NOTICES OF MEMOIRS.

I.—On the Importance of Africa in Vertebrate Palæontology.[1]

By C. W. Andrews, D.Sc., F.R.S. (British Museum, Natural History).

IT is a remarkable circumstance that Africa has long been admitted to be one of the oldest land-areas in the world, portions of it not having been submerged since the Permian period or even earlier. The Reptilia from the Permian and Triassic beds of South Africa are of exceptional interest and importance, because they not only include forms which show relationships with the Amphibia, but also give a clue to the manner in which the reptiles gave rise to the mammals. The fact that the mammals originated from these reptiles may be regarded as demonstrated; this is of particular importance, because, if it can be certainly shown that the Mammalia really originated in Africa, and if parts of that continent have been land since this took place, then it is highly probable that somewhere or other there will be found mammalian remains of various periods, linking up the primitive Triassic or early Jurassic mammals with the modern types. Unfortunately, so far, no Secondary mammalian remains have been found.

When we come to the Tertiary period the case is different, primitive members of the orders Proboscidea, Hyracoidea, and Sirenia having been discovered in the Middle and Upper Eocene beds of the Fayum district of Egypt. These same beds have also yielded remains of animals which show that the anthropoid apes and toothed whales probably originated in the same region. Besides these there are a number of remarkable forms which seem to have died out without leaving any descendants in the fauna of to-day. One of these, *Arsinoitherium*, was a huge hoofed animal carrying a pair of large horns on the nose, and quite unlike anything known elsewhere.

Up to this period Proboscidea are known only from Egypt, but between the Upper Eocene and the Lower Miocene, the next horizon at which they have been found, they had spread over much of the world, having passed out of Africa along some land connexion with Europe or Asia, which broke down the isolation of that part of Africa in which they had originated; the anthropoid apes, Hyraxes, and other members of the same fauna, no doubt spread north with them. In the lowest Miocene beds of Europe and India the Proboscidea are represented by two distinct types. One, *Tetrabelodon*, is really a Palæomastodon with its peculiarities exaggerated; the other form, *Dinotherium*, is very different and presents peculiarities not found in any other of the elephants. In deposits of the same age at Mogara, in Egypt, only *Tetrabelodon* occurs, nor was it known till quite recently that *Dinotherium* had existed in any part of Africa. Last year, however, Mr. C. W. Hobley sent to the British Museum a fragment of a mandible with molars which undoubtedly belongs to a small species of *Dinotherium*, closely similar to *Dinotherium*

[1] From the Journal of the East Africa and Uganda Natural History Society, vol. ii, No. 4. (Abstract.)

cuvieri, a species found in the Lower Miocene beds of France. This specimen was collected by the late Mr. Botry Piggot at Karungu, near the south-eastern shore of Lake Victoria Nyanza, and is the first early Tertiary mammal recorded from tropical Africa. It is of the greatest interest, because it proves the possibility, and even the probability, of mammalian faunas of various ages occurring in that region, and also shows that the separation of *Dinotherium* from the rest of the Proboscidean stock most likely took place in Africa, where the intermediate links may therefore be expected to be found. The finding of this specimen shows what great possibilities of the discovery of completely new forms of extinct animals are afforded by British East Africa. An expedition to German East Africa has already found remains of a gigantic Dinosaur, some of the bones of which are about twice the size of those of the well-known *Diplodocus carnegii*, a reptile which was about 80 feet long. Now this discovery of a new mammalian fauna of Miocene age gives great hopes that in the near future important additions to our knowledge of this region may be made. It is greatly to be desired that anyone finding teeth or bones (or even fragments of them) that appear to be in a fossil condition, should send them to the British Museum for determination; for even though the specimens themselves may not be very good, they may be sufficient to determine whether further collecting on the spot would be likely to lead to valuable results.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, DUNDEE, 1912.

The Relation between the Cambrian Faunas of Scotland and North America.

Address to the Geological Section by B. N. Peach, LL.D., F.R.S.
(President of Section C).

Introduction.

Ever since the announcement made by Salter in 1859 that the biological affinities of the fossils found in the Durness Limestone are more closely linked with American than with European forms, the relation between the older Palæozoic faunas of Scotland and North America has been a subject of special interest to geologists. The subsequent discovery of the *Olenellus* fauna in the North-West Highlands furnished striking confirmation of Salter's opinion. This intimate relationship raises questions of prime importance bearing upon the sequence and distribution of life in Cambrian time in North America and North-West Europe, on the probable migration of forms from one life-province to another, and on the palæogeographical conditions which doubtless affected these migrations.

On this occasion, when the British Association revisits the border of the Scottish Highlands, it seems appropriate to refer to some of these problems. With this object in view I shall try to recapitulate briefly the leading features of the life-history of Cambrian time in Scotland and North America, to indicate the relation which these life-provinces bear to each other, and, from these data, to draw some inferences regarding the probable distribution of land and sea which then obtained in those regions.

The two great rock groups in Scotland that are universally admitted to be older than Cambrian time are the Lewisian Gneiss and the

Torridon Sandstone. The Lewisian Gneiss, as mapped by the Geological Survey, consists mainly of igneous rocks, or of gneisses and schists of igneous origin. But, in addition to these materials, we find, in the Loch Maree region, schists of sedimentary origin, comprising siliceous schist, mica-schist, graphite-schist, limestone, chert, and other sediments. The association of graphite-schist with limestone and chert suggests that we are here dealing with rocks that were formed at or near the extreme limit of sedimentation, where the graphite, the limestone, and the chert were probably accumulated from the remains of plankton. But this assemblage has been so completely altered into crystalline schists that all traces of original organic structure in them have been destroyed.

The Torridonian strata were evidently accumulated under desert or continental conditions, and could therefore furnish little or no evidence bearing upon the development of marine life. That life existed, however, is clear from the presence of phosphatic nodules, containing remains of cells and fibres of organic origin, in the upper division of the system, and from the presence of worm burrows and casts in the Diabaig Beds (Lower Torridon).

Geologists are familiar with the fact that the Cambrian faunas all over the globe present highly specialized types belonging to most of the great groups of marine invertebrate life. Scotland is no exception to this general rule. For the fossils prove that their ancestors must have had a long history in pre-Cambrian time.

The Cambrian Fauna of Scotland.

Beginning with the false-bedded quartzites forming the basal subdivision of the Cambrian strata in the North-West Highlands, we find no traces of organic remains in them, except at one locality, where worm casts (*Scolithus linearis*) were obtained. In the upper subdivision of the quartzites—the pipe-rocks—the cylinders of sand are so numerous that the beds have been arranged in five sub-zones, based on a definite order of succession of different forms probably of specific value. One of them, *Arenicolites* of Salter, may be of generic importance. Worms of this habit are confined to comparatively shallow water, and therefore near the shore-line. Their occurrence helps to confirm the belief that the quartzites were laid down on an ancient shelving shore-line during a period of gentle subsidence. Their presence also indicates the existence of plankton, from which they derived nourishment. Besides the relics of these burrowing Annelids, one of the sub-zones of the pipe-rock has yielded specimens of *Salterella* (*Serpulites Maccullochii*)—a tubicolar Annelid, which becomes more abundant in the overlying fucoid beds, serpulite grit, and basal limestone, where it is associated with *Olenellus* and other typical Lower Cambrian forms.

