NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE THE BRITISH ASSOCIATION, NOTTINGHAM, SEPTEMBER, 1893.

I.—ON THE BASE OF THE CAMBRIAN IN WALES. By H. HICKS, M.D., F.R.S., F.G.S.

IF there be, as has been maintained by the author and others, a very marked unconformity at the base of the rocks usually classed as Cambrian in Wales, the evidence furnished by an examination of those basal beds which indicate shore conditions is of the utmost importance. The author, therefore, in this paper gives a summary of the results bearing on this question which he has obtained in his examinations of these rocks in Wales.

PEMBROKESHIRE.

St. Davids.—The basal beds are exposed on the north and south sides of the pre-Cambrian Axis. Where faults do not intervene the lowest beds are rough conglomerates from 60 to 150 feet in thickness, in which pebbles over a foot in diameter are very frequently met with. The matrix and pebbles vary constantly, as they rest on different parts of the pre-Cambrian Axis, and there is the clearest evidence of an unconformity between the conglomerates and the highest beds of the Pebidian in this area. The overlying beds, which are grits and sandstones, are ripple-marked and show other proofs of having been deposited in shallow shore-water. The author has recently re-examined the basal beds in this area, and has accumulated additional evidence in support of the above view.

Ramsey Island.—The Cambrian conglomerates here rest on pre-Cambrian felstones and breccias. The pebbles are mainly well-rolled fragments of felstones cemented together by a felsitic matrix. Pebbles of quartzite and other materials are occasionally found, but the main amount of the material was undoubtedly derived from the rocks immediately underlying the conglomerates. The underlying rocks had undergone the marked changes now visible in them before the fragments in the conglomerates had been broken off.

Trefgarn.—The pre-Cambrian rocks in this area are mainly felstones of a peculiar type and volcanic ash. The conglomerates which repose on these rocks contain pebbles of large size, which have been proved by microscopical examination to be identical in character with the rocks on whose eroded surface they repose. Here again the marked similarity in the minutest particulars between the rolled fragments and the underlying rocks proves indisputably that the peculiar changes which these rocks have undergone must have taken place before the fragments were broken off, therefore in pre-Cambrian times.

MERIONETHSHIRE.

Harlech Mountain.—Near the centre of the well-known anticlinal of Cambrian rocks in the Harlech Mountain conglomerates are exposed which contain fragments of granitoid rocks, felstones, etc., in addition to pebbles of quartzites and quartz, and it is clear that

they are, though not actually at the base, yet very near the base of the Cambrian rocks of that area. The most important conglomerates, however, in this district are those which were discovered by Professor Hughes and the author on the east side of the Trawsfynydd Road, between Cae Cochion and Penmaen. Here the conglomerates rest unconformably upon an older series of rocks, and large fragments of the latter occur plentifully in the conglomerates.

Anglesey.

As Sir A. Geikie has recently admitted that many of the rocks in Anglesey, coloured on the Geological Survey Map of that island as "altered Cambrian (and partly Silurian)," are "undoubtedly far older than at least any of the Cambrian rocks of Anglesey or Caernarvonshire," the evidence furnished by the basal beds where they rest on these rocks is highly important. The author was the first to point out, in a paper read before the British Association in 1879, that the patch near the centre of Anglesey coloured as "intrusive granite chiefly of Lower Silurian age" contained within its boundary rocks of pre-Cambrian age, evidently the oldest rocks in the island. (The rocks in this patch Sir A. Geikie now says appear to him to be "unquestionably Archæan.") In the year 1884 the author further showed that the Cambrian conglomerates near Llanfaelog contained large pebbles of granitoid and other rocks, which, on microscopical examination, proved to be identical with rocks *in situ* in their immediate neighbourhood.

Professor Hughes has shown by fossil evidence that the beds which overlie the conglomerates near Llanerchymedd are of Upper Cambrian age, and, as these are separated by faults from the conglomerates and grits, it is clearly justifiable to classify these beds as the basal beds of the Cambrian in that area. The basal Cambrian beds near Beaumaris furnish equally convincing proofs of proximity to a shore-line composed of pre-Cambrian schists and felsitic rocks.

Caernarvonshire.

Bangor and Caernarvon.—The basal beds at and near Caernarvon described by Professor Hughes show clearly that they must have been deposited along a shore-line where granitoid and felsitic rocks were undergoing denudation, and the absence there of the usual thickness of overlying Cambrian rocks is due, the author believes, mainly to faults, but in part also to the unevenness of the pre-Cambrian land-surface. There is much evidence in the various areas to show that the pre-Cambrian land-surface was very uneven in character, and that the Cambrian sediments were accumulated along fairly well-defined lines of depression.

