one; for, whilst the rich ores of Bilbao and Elba are becoming scarce, there are still vast quantities of ore available in the north of Scandinavia, in the south of Spain, in Algeria, Canada, Cuba, Brazil, Venezuela, Chili, India, China (notably in the Shansi district), Australia, and South Africa. The high cost of carriage is, of course, an important factor; but the great economies which have and will be effected in transport will reduce this item. The future of the home demand is likely to be affected by the development of the basic open-hearth process of steel-making which enables phosphoric ores to be utilised. In the course of time such phosphoric ores will doubtless occupy a very prominent place in the manufacture of high-class steel. The development of magnetic concentration and of the briquetting of pulverulent ores for furnace use will render possible greater utilisation of poorer ores, while the development of the electric furnace will doubtless render it possible to utilise black sands and other titaniferous iron ores which, although met with in abundance, cannot at present be treated profitably in the blast-furnace. There need, therefore, be no immediate anxiety regarding the supply of the more impure iron ores, the application of which cannot fail rapidly to increase.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science: Seventy-seventh Annual General Meeting held at Leicester, August 1st, 1907.

I.—Address to the Geological Section. By Professor J. W. Gregory, D.Sc., F.R.S., President of the Section.

(*Concluded from the September Number, p.* 418.)

IV. *Plutonists and Ore-formation.*—Belief in the earth's internal fires was most faithfully held amongst geologists by the Plutonists of the eighteenth century, and repudiated with equal thoroughness by the Neptunists, who refused to concede that volcanic action was due to deep-seated cosmic causes. Thus Jameson in 1807 stoutly maintained that volcanoes were superficial phenomena due to the combustion of beds of coal beneath fusible rocks, such as basalt, and that the explosions were due to the sudden expansion of sea-water into steam by contact with the burning coal. Volcanoes, according to this view, were correctly described as burning mountains, giving forth fire, flame, and smoke. The extreme Neptunist and Plutonist schools have long since been extinct, but the controversy is not quite closed. The battlefield is now practically restricted to economic geology, and the issue is the origin of some important ores.

Ore deposits present so many perplexing features that deep-seated igneous agencies were naturally invoked to explain them, and some of the most thorough-going champions of the igneous origin of ores make claims that remind us of the eighteenth-century Plutonists. The question is to some extent a matter of terms. Many of the ores which Vogt, for example, describes as of igneous origin he attributes,

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not to the direct consolidation of material from a molten state, but to eruptive after-actions due to the hot solutions and heated gases given off from cooling igneous rocks. Igneous rocks probably play a notable part in the genesis of most primary ore deposits; for the entrance of the hot ore-bearing solutions is rendered possible by the heat of the igneous intrusions, as Professor Kemp has well shown in his paper on "The Rôle of Igneous Rocks in the Formation of Metallic Veins." Professor Kemp limits the term 'igneous' to materials formed by the direct consolidation of molten material; and this decision seems to me to be most convenient. For example, the quartzite that is so often found beneath a bed of basalt is due to hot alkaline water from the lava cementing the loose grains of sand; the process is an eruptive after-action, but it would be unusual to call such a quartzite an igneous rock.

1. *Igneous Ores.*—That there are ores which are the products of direct igneous origin is now almost universally admitted. The mineral magnetite is a most valuable source of iron, and it is a constituent of most basic igneous rocks. If iron were a high-priced metal, such as tin or copper, of which ores containing one or three per cent. are profitably worked, then basalt would be an ore of igneous origin. Under present commercial conditions, however, basalt cannot be regarded as an iron ore. But if the magnetite in a basic rock had been segregated into clots or masses large enough and pure enough to pay for mining, then they would be iron ores formed by igneous action. There are cases of such segregations large enough to be mined. The most famous is Taberg, a mountain in Småland, near the southern end of Lake Wetter, in Sweden. It is a locality of historic interest; a view of it, as a mountain of iron, was published by Peter Ascanius[1] in the Philosophical Transactions in 1755, and Sefström discovered the element vanadium in its ore in 1830.

Taberg consists of an intrusive mass of rock composed of magnetite, olivine, labradorite, and pyroxene. Many theories of its formation have been advanced. The view generally adopted is that of Törnebohm, who described the rock as a variety of hyperite in which there has been a central segregation of magnetite to such an extent that some of it contains 31 per cent. of iron. Törnebohm claims to have traced a gradual passage from normal hyperite to a variety poor in felspar, then to one without felspar, and finally to a granular intergrowth of magnetite and olivine. This Taberg ore was mined and smelted for iron in the eighteenth century, when transport was more costly and commercial competition less keen than it is to-day. The ore has been worked at intervals as late as 1870; and as the hill is estimated to contain 100 million tons of ore above the level of the adjacent railway, it is not surprising that efforts are being again made to utilise the deposit, in spite of its low grade and high percentage of titanium. The Taberg hyperite has almost reached the line which divides magnetite-bearing rocks from useful iron ores. Its igneous origin, however, has not been universally accepted. The theory has been rejected by so eminent an authority as Posepny,

[1] Vol. xlix, pp. 30–34, pl. ii.

according to whom the ore occurs in solid veins as well as in grains; and he holds that, like other Scandinavian iron ores, it was due to secondary deposition. During a visit to the mountain I failed to see any secondary veins, except of insignificant value. The microscopic sections of the ore show that it is a granular aggregate of olivine, generally with labradorite and pyroxene. Hence I have no hesitation in accepting the view of the Swedish geologists and regard Taberg as a magmatic segregation. Posepny[1] has in this case carried his Neptunist theory of the genesis of ores too far.

At Routivaara, in Swedish Lapland, there is a still larger mass of magnetite, which is claimed, in accordance with the descriptions of Petersson and Sjögren, to be due to segregation from the magma of the surrounding gabbro. This mass of magnetite is of colossal size, but it is of no present economic value owing to its high percentage of titanium and its remote position.

An igneous origin is claimed by Professor Högbom for some small masses of titaniferous magnetite in the island of Alnö, opposite Sundsvall, on the eastern coast of Sweden. This case is of interest, as the surrounding rock is not basic: it is a nepheline syenite, containing only 2 per cent. of magnetite, which, however, has been concentrated in places, until some specimens (according to an analysis quoted by Professor Högbom) contain as much as 64 per cent. of magnetite, 9 per cent. of ferrous oxide, and 12 per cent. of titanic oxide.

The Alnö magnetites, again, are of no practical value, as they are too low in grade and too refractory in nature. I understand that about 500 tons of the material have been smelted, but with unprofitable results, and the rest of the material quarried has been left on the shore. We may therefore accept the iron-bearing masses of Alnö and Routivaara, as well as that at Taberg, as due to magmatic segregation, without having conceded much as to the igneous formation of ores. The process in this case has formed rocks, rich in titaniferous magnetite, from which iron could be obtained, but rocks which no ironmaster is at present willing to buy as iron ore. Whether a basic igneous rock is to be regarded as an iron ore, or as only useful for road metal, depends on cost of treatment. The definition of the term 'ore' is very elastic. Petrographers speak of the minute grains of magnetite or chromite in a rock as its ores; but that is a special use of the term 'ore.' Usually ore means a material which can be profitably worked as a source of metals under existing or practicable industrial conditions.[2] According to this definition, the Swedish deposits of titaniferous magnetite are at present doubtfully within the category of iron ores.

The famous iron mines of Middle Sweden at Dannemorra, Norrberg, Grängesberg, and Persberg occur under different geological conditions; they work lenticles or bands of ores in metamorphic rocks, of which

[1] F. Posepny, "The Genesis of Ore Deposits": Trans. Amer. Inst. Min. Eng., 1893, p. 323.

