We have continued to investigate the great series of plant remains so assiduously collected by Mr. A'Court Smith, and with this object have visited Gurnet Bay, as well as receiving several packages of fossils from thence. While lamenting that they are of so fragmentary a nature, we cannot overlook their importance as almost the last representatives of the great series of floras which maintained themselves in our area throughout the Eocene time. As an illustration of their value, we may instance the fact that while anything like true grasses seem to be wholly wanting in the previous floras, there are many more or less definite indications of them in this. We have reason to hope that renewed working in the still younger beds of Hempstead may lead to further discoveries, for, besides the better known plants described by Heer, pine-cones and a fine aroïdeous fruit have been obtained from them.

NOTICES OF MEMOIRS.

Papers read before the British Association for the Advancement of Science, Birmingham, September, 1886, Section C (Geology).

I.—On Canadian Examples of Supposed Fossil Algæ. By Sir William Dawson, LL.D., F.R.S.

MARKINGS of various kinds on the surfaces of stratified rocks have been loosely referred to Algæ or Fucoids under a great variety of names; and when recently the attempt was made in Europe more critically to define and classify these objects, a great divergence of opinion developed itself, of which the recent memoirs of Nathorst, Williamson, Saporta, and Delgado may be taken as examples.

The author, acting on a suggestion of Sir R. Owen, was enabled in 1862 and 1864, by the study of the footprints of the recent *Limulus polyphemus*, to show that not merely the impressions known as *Protichnites* and *Climactichnites*, but also the supposed fucoids of the genera *Rusophycus*, *Arthrophycus*, and *Cruziana* are really tracks of Crustacea, and not improbably of Trilobites and Limuloids.[1] He had subsequently applied similar explanations to a variety of other impressions found on Palæozoic rocks.[2] The object of the present paper was to illustrate by a number of additional examples the same conclusions, and especially to support the recent results of Nathorst and Williamson.

Rusichnites, *Arthrichnites*, *Chrossochorda*, and *Cruziana*, with other forms of so-called *Bilobites*, are closely allied to each other, and are explicable by reference to the impressions left by the swimming and walking feet of Limulus, and by the burrows of that animal. They pass into Protichnites by such forms as the *P. Davisii* of Williamson, and *Saerichnites* of Billings, and *Diplichnites* of the author. They are connected with the worm tracks of the genus *Nereites* by specimens of *Arthrichnites*, in which the central furrow becomes obsolete, and by the genus *Gyrichnites* of Whiteaves.[3]

[1] "On Footprints of Limulus," Canad. Nat. 1862. "On the Fossils of the Genus *Rusophycus*," *Ibid.* 1864.

[2] "On Footprints and Impressions of Aquatic Animals," Am. Journ. of Science.

[3] Trans. Royal Society of Canada, 1883.

The tuberculated impressions known as *Phymatoderma* and *Caulerpites* may, as Zeiller has shown, be made by the burrowing of the mole-cricket, and fine examples occurring in the Clinton formation of Canada are probably the work of Crustacea. It is probable, however, that some of the later forms referred to these genera are really Algæ related to *Caulerpa*, or even branches of Conifers of the genus *Brachyphyllum*.

Nereites and *Planulites* are tracks and burrows of worms, with or without marks of setæ, and some of the markings referred to *Palæochorda*, *Palæophycus*, and *Scolithus* have their places here. Many examples highly illustrative of the manner of formation of these impressions are afforded by Canadian rocks.

Branching forms referred to *Licrophycus* of Billings, and some of those referred to *Buthotrephis*, Hall, as well as radiating markings referable to *Scotolithus*, *Gyrophyllites*, and *Asterophycus*, are explained by the branching burrows of worms illustrated by Nathorst and the author. *Astropolithon*, of the Canadian Cambrian, seems to be something organic, but of what nature is uncertain.

Rhabdichnites and *Eophyton* belong to impressions explicable by the trails of drifting seaweeds, the tail-markings of Crustacea, and the ruts ploughed by bivalve molluscs.

