiii, p. 370, 1894.)

Encyclopédie Méthodique. (See Proc. Zool. Soc. 1893, p. 582.)

Jardine and Selby, Illustr. Ornith. (See Ibis, 1894, p. 326.)

Moore, F., Lepidopt. Indica. (See Annals Mag., ser. 6, xi, 1893, p. 260, and ser. 6, xiv, 1894, p. 464.)

Siebold, P. F. von, Fauna Japonica. (See Proc. Zool. Soc. 1895, p. 149.)

The date of publication of a species is taken to be that date on which the print in which the name appears is offered for public sale or public distribution.

No author's copy, and no excerpt from any publication distributed privately before such publication is offered for public sale or public distribution, have been accepted.

In the case of privately printed books, entries taken from them are distinguished by the words [*auct. typ.*].

In all cases where the date is doubtful and cannot be definitely ascertained, the date figures are enclosed in brackets [ ], or have some other distinguishing mark—*e.g.* (?)—placed against them.

In the case of plates appearing before the text, the date of each is given if ascertainable (*e.g.* Schreber's "Säugthiere"), but in no case is the date of a plate accepted in preference to the date of text, for the reasons which follow:—

The figure depicted on a plate may, or may not, be the drawing intended by the author; it is the work of the artist, who is also responsible for the descriptive legend. In numerous instances the descriptive legend on a plate is quite erroneous, and has been repudiated by the author in his text. Until the text descriptive of a plate appears, the names on the plate must be considered as *nomina nuda*, and it is open to anyone to describe and rename such *nomina nuda*.

Species "indett.," if figured, are included in the Index.

Misprints are quoted only if considered liable to cause confusion.

The following is an example of the Index as proposed to be carried out. The inclusion of an alphabetical list of species under each genus-name is a matter for consideration, if ever the MS. comes to the printing-office. It can be adopted or rejected at option, and if adopted the duplicate set of slips will be available for the purpose.

In arranging the Index for printing it is proposed to print one alphabetical list from beginning to end; the species-names and the genus-names falling into one order according to the arrangement of their spelling. The following are the reasons for arranging the work under species and not under genera, as in the "Index Kewensis":—

1. No synonymy of species is attempted: that depends on the idiosyncrasy of the systematist.
2. Any attempt at specific synonymy would be fatal to progress, as experience shows that vast changes may take place in a single year.
3. An arrangement under species permits of a generic synonymy, for by running the eye down the second column of the printed work, it will be possible to ascertain the various generic names with which a particular species-name has been connected.

Acervulina, *M. Schultze*, *Org. Polyth.* 67. Rh. 1854.
[acinosa; cretæ; globulosa; inhærens.]
acinosa Acervulina, *M. Schultze*, *Org. Polyth.* 1854, 67.
acuta Alveolina, *Savi & Meneghini*, *Cons. geol. Tosc.* 1851, 206.
Alveolina, *A. D. D'Orbigny*, *Ann. Sci. Nat.*, vii, 306. Rh. 1826.
[acuta; boscii; bulloides; compressa; costulata; cylindrica; decipiens; depressa; ellipsoidalis; elliptica; elongata; eximia; fortisii; etc.]
Archiacina, *Munier-Chalmas*, *B. S. géol. Fr.* [3], vii, 445. Rh. 1879.
[armorica; munieri.]
armorica Archiacina (D'Arch.), *Munier-Chalmas*, *B. S. géol. Fr.* [3], vii, 1879, 445. [Cyclolina.]
—— Cyclolina, *D'Archiac*, *B. S. géol. Fr.* [2], xxv, 1868, 376.
Cyclolina, *A. D. D'Orbigny*, *Foram. Vien.* 139. Rh. 1846.
[armorica; carinata; cretacea; dufrenoyi; impressa; pedunculata; præalta.]

The group and date of the genus are shown by the "Rh. 1854" = Rhizopoda, 1854.

From this description of the "Index Generum et Specierum Animalium," it will be seen that a manuscript comprising 130,000 references is already in existence and is available for daily reference.

Sir William Flower, Dr. Günther, and Dr. Woodward took so much interest in the original scheme that they at once offered the necessary space and cabinets for the storage of the manuscript at the British Museum (Natural History)—an offer of considerable value, as it not only renders the MS. easily accessible to those wishing to consult it, but ensures safety from fire and other destructive agencies. The General Committee of the British Association have been generous enough to assist the work by a donation of £70. This has been of considerable assistance in the purchase of paper, material, etc.

A manuscript of this nature is necessarily imperfect for any one genus until the whole literature has been gone through. As far as possible it is compiled from 1758 upwards, but often a side issue takes the compiler on even into the present year. Every book when completed is ticked off in some well-known Catalogue, and a catalogue slip is made, so as to allow of an alphabetical register.

It is believed that the plan adopted for preparing an "Index Generum et Specierum Animalium" is so arranged and so carried out that the work is completed day by day so far as it goes, and that it would be easy for any individual to continue the carrying out of the scheme to-morrow should there be occasion to do so.

REVIEWS.

I.—Geological Survey of Scotland. Explanation of Sheet 75 of the Geological Survey Map—including West Aberdeenshire, Banffshire, parts of Elgin and Inverness. By Lionel W. Hinxman, B.A.; with Petrological Notes by J. J. H. Teall, M.A., F.R.S. 8vo, pp. 48. Price 1*s.* 6*d.* (Edinburgh: Printed for H.M. Stationery Office, 1896.)