[2] The Oxford Dictionary adopts a still more restricted definition; according to it an ore is "a native mineral containing a precious or useful metal in such quantity and in such chemical combination as to make its extraction profitable."

some are altered sediments; and the view has therefore been held by de Launay and Vogt that the ores also are altered sediments.

That ores are formed by igneous segregation of sufficient size and purity to be of economic importance is a theory which rests on two chief cases—the nickel ores of Sudbury in Canada and the iron ores of Swedish Lapland.

2. *The Sudbury Nickel Ores.*—The nickel ores of Sudbury are the most important historically. They have been repeatedly claimed as of direct igneous origin by Bell (1891), von Foullon (1892), Vogt (1893), Barlow (1903), and by other geologists; and his view was advocated before the Association at the Johannesburg meeting by Professor Coleman. The theory was stoutly opposed by Posepny in 1893, and Professor Beck in 1901 described some of the brecciated ore, and showed that its metallic minerals are sharply separated from the barren rock. He held that such ore must have been formed, not only after the consolidation of the rock, but even after or during its subsequent metamorphism. The views of Posepny and Beck seem to have been established by additional microscopic study of the ores by C. W. Dickson (1903). He has shown that the sulphides are separated from the barren rock by sharp boundaries, and without any indication of a passage between them; that the fragments of ore in the rock have short corners, whereas, had they grown in a molten magma, the angles would have been rounded and the faces corroded. Most of the ore, moreover, occurs as a cement filling interspaces between broken fragments of barren rock and along planes of shearing. The Sudbury ores, therefore, appear to have been deposited from solution during or after the brecciation of the rocks in which they occur, and long after their first consolidation. If Dickson's facts be right, the Sudbury ores are necessarily aqueous and not igneous in origin.

3. *Scandinavian Iron Ores.*—The other important mining field of which the ores are claimed as of igneous origin is Swedish Lapland. Its ores are rich and the ore bodies colossal. One mine, Kirunavaara, yielded over one and a half million tons of ore in 1906, and according to a recent agreement with the Swedish Government the annual output of ore from that mine may be raised to three million tons by 1913.

The chief mining fields of Lapland, although situated to the north of the Arctic Circle, have long been known, for some of them contain veins of copper which were worked, for example, at Svappavaara in the seventeenth century. The iron ores, however, could not be used until a railway had been laid through the swamps of Lapland to carry the ores cheaply to the coast. In 1862 an ill-fated English company began a railway to the Gellivara mines, and thirty years later this was completed across Scandinavia, from the head of the Gulf of Bothnia at Lulea to an ice-free port at Narvik, on the Norwegian coast.

This railway, the most northern in the world, passes the two great mining fields of Gellivara and Kiruna. The mining field of Kiruna is the larger and at present of the greater geological interest, as its structure is simpler and its rocks less altered.

The ore body at Kiruna outcrops along the crest of a ridge two miles long, and it is continued beneath Lake Luossajarvi to the smaller but still immense ore body of Luossavaara. At Kiruna the ore rises to the height of 816 feet above the surface of the lake, and it varies in thickness from 30 to 500 feet, with an average thickness of about 230 feet. According to the report by Professor Walfrid Petersson,[1] submitted this year to the Swedish Parliament, Kirunavaara contains 200 million tons of ore above lake-level, and Luossavaara another 22½ million tons. The ore is high-grade. According to Lundbohm 60 per cent. of the trial pits showed a yield varying from 67 to 71 per cent. of iron, and 21 per cent. of them showed a yield of from 60 to 67 per cent. of iron. The average of nineteen analyses published in Professor Petersson's recent report gives the contents of iron as 64·15 per cent. Unlike the Taberg and Routivaara ores, the percentage of titanium is very low; thus in nineteen analyses given by Petersson the average of titanic acid is only ·23 per cent., and it varies in the specimens from ·04 to ·8 per cent.

The ore lies between two series of acid rocks, which have been very differently interpreted, but will no doubt be fully explained by the researches now in progress under the direction of Mr. Lundbohm. The rocks were first called halleflinta, as by Fredholm, and regarded as of sedimentary origin. They are now accepted as an igneous series, associated with some conglomerates, slates, and quartzites. The ore body itself is bounded on both sides by porphyrites, of which that on the lower or western side is more basic than that overlying the ore to the east. The basic western porphyrite is in contact with a soda-augite syenite of which the relations are still uncertain. Interbedded with the overlying eastern porphyrite are rocks that appear to be volcanic tuffs, and both in the tuffs and in the upper porphyrite are fragments of the Kiruna ore.

Three main theories of the genesis of the Kiruna ores have been proposed. Their sedimentary origin was urged on the ground that they occur regularly interstratified in a series of altered sediments, and that the ores, therefore, are also sedimentary. This view may be promptly dismissed, since the adjacent rocks are igneous.

The second theory has been advanced independently by Professor de Launay and Dr. Helge Bäckström: according to them the porphyrites above and below the iron ores are lava-flows, and the ore was a superficial formation deposited in an interval between the volcanic eruptions. According to de Launay the iron was raised to the surface as emanations of iron chloride and iron sulphide; the iron was deposited as oxide, and most of it subsequently reduced to magnetite during the metamorphism of the district.

The third theory—that the ores are of direct igneous origin—has been maintained by Löfstrand, Högbom, and Stutzer; according to them the ores are segregations of magnetite from the acid igneous rocks in which they occur. The segregation theory has been opposed, amongst others, by de Launay and Vogt. Thus, de Launay maintains that the segregation would have been impossible in such fluid lavas as the Kiruna porphyrites, and is improbable, since there is no transition between the ore and the barren rock.

[1] *Bihang till Rikd. Prot.*, 1907, 1 Saml., 1 Afd., 84 Häft, No. 107, pp. 213, 217.

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The segregation theory has serious difficulties, and is faced by several obvious improbabilities. The ore occurs as a band nearly forty times as long as it is broad. It has the aspect, therefore, of a bed or a lode. The ore has not the granular, crystalline structure of an igneous rock like the hyperite of Taberg, but the aspect of a material deposited from solution or formed metasomatically. It is almost free from titanium, the undesirable constituent so abundant in the ores of Taberg and Routivaara.

The igneous theory cannot, however, be lightly dismissed, as it is supported by the high authority of Professor Högbom, and therefore demands careful consideration.

It has been advanced in two main forms, the one considering the ore to have been deposited at the time when the igneous rocks are consolidating, the other considering it was deposited at a later period. According to Professor Högbom, the ore was syngenetic, being a true magmatic segregation from a syenite. But, according to Dr. Stutzer (1906), the segregation was later than the consolidation of the syenite. He describes the lode as an intrusive banded dyke, of which the chief constituents are magnetite and apatite; and the injection of this dyke pneumatolytically affected the rocks beside it, producing an intermediate zone impregnated with ore, which he compares to contact deposits.[1]

In spite of the high authority of Professor Högbom, I am bound to confess that the Kiruna ores do not impress me as of igneous formation. Their bed-like form, microscopic structure, and poverty in titanium are features in which they differ from those admittedly due to direct magmatic segregation. The microscopic sections that I have examined suggest that both the magnetite and apatite were deposited from solution and later than the consolidation of the underlying porphyrite, which the ore in part replaces. An examination of the field evidence supports the conclusions of de Launay and Bäckström as to the ore being a bedded deposit overlying a lava-flow, but enlarged by secondary deposition.