Dendrophycus, *Dictyolites*, some species of *Delesserites*, *Aristophycus*, and other branching and frond-like forms, were shown to be referable to rill-marks, of which many fine forms occurs in the Carboniferous of Nova Scotia, and also on the recent mud-flats of the Bay of Fundy.

The genus *Spirophyton*, properly so called, is certainly of vegetable origin, but many markings of water action, fin-marks, etc., have been confounded with these so-called ' Cauda-galli fucoids.'

On the other hand, some species of *Palæophycus*, *Buthotrephis* and *Sphenothallus* were shown to be true Algæ, by their forms and the evidence of organic matter, and *Haliserites*, *Barrandeina*, and *Nematophycus* were shown to include plants of much higher organization than the Algæ. With reference to the latter, it was held that the form to which the name *Prototaxites* had been given was really a land plant growing on the borders of the sea, and producing seeds fitted for flotation. On the other hand, certain forms to which he had given the name *Nematoxylon* were allied to Algæ in their structure, and may have been of aquatic habit; very perfectly preserved specimens of these last had been recently found, and had thrown new light on their structure.

The author proposed to apply to all these problematical plants, having a tissue of vertical and horizontal tubes, the general name *Nematophyteæ* or *Nematophyton*.

The paper referred to the history of opinion on these objects and the bibliography of the subject; but this, as well as detailed descriptions, are omitted in this abstract.

II.—On the Relations of the Geology of the Arctic and Atlantic Basins. By Sir J. William Dawson, LL.D., F.R.S.

THE paper relates to the evidence of the specimens brought from the Arctic seas bearing on the existence of an ancient line of Laurentian Huronian, and other Pre-Cambrian rocks; of the extension of the marine fauna of the Atlantic and the American continental plateau

into the Arctic, and of the correspondences of the Cretaceous, Tertiary, and Pleistocene of the Arctic Basin with those of America, and the bearing of these facts on questions of palæogeography.

III.—On the Rocky Mountains, with special reference to that part of the Range between the 49th Parallel and Head-waters of the Red Deer River. By George M. Dawson, D.Sc., F.G.S., etc., Assistant-Director, Geological Survey of Canada.

THE term "Rocky Mountains" is frequently applied in a loose way to the whole mountainous belt which borders the west side of the North American continent. This mountainous belt, is, however, preferably called the Cordillera region, and includes a great number of mountain systems or ranges, which on the 40th parallel have a breadth of not less than 700 miles. Nearly coincident with the 49th parallel, however, a change in the general character of the Cordillera region occurs. It becomes comparatively strict and narrow, and runs to the 56th parallel or beyond with an average width of about 400 miles only. This portion of the western mountain region comprises the greater part of the province of British Columbia. It consists of four main ranges, or, more correctly, systems of mountains, each including a number of component ranges. These mountain systems are, from east to west:—(1) The Rocky Mountains proper. (2) Mountains which may be classed together as the Gold Ranges. (3) The system of the Coast Ranges of British Columbia, sometimes improperly named the Cascade Ranges. (4) A mountain system which in its unsubmerged portions constitutes Vancouver and the Queen Charlotte Islands.

The present paper refers to the Rocky Mountains proper. This system, between the 49th and 53rd parallels, has an average width of about 60 miles, which, in the vicinity of the Peace River, on the 56th parallel, decreases to about 40 miles. It is bounded to the east by the Great Plains, which break into a series of foot-hills along its base; to the west by a remarkably straight and definite valley occupied by portions of the Columbia, Kootanie and other rivers.

Since the early part of the century the trade of the fur companies has traversed this range, chiefly by the Athabasca and Peace River Passes, but till the explorations effected by the expedition under Capt. Palliser in 1858-59 nothing was known in detail of the structure of the range. At the inception of explorations for the Canadian Pacific Railway, Palliser's map was still the only one on which any reliance could be placed, and it applied merely to the portion of the range south of the Athabasca Pass. During the progress of the railway explorations a number of passes were examined, and in 1883 and 1884 that part of the range between the 49th parallel and latitude 51° 30″ was explored and mapped in some detail in connection with the work of the Canadian Geological Survey by myself and assistants.

