in 1895, previously reviewed in this Magazine. Similar evidence of great continental changes of level in Europe have been brought forward by Professor Edward Hull of this country, by Dr. Fridjof Nansen of Norway, and by others.

Professor de la Torre's investigations have also great interest in another field, for he has obtained a Jurassic fauna, which had been previously discovered, but later pronounced wanting in Cuba, by Mr. C. W. Hayes. Professor de la Torre is to be congratulated on his successful researches in geological problems of such great importance and of international interest which have a bearing on the question of cause of the Glacial period.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Sheffield, 1910. Address by the Rev. Professor T. G. Bonney, Sc.D., LL.D., F.R.S., President.

(*Concluded from the October Number, p.* 469.)

SUCH, then, are the facts, which call for an interpretation. More than one has been proposed; but it will be well, before discussing them, to arrive at some idea of the climate of these Islands during the colder part of the Glacial Epoch. Unless that were associated with very great changes in the distribution of sea and land in Northern and North-Western Europe, we may assume that neither the relative position of the isotherms nor the distribution of precipitation would be very materially altered. A general fall of temperature in the northern hemisphere might so weaken the warmer ocean current from the south-west that our coasts might be approached by a cold one from the opposite direction.[1] . . . I am doubtful whether we can attribute to changed currents a reduction in British temperatures of so much as 11°; but, if we did, this would amount to 28° from all causes, and give a temperature of 20° to 22° at sea-level in England during the coldest part of the Glacial Epoch. That is now found, roughly speaking, in Spitzbergen, which, since its mountains rise to much the same height, should give us a general idea of the condition of Britain in the olden time.

What would then be the state of Scandinavia? Its present temperature ranges on the west coast from about 45° in the south to 35° in the north. But this region must now be very much, possibly 1800 feet, lower than it was in pre-Glacial, perhaps also in part of Glacial, times. If we added 5° for this to the original 15°, and allowed so much as 18° for the diversion of the warm current, the temperature of Scandinavia would range from 7° to –3°, approximately that of Greenland northwards from Upernivik. But since the difference at the present day between Cape Farewell and Christiania (the one in an abnormally cold region, the other one correspondingly warm) is

[1] Facts relating to this subject will be found in *Climate and Time*, by J. Croll, 1875, chs. ii and iii. Of course the air currents would also be affected, and perhaps diminish precipitation as the latitude increased.

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only 7°, that allowance seems much too large, while without it Scandinavia would correspond in temperature with some part of that country from south of Upernivik to north of Frederikshaab. But if Christiania were not colder than Jakobshavn is now, or Britain than Spitzbergen, we are precluded from comparisons with the coasts of Baffin Bay or Victoria Land.

Thus the ice-sheet from Scandinavia would probably be much greater than those generated in Britain. It would, however, find an obstacle to progress westwards, which cannot be ignored. If the bed of the North Sea became dry land, owing to a general rise of 600 feet, that would still be separated from Norway by a deep channel, extending from the Christiania Fjord round the coast northward. Even then this would be everywhere more than another 600 feet deep, and almost as wide as the Strait of Dover. The ice must cross this and afterwards be forced for more than 300 miles up a slope which, though gentle, would be in vertical height at least 600 feet. The task, if accomplished by thrust from behind, would be a heavy one, and, so far as I know, without a parallel at the present day; if the viscosity of the ice enabled it to flow, as has lately been urged,[1] we must be cautious in appealing to the great Antarctic barrier, because we now learn that more than half of it is only consolidated snow.[2] Moreover, if the ice floated across that channel, the thickness of the boulder-bearing layers would be diminished by melting (as in Ross's Barrier), and the more viscous the material the greater the tendency for these to be left behind by the overflow of the cleaner upper layers. If, however, the whole region became dry land, the Scandinavian glaciers would descend into a broad valley, considerably more than 1200 feet deep, which would afford them an easy path to the Arctic Ocean, so that only a lateral overflow, inconsiderable in volume, could spread itself over the western plateau.[3] An attempt to escape this difficulty has been made by assuming the existence of an independent centre of distribution for ice and boulders near the middle of the North Sea bed[4] (which would demand rather exceptional conditions of temperature and precipitation); but in such case either the Scandinavian ice would be fended off from England, or the boulders, prior to its advance, must have been dropped by floating ice on the neighbouring sea-floor.