The fucoid beds, which immediately overlie the pipe-rocks, consist chiefly of shales and brown dolomitic bands, with intercalations of grit locally developed. This type of sedimentation indicates that the mud-line was superimposed on the shore-line by subsidence. With this change of conditions there is a change of organisms, for though the burrowing forms (*Scolithus*) are still to be found in the sandy layers, the most characteristic types are those occurring along the bedding planes, known under the name of *Planolites* (Nicholson). They are very varied forms, and were probably produced by many types of errant Annelids. The tubicolar Annelids are represented by *Salterella, Coleoloides*, and *Hyolithes*—an organism which perhaps links the worms with the hingeless Brachiopods. This suggestion gains additional support from the researches of Dr. Walcott in the Middle Cambrian rocks of Canada. It is interesting to note that small Annelids seem to have bored the spines of dead Trilobites. Walcott has found similar borings in the chetæ of Annelids in the Middle Cambrian rocks of Canada.[1]

[1] Smithsonian Misc. Coll., vol. lvii, No. 5, p. 125, 1911.

The researches of Dr. Walcott have proved beyond doubt that representatives of nearly all the divisions of the Annelids are entombed in the Middle Cambrian rocks of Mount Stephen, in British Columbia. We may therefore reasonably infer that the worm casts of *Scolithus* type found in the North-West Highlands are due to Annelids. He has also shown that worm-like Holothurians are to be found in the same beds.[1] In this connexion it may be observed that some of the recent Holothurians have much the same habit of obtaining nourishment from the sands and silts containing organic matter.

Fragments showing the characteristic microscopic structures of the plates and ossicles of Echinoderms have been found in the fucoid beds. These are probably Cystidean. Hingeless forms of Brachiopods also occur, among which may be mentioned *Paterina labradorica* and *Acrothele subsidua*. The type of *Acrothele* suggests a genetic descent from such a tubicolar worm as *Hyolithes*. Of the Gasteropods, only one specimen, belonging to a sub-genus of *Murchisonia*, has been obtained at one locality in Skye. *Helenia bella*, a curved calcareous tube, open at both ends, doubtfully referred to the Dentalidæ by Walcott, is comparatively plentiful. It occurs also in the *Olenellus* zone in Newfoundland.

But the organic remains that render the fucoid beds of exceptional interest and importance are the Trilobites, because they clearly define the horizon of this zone in the Cambrian system and display strong affinities with American types. They are represented by five species and varieties of *Olenellus*, very closely resembling the forms in the Georgian terrane, or *Olenellus* zone, on the east and west sides of the North American continent. The genus *Olenelloides* has also been recorded from these beds. The Crustacea are represented by Phyllocarids, among which we find *Aristozoe rotundata*, likewise characteristic of the *Olenellus* zone of North America.

Next in order comes the serpulite grit, which indicates a recrudescence of the pipe-rock conditions of deposition, and presents the *Scolithus* type of Annelid borings. From the diameter of the pipe and the depth of the burrow it is probable that the worm may have belonged to a different species from any of those whose casts are to be found in lower horizons. This large variety is associated with smaller and more irregular worm casts which have often weathered out and leave the rock honeycombed with hollow casts. The characteristic form from which the zone takes its name is *Salterella* (*Serpulites Maccullochii*). It occurs abundantly along certain calcareous layers that mark pauses in the deposition of the sand. This calcareous type culminates at the top of the zone, where there is a thick, carious, weathering band, crowded with specimens of *Salterella*, forming a passage bed into the calcareous shales at the base of the Durness dolomites. At one locality near Loch an Nid, Dundonnell Forest, Ross-shire, thin shales, intercalated in the serpulite grit, yielded a fine carapace of *Olenellus Lapworthi*—a form of frequent occurrence in the underlying fucoid beds. Professor Lapworth recorded the finding of *Orthoceras* and linguloid shells in the top part of this zone at Eireboll.[2]

Immediately above the serpulite grit in Eireboll and Assynt we find a few feet of dark calcareous shale, with iron pyrites, probably deposited at the limit of sedimentation. This layer, which is singularly devoid of organisms, ushers in the great succession of dolomites and limestones, upwards of 1,500 feet in thickness—perhaps the most remarkable type of sedimentation among the Cambrian rocks of the North-West Highlands. The Geological Survey has divided this calcareous sequence into seven well-marked groups, some of which have as yet yielded no fossils beyond worm casts. Attention will presently be

[1] Smithsonian Misc. Coll., vol. lvii, No. 3, 1911.
[2] GEOL. MAG., 1883, p. 126.

directed to the absence of calcareous forms in many of the bands of dolomite and to the probable cause of their disappearance.

The thin calcareous shale just referred to is followed by dark-blue dolomite limestone, forming the basal portion of the Ghrudhaidh group. It contains sparsely scattered, well-rounded sand grains, with a bed about 3 feet thick, near the bottom, charged with *Salterella pulchella* and *S. rugosa*. In the overlying 20 feet of dolomite the sand grains gradually disappear, and the rock assumes a mottled character, due to innumerable worm casts of the *Planolites* type. Here a second layer, yielding *Salterella pulchella* and *S. rugosa*, supervenes, both forms occurring in the *Olenellus* zone of North America.

The brief summary of the palæontological evidence which has just been given clearly shows that the strata ranging from the middle of the pipe-rock zone to the upper *Salterella* band of the Durness dolomites represent in whole or in part the *Olenellus* zone of North America. Owing to the absence of fossils we have no means of deciding more definitely the base and top of the Lower Cambrian rocks of the North-West Highlands. All the quartzites lying below the middle of the pipe-rock, notwithstanding the absence of zonal forms, have been included in the Lower Cambrian division. This correlation receives some support from the remarkable discovery of Dr. Walcott, who found primitive Trilobites several thousand feet beneath the beds yielding *Olenellus Gilberti*, the form closely allied to the Highland Trilobites.

On the other hand, when we pass upwards for a certain distance from the *Salterella* bands the evidence is insufficient to establish the stratigraphical horizon of the beds. For, in the overlying strata comprising the remainder of the Ghrudhaidh group, the whole of the Eilean Dubh group, and the lower part of the Sail Mhor group, and consisting of dolomites, limestones, and cherts, with little or no terrigenous material, the only fossils that can be shown to be due to organisms are worm casts of the nature of *Planolites*, although the limestone and chert may have originated from the debris of the calcareous and siliceous organisms of the plankton. A noticeable feature of the Ghrudhaidh and Eilean Dubh groups is the occurrence in them of bands of brecciated dolomite on several horizons, which do not imply any break in the continuous sequence of deposits. The total thickness of this portion of the Durness dolomites and limestones, yielding no fossils beyond worm casts, amounts to 350 feet.

But in the upper part of the Sail Mhor group siliceous and calcareous organisms of a higher grade make their appearance. Among the former we find the *Rhabdaria* of Billings. The calcareous forms are represented by (1) Gasteropods, including a single specimen of a Murchisonid, two species of a Pleurotomarid (*Euconia Ramsayi* and *E. Etna*) of a type occurring in the calciferous rocks of Newfoundland and Canada; (2) Cephalopods, comprising two slightly bent forms with closely set septa and wide endogastric siphuncles, showing affinities with those of *Endoceras* and *Piloceras*; (3) Arthropods, represented by the epitome of a large asaphoid Trilobite resembling that of *Asaphus canalis* of Conrad. This evidence is insufficient to determine the exact horizon of these beds, but clearly indicates that we are no longer dealing with Lower Cambrian strata. The Cephalopods are like those found in the Ozarkic division of Ulrich (Upper Cambrian), in North America. According to Schuchert, the Cephalopods with closely set septa are of Cambrian type and older than those of the Beckmantown terrane of American geologists. On the other hand, the asaphoid type of Trilobite is suggestive of a somewhat higher horizon.

No fossils have been found in the overlying Sangomore group, about 200 feet thick, which consists mainly of granular dolomite, with bands of chert, some being oolitic, together with thin fine-grained limestones near the top.