THE area described in this memoir is a mountainous one. A small portion of the Spey Valley lies to the north-west by Cromdale, and a group of metamorphic rocks developed in and around the Haughs of Cromdale and the Braes of Abernethy is noted as the "Cromdale Hills Series." The rocks represent a set of alternating shales and sandstones which have been converted into micaceous and siliceous schists and flagstones. They are thoroughly granulitized, and their sedimentary origin is only occasionally to be recognized in the dark laminæ, which under the microscope are found to be composed of heavy residues such as ilmenite and zircon. In addition to the granulitization, the original mineral particles are drawn out in one determinate direction, giving a striped appearance to the rock in many places that at once catches the eye.

The central portion of the area, east of Glens Lochy and Loin, is occupied by metamorphic rocks grouped as the "Banffshire Series," which includes quartzite (showing in places "rod-" and "mullion-structure"), black schists, mica-schists, slates, and limestone. The original bedding-planes in the limestone are generally recognizable, but the rocks are often intensely crumpled and folded, while additional planes of schistosity have been developed in several places. Overlying these old rocks there are, as at Tomintoul, outliers of Lower Old Red Sandstone. At Carn Meadhonach there is upwards of 500 feet of conglomerate belonging to this formation. No organic remains have yet been discovered in the Old Red strata, which include sandstones as well as breccia and conglomerate. Various glacial phenomena are described, and there are notes on peat and alluvium.

The igneous rocks include portions of the granite-mass of Cairngorm on the south of the area, and large tracts of diorite, epidiorite, and hornblende-schist in the eastern portion of the area, at Kirkton of Glenbucket, etc. Serpentine also occurs.

Among the economic products, building- and paving-stone is obtained from the Old Red Sandstone, and lime for agricultural purposes from the limestone. Iron-ore has been smelted at Nethy Bridge, and manganese-ore was formerly obtained. Diatomite occurs in places, and veins of plumbago have been met with. A few mineral wells are recorded.

In his petrographical notes, Mr. Teall notes the occurrence of zircon, rutile, and ilmenite in the rocks of the Cromdale Hills; and he calls attention to the abundance of cordierite in the metamorphic rocks. Interesting particulars are given of the structure of both metamorphic and igneous rocks.

The absence of a small index to this work is to be regretted, and it should be mentioned that the type is not so clear nor the paper so gcod as in the previously published explanation of Sheet 5.

II.—Elementary Geology. By G. S. Boulger, F.L.S., F.G.S., Professor of Geology, City of London College. Small 8vo, 180 pages, with woodcuts. Price 1*s.* 6*d.* (Collins and Co.: London and Glasgow. Not dated.)

THIS is a revised edition of the late Dr. W. S. Davis's little introductory handbook of Geology. The principles of Geology, and their illustration by reference to main facts concerning the past and present conditions of the earth, are systematically and successively stated in twenty short chapters, concisely written, and illustrated with the woodcuts usually met with in such geological handbooks.

The author avoids, to a great extent, entering into disputed and hypothetical explanations of natural facts. He is clear in his statements, though brief; and has evidently the experience of a sound and practical teacher.

The plan of the book is good for a young earnest geologist, who, seeking for visual evidences, in quarries and cliffs, as well as in museums, will take the successive chapters as leaders for his notebook and method of study. For amateurs this little book of elements can be recommended as opening a way of beginning to learn the subject systematically.

The author has especially in view the aid that can be given to candidates in geological examinations, and he reprints the questions given in "Science and Art" examinations in 1889–96, and 183 questions taken from other sources, with references to the correlative paragraphs in the book.

A good Index completes this well-printed and recommendable little handbook.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 4, 1896. — Dr. Henry Hicks, F.R.S., President, in the Chair.

The President referred to the loss which the Society had sustained by the decease of Professor A. H. Green, M.A., F.R.S., who had served for some years on the Council, and was Vice-President at the time of his death. His wide knowledge of science, his perfect uprightness of character, and his genial good-nature were greatly valued by all those who had the privilege of coming into contact with him.

The President further announced that the Council had that afternoon passed the following resolution:—

> "The Council of the Geological Society are deeply sensible of the loss which they have sustained in the death of Professor Green, M.A., F.R.S., one of their Members, and a Vice-President of the Society. In placing on record their acknowledgment of the services which he has often rendered to the Society, they desire to express their heartfelt sympathy with Mrs. Green and the family in their sudden bereavement."

The President announced that Lady Prestwich, in fulfilment of the terms of a bequest of her late husband, had offered to the Society 260 bound volumes of geological tracts from his Library. Also, that a sum of £800 had been bequeathed to the Society by Sir Joseph Prestwich, the interest to be applied to the triennial award of a medal and fund: this bequest to take effect subsequent to the decease of Lady Prestwich.

The Secretary announced that the Rev. P. B. Brodie, M.A., F.G.S., had presented to the Society a framed platinotype portrait of himself; that Capt. G. E. A. Ross, F.G.S., had presented eight lithographic portraits of distinguished geologists; and that Miss Hawkins had presented a portrait of her late father, Waterhouse Hawkins, Esq.

The following communications were read:—

1. "Additional Note on the Sections near the Summit of the Furka Pass (Switzerland)." By T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S., Professor of Geology in University College, London.