V. *Future Supply of Iron Ores.*—This conclusion is perhaps economically disappointing. The possible existence of such vast segregations of iron in the acid igneous rocks has an important economic bearing. There is only too good reason to fear that the chief iron ores are comparatively limited in depth; for most of them have been formed by water containing oxygen and carbonic acid in solution, which has percolated downward from the surface. Ores thus formed are therefore restricted to the comparatively limited depths to which water can carry down these gases. On the theory, however, that these ores are primary segregations from deep-seated igneous rocks there need be no limit to their depth. They would

[1] In a later paper, of which only a short abstract has been issued, Dr. Stutzer, however, explains that "the intrusion of the ore dyke was at relatively the same time as the formation of the syenite, and that the ores were formed by magmatic separations *in situ*, or as peregrinating magmatic separations (magmatic veins and bedded streams)." He adds that "pneumatolysis plays no inconsiderable rôle in the formation of these veins." Dr. Stutzer's position may be summarised as regarding the ores as collected by segregation, but deposited in their present position by eruptive after-actions.

rather tend to increase in size downward, while maintaining, or even improving, in the richness of their metallic contents. For these bodies may be regarded as fragments of the metallic barysphere which have broken away from it and revolve around it like satellites floating in the rocky crust. On this conception these ore bodies would be of as great interest to the student of the earth's structure as their existence would be reassuring to the ironmaster, haunted as he is by constant predictions of an iron famine at no distant date. It is no doubt true that many of the richest, most accessible, most cheaply mined, and most easily smelted iron ores have been exhausted. The black-band ironstone and the clay iron ores of the coalfields, which gave the British iron industry its early supremacy, now yield but a small proportion of the ores smelted in our furnaces. The Mesozoic beds of the English Midlands and of Yorkshire still supply large quantities of ore. Nevertheless the British iron industry is becoming increasingly dependent on foreign ores. So it would be pleasant to find that the Scandinavian iron mines are not subject to the usual limits in depth. I fear the typical iron deposits of Middle Sweden and of Gellivara will follow the general rule; but Kiruna may be an exception, and its ores may continue far downward along the surface of its sheet of porphyrite. The uncertainty in this case lies in the extent of the subsequent enrichment and enlargement of the bed; if most of the ore is due to secondary deposition, then it may be restricted to the comparatively shallow depths at which this process can act; and though that limit will be of no practical effect for a century or more to come, the ore deposit may be shallow as compared with gold-mines.

The geological evidence may convince us that all the economically important iron ores are limited to shallower depths than lodes of gold, copper, and tin; but this conclusion shall not enrol me among the pessimists as to the future of the iron supply. Twenty years ago a paper on the gold supplies of the world was read to the Association at the request of the Section of Economics. About the time that the report was issued there were sixty-eight mining companies with a nominal capital of £73,000,000 at work upon the Rand. Nevertheless, the author, accepting the view that "the future of South African gold-mining depends upon quartz veins," concluded: "There is as yet no evidence that the yield will be sufficient in amount to materially influence the world's production. As regards India, the prospect is still less hopeful."

That quotation may be excused, as it is not only a warning of the danger of negative predictions, but of the unfortunate consequences that happen when geologists are unduly influenced in geological questions by the opinions of those who are not geologists. In economic geology, as in theoretical geology, we should have greater confidence in the value of geological evidence. Negative predictions are especially rash in regard to iron, it being the most abundant and widely distributed of all the metals. The geologist who knows the amount of iron in most basic rocks finds it difficult to realise the possibility of an iron famine; he can hardly picture to himself some future ironmaster complaining of "iron, iron everywhere, and not

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a ton to smelt." There are reserves of low-grade and refractory materials which the fastidious ironmaster cannot now use, since competition restricts him to ores of exceptional richness and purity. When the latter fail, an unlimited quantity could be made available by concentration processes. The vast quantities of iron ores suitable for present methods of smelting in Australia, Africa, and India show that the practical question is that of supplies to existing iron-working localities, and not of the universal failure of iron ores.

VI. *Mining Geology and Education.*—The genesis of ores and the extent of future ore supplies are intimately connected questions, and the recognition of this fact has led to the remarkable growth of interest in economic geology. This wider appreciation of the practical value of academic geology should, I venture to urge, be recognised among teachers by giving a more honoured place to economic geology.

It was inevitable that until the principles of geology had been firmly established, the detailed study of their application should have been postponed. Now, however, last century's work on academic geology enables the difficult problems connected with the genesis of metalliferous ores to be investigated with illuminating and practically useful results.

British interest in mining education has therefore been revived. Its history has been sadly fitful. Lyell,[1] in 1832, deplored the superiority of the Continent in this respect, as "the art of mining has long been taught in France, Germany, and Hungary in scientific institutions established for that purpose," whereas, he continues (quoting from the prospectus of a School of Mines in Cornwall, issued in 1825), "our miners have been left to themselves, almost without the assistance of scientific works in the English language, and without any 'School of Mines,' to blunder their own way into a certain degree of practical skill. The inconvenience of this want of system in a country where so much capital is expended, and often wasted, in mining adventures, has been well exposed by an eminent practical miner."

Though the chief British School of Mines made a late start, the brilliant originality of its professors soon carried it into the front rank; but in an evil day for the Mining School it was united with a Normal School for the Training of Teachers, now the Royal College of Science, and that school by its great success overwhelmed its older ally. Those interested in economic geology therefore welcome the recent decision to separate the technical from the educational and other courses, while leaving the Schools of Mines and Science sufficiently connected for successful co-operation. This policy should give such opportunities for the teaching of mining research that we may not always have to confess, as at present, that British contributions to mining geology do not rank as high as those made to other branches of our science.

Regrets are sometimes expressed, and perhaps still more often felt, at the tendency in scientific teaching to become more technical; but I, for one, do not fear evil from any such change. It is possible

[1] C. Lyell, "Principles of Geology," vol. i, 2nd ed. (1832), p. 63.

that the educational conflict of the future will be between academic science and technical science, on grounds in some respects analogous to those between classics and science during the last century. The advocates of the educational value of technical science are not inspired by mere impatience with the apparently useless, for they accept the principle that the essence of education is method, not matter. Therefore, they claim that the methods and principles of science can be better taught by subjects which are being used on a large scale in modern industries than by subjects of which the interest is still purely theoretical. Those who fear that academic science will be neglected if technical science be used in education may be encouraged by the brilliant revival of classical research since classics lost its educational monopoly. Academic science is even less likely to be neglected. It will always have its fascination for those intellectual hermits—shall I not say those saints of science?—who prefer to work for love of knowledge, free from the worrying intrusion of the mixed problems and fickle conditions of the industrial world; and the greater the progress of applied science the more urgent will be its demands for help from pure science, and, as a necessary consequence, the wider will be the appreciation and the more generous the endowment of scientific research.

Technical education must be as rigorous as that in academic education, and its connection with the fundamental principles must be as intimate. When so taught, economic problems provide at least as good a mental training as those branches of science which are purely theoretical. If the new Imperial College of Science and Technology carry on the mission for which the Geological Society was founded a century ago, if it inspire its students to have their delight in using past discoveries on the open surface of the earth, so that they may penetrate to what is within, then they will gain that sure knowledge of the formation and distribution of ores which is of ever-growing national importance.

II.—Some Desert Features.[1] By H. T. Ferrar, M.A., F.G.S.

CONTRAST between the deserts on either side of the Nile. The Western Desert, sometimes known as the Libyan Desert, presents all the features which one would expect to find in a region of deficient rainfall. There are broad featureless plains with no very definite drainage systems; there are long lines of sand-dunes stretching for tens of miles across the country; there are centripetal basins, and there are monadknocks or inselbergen, and an almost entire absence of vegetation.