Above this horizon, at a height of over 800 feet above the top of the *Olenellus* zone, we encounter the great home of the fossils peculiar to the Durness Limestone in the Balnakeil and Croisaphuill groups. The former consists mostly of dark limestones, with nodules of chert, and, with a few alternations, of white limestone bands. A few thin layers are charged with worm casts. The overlying group is more varied, the lower part being composed of dark-grey limestones full of worm casts, and with some small chert nodules arranged in lines; the middle portion, of dark granular and unfossiliferous dolomite; and the upper part, of massive sheets of fossiliferous limestone full of worm casts. The total thickness of these two groups in Durness is about 550 feet.

These two subdivisions have yielded over twenty genera and about one hundred species. In Durness sixty-six species have been obtained from the Balnakeil group alone, fifteen of which have not as yet been found in the overlying Croisaphuill group, thus leaving fifty-one species common to both divisions. The Ben Suardal limestones in Skye, which were mapped by the Geological Survey as one division, are regarded, on palæontological grounds, as the equivalents of both these groups. Owing to the number of species common to both subdivisions, the fauna will be here referred to as a whole.

Both siliceous and calcareous organisms are present in this fauna. Among the former we find *Archæoscyphia* (Hinde), described by Billings as *Archæocyathus,* an early Cambrian coral, but shown by Hinde to be a siliceous sponge.[1] The genus *Calathium* is represented by four species. Other genera and species of sponges occur, so that the siliceous nodules, which are very common in both groups, may be in great part due to them. In this connexion it may be mentioned that Hinde obtained sponge spicules from some of the nodules. Hinged Brachiopods have also been collected from these beds, and include *Nisusia* (*Orthosina*) *festinata, N. grandæva,* and *Camarella.*

But the characteristic feature of the fauna is the assemblage of calcareous Mollusca comprising Lamellibranchs, Gasteropods, and Cephalopods, showing a wide range of variation, and consequently a long ancestry. The Lamellibranchs, though represented only by two genera, *Euchasma* and *Eopteria* of Billings, with several intermediate forms, are of extreme interest, as they are only known to occur elsewhere in Newfoundland and Eastern Canada. The Gasteropods, however, furnish the largest number of species—about 48 per cent of the whole. The primitive Euomphalids, *Maclurea* and *Ophileta,* are most characteristic. The former genus has a large number of species, many of which are to be found in the Beekmantown Limestone of Newfoundland and Eastern North America. Only one of the species (*Maclurea Peachi*) is peculiar to Durness. Several species of *Ophileta* are found, some of which likewise occur in the Beekmantown Limestone. *Euomphalus* has also been recorded, while several forms belonging to the nearly allied family of the Turbinidæ, and placed in Lindström's genus *Oriostoma,* are also met with in the Beekmantown Limestone.

Murchisonids and Pleurotomarids number twenty-seven species and show a very wide range of variation. The chief sub-genera of the former are *Hormotoma* and *Ectomaria,* many species of which occur with remarkable variations. All the types of variation found in Durness are to be found in North America, and several of the species are common to both regions. The Pleurotomarids vary in a similar manner, the chief genera being *Raphistoma* and *Euconia,* and a form resembling *Hormotoma,* only with a shorter spire. Species belonging to each of these sub-genera are likewise common to both areas, while some are only known from the North-West Highlands.

The Cephalopods are of equal interest. They are also of primitive type, and, at the same time, show a wide range in form. The

[1] Quart. Journ. Geol. Soc., vol. xlv, p. 125, 1889.

prominent feature in the straighter specimens is the great width of the laterally placed siphuncle, which is generally furnished with endocones and organic deposits. The genus *Piloceras* is the most characteristic type, and shows this peculiar feature best. It has only been recorded from Scotland, Newfoundland, Canada, and the eastern States of North America. The following additional genera are represented, viz., *Endoceras*, chiefly by siphuncles in great variety, *Actinoceras*, *Cyrtoceras*, and, doubtfully, *Orthoceras*. Several forms have been attributed to *Orthoceras*, which, on re-examination, have been found to be the siphuncles of other genera, resembling American types described by Hall and Whitfield.

The whorled Nautiloids provisionally classed with the genus *Trocholites* of Conrad are represented by several distinct forms as yet unnamed.

The Trilobites are of rare occurrence in these two groups of dolomite and limestone. They are fragmentary and poorly preserved. This is doubtless one of the disappointing features connected with this remarkable assemblage of organic remains, for the presence of a zonal form would have helped to define the horizon of these beds. Only one species, *Bathyurus Nero* (Billings), has been identified, which also occurs in the Beekmantown Limestone of Newfoundland. The other Trilobite remains, though poorly preserved, have a Cambrian facies characteristic of North America.

In connexion with this fauna certain features have been observed which throw some light on the absence of calcareous organisms from thick zones of the Durness dolomite and limestone. In my detailed description of the palæontology of the Cambrian rocks of the North-West Highlands in the Geological Survey Memoir, I stated that "in most cases the septa and walls of chambered shells have been wholly or in part dissolved away, so as to leave only the more massive structures of the siphuncles, and worm castings are often found within the chambers where the septa have been preserved. These features seem to indicate that the accumulation of the calcareous mud in which the fossils were embedded was so slow that there was time for the solution of part of an organism before the whole of it was covered up".[1] There is good reason to believe that many organisms wholly disappeared by this process, so that it is reasonable to conclude that the fossils obtained from the Durness dolomites cannot be regarded as furnishing a complete life-history of the forms that originally existed in that sequence of deposits. Attention has already been called to the fact that beneath the two subdivisions now under consideration there are groups of dolomite and limestone which so far have yielded no organic remains beyond worm castings. And even in the important Croisaphuill group, with its fossiliferous zones, there are thick groups of dolomite which have furnished no calcareous organic remains. Obviously the palæontological record in this instance is glaringly incomplete, for we have no reason to suppose that the life of the time flourished in some of the calcareous zones and not in others.

The highest subdivision of the Durness Limestone, measuring about 150 feet in thickness (Durine group), has yielded two species of *Hormotoma*—viz. *H. gracilis* and *H. gracillima*—both of which occur in the two underlying groups. *H. gracilis* occurs in the Beekmantown, the Chazy, and the Trenton Limestones of America.

Before assigning any stratigraphical horizons to the fauna of the Durness dolomites, it is desirable, owing to the American facies of the fossils, to recapitulate the evidence bearing upon the life of Cambrian time in North America. But the Cambrian life-history of Scotland would be incomplete without a brief reference to the recent discovery of fossils along the eastern border of the Highlands.

[1] *Geological Structure of the North-West Highlands*: Geol. Surv. Mem., 1907, p. 380.

In 1911 Dr. Campbell announced in the GEOLOGICAL MAGAZINE that fossils had been found in the Highland border series north of Stonehaven, and, during this year, Dr. Jehu made a similar discovery in rocks belonging to this series near Aberfoyle. Papers on these subjects will be communicated to this section. For my present purpose it will be sufficient to indicate the nature of the fossils and the lithological characters of the rocks containing them.

The Highland border series north of Stonehaven and near Aberfoyle includes sheared igneous rocks, both lavaform and intrusive, with black shales, cherts, and jaspers. North of Stonehaven the fossils occur in thin, dark, flinty pyritous shale, while at Aberfoyle they have been found in shaly films at the edge of the chert bands. Several years ago Radiolaria were detected in the cherts between Aberfoyle and Loch Lomond. From time to time these Highland border rocks have been carefully searched for fossils, but until recently with little success, owing to the intense movement to which they have been subjected, resulting in marked flaser structure in all except the most resistant bands.

The fossils consist chiefly of horny, hingeless Brachiopods, Phyllocarid Crustacea, worm tubes, and the jaws and chetæ of Annelids. The genera of Brachiopods comprise *Lingulella, Obolus, Obolella, Acrotreta,* and *Linarssonia.* The association of these Brachiopods with Phyllocarid Crustaceans resembling *Hymenocaris* and *Lingulocaris* is suggestive of an Upper Cambrian horizon—an inference which is supported by the absence of Graptolites.