The author, during a visit to Switzerland in 1895, had taken the opportunity of completing the examination of the sections on the western side of the Furka Pass, and of glancing again at those previously studied. The white, sometimes slightly quartzose or micaceous marble which, as already described, crosses the summit of the Pass, descends towards the west, but forms a cliff for some little distance by the roadside until it is crossed by the latter, and disappears under débris and turf. Above it is a greyish limestone, at most only subcrystalline in aspect, and retaining traces of organisms, as already noticed. Higher up is a small outcrop of a whitish rock, more like the marble in a very crushed condition than a Jurassic limestone; next comes indubitable Jurassic limestone, and lastly gneiss. In one place the top of the lower mass of marble could be seen within a few inches of dark shaly Jurassic rock. On the eastern side of the Pass two small pits had been opened since the author's last visit; they also showed the top of the marble underneath the Jurassic rock. Both rocks were rather shattered near the junction, but were as different as they well could be. The one resembles the marble, associated elsewhere in the Alps with crystalline schists; the other, a member of the Jurassic system. There is not the slightest sign of a passage between them, but much to suggest faulting. The field evidence is confirmed by study, macroscopic and microscopic, of the specimens. Accordingly the author adheres to the view already expressed, that the white marble is a rock much older than the Mesozoic era.

2. "Geological and Petrographical Studies of the Sudbury Nickel District (Canada)." By T. L. Walker, Ph.D., M.A. (Communicated by J. J. H. Teall, Esq., M.A., F.R.S., Sec.G.S.)

Sudbury is a small town situated in Northern Ontario, in the centre of the nickel-mining district. North of the Great Lakes granite and gneiss form almost boundless terranes, interrupted only by belts of Huronian rocks, which are in turn associated with post-Huronian eruptives, the most important of which are the large nickel-bearing massives.

The Huronian rocks in the vicinity of Sudbury were examined by Professor Bonney, who published his results in the Quarterly Journal of this Society (vol. xliv, 1888). These rocks form a large belt extending from the northern shore of Lake Huron north-eastward for several hundred miles. In the immediate vicinity of Sudbury they are composed of quartzite, mica-schist, phyllite, slate, volcanic breccia, and greywacke.

Far more interesting are the nickel-bearing rocks, which are eruptive and form long elliptical stocks which conform to the strike of the Huronian rocks containing them. Contact-action indicates that they are younger than the rocks previously referred to. The smaller eruptives are composed of greenstone, which appears to have been formed from norite or gabbro. Some of the larger eruptives, however, have been highly differentiated on cooling, as they are now composed of granite and greenstone with gradual transitions from the one to the other. The greenstone generally forms one side of the eruptive, and on the outer border is often characterized by large masses of nickeliferous pyrrhotite, chalcopyrite, and nickeliferous pyrite, with frequent smaller masses of magnetic iron-ore rich in titanic acid. The writer regards these mineral masses as genetically related to the greenstone and granite, in that they appear to be the extreme products of differentiation. About half the world's nickel supply is drawn from these deposits.

The greenstone is generally somewhat altered, but at times it is only slightly changed, when it is seen to be typical norite.

The alteration of augite and hypersthene is described in detail, and the term "migration" is suggested for the process in which secondary hornblende is formed in plagioclase, as if bastite-substance had been carried in solution along the cleavage-lines of the felspar and by reacting upon its host had produced secondary hornblende. Hornblende so formed is referred to as "emigrated hornblende." Areas of uralitic hornblende generally extinguish under crossed nicols in two portions. On a very favourable section it was possible to determine that the two portions of hornblende are in definite crystallographic orientation—namely, that of twinning on the orthopinacoid, as is common in hornblende-crystals.

A mineral resembling wöhlerite was found to be relatively abundant in some of the more acid rocks of the Windy Lake eruptive.

The nickeliferous rocks are cut by younger eruptives—stocks of granite and dykes of olivine-diabase.

A few pages are devoted to the subject of differentiation, in which it is pointed out that no one of the generally accepted theories is able to account for all the phenomena observed in the differentiation of the nickel-bearing rocks of the Sudbury district. Stress has been laid upon the part which gravitation undoubtedly plays in producing heterogeneity in eruptive rocks. All the old theories of differentiation are directed to explain the presence of basic borders on more acid central portions, while they do not account for those cases where the central portions of stocks are basic and the margin acid. They fail also to give any explanation of the commonest case, namely, the eruptive showing little or no differentiation. These different cases are not only explained, but predicted, by the application of the principle of gravitation to slowly-cooling eruptive magmas.

3. "On the Distribution in Space of the Accessory Shocks of the Great Japanese Earthquake of 1891." By Charles Davison, Sc.D., F.G.S.

The object of the author in this paper is to consider the geographical distribution of the numerous shocks which preceded and followed the great earthquake of 1891. A brief summary of Professor Ōmori's work on the distribution of the after-shocks of this earthquake is given, and the difference between his method of treatment and that adopted in the present paper pointed out; the author furthermore indicates possible sources of error in his maps, and explains how these may be practically neglected.

In a map of the coast within the Mino-Owari district, the boundary of the area over which the principal shock was felt is enclosed by a line which bifurcates towards the south. The longer axis of this area coincides generally, as shown by Professor Koto, with the direction of a fault-scarp which, however, is only prolonged into the south-eastern fork of the disturbed area. This the author speaks of as the main fault, and he infers the evidence of a secondary fault running along the southern fork.

In discussing the preparation for the great earthquake, reasons are given for believing that the distribution of earthquakes in

1890–1 was little, if at all, due to the marked shock of May 12, 1889, but that the earthquakes of these years were preparatory to the great earthquake, the consequent relief at numerous and widely distributed points equalizing the effective strain along the whole fault-system, and so clearing the way for one or more almost instantaneous slips along its entire length. This outlining of the fault-system points to the previous existence of the faults, and implies that the great earthquake was due not to the rupturing of the strata, but probably to the intense friction called into action by the sudden displacement.