Access to this, the southern portion of the Rocky Mountains within Canadian territory, being now readily obtained by the railway, its mineral and other resources are receiving attention, while the magnificent alpine scenery which it affords is beginning to attract the attention of tourists and other travellers.

The results of the reconnaissance work so far accomplished are

presented in the form of a preliminary map, accompanied by descriptions of routes and passes, and remarks on the main orographic features of the range.[1]

IV.—The Anorthosite Rocks of Canada. By Frank D. Adams, Geological Survey of Canada.

THIS series of rocks has also been called the Upper Laurentian or Norian series. The name anorthosite is perhaps preferable, as it refers to their distinguishing characteristic as compared with the orthoclase rocks of the Lower Laurentian, viz. the predominance in them of plagioclase or anorthose felspar. These rocks form detached areas in the great Laurentian districts, and bear a strong resemblance in part to the gabbros and gabbro-diorites of Scandinavia, and in part to the labradorite rock of the same country. It is, however, by no means certain that the rocks of the two countries are of the same age. At least nine of these areas are now known to exist in Canada, and there is also one in the State of New York. In addition to plagioclase, which generally predominates largely, these rocks contain rhombic and monoclinic pyroxenes (including augite, diallage, hypersthene, and probably enstatite), olivine, magnesia, mica, spinel (including both pleonaste and picotite), garnet, iron-ores, pyrite, and apatite. Orthoclase is seldom or never found, except in veins cutting the anorthosite. The hornblende, mica, and pyroxenes are intimately associated and often intergrown, all of them sometimes being found in the same thin section. Garnet occurs sparingly, and generally near the contact of the anorthosite with the gneiss. When the olivine comes against plagioclase, it is always bounded by a double concentric zone, the outer zone consisting of hornblende, and the inner, or that next to the olivine, consisting of a pyroxene. While the iron-ores associated with the Lower Laurentian gneisses are generally free from titanium, those associated with the anorthosite rocks are always highly titaniferous; a fact which makes the study of these rocks a matter of considerable economic interest. The anorthosite varies a good deal in composition, some areas, for instance, being rich in olivine, while others are destitute of that mineral, and different portions of even the same area often showing wide differences in this respect. The rock also shows a good deal of variation in structure. It is rarely quite massive, frequently well foliated, but usually consists of a rather coarsely crystalline groundmass, through which are scattered irregular strings and masses composed of iron-ore, bisilicates, and mica, as well as larger porphyritic crystals of plagioclase. Even when it is tolerably constant in composition, there is generally a great variation in size of grain, coarse and fine alternating in rude bands or rounded masses. In the case of some of the areas there can be but little doubt that the anorthosite is eruptive, in others, however, it seems to be interstratified with the Laurentian gneiss, and in one of them to merge imperceptibly into it. The original relations of the rocks are, of course, much obscured by the effects of subsequent heat and pressure. The evidence at present, however, seems to indicate that these anorthosites are the result of some kind of extravasation, which in those early times corresponded to what in modern times we call volcanic eruption.

[1] See Reports and Maps Geological Survey of Canada.

V.—Notes on the Crystalline Schists of some parts of Ireland. By C. Callaway, D.Sc., M.A., F.G.S.

THE author gives a summary of results obtained by a preliminary survey of the principal areas of Irish metamorphic rocks, viz.—

1. Donegal, including parts of the adjacent counties of Londonderry and Tyrone.

2. Connemara, extending the term to cover the region lying between Westport, co. Mayo, and the granitic mass west of the town of Galway.

3. The south-eastern corner of the county of Wexford.

In each of these areas the following facts were observed:—

(*a*) A series of hypometamorphic rocks, consisting typically of fine-grained schists, altered grits, and quartzites. A clastic structure is more or less distinct in the three areas, but is least evident in Connemara.