In the published Geological Survey maps these Highland border rocks are queried as of Lower Silurian age. This correlation was based partly on their resemblance to the Arenig volcanic rocks and Radiolarian cherts of the Southern Uplands, and partly because, as shown by Mr. Barrow, they are overlain by an unconformable group of sediments, termed by him the Margie Series. The cherts, the green schists, and the Margie Series have shared in a common system of folding, and are unconformably surmounted by Downtonian strata near Stonehaven. Though the original correlation may not be strictly correct, it is probable, in my opinion, that representatives of both the Arenig and Upper Cambrian formations may occur in the Highland border series, and, further, that Upper Cambrian strata may yet be found in the Girvan area, as originally suggested by Professor Lapworth in correspondence with Dr. Horne.

The Cambrian Fauna of North America.

[We are unable, from want of space, to give the particulars here related by Dr. Peach, and therefore quote only the conclusions at which he has arrived.]

The palæontological evidence adduced regarding the relation of the Cambrian fauna of the North-West Highlands to that of North America leads to the following conclusions:—

1. The Lower Cambrian fauna of the North-West Highlands, distinguished by the genus *Olenellus* and its associates, is almost identical in character with that of the Georgian terrane of the western life-province of North America, and essentially different from the Lower Cambrian fauna of the rest of Europe.

2. No forms characteristic of the Middle Cambrian division, either of Europe or North America, have as yet been found in the North-West Highlands; but this division may be represented by the unfossiliferous dolomites and limestones of the Ghrudhaidh, Eilean Dubh, and the lower Sail Mhor groups.

3. The fossiliferous bands of the Sail Mhor group may be the equivalents of the lower part of the Upper Cambrian formation.

4. The Balnakeil and Croisaphuill groups of the Durness dolomites

and limestones contain a typical development of the molluscan fauna of the Beekmantown Limestone, belonging to the western life-province of North America. As the Beekmantown Limestone is succeeded by shales, with Arenig Graptolites, it follows, in accordance with British classification, that these groups must be of Upper Cambrian age.

5. The highest subdivision of the Durness Limestone (Durine) has not yielded fossils of zonal value, and the members of this group are not overlain in normal sequence by graptolite-bearing shale or other sediments.

Cambrian Palæogeography between North America and North-West Europe.

In attempting to restore in outline the distribution of land and sea in Cambrian time between North America and North-West Europe, reference must be made to various investigators whose researches in palæogeography are more or less familiar to geologists. Among these may be mentioned Suess, Dana, De Lapparent, Frech, Walcott, Ulrich, Schuchert, Bailey Willis, Grabau, Hull, and Jukes-Browne. The views now presented seem to me to be reasonable inferences from the palæontological evidence set forth in this address.

In the North-West Highlands there is still a remnant of the old land surface upon which the Torridonian sediments were laid down. There is conclusive evidence that the pre-Torridonian land was one of high relief. As the Torridonian sediments form part of a continental deposit it may be inferred that the Archæan rocks had a great extension in a north-westerly direction. The increasing coarseness of the deposits towards the north-west suggests that the land may have become more elevated in that direction. At any rate, the pile of Torridonian sediments points to a subsidence of the region towards the south-east, and probably to a correlative movement of elevation towards the north-west.

The sparagmite of Scandinavia is an arkose resembling the dominant type of the Torridon Sandstone; is of the same general age, and has evidently been derived from similar sources in the Scandinavian shield. In eastern North America coarse sedimentary deposits form part of the newer Algonkian rocks, which are still to be found rising from underneath the Cambrian strata in the region of the great lakes. These materials were obtained from the great Canadian shield, which must have formed a large continental area during their deposition.

It is reasonable to infer that these isolated relics of old land surfaces were united in pre-Torridonian time, thus forming a continuous belt from Scandinavia to North America. During the period which elapsed between the deposition of the Torridon Sandstone and the basement members of the Cambrian system a geosyncline was established which gave rise to a submarine trough, trending in an east-north-east and west-south-west direction, both in the British and North American areas. In the latter region it extends from Newfoundland to Alabama, its south-eastern limit being defined by the old land surface of Appalachia. The extension of this Appalachian land area in a north-east direction beyond the limits of Nova Scotia and Newfoundland was postulated by Dana and other American writers. This geosyncline remained a line of weakness throughout Palæozoic time, both in Britain and North America, which resulted in the Caledonian system of folding in Britain, and in the Taconic, Appalachian, and Pennsylvanian systems in North America. Hence it is manifest that the original shore-lines of this trough are now much nearer each other than they were in Cambrian time.

The Cambrian rocks of the North-West Highlands were laid down along the north-west side of this trough during a period of subsidence, for the great succession of Durness dolomite and limestone, with little or no terrigenous material, is superimposed on the coarser sediments of

that formation. On the other hand, the Cambrian strata of Wales seem to have been deposited along the southern limit of this marine depression. The Archæan rocks that now constitute the central plateau of France may have formed part of its southern boundary. The extension of this land area towards the north-east may have given rise to the barrier that separated the Baltic life-province from that of Bohemia, Sardinia, and Spain. In my opinion, this southern land area in Western Europe was continuous across the Atlantic with Appalachia. For the life sequence found in the Cambrian rocks of New Brunswick is practically identical with that of Wales and the Baltic provinces, thus showing that there must have been continuous intercourse between these areas. Along this shore-line the migration of forms seems to have been from Europe towards America. On the other hand, along the northern shore the tide of migration seems to have advanced from America towards the North-West Highlands. The question naturally arises, what cause prevented the migration of the forms from one shore of this trough to the other? American geologists are of opinion that this is probably due to the existence of land barriers; but, in my opinion, it can be more satisfactorily accounted for by clear and open sea, aided by currents.

The south-western extremity of the American trough in Lower Cambrian time opened out into the Mississippian sea, which was connected with the Pacific Ocean, and stretched northwards towards the Arctic regions. Reference has already been made to Walcott's discovery in Nevada of the primitive Trilobite *Nevadia Weeksi*, from which he derives both branches of the Mesonacidæ, one branch linking *Nevadia*, through *Callavia*, *Holmia*, and *Wanneria*, with *Paradoxides*, the other connecting *Nevadia* with *Olenellus*, through *Mesonacis*, *Elliptocephalus*, and *Pædumias*.

In Nevada the genus *Holmia*, as already shown, is associated with the primitive type *Nevadia*. *Wanneria* is found in Nevada, in Alabama, and in Pennsylvania, thus showing that this genus is common to the Mississippian sea and to the long trough north-east of Alabama. *Mesonacis* has been obtained in the submarine depression at Lake Champlain, at Bonne Bay, Newfoundland, and at the north side of the Straits of Belle Isle. *Elliptocephalus* has been recorded from the New York State. *Olenellus* has been found in Nevada, in Vermont, and in the North-West Highlands. All the genera now referred to may have migrated along the north-western shore of this trough.

As regards the distribution of the genus *Callavia*, this form has been met with in Maine, in Newfoundland, and in derived pebbles in a conglomerate in Quebec. Two species have been recorded in Shropshire. These forms probably moved along the southern shore of this sea from Wales to North America.

Reference has already been made to the fact that, in the interval between Lower and Middle Cambrian time, in certain areas in North America, the Lower Cambrian rocks were locally elevated and subjected to erosion. During this interval the southern end of the trough seems to have had no connexion with the Mississippian sea, for in Middle Cambrian time, as already indicated, the *Paradoxides* fauna is found in the trough on the east side of North America, whereas on the west side it is represented by the *Olenoides* fauna.