The distribution of the after-shocks is then discussed, and it is maintained that the after-shocks of the Mino-Owari earthquake for the first fourteen months were subject to the following conditions—decline of frequency, decrease in the area of seismic action, and a gradual but oscillating withdrawal of that action to a more or less central district.

Professor John Milne, F.R.S. (who has lately returned from Japan and intends now to reside in this country), said that the Mino-Owari earthquake had furnished a greater number and a more varied series of seismic phenomena for analysis than had been noted in connection with any disturbance previously recorded. When this earthquake took place an enormous fault, which can be traced over a length of more than forty miles, appeared upon the surface, and it was usually supposed that the sudden rupture and displacement of vast masses of material along this line were the cause of the earthquake.

On account of a peculiar distribution of shocks which took place prior to 1891, Mr. Davison argued that the fault or faults in the Mino-Owari district were outlined before the occurrence of the great earthquake, which was, therefore, only the result of their extension. This may have been so, but it must be remembered that before 1891 the number of shocks occurring in the Mino-Owari plain were not numerous; and as we pass from 1889 to 1891 we cannot say that they increased in number, while their distribution, as exhibited by maps, was largely dependent upon the observing-stations. Where the maps showed blank spaces, in many cases the country was mountainous, and there were no observers. The present author's method of treatment of the statistics relating to "after-shocks" no doubt possesses advantages over that previously used by Professor Ōmori, but the results arrived at, so far as they are comparable, closely accord. It was at the speaker's suggestion that the study of after-shocks was taken up, and he must congratulate Professor Ōmori at having obtained results far beyond and of greater importance than anything anticipated at the outset. Professor Ōmori added to our knowledge respecting the expiring efforts in a seismic area; while Mr. Davison, amongst other things, has thrown new light upon the change in subterranean conditions which culminated, on October 28, 1891, in a shaking which could be recorded from pole to pole.

CORRESPONDENCE.

CALAÏS NEWBOLDI.

Sir,—Since the publication of my paper "On a Fossil Octopus (*Calaïs Newboldi*, J. de C. Sby. MS.), from the Cretaceous of the Lebanon," in the Quart. Journ. Geol. Soc., vol. lii, p. 229, 1896, I find that the name *Calaïs* has been twice used—first by F. L. de Laporte in 1836 (Silbermann, *Revue Entomologique*, vol. iv, p. 9) for a genus of Coleoptera; secondly by J. A. Boisduval, also in 1836 ("J. A. Boisduval, Species Général des Lepidoptères," vol. i, p. 584; quoted as a synonym of *Idmais*, Boisd.). Under these circumstances it becomes needful to propose a new generic name for Sowerby's *Calaïs*; I would therefore suggest that the name of *Palæoctopus* replace that of *Calaïs*, which is preoccupied by a genus of Coleoptera. Henry Woodward.

LIFE-ZONES IN CARBONIFEROUS ROCKS: A CORRECTION.

Sir,—I observe that in your last number (p. 519), the British Association Report on Life-zones in the British Carboniferous Rocks is stated to have been drawn up by me, whereas it was the work of the Secretary, Mr. E. J. Garwood. John E. Marr.

70, Huntingdon Road, Cambridge.

LINNÆUS ON THE APPENDAGES OF TRILOBITES.

Sir,—In the May number of the *American Geologist*, Dr. C. E. Beecher has published an article entitled "On a Supposed Discovery of the Antennæ of Trilobites by Linnæus in 1759." As this article refers to my short communication to the Geological Magazine, p. 142, March, 1896, I shall be glad if you will afford some space for a few remarks in reply to the interpretation of Linné's figure proposed by Beecher.

To begin with, I regret that, in the introductory words, I have used so inaccurate an expression as to suggest that Linné's paper had been overlooked ever since its first appearance, while I have only taken into consideration the period which I have spoken of as a time of important researches into the ventral structure of Trilobites.

Beecher sums up his reasoning concerning the organs, regarded by Linné as antennæ, in the following terms: "It necessarily follows that the cephalon of the specimen figured by Linnæus is without free cheeks, and with this interpretation of the figure, the supposed antennæ can only be homologized with the thickened border between the points where the facial suture cuts the anterior margin." This conclusion is drawn under the supposition that the disputed organs are not antennæ, but no conclusive evidences are adduced that they are not. Before entering upon an examination of Beecher's arguments, I think it suitable to give a short review of the modes in which the head of *Parabolina spinulosa*, Whalb., is usually found preserved. In the zone which is characterized by this fossil, it occurs in the greatest profusion; but owing to the friability of the matrix, it is often difficult to protect the specimens from destruction when kept in collections. Entire heads are not rare, but they more commonly display only the central shield between the facial sutures; other specimens present the same part, but with the portion situated before the glabella and the ocular ridges broken off. That the free cheeks are wanting in the specimen figured by Linné, I have so much the less reason to doubt, as I have in my own collection heads of *Parabolina* quite agreeing with the Linnean figure, but for the parts there visible before the glabella. The free cheeks are indubitably absent for the greater part, but a small portion of them behind the eyes seems to be coherent with the fixed cheeks, since the outer margin of the whole presents an uninterrupted curvature, just like that seen in Linné's delineation. I cannot explain the cause of this shape; it may, perhaps, be due to the form of the inflected portion of the free cheeks. However, a further examination of Linné's drawing does not confirm Beecher's suggestion as to the nature of the parts which Linné called antennæ. If these were to be interpreted as the thickened border between the facial sutures, they ought not to have been pointed towards the end, nor to have been so long as they are. These circumstances might, however, be considered as depending upon carelessness of the draughtsman; and I should scarcely have mentioned them, if they had not been combined with another detail, which cannot be accounted for as due to such carelessness. Before the frontal lobe of the glabella there is a smaller rounded lobe projecting between the pieces in question, which is not only a little larger, but also more distinct in the original figure than in Beecher's reproduction. The form of this lobe seems to me to preclude the idea that we have before us the thickened frontal margin. But if we imagine the foremost part of the central shield before the glabella to be broken off, as is often the case, there is another part which has just that position, quite the same shape, and the same size as that lobe, viz. the anterior part of the hypostome, or, more strictly speaking, of its central portion. This organ is very often met with amongst the specimens imbedded in the slates. From beneath this lobe the antennæ appear springing forth, and their bending can easily be imagined continued beneath the hypostome, to their points of attachment at the sides of the same.