The Eastern Desert, or the Etbai, on the other hand, displays an integrated drainage system; sand-dunes are conspicuous by their absence; vegetation is not scarce; and comparatively high mountains form a backbone to the country. These mountains are a true chain and form the water-parting between the Nile and the Red Sea. This water-parting is very much nearer the east coast, and, as in South Africa, so here we have the shorter and steeper eastward draining wadis

[1] By permission of the Director-General, Survey Department, Egypt.

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beheading the longer westward drainages. The highest peaks usually consist of granite, which is sometimes foliated, and these high peaks, which rise majestically above the denuded schistose rocks, are not always on the actual watershed. Forms of rock and mountain sculptured by sandblast are not obvious, for the rain which occasionally falls destroys these and produces typical water-graded slopes.

The western desert surfaces consist of a thin veneer of waste, except where monadknocks or the escarpments of the oases display solid rock. This veneer of waste is protected, as in the Antarctic regions, by a layer of pebbles, which prevents the wind transporting the lighter material and prevents the rain-water from flowing in definite channels.

The eastern, or Etbai, desert shows bare hillsides, and the steep cliffs which form the wadi-walls are quite free from débris. The wadis or dry watercourses are at present being aggraded, and it is only in the wadi-beds that one finds the alluvium. This alluvium of boulders and rock-débris is usually from 5 to 50 feet in depth, and may be described as a torrential deposit. The only sorting of materials that is obvious in this region is that sorting due to water-action, where the volume of water and the slope of the ground are the determining factors.

Sorting of fine material from the coarse is not as common as one would expect. A high wind (Beaufort scale, force 8) will only move pebbles and grit less than 5 mm. in diameter, so that a succession of winds of unprecedented force would be necessary to produce 'pebble beds.' The pebbles of the gravels on the western plateau, near Wadi Natrum, are all rounded and water-worn, and form a heavy mantle over the land which prevents the wind from picking up the lighter material from below, which they protect. It is only those stones on the surface that are wind-etched or show the faceted form. These gravels were deposited during the pluvial period, immediately preceding the present arid one, and therefore it would seem that the only reliable test to prove that a deposit was a desert formation would be to find in it tetrahedral and wind-etched stones.

Photographs were exhibited to show some of the points referred to in this paper.

III.—The Origin of the Upper Keuper of Leicestershire. By T. O. Bosworth, B.A., F.G.S.

The Condition of the Rocks beneath the Keuper.—The Charnian igneous rocks beneath the Keuper are comparatively fresh right up to their surfaces, but where the marl has been denuded and the rocks are exposed to the present climate they are decomposed.

The Surface Features of the Rocks beneath the Keuper.—Smoothed, fretted, and curiously carved surfaces are seen at Mount Sorrel,[1] Croft, Sapcote, Groby, etc., and usually wherever the marl rests on igneous rocks. They are often pitted and sometimes highly polished (e.g. at Narborough). But where the rocks are cleaved or broken, as

[1] Professor Watts, Geographical Journal, June, 1903.

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at Swithland and Bardon, the floor beneath the Keuper is rough and craggy.

The Nature of the Deposits.—Everywhere the beds dip in the direction of the surface slopes on which they lie, and the amount of dip depends upon the steepness of the slope. Catenary bedding is seen at Croft and Groby. Near the rocks the marl contains grit and stones, and there is generally a breccia at the base. The stones are of varied sizes, sometimes worn and sometimes very angular. They are in a remarkably fresh condition.

Both stones and grit are derived entirely from the particular rocks which the beds containing them surround. In these beds there is often a small amount of quartz sand, sometimes apparently wind-worn. It yields the same heavy minerals as the Upper Keuper Sandstone.

In many cases, e.g., around the South Leicestershire igneous rocks, this sand cannot be of local origin.

At Croft some of the Upper Keuper Sandstone consists of almost spherical grains, and appears to be a desert sand.

Near Leicester the sandstone is uniformly false-bedded from the south-west, and *Estheria* and fish-scales occur upon the false-bedding planes. Heavy mineral separations have been prepared from a large number of localities throughout the country. The mineral grains are generally very much worn. The most plentiful are garnet, magnetite, zircon, tourmaline, and rutile.

In the normal Keuper Marl bands showing false bedding, ripple-marks, and salt pseudomorphs are generally common.

But such evidence of subaqueous deposition as there is points rather to the existence of occasional streams and salt pools than to the deep waters of one great Keuper lake.

It is inferred that the Upper Keuper is a desert accumulation.

IV.—The Relation of the Keuper Marls to the Pre-Cambrian Rocks at Bardon Hill. By W. Keay, Assoc. M. Inst. C. E., and Martin Gimson, Stud. Inst. C. E.

BARDON HILL is situated in the Charnwood Forest area, about ten miles north-west from Leicester. The hill rises to an elevation of 912 feet, and is higher than any of the land intervening between this point and the German Ocean.

The hill consists of Keuper marls resting unconformably upon Pre-Cambrian rocks, the latter protruding about 100 feet through the marls.

The object of this paper is—(1) To remark upon the unusual elevation of the Keuper marls. (2) To consider the probability of the entire submergence of the hill during the Triassic period.

1. *Elevation.*—Acting upon a statement of Professor Phillips that "the Triassic system offers the remarkable fact of never rising to elevations much above 800 feet," the authors by personal inspection, where possible, and by the aid of ordnance levels failed to discover any point on the Trias in England reaching a greater height than 800 feet except at Bardon Hill. Here, 'skerry' bands in the Keuper

marl may be seen at a height of 810 feet, and the marl may be traced in the fissures of the Cambrian rocks to a height of 880 feet. Hence the conclusion that the Keuper marls at Bardon reach an elevation at least as high and possibly higher than at any other point in the same strata in England.

2. *Submergence.*—The probability of Bardon Hill (912 feet), and therefore the whole Charnwood area, being entirely submerged during Triassic times presents itself as a problem.

The authors find at 810 feet two distinct 'skerry' bands resting upon, and overlain by, Keuper marl. In the Siberia Quarry the marl is found filling in two joints which rise nearly vertically a height of 80 feet. This 'filling' may be traced in the joints to a level of 880 feet, or 32 feet below the summit of the hill. There is no evidence suggesting the sudden termination of the marl at this level, but further tracing was prevented by vegetation. It is obvious that the marl must have been deposited from an elevation higher than 880 feet.

Further evidence in support of submergence is offered as follows:—The general dip of the marls in this district is from 1° to 3° S.E. Allowing an inclination of 1° only, or 90 feet per mile from a point at the junction with the Rhætics near Leicester, this would give (on the assumption that this inclination originally extended to Bardon) a covering of over 200 feet of marl above the present hill.

V.—On a hitherto unnoticed Section of the *Amaltheus spinatus* Zone and the Transition Bed in the Middle Lias at Billesdon Coplow, Leicestershire. By A. R. Horwood.[1]

The author, after alluding to a section published by E. Wilson in the Geological Magazine, 1889, p. 296, of the Marlstone in the railway cutting at Tilton, Leicestershire, referred to a statement by that writer regarding it as the only exposure of the *Amaltheus spinatus* zone and Transition bed in the county.

Some recent researches, however, have resulted in the discovery of these beds in a little quarry on the road between Tilton village (some distance from the cutting quoted) and Billesdon Coplow, forming part of the escarpment called Life Hill, and about 700 feet O.D. There the very characteristic Gasteropod and Cephalopod zone of the Transition bed is well developed; and so uniform is this horizon in position and faunal contents that the author wished to see more stress laid on it than had previously been done, as indicating the uppermost beds of the Marlstone wherever found, being indeed a safe guide where other beds were wanting to denote this.