(*b*) A group of highly crystalline schists, displaying no trace of an original sedimentary origin, dipping as if it passed below the hypometamorphic rocks. At Wexford there are true gneisses. In Connemara the rocks are less felspathic, the chief types being quartzose gneiss, quartz-schist, mica-schist, hornblende-schist, quartzite, and crystalline limestone. This description will also apply to Donegal.

(*c*) Granite, underlying (*b*), and in Connemara and Donegal clearly intrusive.

The author urges that this analogy is not due to the metamorphic action of the granite; for—

1. The mineral characters apparent in the schists adjacent to the granite are uniformly distributed through the lower series from bottom to top.

2. The evidence collected is hostile to the view that this lower series ever graduates into the upper.

It is concluded that the balance of proof is in favour of the Archæan age of the bulk of the Irish schists.

1. In the Wexford district the schists are thrown against Cambrian and Ordovician rocks by faults, and do not pass into them in the localities alleged by the Irish Survey.

2. In Connemara conglomerates of Llandovery age contain large rounded fragments, not only of the older schistose series, but also of its intrusive igneous rocks.

3. In the Ulster region the metamorphic area is separated from the Ordovician rocks of Pomeroy by a ridge of granite and diorite three miles in breadth.

The lithological analogies between the Irish schists and the Archæan rocks of Anglesey and other British metamorphic districts are also of weight in the argument.

VI.—On the Discovery of Fossil Fish in the New Red Sandstone (Upper Keuper) in Warwickshire. By the Rev. P. B. Brodie, M.A., F.G.S.

THE author observed that, considering the thickness and extent of the New Red Sandstone in Great Britain, the paucity and rarity of fossils was remarkable, especially when compared with the abundant fauna and flora of the Trias in Europe. In a field so comparatively

barren any addition, therefore, to either is interesting to the palæontologist. Many years ago the author discovered a ganoid fish—the last apparently of the genus *Palæoniscus superstes*—figured and described by the late Sir Philip Egerton (Journ. Geol. Soc. vol. xiv. p. 164) in the Upper Keuper at Rowington (six miles north-west of Warwick); and he now records another discovery of several small fish near there, probably *Semionotus*—at present in Dr. Traquair's hands—which is the first time this genus has been recorded from the British Trias. The remains of small Cestracionts are not unfrequent in one particular band of sandstone in Warwickshire and Worcestershire, with occasional footprints in the former county of *Labyrinthodon*. Ganoid fish are so rare that these above named are, as far as the author is aware, the only ones known, with one exception, which cannot be secured, in the Upper Keuper; the curious *Dipteronotus* having been found in the Lower Keuper (waterstones) at Bromsgrove, in Worcestershire. The author gave a section of the quarry containing the fossils above referred to, and stated that he considered that the New Red Sandstone in Warwickshire, as the Rev. J. Mello has adopted in Cheshire, might fairly and advantageously be divided into Upper and Lower Keuper, the two series of sandstones being different lithologically, and being separated by a considerable thickness of red marl, the lower sandstones being especially characterized by remains of *Labyrinthodon* and other peculiar reptiles, a fine and unique collection being preserved in the Warwick Museum.

VII.—On the Range and Extent and Fossils of the Rhætic Formation in Warwickshire. By the Rev. P. B. Brodie, M.A., F.G.S.

THE author in this paper first gives an account of the range, thickness, and fossils of the upper portion of the Rhætic formation—viz. the 'White Lias,' supposing that it really belongs to this, but to which it is now generally assigned, showing that it is very rarely seen in conjunction with the underlying shales, and that where they occur in one or two important sections the White Lias is absent. A list of the fossils is given, which are few and ill-preserved, *Ostrea intusstriata* and a species of *Avicula* (*Monotis*) being the most characteristic. A full account is given of the succeeding grey and black Rhætic shales with occasional intercalated shelly limestone and sandstone; and though, as a rule, good sections are rare, there were certain railway-cuttings which laid open several very interesting and instructive ones, and enabled the author to obtain a series of characteristic fossils, including the Radiata, by no means common and local, the *Ophiolepis Damesii*. It was stated that these occupied a considerable area in the southern division of the county, appearing again on the north-east, near Rugby, and as a rule succeeded by the basement beds (insect and saurian beds) of the Lower Lias, which were in places seen in conjunction with these shales. It was further observed that they probably underlie the Lias in its course through the county; and the author concluded by showing the general range of the Rhætics from the coast of Devon to the coast of Yorkshire; which, although not comparable either in thickness or abundance and variety of fossils with the rich, varied, and peculiar

Continental series, is still sufficiently marked and important in this county and elsewhere to make it a distinctive and independent formation.