If, then, our own country were but little better than Spitzbergen as a producer of ice, and Scandinavia only surpassed Southern Greenland in having a rather heavier snowfall, what interpretation may we give to the glacial phenomena of Britain? Three have been proposed. One asserts that throughout the Glacial Epoch the British Isles generally stood at a higher level, so that the ice which almost buried

[1] R. M. Deeley, Geol. Mag., 1909, p. 239.

[2] E. Shackleton, *The Heart of the Antarctic*, ii, 277.

[3] It has indeed been affirmed (Brögger, *Om de senglaciale og postglaciale nivaforandringer i Kristianiafelted*, p. 682) that at the time of the great ice-sheet of Europe the sea-bottom must have been uplifted at least 8500 feet higher than at present. This may be a ready explanation of the occurrence of certain dead shells in deep water, but, unless extremely local, it would revolutionize the drainage system of Central Europe.

[4] Geol. Mag., 1901, pp. 142, 187, 284, 332.

them flowed out on to the beds of the North and Irish Seas. The boulder-clays represent its moraines. The stratified sands and gravels were deposited in lakes formed by the rivers which were dammed up by ice-sheets.[1] A second interpretation recognizes the presence of glaciers in the mountain regions, but maintains that the land, at the outset rather above its present level, gradually sank beneath the sea, till the depth of water over the eastern coast of England was fully 500 feet, and over the western nearly 1400 feet, from which depression it slowly recovered. By any such submergence Great Britain and Ireland would be broken up into a cluster of hilly islands, between which the tide from an extended Atlantic would sweep eastwards twice a day, its currents running strong through the narrower sounds, while movements in the reverse direction at the ebb would be much less vigorous. The third interpretation, in some respects intermediate, was first advanced by the late Professor Carvill Lewis, who held that the peculiar boulder-clays and associated sands (such as those of East Anglia), which, as was then thought, were not found more than about 450 feet above the present sea-level, had been deposited in a great freshwater lake, held up by the ice-sheets already mentioned and by an isthmus, which at that time occupied the place of the Strait of Dover. Thus, these deposits, though directly due to land-ice, were actually fluviatile or lacustrine. But this interpretation need not detain us.

. . . .

Each of the other two hypotheses involves grave difficulties. That of great confluent ice-sheets creeping over the British lowlands demands, as has been intimated, climatal conditions which are scarcely possible, and makes it hard to explain the sands and gravels, sometimes with regular alternate bedding, but more generally indicative of strong current action, which occur at various elevations to over 1300 feet above sea-level, and seem too widespread to have been formed either beneath an ice-sheet or in lakes held up by one; for the latter, if of any size, would speedily check the velocity of influent streams.

. . . .

Some authorities, however, attribute such magnitude to the ice-sheets radiating from Scandinavia that they depict them, at the time of maximum extension, as not only traversing the North Sea bed and trespassing upon the coast of England, but also radiating southward to overwhelm Denmark and Holland, to invade Northern Germany and Poland, to obliterate Hanover, Berlin, and Warsaw, and to stop but little short of Dresden and Cracow, while burying Russia on the east to within no great distance of the Volga and on the south to the neighbourhood of Kief. Their presence, however, so far as I can ascertain, is inferred from evidence[2] very similar to that which we

[1] See Warren Upham, Monogr. U.S. Geol. Survey, xxv, 1896. This explanation commends itself to the majority of British geologists as an explanation of the noted parallel roads of Glenroy, but it is premature to speak of it as "conclusively shown" (Quart. Journ. Geol. Soc., vol. lviii, p. 473, 1902) until a fundamental difficulty which it presents has been discussed and removed.

[2] A valuable summary of it is given in *The Great Ice Age*, J. Geikie, chs. xxix, xxx, 1894.