Another feature to be noted in the higher part of the Rock-bed, hitherto unnoticed or but little emphasised by previous writers on Liassic geology, was the occurrence of a very well-marked encrinital limestone band, varying from a foot to eighteen inches, though often less, of a very hard nature, less subject to the effects of weathering and decomposition than the Marlstone itself, which occurs some three or four feet lower in the section. This is to be found also on Tilton

[1] Read before Section C (Geology), British Association, Leicester, 1907.

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Hill, indicating there also the existence of higher beds than previously known. Its composition was much like some forest marbles, entirely differing from that of beds above or below, though traces of a similar structure occurred less regularly, but never as a definite layer or seam, in other parts of the section.

The horizon of Wilson's type-specimen of *Eodiadema granulata* had never been definitely ascertained, nor indeed that of the majority of the Gasteropods, etc., described by him as coming from Tilton, but found in the débris used in the construction of the East Norton embankment.

The Billesdon Coplow section solved this question, for there the same Echinoderm was found with a number of the same genera and species of Gasteropoda, Cephalopoda, etc. It had also been found by others, and there was an example from Desborough in the Invertebrate Department of the Leicester Museum under the writer's charge.

In conclusion the author wished to reiterate his remarks as to the importance for zonal purposes of this Gasteropod band of the Transition bed of the Middle Lias.

The character of the fauna stamped it decidedly as purely littoral or coastal, whilst that of the beds below, containing as they did chiefly Brachiopoda and deeper-water Lamellibranchs and Cephalopods, pointed to their being of a more pelagic nature.

It marked a change in the physical conditions which predominated at that period, and as such was rightly named a 'Transition bed,' for the Upper Lias fauna was itself only a modification of it, with some differences of lithological composition in the strata and of species in the fauna which characterised it.

Probably the inset of more littoral conditions took place between the formation of the thick encrinital seam mentioned above and that of the Transition bed. Certainly pelagic conditions, judging from the lithology and fauna of the beds below, seemed to come to a close about the time when this encrinital seam was deposited.

The thickness of the strata and the fauna of the two sections, the one at Tilton as described by Wilson and the other as discovered at Billesdon Coplow by the writer, were, with some slight differences, due to local causes, more or less identical.

VI.—Notes on the Ancient Volcanoes of Basutoland. By Rev. S. S. Dornan.

Basutoland is a high plateau between the Vaal and the Orange Rivers. It is the culminating point of the great plateau which fills the whole interior of the sub-continent. Upon this plateau, as a foundation, stand the great volcanic ranges, more than 11,000 feet high.

From the Caledon River to the edge of the great volcanic plateau is about fifteen miles. This plain is fairly level, and is interspersed with flat-topped mountains rising to 1,500 feet above the plain. These represent the original level of the country. The geology of the country is exceedingly simple. It is filled with the Stormberg series, lying nearly horizontal. The total thickness of these rocks

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amounts to 6,000 feet, of which the volcanic beds amount to 4,000 feet. The sandstones are loose and friable, and contain remains of plants, dinosaurs, and crocodiles.

The volcanic beds are the most striking rock features of the country, as they compose all the highest summits of the great ranges of mountains known as the Drakensberg and Malöte.

The vents from which the lavas and ash proceeded which have built up these great piles of rock can be roughly arranged in three or four parallel lines, corresponding to the present ranges of mountains. The first range consists of Machache, Thaba 'Telle, etc.; the second of Dikolobeng, Mokhele, etc.; the third of Mount Hamilton and Motai; and the last of the great summits of the Drakensberg, such as Mont aux Sources, Champagne Castle. Most of these mountains are 10,000 feet high and upwards. The rivers run in the synclines between these ranges of mountains, as a glance at the map shows.

The volcanic beds consist of lavas and ashes, with occasional silicious tuffs, intersected with intrusive sheets and dykes. Most of the lavas are amygdaloid; scoriaceous varieties also occur, but they are much less common. The beds are often full of pipe-like vesicles, filled with calcite, but often empty. These vesicles are inclined towards the vent. Basaltic lavas are common, and andesites also occur.

A short description of four of the most prominent peaks will serve as examples of the others.

(1) Thaba 'Telle. It is about 7,800 feet high, with steep—in some places precipitous—sides. It is composed of doleritic amygdaloid lavas, alternating with beds of ash. The plug is agglomerate, evidently the remains of the old throat. The lavas are full of steam holes. Thick deposits of purple ash also occur. Near the base of the mountain is a large intrusive sheet, surrounding what was formerly a subsidiary cone, but is now nothing more than a mere conical plug of agglomerate.

(2) Thaba Tsuen. This mountain is slightly lower than the preceding, but of beautiful conical shape. The height is 7,529 feet. It consists of two terraces and the agglomerate plug. The total thickness of lavas, ashes, and agglomerate is 1,600 feet. The plug proper rises from the second terrace, which slopes gently inwards, indicating the roots of the old cone. The plug is composed of coarse doleritic lava and agglomerate, and is about 500 feet high. It is a prominent landmark, and even more typically volcanic than many of the other peaks. The deposition of the lavas was not continuous, as there are thin intercalated beds of sandstone. The same feature occurs on all the other mountains examined.

(3) Thaba de Noha. This is a portion of the great Mokhele range. The plug and a portion of the old crater walls remain. The lavas at one point are glassy and steeply inclined, at another scoriaceous. There are also thick beds of ash. The characteristics of the lavas in this range are similar to the peaks previously mentioned.

(4) Thaba 'Ntso. This mountain is 7,560 feet high. It is part of a great range running perpendicular to the course of the Orange River. The composition of the lava beds is similar to Thaba de

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Noha, the principal difference being that the beds of ash are thicker and better consolidated, evidently pointing to deposition in deeper water.

Many of the very highest peaks, such as Mont aux Sources, Motai, Mount Hamilton, are not described here, as the writer has never been able to visit them.

A short notice of the intrusive sheets and dykes is a necessary complement to the description of the lavas. These dykes, etc., are posterior to the volcanic beds which they traverse. None, so far as the writer knows, have the characteristic of a lava-flow.

They vary much in size, from a few inches thick and a few yards long up to 20 feet or more in thickness and several miles in length. Two remarkable examples of the latter kind occur in South Basutoland, near Mohales' Hoek. The dolerite is columnar, and as straight as if laid out artificially. Small displacement of the neighbouring strata is a conspicuous feature of these dykes.

The country owes its present configuration to two series of earth movements — one from west to east and the other from south to north, long afterwards. There is no evidence of denudation before the deposition of the lavas, and the writer is of opinion that the lavas were not all subaqueous.

VII.—Life-Zones in the British Carboniferous Rocks.[1]

THE part of the Report for 1906 which deals with the Carboniferous zones in Flintshire was founded on work done by Dr. Hind and Mr. Stobbs. Their conclusions were presented in a paper read before the Geological Society of London on April 4th, 1906. The Committee are not unanimously in agreement with some of the conclusions. On reference to the Abstr. Proc. Geol. Soc., No. 827 (1906), pp. 88–92, it will be seen that differences of opinion exist both as to the sequence and classification of the Carboniferous rocks of Flintshire.

In 1895, at the meeting of the Association at Ipswich, a paper was read before Section C by Messrs. Garwood and Marr in which they suggested "that a Committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists to whom these fossils may be submitted."[2] As the result of that paper the present Committee was appointed at the same meeting.