Though I think this interpretation to be more in harmony with the Linnean figure, I admit that the question is not so clear as could be desired. But I believe I am fully justified in having directed the attention of scientists to this early mention of antennæ in Trilobites, each palæontologist being, of course, entitled to attach just as much importance to it as his conviction demands.

By several expressions in Beecher's paper, I feel called upon to repeat from my earlier communication that "this reference to an old"—and isolated—"observation, can by no means abate anything of the value of the brilliant discoveries of our days" made by the eminent palæontologists cited by Beecher, or by that distinguished investigator himself. SV. LEONK. TÖRNQUIST.

LUND, *September*, 1896.

ANGLESEY AGGLOMERATES.

SIR,—In his short paper in your current (November)[1] number, Sir A. Geikie is very ready to give up his opinion as to the agglomeratic character of certain fragmental rocks in Anglesey, but I hope my own opinion was based on too solid a foundation to be so easily overthrown. After reading this retractation, I turned to Sir A. Geikie's and my own original description of these agglomerates, quoted below, and it appeared to me at once that if the phenomena in the Isle of Man were the same as in Anglesey, the rocks in the former locality could not be "crush-conglomerates." I therefore turned again to the description of these "crush-conglomerates" as given by Mr. Watts, and this is what he says:—"The fragments exhibit a great uniformity in composition, and nothing has hitherto been found in them but grits and slates," which "could all be matched either in the transition series or else in the main grits and slates" (between which the crush has taken place). "Although Mr. Lamplugh was alive to the importance of looking out for the existence of fragments of igneous rocks and other strangers, and collected a number of specimens to be tested with this point in view, not a single fragment of any other rock has up to the present been detected."[2]

We cannot doubt that Sir A. Geikie is equally alive to the importance of this feature, and, indeed, his new descriptions of the rocks in Anglesey indicate as much, but I think in his enthusiasm he must have forgotten his older, fuller, and, I think, more accurate account of them. This is what he first said about the rocks at Llangefni: "The agglomerates . . . contain abundant blocks of reddish quartzite, pieces of various felsites and of finely amygdaloidal andesites."[3] My own statement is practically identical: "They contain huge masses of quartzite and igneous rocks."[4] These are certainly not descriptions of the rocks of the neighbourhood between which the crushing could have taken place. Sir A. Geikie *now* writes: "The strata affected appear to have been originally shales or mudstones (with possibly some fine felsitic tuffs), alternating with bands of hard siliceous grit."[5] These two descriptions are very different. Can Sir A. Geikie reconcile them?

Of the rocks near Cemmaes he originally wrote (of the vent on Mynydd Wylfa): "It is filled with a coarse agglomerate, among the large blocks in which fragments of quartzite, limestone, felsite, grit, and shale may be noticed" (five varieties of rock); and the vent on the west side of Cemmaes harbour "appears to have been drilled

[1] GEOL. MAG., Dec. IV, Vol. III, p. 481.
[2] Q.J.G.S., vol. li, p. 591.
[3] *Ibid.*, vol. xlvii, p. 130.
[4] *Ibid.*, vol. xliv, p. 487.
[5] GEOL. MAG., Dec. IV, Vol. III, p. 481.

through some of the thick limestone bands of the district. Large masses of vertical and crumpled limestone beds, as well as quartzite, have been caught up in the agglomerate, together with abundant blocks of grit, fragments of shale, and pieces of a pale felsite"[1] (five varieties again). Of the vent at Porth Cenal my own description is: "The most remarkable feature is the occurrence of great quartz lumps, which are of all sizes and shapes, and lie promiscuously in an agglomerate of slates, grit, and dust," and, "in the headland of Pen-y-parc we get another agglomerate of quartz lumps and ash"; and, after observing that these rocks (the limestone not being mentioned as being merely torn from the sides of the vent) are not those of the immediate neighbourhood, I added: "We cannot here refer [these agglomerates] to the action of a crush-fault,"[2] a remark which shows that I was not unaware of this alternative. These descriptions, with the interchange of "felsite" and "ash," are fairly consistent, but Sir A. Geikie's new description is: "The huge blocks of limestone, there to be seen isolated among fragmentary grits and slates, are referable to the disruption of some of the limestone bands which occur abundantly in the neighbourhood" (quite so). "A gradation may be traced from the slates and grits outside the areas of more severe dislocation into the intensely crushed and sheared 'agglomerate.'"[3] Where is here the quartzite, and the felsite, and the drilling?