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have discussed in the British lowlands. That Scandinavia was at one time almost wholly buried beneath snow and ice is indubitable; it is equally so that at the outset the land stood above its present level, and that during the later stages of the Glacial Epoch parts, at any rate of Southern Norway, had sunk down to a maximum depth of 800 feet. In Germany, however, erratics are scattered over its plain and stranded on the slopes of the Harz and Riesengebirge up to about 1400 feet above sea-level. The glacial drifts of the lowlands sometimes contain dislodged masses of neighbouring rocks like those at Cromer, and we read of other indications of ice action. I must, however, observe that since the glacial deposits of Möen, Warnemünde, and Rügen often present not only close resemblances to those of our eastern counties but also very similar difficulties, it is not permissible to quote the one in support of the other, seeing that the origin of each is equally dubious. Given a sufficient 'head' of ice in northern regions, it might be possible to transfer the remains of organisms from the bed of the Irish Sea to Moel Tryfaen, Macclesfield, and Gloppa; but at the last-named, if not at the others, we must assume the existence of steadily alternating currents in the lakes in order to explain the corresponding bedding of the deposit. This, however, is not the only difficulty. The 'Irish Sea glacier' is supposed to have been composed of streams from Ireland, South-West Scotland, and the Lake District, of which the second furnished the dominant contingent; the first-named not producing any direct effect on the western coast of Great Britain, and the third being made to feel its inferiority and "shouldered in upon the mainland". But even if this ever happened, ought not the Welsh ice to have joined issue with the invaders a good many miles to the north of its own coast? Welsh boulders at any rate are common near the summit of Moel Tryfaen, and I have no hesitation in saying that the pebbles of riebeckite-rock, far from rare in its drifts, come from Mynydd Mawr, hardly half a league to the E.S.E., and not from Ailsa Crag.

. . . .

During the last few years, however, the lake-hypothesis of Carvill Lewis has been revived under a rather different form by some English advocates of land-ice. For instance, the former presence of ice-dammed lakes is supposed to be indicated in the upper parts of the Cleveland Hills by certain overflow channels. I may be allowed to observe that, though this view is the outcome of much acute observation and reasoning,[1] it is wholly dependent upon the ice-barriers already mentioned, and that if they dissolve before the dry light of sceptical criticism the lakes will "leave not a rack behind". I must also confess that to my eyes the so-called 'overflow channels' much more closely resemble the remnants of ancient valley-systems, formed by only moderately rapid rivers, which have been isolated by the trespass of younger and more energetic streams, and they suggest that the main features of this picturesque upland were developed before rather than after the beginning of the Glacial Epoch. I think that even 'Lake Pickering', though it has become an accepted fact with

[1] P. F. Kendall, Quart. Journ. Geol. Soc., vol. lviii, p. 471, 1902.

several geologists of high repute, can be more simply explained as a two-branched 'valley of strike', formed on the Kimeridge Clay, the eastern arm of which was beheaded, even in pre-Glacial times, by the sea. As to Lake Oxford,[1] I must confess myself still more sceptical.

. . . .

The submergence hypothesis assumes that, at the beginning of the Glacial Epoch, our Islands stood rather above their present level, and during it gradually subsided, on the west to a greater extent than on the east, till at last the movement was reversed, and they returned nearly to their former position. During most of this time glaciers came down to the sea from the more mountainous islands, and in winter an ice-foot formed upon the shore. This, on becoming detached, carried away boulders, beach pebbles, and finer detritus. Great quantities of the last also were swept by swollen streams into the estuaries and spread over the sea-bed by coast currents, settling down especially in the quiet depths of submerged valleys. Shore-ice in Arctic regions, as Colonel H. W. Feilden[2] has described, can striate stones and even the rock beneath it, and is able, on a subsiding area, gradually to push boulders up to a higher level. In fact, the state of the British region in those ages would not have been unlike that still existing near the coasts of the Barents and Kara Seas. Over the submerged region southward, and in some cases more or less eastward, currents would be prevalent; though changes of wind would often affect the drift of the floating ice-rafts. But though the submergence hypothesis is obviously free from the serious difficulties which have been indicated in discussing the other one, gives a simple explanation of the presence of marine organisms, and accords with what can be proved to have occurred in Norway, Waigatz Island, Novaia Zemlya, on the Lower St. Lawrence, in Grinnell Land, and elsewhere, it undoubtedly involves others. One of them—the absence of shore terraces, caves, or other sea marks—is perhaps hardly so grave as is often thought to be.

. . . .