Much has since been done, largely owing to the work of the Committee, and especially by the researches of Dr. A. Vaughan, whose well-known paper on the "Palæontological Sequence in the Carboniferous Limestone of the British Area" has in an eminently

[1] Report of the Committee, consisting of Mr. J. E. Marr (Chairman), Dr. Wheelton Hind (Secretary), Dr. F. A. Bather, Mr. G. C. Crick, Dr. A. H. Foord, Mr. H. Fox, Professor E. J. Garwood, Dr. G. J. Hinde, Professor P. F. Kendall, Mr. R. Kidston, Mr. G. W. Lamplugh, Professor G. A. Lebour, Mr. B. N. Peach, Mr. A. Strahan, Dr. A. Vaughan, and Dr. H. Woodward. Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report British Association, 1895 (Ipswich), p. 696.

successful manner shown the possibility of the task for the consideration of which the Committee was initially appointed.

The Committee in submitting this final report desire to place on record their appreciation of the energy and enthusiasm of their secretary, Dr. Wheelton Hind.

Report on the work done.—Mr. H. Bolton, in an admirable paper, brought before the Geological Society the work he had done on the fauna of a marine horizon at the base of the Bristol Coalfield, a work towards which a portion of the grant was applied some two years ago. His paper will doubtless appear in the Society's Quarterly Journal, and it is unnecessary to say more here.

Mr. Tait, collector of the Geological Survey of Scotland, has been examining the Millstone Grit succession east of Lancaster this Summer; and Mr. Watson, of Owens College, has been working in the upper part of the valley of the Nidd. It has not been possible to examine their collections in time for this report.

The Secretary was fortunate enough to secure a fine collection of plants obtained in an abortive attempt to find coal at Thirshfield, near Grassington, in the valley of the Wharf. The exact place of the sinking is lat. 54° 3′, long. 2° 2′, and the shales are stated to be those which occur below a bed of Millstone Grit.

Mr. Kidston has kindly examined the specimens for him, and the following list is the result:—

Sphenopteris elegans, Bgt.
Calymmatotheca Stangeri, Stur.
Rhodia Moravica, Ett., sp.
Sphenopteris sp.
Calamites Ostraviensis, Stur.
Calamites sp.
Sphenophyllum tenerrimum, Ett., sp.
Lepidodendron sp.
Lepidostrobus sp.
Small Lycopodiaceous bract.
Rhabdocarpus (?) sp.

Mr. Kidston states, with regard to the horizon: "I have not the slightest doubt that the bed these specimens come from is on the horizon of the Upper Limestone group of the Carboniferous Limestone Series of Scotland." At any rate, we know that the Lower Limestone group of Scotland has a fauna which indicates the Upper *Dibunophyllum* zone.

VIII.—The Faunal Succession in the Carboniferous Limestone of the South-West of England.[1]

THE work has progressed steadily, but less rapidly than was anticipated owing to the necessity which has arisen of investigating the validity of certain genera and the correct application of specific names.

1.—*The Avonian Sequence in Gower.*

The zoning of the Avonian sequence of the Gower Peninsula, undertaken in conjunction with Mr. E. E. L. Dixon in the Summer of 1905, is now completed, and the results will be presented to the Geological Society early next session.

[1] Report of the Committee, consisting of Professor J. W. Gregory (Chairman), Dr. A. Vaughan (Secretary), Dr. Wheelton Hind, and Professor W. W. Watts, appointed to enable Dr. A. Vaughan to continue his Researches thereon. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

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In this investigation the chief interest, from a zonal standpoint, centres in the occurrence of a higher faunal level than is known from any other point of the South-Western Province. The level here referred to is that of the Oystermouth Beds, of which the well-known Bishopston rotten-stones are the degraded representatives. The list of genera from these beds is practically identical with that from the Upper Tournaisian—a fact which may be taken to imply equivalence of environment. Important conclusions as to variation in time during the Viséan period have therefore been reached by comparing the several species of each genus at the Oystermouth level (uppermost Viséan) and those of the same genus in the Upper *Zaphrentis*-zone (Upper Tournaisian). The comparison of these two levels determines those characters of each genus which are indicative of old age; whereas the comparison of the Brachiopods (or of the Corals) at one and the same level determines those characters which are affected by convergence.

Mr. Dixon's careful study of the conditions of deposition which are implied by the several lithic types increases very greatly the value of the zonal investigation by preventing the error of mistaking a change of fauna with change of conditions for a true zonal sequence dependent upon evolution.

2.—*The Carboniferous Sequence from Rush to Skerries, Co. Dublin.* (*In conjunction with* Dr. C. A. Matley.)

The stratigraphical relations have been admirably worked out by Dr. Matley, in spite of a quite remarkable intricacy of tectonic detail.

From a zonal point of view the main subject of inquiry is the true relative position of four distinct series whose sequence with one another is broken either by faults or gaps. The problem has been solved by a broad comparison of the coral faunas and their sequence in the South-Western Province. The relative position of the several portions has thus been established, and it has consequently become possible to draw up a detailed faunal sequence for the whole section. This sequence starts in the Upper Tournaisian, and extends beyond uppermost Avonian, being, however, notably incomplete in its middle portion.

The highest beds, which still exhibit an abundant Avonian fauna (the Upper *Cyathaxonia* beds), include a maximum of *Posidonomya Becheri*, and at the same time contain several strikingly specialised forms of Corals and Brachiopods which also occur in the Lower Limestones of Scotland and in the uppermost Limestones of the western Midlands and Settle. Much light has thus been thrown upon the true correlation of the uppermost Avonian rocks in widely distant areas.

These results will be published at an early date.

3.—*Palæontological Work.*

The palæontological work arising out of these two papers has been very considerable, and is as yet incomplete.

Minute study of the material collected, and comparison with that already gathered from the South-Western Province and other British localities, has shown the necessity of a re-investigation of the value of the characters upon which certain genera have been founded—e.g., the presence of a septum in Orthotetids, the existence of original fringes in Athyrids, the septation of Zaphrentids, etc.

I am also engaged upon the study of the types of Carboniferous Brachiopods preserved in the British Museum, and in this task Mr. S. S. Buckman has very kindly placed his long experience at my service.

I have also to acknowledge the great help which I have received from Mr. R. G. Carruthers in studying the Zaphrentids, and from many fellow-geologists who have sent me material for examination, and thus allowed me to keep in touch with the progress of research outside the areas in which I have myself worked.

So much remains to be done that I feel justified in asking for the continuance of this Committee for yet another year.

IX.—Note on a New Section in the Glacial Gravels of Holderness. By T. Sheppard, F.G.S., and J. W. Stather, F.G.S.[1]

THE North-Eastern Railway Company has recently been making some extensive excavations in a hill situated between the well-known Kelsey Hill and Burstwich Gravel-pits in Central Holderness. At the present time the section exposed is probably the finest of its kind in the country. The cutting is made through the heart of the hill, and the exposed section is 1,300 feet long and 45 feet high in the centre, from which the section gradually slopes. The sides of the hill are flanked by Boulder-clay, and irregular masses also occur at intervals in the gravel. There are two types of Boulder-clay visible, the upper or Hessle Clay, containing a preponderance of Cheviot rocks, and the purple or middle Boulder-clay with its Carboniferous limestones and basalts. The gravels are somewhat similar to those described by Mr. Clement Reid at Kelsey Hill as Interglacial, but the present authors consider them to be merely part of the terminal moraine of the North Sea ice-sheet. In addition to the far-travelled boulders, a lengthy list of marine shells, mostly of an Arctic type, has been compiled, and the species *Cyrena* (*Corbicula*) *fluminalis*, a fresh-water form, also abounds. An interesting collection of mammalian remains has been secured, and includes bones of *Elephas primigenius*, Rhinoceros, Walrus, Red Deer, *Bison priscus*, Horse, and *Bos*. Some of these bear evidence of having been gnawed by the Hyæna. It is thought that the shells and mammalian remains have been caught up by the moving ice mass, and in this way incorporated in the moraine.