The fact is that one main reason, amongst others, in my mind at least, for calling these Anglesey masses agglomerates, was the occurrence in them of a variety of rocks not like those of the immediate neighbourhood; while the main reason for believing the Manx rocks to be "crush-conglomerates" is that the rocks in them are of those kinds only which occur on either side of the area of crushing. The phenomena in the one case are, therefore, not the same as those in the other. J. F. Blake.

November 4, 1896.

THE OLD RED SANDSTONE OF SCOTLAND.

Sir,—Regarding the statement of Professor Davis in last month's issue of this Magazine, it gives us great pleasure to receive his explanation that the terms Devonian and Old Red Sandstone had been used synonymously in his paper, and not as representing two distinctly different conditions of deposit. But he must be well aware that this loose application of these two terms has long fallen into disuse in British geology, and that they now stand for two different types of deposit. Hence it was quite natural for anyone reading his footnote to suppose that his "Devonian erosion" refers to his notice of Sir A. Geikie's plain of marine denudation given in the body of the paper; while his reference to the Old Red Sandstone stands for something quite distinct. Further, as he says himself, having been principally indebted to "English writings" for his knowledge of the structure of this country, we thought it

[1] Q.J.G.S., vol. xlvii, p. 134.
[2] *Ibid.*, vol. xliv, pp. 517-8.
[3] Geol. Mag., Dec. IV, Vol. III, p. 482.

but fair to consider he had been led by Sir A. Geikie's description of the succession of physical events in Scotland after the plication of the earlier Palæozoic rocks, to infer that there had been two distinct periods of denudation, the one marine and the other fresh-water. We sincerely trust that this explanation will be acceptable to Professor Davis of the reading we placed upon his footnote.

But let us now turn to the much more important subject: Is there any evidence of two distinct periods of denudation—a marine, to which the plain of marine denudation is to be referred, and a fresh-water, to which the Old Red Sandstone deposits are to be assigned? Professor Davis, at least on this point, evidently believes that there must have been a vast denudation prior to the deposition of the Old Red Sandstone deposits, and that this denudation may have taken place without leaving any trace of its deposits. But he does not decide as to whether this denudation was subaerial or marine. If he believes that a vast subaerial denudation took place partly previous to, and partly contemporaneous with, the deposition of the Old Red Sandstone rocks of Scotland, then we are at one with him. But if, on the other hand, he believes with Sir A. Geikie, that a great marine denudation took place which has left not a "rack behind" in the shape of deposits, but is only represented by a plain of marine denudation, then we beg to express our dissent.

It seems to us Professor Davis takes but a partial and limited view of the structure and relationship of the Scottish Old Red Sandstone to the older Palæozoic mountain-chain. He states that the Old Red Sandstone lies unconformably upon the floor of ancient rocks. This is doubtless correct so far as the Moray Firth area, and all Old Red Sandstone areas north of the Grampians, are concerned; but had he extended his traverse of the Old Red Sandstone to the boundary fault between Ayrshire and Midlothian he would have found that the Old Red Sandstone conformably succeeds the Silurian of these districts. It is here, in our view, where the *missing link* is found. With Ramsay, Geikie, and others, Professor Davis seems to overlook the significance of this important fact. In this connection a feature of some interest may be referred to. In Lanarkshire a band of shale about 5,000 feet above the base of the Old Red Sandstone contains *Orthoceras dimidiatum*, *Spirorbis Lewisii*, and a graptolite. These being unquestionably Silurian fossils, may not this band of shale and underlying sandstones, conglomerates, etc., be the equivalents of the Downton Sandstones? Again, we have shown that the Caithness rocks must be assigned to a higher horizon than those of Strathmore, while we think we have given strong evidence, both physical and palæontological, for believing that the whole of the series from the passage beds of Lanarkshire, through the middle series of Strathmore, into the highest members of the group in the Orkney Islands, are of marine origin; and it is to this age we would refer the plain of marine denudation seen in the Highland mountains.

Professor Davis advances two objections to the plain now seen in the Highland mountains being of such high antiquity as we have given it — first, that it could not have survived the subsequent deformation, as seen in the angles to which the Old Red Sandstone has been tilted; and second, that it can hardly have been longer exposed to dissection than since the latter part of Mesozoic time. Now if Professor Davis takes a geological map of Scotland and examines it, he will find two great faults running across Scotland: within these faults he will find the later Palæozoic rocks tilted and crushed at considerable angles, this being an area of faulting and corrugation; outside these faults, however, the later Palæozoic rocks lie at low angles, showing little evidence of disturbance, and we believe not enough to destroy the old marine peneplain. On these areas the later Palæozoic rocks, including both the Old Red Sandstone and the Carboniferous series, lay piled in their almost normal horizontal position, to the height of thousands of feet, and so preserving the old marine peneplain from the action of the subaerial forces which otherwise must have destroyed it; and presenting it as we see it at the present day. It was upon this cover of horizontal rocks, we believe, the river systems of the Highlands were first traced.

P. Macnair and J. Reid.

THE STRUCTURE OF GLACIER-ICE.