But other difficulties are far more grave. The thickness of the Chalky Boulder-clay alone, as has been stated, not unfrequently exceeds 100 feet, and, though often much less, may have been reduced by denudation. This is an enormous amount to have been transported and distributed by floating ice. The materials also are not much more easily accounted for by this than by the other hypothesis. A continuous supply of well-worn chalk pebbles might indeed be kept up from a gradually rising or sinking beach, but it is difficult to see how, until the land had subsided for at least 200 feet, the Chalky Boulder-clay could be deposited in some of the East Anglian valleys or on the Leicestershire hills. That depression, however, would seriously diminish the area of exposed chalk in Lincolnshire and Yorkshire, and the double of it would almost drown that rock. Again, the East Anglian Boulder-clay, as we have said, frequently abounds in fragments and finer detritus from the Kimeridge and Oxford Clays.

[1] F. W. Harmer, Q.J.G.S., vol. lxii, p. 470, 1907.
[2] Q.J.G.S., vol. xxxiv, p. 556, 1878.

But a large part of their outcrop would disappear before the former submergence was completed. . . . The instances, also, of the transportation of boulders and smaller stones to higher levels, sometimes large in amount, as in the transference of 'brockram' from outcrops near the bed of the Eden Valley to the level of Stainmoor Gap, seem to be too numerous to be readily explained by the uplifting action of shore-ice in a subsiding area. Such a process is possible, but we should anticipate it would be rather exceptional.

Submergence also readily accounts for the above-named sands and gravels, but not quite so easily for their occurrence at such very different levels. . . . In other words, the sands and gravels, presumably (often certainly) mid-Glacial, mantle, like the Upper Boulder-clay, over great irregularities of the surface, and are sometimes found, as already stated, up to more than 1200 feet. Either of these deposits may have followed the sea-line upwards or downwards, but that explanation would almost compel us to suppose that the sand was deposited during the submergence and the upper clay during the emergence; so that, with the former material, the higher in position is the newer in time, and with the latter the reverse.

. . . .

The passing of the great Ice Age was not sudden, and glaciers may have lingered in our mountain regions when Palæolithic man hunted the mammoth in the valley of the Thames, or frequented the caves of Devon and Mendip. But of these times of transition before written history became possible, and of sundry interesting topics connected with the Ice Age itself—of its cause, date, and duration, whether it was persistent or interrupted by warmer episodes, and, if so, by what number, of how often it had already recurred in the history of the earth—I must, for obvious reasons, refrain from speaking, and content myself with having endeavoured to place before you the facts of which, in my opinion, we must take account in reconstructing the physical geography of Western Europe, and especially of our own country, during the Age of Ice.

Not unnaturally you will expect a decision in favour of one or the other litigant after this long summing up. But I can only say that, in regard to the British Isles, the difficulties in either hypothesis appear so great that, while I consider those in the 'land-ice' hypothesis to be the more serious, I cannot, as yet, declare the other one to be satisfactorily established, and I think we shall be wiser in working on in the hope of clearing up some of the perplexities. I may add that, for these purposes, regions like the northern coasts of Russia and Siberia appear to me more promising than those in closer proximity to the North or South Magnetic Poles. This may seem a "lame and impotent conclusion" to so long a disquisition, but there are stages in the development of a scientific idea when the best service we can do it is by attempting to separate facts from fancies, by demanding that difficulties should be frankly faced instead of being severely ignored, by insisting that the giving of a name cannot convert the imaginary into the real, and by remembering that if hypotheses yet on their trial are treated as axioms, the result will often bring disaster, like building a tower on a foundation of sand. To scrutinize, rather than to advocate any hypothesis, has been my aim throughout this address, and, if my efforts have been to some extent successful, I trust to be forgiven, though I may have trespassed on your patience and disappointed a legitimate expectation.

II.—INDEX GENERUM ET SPECIERUM ANIMALIUM. Report of a Committee consisting of Dr. HENRY WOODWARD (Chairman), Dr. F. A. BATHER (Secretary), Dr. P. L. SCLATER, Rev. T. R. R. STEBBING, Dr. W. E. HOYLE, Hon. WALTER ROTHSCHILD, and Lord WALSINGHAM.[1]

CONTINUOUS and steady progress has been made by Mr. Davies Sherborn in the preparation of Volume II of this Index. Since the report for last year was sent in, Mr. Sherborn has dealt with the remainder of the separate works of authors whose names begin with C, and of these the various editions of Cuvier proved exceptionally long and tedious to analyse. Other works have also been dealt with as opportunity offered.