X.—On a Marine Peat from the Union Dock, Liverpool.[1] By J. Lomas, A.R.C.S., F.G.S.

DURING excavations in the Union Dock on the Mersey Docks and Harbour Board Estate in the South End of Liverpool a very remarkable peat band was discovered. Reckoning downwards from a datum-line 3 feet above Old Dock Sill a section showed:—

[1] Read before Section C (Geology), British Association, Leicester, 1907.

	ft.	ins.
Sand with black carbonaceous bands	4	0
Peat	0	6
Blue clay with rootlets	4	0
Sand with thin bands of peat	2	10
Boulder-clay	3	2
Bunter pebble beds	8	0+

The upper peat was entirely composed of marine plants, laminaria predominating. On the fronds were numerous encrusting organisms, such as polyzoa, hydrozoa, the fry of young molluscs, etc.

The lower peat, while consisting mainly of marine plants, contained a few drifted pieces of oak and other land plants.

The sands accompanying the peat resemble those of the Mersey Bar, and besides the quartz which makes up the bulk of the deposit, contain zircon, garnet, tourmaline, dolomite, kyanite, rutile, staurolite, orthoclase, felspar, biotite and muscovite, shell fragments, foraminifera, sponge spicules, and polyzoa.

The deposit was probably accumulated in a sheltered bay in the old estuary of the Mersey.

The chief interest lies in the fact that peat may be formed from marine as well as from land plants.

XI.—The Distribution of Radium in the Rocks of the Simplon Tunnel.[1] By Professor J. Joly, Sc.D., F.R.S.

THE principal classes of material which enter into the composition of the massif of the Simplon are: (*a*) The Jura-Trias sediments, lithologically often much alike and much interfolded; (*b*) the Palæozoic crystalline schists; and (*c*) the gneiss of Monte Leone and the Antigorio gneiss, both stated to be of Archæan age. These rocks throughout contain radium, and for the most part in quantities much above what hitherto has been ascribed to sedimentary or igneous rocks.

Some thirty-six typical samples, taken from various points in the tunnel, have been examined. The poorest in radium are certain anhydrite rocks. Certain amphibolite schists go very high. The Antigorio gneiss rises from $10{\cdot}5 \times 10^{-12}$ and $8{\cdot}0 \times 10^{-12}$ grams radium per gram of rock at the Italian entrance to $23{\cdot}7 \times 10^{-12}$ at 4,000 metres inwards. Some of the Archæan gneisses yielded very high results.

Such quantities of radium if generally distributed throughout the rocks of the massif would be sufficient to disturb any forecast of the temperature which under normal conditions would be encountered at the level of the tunnel. It is suggested that the radium was, in fact, the source of the discrepancy between the predicted and the observed rock temperatures.

As it is improbable that these results are unique and apply only to this particular sedimentary accumulation and locality, they appear to point to hitherto unsuspected quantities of radium (and its parent elements) in the immediate surface materials of the earth. It seems impossible to avoid the conclusion that these elements were precipitated

[1] Read before Section C (Geology), British Association, Leicester, 1907.

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along with the sediments entering into the composition of the massif. The question then arises whether the accumulation of such quantities of radio-active elements may not enter as a factor in the events attending mountain-building. It can be shown that an area of sedimentation whereon has been accumulated some 10,000 metres of sediments, having a richness in radium comparable with the Simplon rocks, must necessarily become an area of greatly lessened crust-rigidity, and would hence become the probable site of crust-flexure under tangential compressive stress.

Further investigation will be required before such views can be generalised and the importance of radium as a source of instability of the earth's crust be determined. Apart from any speculations as to the influence of radium as the cause of an energetic substratum, the shifting of radium and its parent elements by denudation must be regarded as a convection of thermal energy, and this convection, if the quantities involved are sufficient, must, under the conditions referred to above and the unceasing action of denudation, become rhythmic in operation, and at the same time must result in shifting the areas of high temperature and crust-weakness from age to age as the site of sedimentary accumulation changes.

XII.—The Felsitic Agglomerate of the Charnwood Forest.[1] By F. W. Bennett, M.D., B.Sc.

The rocks lying between the Beacon Series and the Blackbrook formation comprise a greater variety than has been hitherto recognised. Three main beds can be distinguished, which may be called the coarse, white, and pink grits. The pink grit, which is the uppermost bed, is the one to which almost exclusively the name of 'Felsitic Agglomerate' has been hitherto given.

Careful examination of the rocks in the Buck Hills has now conclusively proved that they belong to the Felsitic Series.

The rocks in the north-west of the Forest have always given rise to much difficulty. It is possible to trace the Felsitic Agglomerate as a distinct series of rocks in Timberwood Hill. The ground in this part of the Forest has been extremely faulted, and a good example of this occurs in Collier Hill.

To the north of the monastery, rocks have now been traced which evidently lie on the horizon of the Felsitic Series. They differ in some ways from the ordinary agglomerate type, especially as regards their texture, which becomes highly crystalline. It is found that these Felsitic rocks have been intruded into by igneous flows, both near the Cademan area and also in Bardon Hill; and it is probably due to this cause that the texture of the rock has been so much altered.

The position of these beds in relation to the Bomb rocks makes it probable that they correspond to the Felsitic Series, and this correlation is confirmed by comparison of some of the more recently discovered types with those of the ordinary Felsitic Agglomerate rocks.

[1] Read before Section C (Geology), British Association, Leicester, 1907.

XIII.—On the Occurrence of Boulders of Strontia in the Upper Triassic Marls of Abbots Leigh, near Bristol.[1] By Herbert Bolton, F.R.S.E., F.G.S.

A CONSIDERABLE area of the park attached to Leigh Court, near Bristol, has been found to be underlaid by a remarkable deposit of huge boulders of strontia embedded in Triassic marls. The boulders in various places appear above the surface. The soil varies in depth from a few inches to 4 feet, and rests upon the irregular surface of the marl-beds containing strontia. The boulders of strontia are found of all sizes, from a pea up to masses estimated at 100 tons in weight. In one instance the breaking-up of a single boulder of strontia occupied six men for five weeks. Six hundred tons of the mineral were found in one pit, 15 yards long by 21 yards wide.

The upper surface of the boulders is usually deeply grooved, the grooves running approximately north and south. The boulders readily split into slabs along lines coinciding with the grooves. The deposit up to the present has not exceeded a greater depth than 11 feet. The yield of strontia is about 2,000 tons per acre.

XIV.—Investigation of the Fossiliferous Drift Deposits at Kirmington, Lincolnshire, and at various localities in the East Riding of Yorkshire.[2] By J. W. Stather, F.G.S.

AS was intimated in our report for 1905, the work during the past year has been directed to the investigation of the deposit at Bielsbeck, or Bealsbeck, in the Vale of York, which was examined between seventy and eighty years ago by the Rev. W. V. Harcourt, and yielded the remains of numerous extinct mammals. The object of our investigation was mainly to ascertain if any further evidence could be obtained to show the relation of this fossiliferous deposit to the glacial drifts.

The work, which was carried out under the superintendence of Professor P. F. Kendall, Messrs. G. W. B. Macturk, Thomas Sheppard, and the Secretary, confirmed the statements of the previous observers: (1) that the deposits yielding the bones rested immediately on the Keuper Marl; (2) that they have been accumulated in a boggy hollow on an old land surface; and (3) that at this particular locality there is no material that can be assigned to the direct agency of ice. It therefore still remains a debatable question whether the bone-bearing material was accumulated before, during, or since the Glacial period; and it would appear that the elucidation of this matter will depend upon the investigation of a wide area to determine what was the condition of the Vale of York during that period.