In Upper Cambrian time a great transgression of the sea towards the north supervened. The *Dikelocephalus* fauna is found on both sides of America, thus showing that the previous land barrier had been submerged. While this genus occurs in Wales and the Baltic provinces, it has not as yet been recorded from the North-West Highlands, but I quite expect that this discovery may be made at some future time.

Along the northern side of the American trough clear-water conditions prevailed, owing to the northward recession of the shore-line, which

led to the accumulation of a great succession of calcareous deposits, including the Beekmantown Limestone, to which reference has already been made. Schuchert, as already stated, has pointed out that, in the lower part of the Ozarkic (Upper Cambrian) System, in Minnesota and Wisconsin, the Gasteropod genera *Holopea, Ophileta,* and *Raphistoma* are associated with two species of *Dikelocephalus*. This molluscan fauna is evidently the precursor of that of the Beekmantown Limestone. It was probably from this central region of America that the calcareous fauna of Beekmantown migrated to the submarine trough in the typical Champlain region, and through Newfoundland to the North-West Highlands of Scotland.

The section at St. John, New Brunswick, where the Baltic and Welsh types of the *Olenus* fauna occur, shows that the southern shore-line of the trough must then have occupied much the same relative position as in Lower and Middle Cambrian time. In the same region the strata containing this fauna, with *Peltura scarabæoides* and *Dictyonema flabelliforme,* are overlain by dark shales with Arenig Graptolites. These Graptolite-bearing terrigenous deposits eventually extended across the trough northwards, till, in Newfoundland, they came to rest on the Beekmantown limestones.

In the Lake Champlain region, in the Chazy Limestone, which there immediately succeeds the Beekmantown Limestone without the intervention of the Arenig Graptolite shale, there is a survival of the Beekmantown molluscan fauna with only such slight modifications as to indicate genetic descent. In the same trough the descendants of this fauna are to be found in the Trenton Limestone.

In this connexion it is worthy of note that the molluscan fauna and the corals of the Stinchar and Craighead Limestones of Upper Llandeilo age in the Girvan district of the Southern Uplands have an American facies, as first suggested by Nicholson. The appearance of American types in these limestones may be accounted for in the following manner: Attention has already been called to the divergent types of sedimentation presented by the Upper Cambrian strata of the North-West Highlands and of the South-East Highlands, at Stonehaven and Aberfoyle. In the former case there is a continuous sequence of dolomites and limestones, while in the latter we find a group, comprising Radiolarian cherts and black shales, associated with pillowy spilitic lavas and intrusive igneous rocks, indicating conditions of deposition at or near the limit of sedimentation. But, notwithstanding the different types of sedimentation and the divergent faunas in the two areas, I believe that during the Upper Cambrian period, and probably for some time thereafter, continuous sea extended from the North-West Highlands to beyond the Eastern Highland border. The Upper Cambrian terrigenous sediments which we now find at Stonehaven and Aberfoyle must have been derived from land to the south. In Llandeilo time the Arenig and Lower Llandeilo rocks of the Girvan area were elevated and subjected to extensive denudation. On this highly eroded platform, as first proved by Professor Lapworth, coarse conglomerates, composed of the underlying materials, were laid down in association with the Stinchar and Craighead Limestones. In my opinion the appearance of the American forms in these limestones is connected with the movement that produced this unconformability in the Girvan area. This local elevation was probably associated in some form with the great crustal movements that culminated in the overthrusts of the North-West Highlands and caused the intense folding and flaser structure of the rocks along the Highland border. By these movements shore-lines may have been established between the north side of the old Palæozoic sea and the Girvan area, which permitted the southern migration of the American forms.

Note. Since writing the above my attention has been directed to the recent work of Bassler on *The Early Palæozoic Bryozoa of the Baltic*

Provinces, published by the Smithsonian Institution in 1911. In his introduction the author has shown that the Ordovician (Lower Silurian) and Gothlandian (Upper Silurian) rocks of the Baltic Provinces contain a large percentage of Bryozoan species, in common with the Black River, Trenton, and Niagara Limestones of the same relative age in Eastern North America. This fact suggests that during Lower and Upper Silurian time the old lines of migration were still open, and that the Bryozoa, being of clear-water habit, were able to cross the old trough from side to side.

III.—British Association for the Advancement of Science, Eighty-second Annual Meeting, held at Dundee, September 4–11, 1912. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Presidential Address by *Dr. Benjamin N. Peach, F.R.S.*

Professor Thomas J. Jehu.—Address on the Geology of the Country around Dundee and St. Andrews.

Mr. E. B. Bailey.—A Mull Problem: The Great Tertiary Breccia.

Mr. C. I. Gardiner.—On the Silurian Inlier of Usk.

Mr. T. O. Bosworth.—The Heavy Mineral Grains in the Sandstone of the Scottish Carboniferous.

The Rev. A. Irving.—Preliminary Note on a Buried River Channel near Peterborough.

Report of the Committee on the Composition and Origin of the Crystalline Rocks of Anglesey.

Report of the Committee on the Bembridge Limestone at Creechbarrow Hill.

Dr. Robert Campbell.—The Discovery of Fossils in the Jasper and Green Schist Series of the Highland Border at Craigevin Bay, Stonehaven.

Dr. Robert Campbell.—The Downtonian and Old Red Sandstone of Kincardineshire.

Dr. R. H. Traquair, F.R.S.—On *Cyathaspis* from the Downtonian Rocks of Stonehaven.

Professor T. J. Jehu.—Discovery of Fossils in the Boundary Fault Series near Aberfoyle.

Mr. Archibald W. R. Don.—On the Nature of *Parka decipiens*.

Mr. John H. Wilson.—Uncharted Volcanic Necks at St. Andrews.

Report of Committee on the *Index Animalium* (also in Section D, Zoology).

Dr. John S. Flett.—The Sequence of Volcanic Rocks in Scotland in relation to the Atlantic–Pacific Classification of Suess.

Mr. George Barrow.—The Older Granite in Lower Dee-side.

Mr. G. W. Tyrrell.—The Alkaline Igneous Rocks of Ayrshire.

Dr. William Mackie.—The Volcanic Rocks around the Ord Hill of Rhynie, Aberdeenshire.

Dr. A. W. Gibb.—On an Actinolite-bearing Rock associated with Serpentine.

Mr. Edward Greenly.—On the Origin of some of the Mica-schists of Anglesey.

Mr. Albert Gilligan.—The Millstone Grit of Yorkshire—New Evidence of its Source of Origin.

Mr. Albert Jowett.—Notes on the Volcanic Rocks and their Associated Sediments of the Forfarshire Coast between the Red Head and Montrose.

Dr. W. T. Gordon.—The Fossil Flora of the Pettycur Limestone in relation to Botanical Evolution.

Dr. Marie C. Stopes.—Palæobotany *versus* Stratigraphy in New Brunswick.

Dr. B. N. Peach, F.R.S., & Dr. J. Horne, F.R.S.—The Archæan Rocks of the Island of Lewis.

Dr. J. S. Owens.—The Settlement and Transport of Sand in Water.

Mr. George Barrow.—On Buckled Folding.

Mr. Edward Greenly.—A Theory of the Menai Strait.

Mr. J. D. Falconer.—On the Origin of 'Kopjes' and 'Inselberge'.

Mr. G. W. Grabham.—Note on the Country North of Lake Albert.

Dr. J. W. Spencer.—Post-Glacial Changes of Level *versus* Recent Stability of the Lake Region of North America.

Mr. A. R. Horwood.—On a Fossiliferous Tufa occurring beneath Chalky Boulder-clay at Launde, Leicestershire.

SECTION A.—MATHEMATICAL AND PHYSICAL.

Dr. J. Milne, F.R.S.—Report on Seismological Investigations.

SECTION E.—GEOGRAPHY.