VIII.—On the Silurian Rocks of North Wales. By Professor T. M'Kenny Hughes, M.A., F.G.S.

THE author begins by describing some sections in the Silurian rocks of North Wales. Some of them are in the lower part, some in higher beds. He gives lists of fossils from the various horizons in each. He then, by means of these and by what he calls syntelism, that is, the occurrence of similar sequences of beds of the same characters, lithological or other, points out the corresponding parts of the various sections described.

He then does the same for the Silurian of the eastern borders of the Lake district, and, having in this manner constructed a vertical section of each, compares the two districts and shows that there is an identical series in each, with all the important zones of one represented in the other, except that in the part of North Wales which he has worked out he has not yet detected beds as high as the newer part of the series in the Lake district.

IX.—Notes on some Sections in the Arenig Series of North Wales and the Lake District. By Professor T. M'Kenny Hughes, M.A., F.G.S.

IN this paper the author describes a number of sections which cross the Arenig series in different parts of England and Wales, and endeavours to explain some apparent discrepancies in what is generally a remarkably constant set of beds.

He starts with the Portmadoc section, where he considers that the chief differences of opinion have arisen from mistakes in the explanation of the geological structure of the district, especially from the wrong identification of some grit bands on opposite sides of important faults.

Following the series to the north he shows that, although they vary in thickness, the principal zones are still represented near Carnarvon; and, discussing the question of the unconformity of these beds on the Lower Cambrian, he points out that the Lower Cambrian rocks are seen to vary so much both in character and thickness within short distances in the neighbourhood of the existing outcrop of the Archæan that any argument founded upon their thinning-out or their different texture must be received with distrust in an area where they are known to have been deposited on the flanks of mountain ranges of pre-Cambrian age.

He then describes some localities in the Lake district where the occurrence of the same zones has been determined, and points out the difficulty of getting rid of such great thicknesses of deposits of fine mud as would be implied in the usual interpretation of those areas.

X.—On the Pleistocene Deposits of the Vale of Clwyd. By Professor T. M'Kenny Hughes, M.A., F.G.S.

THE author cautions observers against inferring too hastily the glacial origin of beds from their containing glaciated boulders.

He describes the drifts of the western part of North Wales, grouping them under two heads:—

1. The Older or Arenig Drift, or that in which boulders were transported from Arenig into the Vale of Clwyd; and

2. The Newer or Clwydian Drift, or that due to the destruction of the older glacial deposits by marine action, during which boulders were carried on floating ice from the north, and flints travelled in the shingle round the coast. All the shells found in it are of species still living on the adjoining coast: but some of the shells found in what he considers part of the same series of deposits in neighbouring districts are of a more arctic type, and may beleng to an earlier part of the same epoch.

He then gives an account of the principal caves explored about the Vale of Clwyd, and explains their relation in each case to the drifts of the district; inferring that, while some of them may be older than the marine Clwydian drift, and some may possibly be even preglacial, yet that none of the bone-deposits so far found in any of them can be referred to so early a date.

XI.—Supplementary Note on Two Deep Borings in Kent. By W. Whitaker, B.A., F.G.S., Assoc.Inst.C.E.

THE paper "On Deep Borings at Chatham," communicated in abstract to the last meeting of the Association, was afterwards read, with various additions, to the Geological Society. Since then, however, further information has been got, some of which is of importance, especially in view of the fact that the South Eastern Railway Company is about to make a deep trial-boring at Dover.