[1] Read before Section C (Geology), British Association, Leicester, 1907.

[2] Report of the Committee, consisting of Mr. G. W. Lamplugh (Chairman), Mr. J. W. Stather (Secretary), Dr. Tempest Anderson, Professor J. W. Carr, Rev. W. Lower Carter, Dr. A. R. Dwerryhouse, Mr. F. W. Harmer, Mr. J. H. Howarth, Rev. W. Johnson, Professor P. F. Kendall, and Messrs. G. W. B. Macturk, E. T. Newton, H. M. Platnauer, Clement Reid, and Thomas Sheppard. (Drawn up by the Secretary.) Read before Section C (Geology), British Association, Leicester, 1907.

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The absence of glacial deposits in this part of the country may, on the one hand, imply that the area was never glaciated; or, on the other hand, it may mean that glacial deposits once existing have been entirely removed. If the former be the case, the bone-bearing deposits might belong to the pre-Glacial or to any younger stage; while if the latter supposition should find confirmation the deposit must be later than the glaciation.

The site of the original excavation is still visible, the hollow from which the 'marl' was dug being now a reedy pond. The new sections consisted of four pits sunk in the vicinity of the pond.

These pits were roughly from two to four yards square, and were carried down until the Keuper Marl was reached or the work was stopped by the influx of water. They were supplemented by several boreholes put down to determine the extent of the deposit.

The sections revealed in the pits were as follows:—

Section 1.

	ft.	ins.
Surface soil	0	9
Sand, with small pieces of angular chalk and flint	2	0
Gravel of rounded chalk and subangular flint	1	6
Silty blue-black marl or loam, the upper surface very irregular and penetrated by 'pipes' and pockets of gravel from the bed above	3	9
Marl as above, with specks of vivianite	1	0
Black marl	6	0
Lighter-coloured marl, passing downwards into gravel (chiefly flints)	7	6
Total depth reached ...	22	6

Section 2.

Surface soil	0	9
Sand	1	9
Gravel	2	0
Dark silty marl, with gravel	2	6
Dark marl	4	0
Lighter marl	4	0
	15	0

Section 3.

Soil	1	0
Sand	2	0
Gravel	3	0
Grey marl, passing downwards into black	7	6
Coarse gravel	0	6
Solid Keuper Marl, blue	3	0
Solid Keuper Marl, red	1	0
	18	0

Section 4.

Soil	0	9
Sand	3	6
Gravel	1	6
Keuper Marl, its surface dipping at 1 in 3 towards the old marl-pit	1	3
	7	0

From the black muds or marls which occurred below the superficial gravels in these pits the following fossils were obtained :—

Bones.—For the following determination we are indebted to Dr. C. W. Andrews, F.R.S., of the British Museum (Natural History), South Kensington.

MAMMALIAN REMAINS.

Cervus sp.
Bos sp. (two vertebræ).
Bos sp. (smaller than *longifrons* or *primigenius*).
Bos primigenius.
Elephas (rib and left scapula).

The bones were not confined to any particular layer, but were distributed sporadically throughout the mass of the marl. The overlying gravels, however, contained neither bones nor other vestige of contemporaneous life, possibly because of their removal by percolating water.

Shells.—The molluscan remains distributed through the marl belong to existing land and fresh-water species, many of which are still living in the neighbourhood. They are all species of wide range, and afford no definite indications as to climate. These species, kindly determined for the Committee by Mr. J. W. Taylor, of Leeds, are as follows :—

MOLLUSCA.

Limnæa peregra.
,, *palustris.*
,, *truncatula.*
Succinea putris.
,, *elegans.*
Hyalinia nitidula.
Zonites fulvus.
Helix nemoralis.
,, *hispida*, var. *concinna.*
,, *pygmæa.*
,, *pulchella.*
Vertigo antivertigo.
,, *pygmæa.*
Cochlicopa lubrica.
Carychium minimum.
Pisidium amnicum.
,, *pusillum.*
,, *nitidum.*
,, *milium.*
,, *obtusale.*
Bythinia tentaculata.
Valvata cristata.
Planorbis spirorbis.
,, *contortus.*
,, *glaber.*
,, *marginatus.*

Plants.—The material also contained plant remains, but was difficult to wash and sift. Some small seeds were, however, picked out by Mr. Stainforth, and were submitted to Mr. Clement Reid, F.R.S., for determination, who recognised the following :—

SEEDS OF PLANTS.

Ranunculus scleratus.
,, *repens.*
Viola sp.
Œnanthe aquatica, Poir.
Rumex.
Sparganium erectum?
Carex.
Alisma plantago.

With regard to the above list Mr. Reid remarks: "If these were all that were found at Bielsbeck, they are an exceptionally poor set, which shows nothing as to climatic conditions." "There are only one or two seeds of meadow plants among them, and no dry-soil plants."

Insects.—Besides the above the deposit contains the remains of beetles, but much of the material has not yet been specifically determined. The following may be mentioned :—

COLEOPTERA.

Donacia (sp.?) (an almost complete specimen).
Hister (sp.?) (elytron).

Further Notes on the Deposits.—The Bielsbeck bone-bearing deposits apparently occupy a depression or hollow in the Keuper Marl of undetermined width, and it appears as though this hollow is isolated and inclosed by the marl, though it is just possible that it may represent a portion of a filled-in valley or trench, the direction of which has not been traced.

Scattered through the marl at various depths were angular or slightly rounded black flints in large numbers, and these in some cases formed a definite layer. Along with the flints were occasional pebbles of quartz and of sandstone (probably Carboniferous). None of these pebbles showed striæ or other indication of glacial action.

The overlying gravel was mainly composed of flint and chalk from the neighbouring Wolds, along with scattered fragments of quartz, sandstone, etc. (like those found in the underlying marl), and *Gryphæa* and other fossils from the Lias. This gravel is the feather-edge of a wide fan which can be traced up to the mouth of a valley that drains from the Wolds at Market Weighton. In the thicker parts of this gravel, towards the mouth of the valley, other pebbles besides the above have been detected, including the well-known porphyrite which is characteristic of the upper part of the East Yorkshire drifts. The wide extent and depth of this gravel suggests that it has been spread out by floods from the melting ice, when the ice-margin abutted upon the eastern slopes of the Wolds. The present valley appears to be too short to supply a stream powerful enough to spread a sheet of gravel of these dimensions.

The thanks of the Committee are due to W. H. Fox, Esq., for permission to excavate; to the tenant, Mr. Howes; to Mr. W. H. Crofts; and to the contractor, Mr. Thomas Moate.

The Committee had contemplated work on another site in East Yorkshire, but have found difficulty in obtaining the requisite permission. Pending a final settlement of this matter, they ask for reappointment, with power to use the unexpended balance of their grant.

REVIEWS.

I.—Official Contributions to the Palæontology of South Australia. By R. Etheridge (Jun.[1]). Records of Northern Territory Boring Operations. By H. Y. L. Brown, Government Geologist. Folio; pp. 22, with 12 plates. (Adelaide, 1907.)

In continuation of the Northern Territory Report, No. 17 deals with Permo-Carboniferous fossils of Cape Dombey, etc. The only specimens capable of specific determination belong to *Aulosteges*, viz. *A. Baracoodensis* (pl. i, figs. 1–5). This shows internal structure.

No. 18. Carboniferous fossils from Fossil Head, etc. A considerable series, including Brachiopoda, Pelecypoda, Gasteropoda, and Cephalopoda, are described and figured, namely:—

[1] [Mr. Etheridge being deceased, Mr. Robert Etheridge ceases to be 'Junior.'—Edit. G.M.]