Presidential Address by *Colonel Sir Charles M. Watson, K.C.M.G.*

Colonel C. F. Close.—The International Map.

Mr. E. A. Reeves.—Recent Improvements in Surveying Instruments.

Dr. H. M. Ami.—Geographical Progress in Canada.

Sir H. G. Fordham.—Notes on British and Irish Itineraries and Road Books.

Sir Clements Markham.—Antarctic Discovery.

Dr. F. Oswald.—From the Victoria Nyanza to the Kisii Highlands.

Mr. H. M. Cadell.—The Development of some Scottish Rivers.

Mr. A. H. Garstang, F.R.S.—Some Canons of the Cevennes.

Dr. J. W. Spencer.—Submarine Canon of the Hudson River.

Dr. W. S. Bruce.—The Antarctic Continent.

Mr. E. A. Martin.—Dew-Ponds and Mist-Ponds.

IV.—INDEX GENERUM ET SPECIERUM ANIMALIUM.[1]

Final Report of the Committee, consisting of Dr. HENRY WOODWARD (Chairman), Dr. F. A. BATHER (Secretary), Dr. W. T. CALMAN, Dr. W. EVANS HOYLE, the Hon. WALTER ROTHSCHILD, Dr. P. L. SCLATER, the Rev. T. R. R. STEBBING, and Lord WALSINGHAM.

DURING the year 1911-12 work on this *Index* has proceeded steadily, and a large number of volumes has passed through the hands of Mr. C. Davies Sherborn.

Huebner's entomological works have been thoroughly examined, and the results of the researches of many workers have been embodied in a paper by Sherborn & Prout in the *Annals and Magazine of Natural History* for January, 1912. All the books of Fallén and Fabricius have been indexed, as also those of Fischer von Waldheim and John Fleming.

[1] Read before the British Association, Sections C (Geology) and D (Zoology), Dundee, September, 1912.

with many others. Increased cabinet accommodation has been necessary, and this has been, as before, provided at the Natural History Museum by the Keeper of the Geological Department.

As regards the continuation of the work, the Committee has great pleasure in reporting that the Trustees of the British Museum have included the compilation of the *Index Animalium* in the General Library Service of the British Museum (Natural History). It has thus become an official undertaking, and Mr. Sherborn will rank as 'Special Assistant' on the staff. This is most gratifying to all parties concerned, for it ensures the safety and completion of the manuscripts which have accumulated during the past twenty-two years. There are now some 664,000 slips, representing 332,000 entries in duplicate, and a great mass of manuscript notes on the dates of books which have passed or will pass through the compiler's hands. Much of this has been printed separately or been included in the official catalogue of the libraries of the British Museum (Natural History).

All manuscripts and documents connected with the work have been handed over by the Committee to the Trustees of the British Museum for preservation in the Natural History Museum, where they may be seen, on application during official hours, by those interested.

In making this final report the Committee desires to express its own and Mr. Sherborn's sincere thanks, not only to the Trustees of the British Museum for their past and present help but also to those Societies that have from time to time aided the work with pecuniary grants—namely, the Royal Society and the Zoological Society of London. Above all, those thanks are due to the British Association for the consistent way in which it has supported the undertaking for the past twenty years, support which alone made possible the successful termination of the first part (1758–1800). The Association will doubtless join the Committee in renewing its thanks to the Syndics of the Cambridge University Press for their generosity in printing and publishing this part. It was issued in October, 1902, as a handsome octavo volume of 1,255 pages, containing 61,600 entries, at the price of 25*s*. On the value of that volume to the zoologist there is no need to insist here; it has spoken for itself to everyone who has taken the trouble to consult it. The manuscript of the second part (1801–50) is well advanced, and will now proceed safely towards completion under new auspices.

Your Committee cannot cease its connexion with this important work without an expression of gratitude to Mr. Davies Sherborn for his devoted labours in the past, and of confidence in his energy to carry to a conclusion the second part of the *Index Animalium*.

V.—Palæobotany *versus* Stratigraphy in New Brunswick.[1] By Marie C. Stopes, D.Sc., Ph.D., F.L.S.

Outline of the controversy, which dates from 1866. The so-called 'Fern Ledges' near St. John, New Brunswick, have a rich fossil flora, but almost no animal remains. Sir W. Dawson described the plants as Devonian. Confusion still exists owing to the mixture of true Devonian plants from Gaspé, etc., in the same monograph of Dawson's. Recent attempts include the beds in the Silurian, for 'stratigraphic' reasons. The necessity of field work as well as palæontological determinations. The author's work in the field; notes on relative dips of the beds, the so-called 'slates', intrusive rocks, and contortions. Observations indicate existence of considerable overthrust. Palæobotanical data. Re-determination of supposed 'unique' species. Type-specimens lent by the Canadian museums and brought to London

[1] Abstract of papers read before the British Association, Section C (Geology), Dundee, September, 1912.

and Paris for comparison with standard collections, resulting in identification of a large proportion of well-known European types in the 'Fern Ledges' flora, all Carboniferous and mostly typical of Westphalian division in Coal-measures. Note the value of fossil plants, as the Carboniferous age of the beds was recognized by Geinitz in 1866 from a single specimen of a fern leaf. The author did the work for the Canadian Geological Survey, to the kindness of whose Director is due the permission to give this résumé of the results.

VI.—The Fossil Flora of the Pettycur Limestone in relation to Botanical Evolution.[1] By W. T. Gordon, M.A., B.A., D.Sc.

THE oldest flora of which we have considerable knowledge is that represented in Upper Devonian rocks, but the plants obtained from Lower Carboniferous strata do not differ markedly from the Devonian types, and so may be included in the Devonian flora. Examples of petrified plants of Lower Carboniferous age have been recorded from several localities in Scotland, but they are nowhere so abundant as at Pettycur, near Kinghorn, Fife. The flora of the Pettycur Limestone, then, has a double interest; the remains constitute fragments of the oldest known flora, and, as they are petrified, the internal structure of these plants may be studied.

Although the Devonian flora is very distinct from that of the succeeding Permo-Carboniferous epoch, yet the organization does not indicate that the plants were primitive. Indeed, all one can say is that the assemblage, as a whole, appears to be less highly specialized than that represented in Upper Carboniferous strata.

As the horizon of the Pettycur rocks is rather high in the Calciferous Sandstone Series, we would expect to find some species whose structure indicated a transition between Devonian and Upper Carboniferous forms. In some cases I believe that such specimens have been discovered. For example, we find several genera belonging to one order, or several species to the one genus, and in such cases one form is more generalized in structure than the others, while the less generalized forms appear to be more closely allied to Upper Carboniferous types.

Among the *Lepidodendra,* for instance, *Lepidodendron Pettycurense,* Kidston, has a perfectly solid central axis; the xylem cylinder in *Lepidophloios Scottii,* Gordon, is occasionally solid in places, but at other parts of the same specimen a mixed pith, consisting of parenchyma and short tracheides, may be noted. *Lepidodendron Veltheimianum,* Sternb., on the other hand, has a well-marked parenchymatous pith containing no tracheides. A line of development is thus suggested by this series, and when we turn to the Coal-measure flora a parallel series may be shown. The lowest member among the Upper Carboniferous *Lepidodendra* has a mixed pith, and hence we conclude that the Pettycur plants show less specialization than those of a later date, though the organization is similar in each case. Such parallel series may also be demonstrated in other groups, particularly among the ferns and Pteridosperms.

The various reproductive members met with at Pettycur also exhibit certain peculiarities. The most complex cryptogamic cone yet discovered—*Cheirostrobus Pettycurensis,* Scott—was recorded from this locality. Certain characteristics common to several groups are combined in the cone, which is thus both complex and generalized.