Sir,—When at Chamonix on September 24, 1896, I visited the Glacier des Bossons. At the termination of the glacier, where the stream was flowing out, the ice was melting in a most interesting manner, which fully bears out the description and drawings of the structure of glacier-ice (by polarized light) given by Messrs. Deeley and Fletcher in the Geological Magazine, 1895, pp. 152–162. The ice was disintegrating into separate pieces of irregular form, each an inch or thereabouts in diameter (there may have been larger and smaller pieces), and fitting exactly together, with interlocking projections and cavities, so that the structure reminded one of a toy dissected map. Here, then, we have the glacier-ice dissected for us by nature and its structure displayed to the naked eye, without the aid of a polariscope. As I had no polariscope with me I cannot say whether each piece consisted of a single crystal or of an aggregate of crystals.

Bernard Hobson.

P.S.—Perhaps by immersing blocks of glacier-ice in hot water the structure might be brought out artificially.

THE JUBILEE OF THE PALÆONTOGRAPHICAL SOCIETY: A SUGGESTION.

Sir,—On reading the interesting account of the work of the Palæontographical Society that appeared in your valuable Magazine, it occurred to me that the jubilee of this Society might well be commemorated in some way more useful and more permanent than the eating of a dinner. The practical proposal that I now beg to offer is the outcome of considerable use of the volumes issued by the Palæontographical Society; for that has led to the discovery of a great need. The need is that of a serviceable index to each or all of the completed monographs. Personally I have felt the absence of such a help most sorely in Davidson's large work on the Brachiopoda, and have wasted much time in searching for such well-known British species as *Productus Martini* or *P. productus*, *Lingula Voltzii*, and *Hemithyris angustifrons* (I mention examples from the last two days only). My colleagues say that equal difficulty is experienced with other monographs. We shall perhaps be told that indices are already published to these monographs; that may be, but they rarely contain what one wants, and some of them are not even arranged in alphabetical order. The proposal, then, is that a real index should be compiled to all the volumes as yet published by the Palæontographical Society; that it should contain every name mentioned, either in the text or in the explanation to the plates, whether synonym, variety, species, or genus; that these names should be arranged alphabetically under both generic and trivial names; that the index should be compiled by some experienced person or persons; that it should be published in octavo form, two columns to a page, certainly not in quarto form, and not on thick paper. The cost of preparing and publishing such an index might be defrayed partly by special subscription, partly by substituting it for a portion of the volume for one year. Most scientific men, including the members of the Palæontographical Society, would probably be more grateful for a good index than for another instalment of new species. By publishing this letter in your widely-read Magazine, you will perhaps elicit the views of geologists in general, and the Council of the Palæontographical Society would see what support was likely to be forthcoming.

F. A. Bather.

OBITUARY.

CAPTAIN MARSHALL HALL.

Born February 6, 1831. Died April 14, 1896.

Marshall Hall, late Captain in the Royal East Middlesex Militia, J.P. for Wilts, F.G.S., F.C.S., etc., was born in London on February 6, 1831, and died at Parkstone, Dorset, April 14, 1896.

As the only child of an eminent physician and physiologist, he was brought up in an atmosphere of science from early days, and it is to this circumstance that his *penchant* for things scientific was in a great measure due. Thus, he was at all times very handy with his microscope, which he found useful both in his chemical and mineralogical investigations. Besides an interest in science, mountaineering and yachting had strong attractions for him, and it was these three factors which largely influenced his career.

No one science could claim his exclusive allegiance; but he evinced an interest in Geology when he became a Fellow of the Geological Society in 1866, most probably at the suggestion of his intimate friend, Morris. Shortly after taking this step a brief notice from his pen, in the Geological Magazine, showed that he had already begun to interest himself in the glaciers of Norway, as he claimed to have made a rough survey of ice-tracts at the end of fjords where no yacht had ever been seen before.

Probably the best thing that Marshall Hall ever did for scientific investigation was by organizing the cruise of the "Norna" in 1870. It is true that on this occasion he was ably seconded by two remarkable men, Saville-Kent and Edward Fielding; to the former of whom especially the scientific credit of this most successful essay in marine zoology was due. Still, it was on the initiation, and mainly at the expense, of Marshall Hall that these results were obtained; and they are all the more striking when we remember that this expedition took place three years before the "Challenger" started on her memorable voyage.

A few years afterwards (1874) we find Marshall Hall, still full of enthusiasm, making a proposal in the Geological Magazine for a "Swiss Geological Ramble"; and he asks the then President of the Geologists' Association (Dr. Woodward) what he would think of this extended excursion. Two years subsequently he was busily engaged, in conjunction with Sorby, Haughton, Heddle, and others, in founding the Mineralogical Society. The first contribution to the Journal of that Society (August, 1876) is a short note written by himself and Clifton Ward "Upon a portion of Basalt from the Mid-Atlantic."

From time to time he contributed short papers to the Mineralogical Society, not forgetting to suggest collaboration amongst mineralogists. As he was now for the most part resident in Switzerland, the rocks of the Val d'Anniviers and the Saasthal supplied him with a congenial theme. Here both his chemical knowledge and his climbing propensities were of use. Thus, in 1882 he narrates how he traced certain euphotides and serpentines to an *arrête*, some 10,000 feet high, descending from the Allalinhorre, and he compares the rocks thus observed *in sitû* with transported masses occurring in the neighbourhood of Veytaux and Geneva.