Valuable assistance has been rendered by Mr. Hartley Durrant, who lent from Lord Walsingham's library (presented to the Trustees of the British Museum) a fine copy of the extremely rare work by Billberg, *Enumeratio Insectorum*, 1820, which has been indexed and made available for reference.

The slips, which are preserved in the British Museum (Natural History) by the kindness of the Trustees, are quite in order for those who wish to consult them, and are of exceptional value to anyone monographing a particular genus.

Mr. Sherborn and Mr. H. O. N. Shaw have written a paper clearing up the difficulties surrounding Sowerby's *Conchological Illustrations* and Gray's *Descriptive Catalogue of Shells*,[2] and Mr. Sherborn himself has written on the dates of the parts of Burmeister's *Genera Insectorum*, 1838–46.[3]

Systematic and regular work on this Index is greatly encouraged by the friendly attitude of the Association, and the Committee, in recommending its own reappointment, earnestly ask the Association to continue this valuable help by a further grant of £100.

III.—OUTLINES OF THE GEOLOGY OF NORTHERN NIGERIA. By Dr. J. D. FALCONER, M.A., F.G.S.[4]

THE Protectorate of Northern Nigeria lies for the most part between Lake Chad and the confluence of the Rivers Niger and Benue, and comprises an area of about 255,700 square miles. Crystalline rocks are exposed over about half of this area, and among them two series have been recognized: (1) a series of hard, banded, and much granitized gneisses of an Archæan type; (2) a series of quartzites,

[1] Read before the British Association Meeting, Sheffield, 1910 (Section D).
[2] Proc. Malac. Soc., September, 1909, pp. 331–40.
[3] Ann. Mag. Nat. Hist., January, 1910.
[4] Read before the British Association Meeting, Sheffield, 1910 (Section C).

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phyllites, schists, and gneisses of sedimentary origin with associated amphibolites, hornblende schists, and other more or less metamorphosed igneous rocks. The two series, which were probably originally unconformable, have been folded together along axes which are predominantly meridional in direction. They have also been pierced by numerous igneous intrusions, which are readily subdivided into an older and a younger group. The older group consists principally of granites, wholly or partially foliated, which have been affected to a varying extent by the forces which produced the metamorphism of the gneisses and schists. The members of the younger group are non-foliated, and include such types as tourmaline granite, riebeckite granite, augite syenite, augite diorite, and numerous associated dyke rocks.

Rocks of Cretaceous age are found in the valleys of the Benue and the Gongola and in the angle between the two rivers. They are invariably gently folded and sometimes broken and faulted, and consist of a lower series of sandstones and grits, in part salt-bearing, and an upper series of limestones and shales, with numerous fossils of Turonian age. The post-Cretaceous rocks, which rest unconformably upon the Cretaceous Limestone, and are probably all of Eocene age, occur over three detached areas: (1) in Sokoto Province and the Niger Valley, (2) in Bauchi and Bornu, and (3) in Yola. The Sokoto Series, which contains marine intercalations yielding abundant Eocene fossils, is continuous southward with the sandstones, grits, and ironstones of the Niger Valley. The correlation of the sandstones, grits, and clays of Bauchi, Bornu, and Yola with the Eocene rocks of Sokoto and the Niger Valley is based partly upon lithological similarities and partly upon the absence of evidence of any extensive post-Eocene submergence of the Protectorate.

Extensive fields of basaltic lava occur in Southern Bornu and on the borders of Bauchi and Nassarawa; and numerous puys of trachyte, phonolite, olivine basalt, and nepheline basalt are distributed throughout Southern Bauchi, Muri, and Yola. The puys and lava-fields alike are the product of Tertiary volcanic activity.

During the latter part of the Tertiary period there appear to have been repeated minor oscillations of the crust, which culminated in the elevation of the Bauchi plateau and the Nassarawa tableland, the depression of the Chad area, and the establishment of the present river system.

IV.—The Occurrence of Marine Bands at Maltby. By Wm. H. Dyson.[1]

During the sinking operations at Maltby the writer has located the stratigraphical position of the fossils found and has inspected the excavated debris day by day. Although all fossils have been collected, reference is only here made to the marine bands.