In the megaspore of *Lepidodendron Veltheimianum,* Sternb., the archegonium has been recorded, and it does not differ from that of the living *Selaginella* or *Isoëtes.*

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

To sum up, then, the flora represented in the Pettycur Limestone appears, on the whole, to contain more generalized and simpler types than occur in the Coal-measure and later strata, and these types may be arranged in order so as to suggest certain possible lines of evolution.

VII.—On the Nature of *Parka decipiens*.[1] By Archibald W. R. Don, B.A.

THIS paper was the outcome of an attempted re-investigation of *Parka*, chiefly microscopical, with the aid of Schultz's solution (strong nitric acid and potassium chlorate). Being the only common and quite the most characteristic fossil of the Lower Old Red Sandstone of the Kincardine-Forfar-Perth area, it has naturally attracted considerable attention. The nature of *Parka* has been a subject of speculation ever since its discovery at Parkhill in 1831 by Dr. Fleming. He described it as probably allied to *Juncus* or *Sparganium*, and Hugh Miller, on the whole, agreed as to its vegetable nature. Mantell stoutly maintained it to be 'batrachian eggs'. Lyell thought it the egg-packet of *Pterygotus*, and this determination was accepted by Salter, Woodward, Powrie, and others. In 1890, however, Messrs. Reid, Graham, and Macnair, having convinced themselves of its vegetable nature, sent specimens to Sir W. Dawson, who, with Professor Penhallow, submitted it to a microscopical examination. They clearly showed it to be vegetable, and after boiling it in nitric acid, demonstrated the presence of spores within the carbonized tissue.

The conclusions, other than this main one, arrived at by former investigators have not as yet been confirmed by the present re-examination, the chief results of which, therefore, tend unfortunately to be more destructive than constructive. Hitherto no evidence for heterospory has appeared. The 'prothalli' have not been found. The mode of attachment and other vegetative features have not been elucidated, and an agnostic attitude is assumed, pending further discoveries, with regard to those formerly attributed to *Parka*. No evidence has appeared with regard to the supposed varieties '*media*' and '*minor*'. An attempt, admittedly tentative, has been made to form some conception of the original structure and shape of *Parka*, based on examination of certain excellently preserved impressions of its two surfaces. The main conclusion is that the original spore-containing tissue was almost flat, not spherical (and made up of numerous adjacent lens-shaped spore-sacs)—a structure, in fact, in no way comparable to anything Hydropteridian, and unlike any known sporangia of to-day. There was, certainly, intimately connected with it a so-called 'indusium'. Such a reconstruction must, however, be understood to be hypothetical, and not an ascertained fact. Certain cell-layers and tissues revealed by the more gentle action of the Schultz's solution may, however, help towards an ultimate solution of the perennial problem of *Parka decipiens*.

VIII.—Discovery of Fossils in the Boundary Fault Series, near Aberfoyle.[1] By T. J. Jehu, M.A., M.D.

THIS Series is well exposed between Loch Lomond and Callander, forming a narrow belt separated by a reversed fault from the Lower Old Red Sandstone on the south-east, and probably by a line of thrust from the Leny Grits on the north-west. It consists of black and grey shales, cherts, grits, and calcareous beds, with which are associated some altered igneous rocks. Adjoining the crushed and veined rock which runs along the boundary of the Lower Old Red Sandstone, patches of sheared serpentine are seen at several places, sometimes

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

associated with a coarse basic igneous rock somewhat brecciated, as at Maol Ruadh. These probably represent igneous intrusions. Near Loch Lomond grits only are exposed. At the north-east end, near Callander, the belt consists largely of grits, but at Kilmahog quarry there is a good exposure of black shales with an interbedded limestone identical in character with the limestone in the Margie Series described by Mr. G. Barrow (Q.J.G.S., 1901).

The belt in the Aberfoyle area emerges from under the Upper Old Red Sandstone north of Gualann and extends north-eastwards to a mile north-east of Aberfoyle. Widest near Gualann—about half a mile. General strike of beds north-east and south-west; general dip north-west, at high angles. Beds often isoclinally folded along crush-planes striking north-east and south-west. Apparent order of succession from below upwards near Kelty Water: (1) Hornblendic and chloritic schists, probably representing intrusive sheets; (2) thin band of chert and black shale, only traceable for about a mile; (3) band of grit which as traced to north-east comes to abut against Lower Old Red crush rock; (4) thicker band of black shales and cherts; (5) Grit. The Leny Grit follows on the north-west, but at other places it appears to come directly on the black shales and cherts.

Difficulty in distinguishing the grits of the Boundary Fault Series from the Leny Grits. The latter are generally greenish, the former greyish and weathering yellowish-brown, and are peculiar in containing fragments of black shale, chert, and vesicular volcanic matter. Lumps and courses of a very dark grit also occur in the black shales. The shales are usually black, carbonaceous, staining the fingers; generally very crushed. The cherts are pale grey to dark in colour, often finely banded with frequent interleaves of black shale. Joints and veins at right angles to the bedding often numerous. Thin cherty bands and nodules often seen in the shales. Some of the rocks are a crushed mass of black shale and cherty material. The beds are often distinctly brecciated.

Remains of Radiolaria discovered by Dr. Peach some years ago in cherts near Gualann. Recently a number of fossils have been found in pale-grey chert bands, 1 to 3 inches thick, in an exposure on the south-east side of the Bofrishlie Burn, about 400 yards north-west of Arndrum. The fossils occur in muddy films in the chert. Belt here only 300 to 350 feet wide. Some of the shales and cherts are thrust over the disrupted edges of the bands which have yielded fossils. A little north-west the cherts are brecciated, and courses of grit occur in the black shales, also showing signs of brecciation. Some calcareous bands occur in the shales in the bed of the stream. The fossils are almost all hingeless Brachiopods, and the following forms have been determined by Dr. Peach:—

Acrotreta sp., *Lingulella* sp., ? *Obolus* sp., *Obolella* sp., also the flattened chetæ of Polychæte worms.

The fossils indicate that the series is probably of Upper Cambrian age.

IX.—On the Origin of some of the Mica-schists of Anglesey.[1] By Edward Greenly.

In the south-east and centre of Anglesey extensive tracts of country are occupied by mica-schists in which it is a very rare thing to find any survival of the original structures. They are holocrystalline rocks, usually with strong parallel structure, and composed essentially of quartz, alkali-felspars, and a white mica. In certain compact varieties, however, especially about Y Graig, Holland Arms, traces of felsitic texture can be found. Dr. Teall, who has examined the rocks in the field as well as under the microscope, regards them as in all

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

probability broken down and partially reconstructed porphyritic felsites, and considers that some lenticular aggregates which they contain may be looked upon as broken-down porphyritic felspars. Twenty-five years ago Dr. Callaway recognized the felsitic origin of these rocks, and the present investigations fully confirm that conclusion.[1] Similar structures have now been found in the rocks of the central area, on its western coast near Trecastell. These schists, therefore, may be looked upon in general as derived from acid igneous rocks. In other parts of both areas, however, mica-schists in continuity with them are found in intimate relations to schists of sedimentary origin, so that it is probable that pyroclastic material was present in the original igneous series.

X.—The Older Granite in Lower Dee-side.[2] By G. Barrow, F.G.S.