More recently, and since he came back to England, Marshall Hall returned with renewed ardour to an old love—the study of glaciers. His Alpine experiences helped him here. In this connection his friend and *collaborateur*, Professor Forel, writes[1] that Hall had often contributed original notes to the reports on glacial variations issued by himself. Later, in 1891, when living at Parkstone, Marshall Hall continued to follow up this subject with great eagerness, and obtained from the Alpine Club the formation of a committee charged with the care of studying the oscillations of the glaciers in different parts of the British Empire. In 1893 he contributed a short paper to the Geological Magazine on "Glacier Observations, more especially Colonial," being the substance of two articles which had already appeared in the *Alpine Journal*. He was successful also in interesting the Colonial authorities in his scheme.

[1] "In Memoriam": Alpine Journal, August, 1896, p. 176.

Finally, in 1894, at the International Geological Congress of Zurich he initiated the formation of the "Commission Internationale des Glaciers," being himself elected representative for Great Britain and the Colonies.

A wide field had in this way been found for the exercise of his energies, and there seemed every prospect that he might continue to do much good work, when, to the great sorrow of his family and numerous friends, he was carried off, after a short illness, at the age of 65, just as his plans for the universal study of glacier action were beginning to bear fruit.

Marshall Hall is not to be estimated merely by his writings, which, like his speeches, were for the most part exceedingly brief. His strength rather lay in his faculty of bringing men together, and for this purpose his genial disposition and agreeable manners eminently qualified him. In the heyday of life he discharged these functions in a generous and hospitable spirit. Unfortunately, as time went on, his physical infirmity of deafness, in conjunction with other causes, tended to withdraw him from society at large, though never from social intercourse. To the last he struggled bravely against all these difficulties, frequently busy, but, as he says in a letter written a few months before his death, grown older and less inclined to work. "Not that I am often idle," he remarks; "things come in all of a heap, then comparative repose, then more work. There will not be much to show for *sundry years*, even if I got folks to do anything systematic. So far, the New Zealanders are my best men."

Those *sundry years* he was not destined to realize, and now that the originator is gone will the work be continued?

HENRY JAMES SLACK, F.G.S., F.R.M.S.

Born October 23, 1818. Died June 16, 1896.

Among the pioneers of science. more especially interested in the promotion of microscopical investigations in Biology, the name of Henry James Slack must be engraved upon the annals of the present century, of which his life had covered nearly 78 years.

H. J. Slack was educated at Dr. Evans' school, North End, Hampstead, and at the age of seventeen he entered a wool-broker's office in the City, in which he speedily became a partner, but he retired in 1846, finding the business uncongenial to his literary and scientific inclinations: he then devoted himself to legal and forensic studies, and was in due course "called," but although a keen debater, and intensely fond of either a scientific or political discussion, he never practised at the Bar.

Whilst residing at Ilfracombe, in 1849, he wrote several articles which appeared in the *North Devon Journal*, and in 1852 he became proprietor and editor of the *Atlas* newspaper, to which Walter Savage Landor contributed some poems on Garibaldi. He also acted as temporary editor of the *Westminster Quarterly*; and contributed numerous articles both to newspapers and other periodical publications. In 1860 Henry James Slack commenced to write leaders for the *Weekly Times*, which he continued until 1884.

Keenly alive to all political and social reforms, and spending his time and money most generously in the cause of national and unsectarian education, he was at the same time earnestly devoted to scientific pursuits. He joined the Geological Society of London in 1849 (having been at the time of his death a Fellow for 47 years). Among his numerous scientific papers three only bear directly on Geology, namely: "On Coccoliths and Coccospheres in Reigate Sandstone"; "Notes on the Comparative Geology of the Earth and Moon"; and "Life Changes on the Globe."

One of his most valuable labours for the promotion of science was the editing of *Recreative Science* (published by Messrs. Groombridge and Sons), which was enlarged successively into the *Intellectual Observer*, and lastly into the *Student*. As the popular exponent of science, this periodical occupied, for about twenty years, a first-class position, and possibly might have survived even to the present day, but for the triple dangers of alterations *in form, in size*, and *in title*, which it underwent at the hands of its metamorphotic publishers and editor, had not the former terminated their publishing business, and the latter his duties as editor! Dr. S. P. Woodward, Dr. G. S. Brady, Dr. P. Lutley Sclater, Dr. H. Woodward, Dr. P. Martin Duncan, Dr. Wright, Professor Sir Wyville Thomson, and many other distinguished men of science, contributed to Mr. Slack's monthly magazine, and its pages abounded with good scientific articles.

Of the Royal Microscopical Society he may be said to have been one of the founders, and he filled in succession the offices of Secretary and of President. In addition to the keen interest which Mr. Slack took in all microscopical research, he was also an enthusiastic student of Astronomy, and erected a telescope about 1867, at his residence in Camden Square, which had some points of novelty, being a Newtonian, mounted equatorially on a stand designed by Mr. Browning and himself, having a silver-on-glass speculum and a prism instead of a mirror at the eye-tube (see *Intellectual Observer*, vol. ix, p. 276). Always interested in politics and in all matters relating to education and social progress, and being a strong democrat in principles, in 1879, when President of the National Sunday League, he instituted Sunday Evening Entertainments for the People, giving popular scientific lectures himself, with illustrations, and always with selections of good classical music.

His scientific papers mostly appeared in the *Intellectual Observer* and *Student*, and bear chiefly upon microscopical research. Some of his work on Infusoria was published in a small book entitled "Marvels of Pond Life," which passed through three editions.

In later years Mr. Slack removed from London to a delightful country residence, Ashdown Cottage, Forest Row, Sussex, where he spent the last ten or fifteen years of his always happy, busy, literary and scientific life.

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JANUARY, 1896.

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