The boring at Chattenden Barracks, near Chatham, has been finished, being taken to a depth of over 1160 feet, the bottom of the Gault being reached at 1162 feet, where sand (Lower Greensand) was found and water got. In my account of the section it was left, in Gault, at 1103 feet, and I ventured to say that "some 60 feet more would reach the bottom of that formation"; this happened in 59 feet. I did not venture, however, to predict the finding of Lower Greensand, as, from the thinness of that series at Chatham, a little southward, it was quite possible that it might soon disappear northward.

The almost exact correspondence of the combined thickness of Chalk and Gault here, 872 feet, with the same total at Chatham (875 and 878 feet in two borings) is noteworthy. Of course there is no Upper Greensand, which formation is absent at the outcrop on the south.

The Dover boring has been carried a few feet deeper and abandoned. I have visited the site, and procured a good set of specimens of the bottom clays, of which we had but a few small pieces before.

These specimens have been carefully examined, and the result of this examination is, I think, worthy of notice. As regards fossils it is simply negative, my colleagues, Mr. G. Sharman and Mr. E. T. Newton, after washing and sifting pieces of many specimens, were unable to detect any organism, with a solitary exception, and *that* was a simple example of a species of *Rotalia*, which, struggling into existence in Silurian times, has managed to survive to the present day! I have some doubts, too, whether this one fossil may not have fallen

down the bore. Anyway it proves nothing. As regards the character of the beds, however, I think that a reasonable conclusion may be inferred from the specimens.

In my published account certain beds are referred, with some doubt, to the Lower Greensand. The reference is wrong and the doubt right, for the top five feet, of the 49 credited to Lower Greensand, really belong to the base of the Gault, and the bottom thirteen feet to the Wealden, as I believe. The Lower Greensand is left, therefore, with only 31 feet of clayey sand. It is curious that specimens from the bottom part (838 to 848 feet) are exactly like the corresponding specimens from the bottom part of the Lower Greensand in the Chatham boring (932 to 943 feet), the two sets having about the same vertical extent (10 or 11 feet).

These specimens remind one of the division known as the Sandgate Beds, and I am inclined to think that this division alone occurs at Dover, the Folkestone Beds above and the Hythe Beds below having thinned out, although both those divisions are thicker than the Sandgate Beds at the outcrop.

The clayey beds beneath have been proved to a thickness of some 80 feet, the boring ending at about 930 feet. In my paper I spoke of chalky matter occurring in them, but in this I was wrong. The white specks in the small specimens first seen certainly looked calcareous, but the examination of better specimens has shown that they are anything but that. Indeed, the prevailing character is the absence of any effervescence when the clays are treated with hydrochloric acid; in many cases peculiarly fine-grained whitish beds simply absorb the acid, without any effervescent action.

On comparing the specimens with other clays, they were found to be unlike any of the marine Cretaceous and Jurassic clays, and it seemed to me that their affinities lay rather with the Wealden series, and probably with the lower, or Hastings division, than with the Weald Clay.

I have only lately been able to test this by the help of a set of specimens that Mr. G. Maw has been kind enough to send me. On examining them I found that three specimens of Weald Clay, from Surrey, effervesced readily, which is perhaps not surprising as they came in two cases from close to Horsham stone, and in the other from near a Paludina-bed. Nine specimens from a more distant district, Dorsetshire, did not effervesce; but one can hardly give the exact position of these in the Wealden Series. Ten specimens from the Ashdown Series, the lowest division of the Hastings Beds, not only, in some cases, resembled Dover specimens in character (I speak from memory, not having had the two sets side by side), but in every case refused to notice the presence of hydrochloric acid.

Should this classification be right, it serves to strengthen very much the conclusion, in my paper, that Dover is on all grounds a good site for a deep trial-boring,[1] for it looks as if the bottom part of the great Wealden Series came there within 600 feet of the surface in the low ground, the boring being described on a site 280 feet above the sea.

[1] Quart. Journ. Geol. Soc. 1886, vol. xlii. p. 44.