A BRIEF description was given of the mode of occurrence and composition of one of the older Granite intrusions in Lower Dee-side. In place of forming large coherent masses it tends rather to minute subdivision, permeating the crystalline gneisses over large areas. Excellent examples of *lit-par-lit* intrusion may be seen on the north side of the Dee, about, and west of, Banchory. The granitic material in these cases forms minute sills, varying from an inch to several feet thick, and almost rigidly parallel to the foliation of the associated gneiss into which it has been intruded. The ground here is comparatively flat, and the method of feeding the sills cannot be clearly made out. But on the opposite or south side of the river the ground is much steeper, and in the hill-faces dyke-like intrusions can be seen, from which the sills proceed. They commence a little below the crest of the dyke, where they are smallest and shortest; they are seen to become steadily thicker and longer as we descend further below the crest of the dyke. In the interior of the latter the granite is usually grey, and contains more biotite than muscovite; oligoclase is also usually abundant; the oligoclase and biotite steadily diminish in amount as the rock is traced towards the taper end of the sills. At this point there is little oligoclase, and often no biotite; muscovite is fairly common, often in large crystals, and the bulk of the felspar is of alkaline composition. It appears that the fissures in which the dykes occur were filled with igneous material, and that under great pressure the walls were burst open and the still liquid material forced out, and thus separated from that which had already segregated out. The phenomenon may be described as magmatic differentiation intensified by dynamic action. Further, the material (pegmatite) which occurs on the extreme ends of the sills is often far coarser than that met with in the centre of the dyke; the distribution of coarse and fine material being thus the reverse of that usually met with in small intrusions.

This separation of the more acid and less acid material occurs in connexion with every dyke and sill over the entire Dee-side area between Banchory and Aberdeen; the pegmatitic material forming a fringing margin, the breadth of which varies considerably. The largest of the sill-like masses occurs at Aberdeen, and part of the city is built on it; its great fringe of pegmatite veins is well displayed on the banks of the Dee near the railway bridge.

The separation of the material rich in oligoclase and biotite from that richer in alkali-felspar and muscovite is not confined to each separate intrusion; it holds good for the intrusion as a whole. Well to the south of the Dee, especially nearer the coast, nearly the whole of the intrusions are more alkaline than those nearer the Dee; the

[1] See Brit. Assoc. Report, Manchester, 1887; also Q.J.G.S., 1897 and 1902.

[2] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

pegmatite remains of much the same composition, but there is a considerable amount of schorl present in the southern area that is distinctly rare in the northern.

There is considerable variation in the amount of foliation shown by these intrusions. In the moderate-sized or larger ones the centre is usually unfoliated, or but slightly so; towards the margins the foliation is more marked. The pegmatite fringe is rarely foliated if it occurs as veins or dykes; but it usually is more or less foliated if in thin sills. The foliation over most of the area is protoplastic; post-consolidation crushing is rare. Indeed, it is only well seen in one case, where the granite has reached the present surface far south of the main series of intrusions, and within a lower temperature zone. This intrusion is cut open by a branch of the Cowie Water, close to the Stonehaven Road from Banchory.

XI.—On a Fossiliferous Tufa occurring beneath Chalky Boulder-clay at Launde, Leicestershire.[1] By A. R. Horwood.

In the Report on Erratic Blocks of the British Isles, presented at the Winnipeg Meeting, 1909 (Report B.A., 1909, p. 176), I mentioned the occurrence of a large boulder of tufa found by the side of a stream, the River Chater, at Launde, Leicestershire. At the time I had no doubt the rock was an erratic.

Since then Mr. A. J. S. Cannon has brought me a specimen of the same rock containing land-shells, which he informed me he had found in situ in the same locality. Recognizing the importance of this discovery I accompanied him later to examine the section, with the result that this rock was found in two different places a quarter of a mile apart.

At the first point a section is exposed in the stream-side as follows :—

	ft.	in.
1. Soil	0	6
2. Chalky Boulder-clay, sand and gravel, with Jurassic fossils	*c.* 2	0
3. Calcareous tufa, with plants and land-shells, also *Pisidium*, Entomostraca	0	6
4. Peat, with plant-remains and shells	1	0
5. Tufa, similar to 3	0	6
6. Inclined *margaritatus* shales (Middle Lias)	3	0
	7	6

The disturbed character of the basal beds has no connexion with beds 1 to 5, which are clearly undisturbed, and have not been inverted or thrown out of position since they were deposited.

The importance of this section is evident, for with the exception of a deposit containing plants, Annelids, Crustacea, and Mollusca at Aylestone in the Soar Valley in Holocene deposits, and a similar fauna at Medbourne in the Welland Valley (not yet described), the Launde section is the only ancient one so far discovered in Leicestershire.

In the same district at Launde the tufa was found exposed in ditch-bottoms and rabbit-holes under superficial deposits, some 2,000 feet away. The nearest sections of the same or later age are in Rutland at Apethorp, near Stamford, and at Casewick. I have been favoured by Mr. A. S. Kennard with specimens of the shells collected by J. F. Bentley at Stamford, and described by Professor T. R. Jones, and there is a close similarity between such species as *Helix rotundata, Vitrea radiatula,* and *Carychium minimum,* which are the dominant shells at Launde. There are more than twenty species of land and fresh-water shells, besides plants, that remain to be examined. No mammalian remains have been found, nor evidence of the activity of man in this locality.

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.

XII.—The Discovery of Fossils in the Jasper and Green Schist Series of the Highland Border at Craigeven Bay, Stonehaven. By Robert Campbell, M.A., D.Sc.

BETWEEN Craigeven Bay and Garron Point occurs a series of crushed spilitic lavas with intercalated black shales, jaspers, and cherts. In their lithological characters these resemble closely the green igneous rocks and associated sediments which appear at intervals along the line of the Highland Boundary fault, and which are shown on the Geological Survey maps as of (?) Arenig age. In August, 1909, on the occasion of a visit to Craigeven Bay in company with Dr. B. N. Peach and Dr. W. T. Gordon, we succeeded in finding in the black shales several fossils, including a linguloid shell and a bivalve Phyllocarid Crustacean. The assistance of Mr. D. Tait, of H.M. Geological Survey, was obtained in making a detailed search in the fossiliferous beds. Dr. Peach, to whom the fossils were submitted for determination, has identified the following forms: *Lingulella, Obolella, Acrotreta, Linnarssonia,* and *Siphonotreta*; a bivalve Phyllocarid allied to *Caryocaris* and *Lingulocaris*; and cases of a tubicolar worm. The above genera are most commonly found in the lowest division of the Lower Silurian (Ordovician) system and in the Upper Cambrian. Dr. Peach, while admitting that the exact horizon of the fossils is still a matter of doubt, suggests that, since Graptolites are absent, they are more likely to belong to the Upper Cambrian than to the Ordovician. Whatever may be the ultimate decision as to their stratigraphical horizon the discovery of the above fossils leaves very little doubt that the boundary fault series is *not* pre-Cambrian.

The (?) Upper Cambrian rocks at Craigeven Bay are separated from the Dalradian Schists by a reversed fault, and are overlain unconformably by Upper Silurian (Downtonian) strata.

REVIEWS.

I.—Monograph on the Sub-oceanic Physiography of the North Atlantic Ocean. By Edward Hull, M.A., LL.D., F.R.S. With a chapter on the Sub-oceanic Physical Features off the coast of North America and the West Indian Islands. By Professor Joseph W. W. Spencer, M.A., Ph.D. Folio (18 by 12½ inches); pp. viii, 42, with 11 maps (9 coloured). London: Edward Stanford, Long Acre, W.C., 1912. Price 21*s.* net (post free in United Kingdom 21*s.* 7*d.*).

IN Professor Hull's Atlas of Maps with its accompanying text we have a summary of the author's long-continued observations and deductions concerning the eastern coast of the North Atlantic, and his work is supplemented by that of his friend Professor J. W. Spencer on the Atlantic coast of North America and the West Indian Islands. It brings before the student a collection of facts on submarine coastal features which, if not all new to us, are so ably put forward that they cannot fail to attract the attention of a large class of persons interested in the cartography of the British Islands, especially in their relation to neighbouring lands, of which, at no distant period, they formed a solid part.

[1] Abstract of paper read before the British Association, Section C (Geology), Dundee, September, 1912.