Taking the top of the Barnsley Coal (2452 ft. 2 in. deep or

[1] Read before the British Association Meeting, Sheffield, 1910 (Section C).

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2193 ft. 5 in. below Ordnance datum) as a base-line, the lowest marine band, 8 ft. 7 in. thick, occurred 340 ft. 1 in. above the Barnsley Coal, the section being 1 ft. 11 in. of bastard cannel overlain by 6 ft. 8 in. of blackish bind with balls of pyrites, and contained the following fossils, mostly preserved in pyrites: *Lingula mytiloides*, ? *Posidoniella*, *Pterinopecten carbonarius*, *P. papyraceus*, *Scaldia carbonaria*, *Euphemus urei*, *Macrocheilina* sp., *Glyphioceras* sp., *Cœlacanthus*, ? *Cheirodus*, *Megalichthys*, *Rhadinichthys monensis*, *Rhizodopsis sauroides*. Among these *Macrocheilina* was fairly abundant.

The next bed occurred 564 ft. 1 in. above the Barnsley Coal. The material was dark-blue bind with ironstone and small cank-balls, and the following forms were present: *Lingula mytiloides*, *Orbiculoidea nitida*, *Myalina compressa*, *Straparollus* sp., *Euphemus urei*, *Naticopsis* sp., *Pleuronautilus costatus*, *Solenocheilus cyclostoma*, *Acanthodes*, *Cladodus*, *Cœlacanthus*, *Megalichthys*, *Platysomus*, *Elonichthys* or *Acrolepis*, *Rhizodopsis*. Among these *Straparollus* is new to the Middle Coal-measures.

The next marine band, 20 ft. 0½ in. thick, lies 708 ft. 10½ in. above the Barnsley Coal, the section being 19 ft. 0½ in. of dark greyish-blue shale with hard cank-balls, resting on 12 inches of argillaceous limestone. It contains an abundant fauna, including twenty-six genera and thirty-five species of invertebrates, all marine forms. *Chonetes laguessiana*, *Lingula mytiloides*, *Orbiculoidea nitida*, *Productus anthrax*, *Ctenodonta lævirostris*, *Myalina compressa*, *Nucula æqualis*, *N. gibbosa*, *N. luciniformis*, *Nuculana acuta*, *Posidoniella lævis*, *P. sulcata*, *Pseudamusium anisotum*, *P. fibrillosum*, *Pterinopecten papyraceus*, *Scaldia carbonaria*, *Schizodus antiquus*, *Syncyclonema carboniferum*, *Euphemus d'orbignyi*, *E. urei*, *Loxonema acutum*, *L. ashtonense*, *L.* sp., *Rhaphistoma radians*, *Bellerophon* sp., ? *Dimorphoceras gilbertsoni*, *Ephippioceras clittellarium*, *Gastrioceras carbonarium*, ? *Glyphioceras paucilobum*, *G. phillipsi*, *G. reticulatum*, *G.* sp., *Orthoceras asciculare*, *O. sulcatum = koninckianum*, *O.* sp., *Pleuronautilus costatus*, *Acanthodes*, *Cœlacanthus*, *Elonichthys*, *Listracanthus*, *Megalichthys*, *Platysomus*, *Rhizodopsis sauroides*. Among these *Pseudamusium anisotum* has not hitherto been found above the Carboniferous Limestone. Among the fish-remains *Listracanthus* should be noted.

The highest bed occurs 1000 feet below the summit of the Middle Coal-measures and 1244½ feet above the Barnsley Coal. It is 10 ft. 11 in. thick, consisting of grey bind with ironstone bands, of greasy appearance. The fauna is poor, but Goniatites are not uncommon. *Lingula mytiloides*, *Orbiculoidea nitida*, *Myalina compressa*, *Nuculana acuta*, ? *Bellerophon* sp., *Glyphioceras phillipsi*, *G.* sp., *Orthoceras* sp., *Listracanthus*, *Megalichthys*, *Rhadinichthys monensis*. Among the fish-remains *Listracanthus* is to be recorded.

The writer is indebted to Dr. Wheelton Hind, F.G.S., and Dr. A. Smith Woodward, F.R.S., for examining and naming the fossils.