Bethesda, Llyn Padarn, and Moel Tryfaen.—The basal beds of the Cambrian in these areas, where not removed by faults, are also conglomerates, and the fragments in the conglomerates are mainly such as would be derived by denudation from the ridge of rocks in the neighbourhood which had been claimed by the author and Professor Hughes as of pre-Cambrian age. These views, put forward

by them in the year 1877, were not accepted by the chiefs of the Geological Survey; but in the year 1891, in his anniversary address to the Geological Society, Sir A. Geikie admitted that the rocks in this ridge, "variously termed quartz porphyries, felsites, and rhyolites," were not intrusive in the Cambrian rocks, as marked on the Survey Maps, but "the oldest members of the volcanic series," and that "there is no true passage of the sedimentary rocks into it; on the contrary, the conglomerates which abut against it are in great part made out of its fragments, so that it must have been already in existence before these Cambrian strata were deposited."

The grits and slates which overlie the conglomerates in these areas have always been classed by the Geological Survey as Lowest Cambrian; therefore any attempt on the part of the Geological Survey to extend the term Cambrian so that it might include the much older rocks which the surveyors had incorrectly marked as intrusive, and "chiefly of Lower Silurian age," the author thinks is unwarrantable. The error which caused the surveyors to class other pre-Cambrian rocks as "altered Cambrian" equally renders it impossible to group those with the Cambrian, especially as in no instance has it been shown that the so-called "altered Cambrian rocks" have their equivalents amongst the unaltered Cambrian rocks of the Survey. Moreover, it is certain that there is a marked unconformity at the base of the Cambrian (unaltered Cambrian of the Survey) in all the areas in Wales where the beds are seen to rest on the rocks classed by the author and others as of pre-Cambrian age.

II.—Notes on a Hornblende-Pikrite from Greystones, Co. Wicklow. By W. W. Watts, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

IN this paper the author gave a description of a rock which forms a dyke in the Cambrian slates and grits of Greystones, in Co. Wicklow. It is a dark, dense, coarsely-crystalline rock, showing large crystals of hornblende with lustre-mottling, owing to the weathering-out of olivine crystals. It becomes finer-grained at the margins. An analysis by Dr. Sullivan was added.

The hornblende is of the usual green type, and occurs in large crystals enclosing pseudomorphs of olivine, now made up of magnetite and probably a colourless amphibole. A colourless hornblende also occurs either as cores or borders to the green crystals. A third type of hornblende present shows few cleavage cracks and much magnetite dust. Apatite is a constituent, but there is no felspar in the rock. The margin of the dyke is much sheared and phacoidal in structure.

III.—Notes on the Perlitic Quartz Grains in Rhyolite. By W. W. Watts, M.A., F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

THE author exhibited specimens of that variety of the Sandy Braes Rhyolite from County Antrim which was formerly called Perlite. A microscopical examination of the rock shows crystals

of sanidine and grains of quartz embedded in a brown glass. The latter shows perlitic structure in great perfection. In addition, however, the grains of quartz exhibit a series of cracks, which are distinctly perlitic in character. Thus a structure which was supposed to be confined to glasses that have cooled rather rapidly is shown to occur rarely, but occasionally, in crystals. Hitherto only one case has been observed in which the cracks entered from the crystals to the matrix; the perlitic cracks in the two constituents are for the most part independent.

IV.—On the Minute Structure of the Skeleton of "Monograptus Priodon." By Professor W. J. Sollas, D.Sc., F.R.S. [Communicated by permission of the Director-General of the Geological Survey.]

REMAINS of *Monograptus priodon* in an exceptionally perfect state of preservation occur in the Silurian limestone of Barnham Hill, Co. Tipperary, and are exhibited in the official collection of the Geological Survey in Dublin. These have been examined in thin slices under the microscope, and as a preliminary result the author describes the structure of the wall.

Most of the sections are transverse and display the cœnosarcal canal and one hydrotheca; they measure a little over 1·5 mm. along the greater, and about 1 mm. along the shorter axis. The wall, 0·025 mm. in thickness, consists of black carbonaceous material in a more or less fragmentary condition, but sufficiently continuous to enable the existence of three layers to be determined: an outer and inner, which are very thin, separated by a space, now filled with calcite, from a thicker middle layer, which measures from 0·005 to 0·001 mm. across. The middle layer sometimes breaks up into threads, and the superficial films have a reticular appearance, which may, however, be due to *post-mortem* changes. In the region of the virgula and also along the free edges of the thecæ the wall thickens, partly by an enlargement of the space between the layers, and partly by a thickening of the middle layer. Thus, in one example the total thickness of the wall in the virgular region is 0·075 mm., and of the virgula itself, which represents the middle layer, 0·037 mm.; similarly at the margin of the theca the total thickness was found to be 0·085 mm., the included middle layer measuring 0·045 mm. Thin threads of carbonaceous material extend from the middle to the superficial layers, and are particularly obvious in the thickened regions. The virgula would appear to possess no independent existence; it seems to be merely a thickening of the middle layer.

V.—On the Origin of Intermediate Varieties of Igneous Rocks by Intrusion and Admixture, as observed at Barnavave, Carlingford. By Professor W. J. Sollas, D.Sc., F.R.S.

THE two principal kinds of Rocks composing the mountain of Barnavave are a dark-coloured, almost black, gabbro and a light-coloured, almost white, granophyre. This extreme contrast in

colour renders the study of their relations to each other in the field a comparatively easy task. The gabbro, which overlies the granophyre, was the first-formed rock, and had already cooled and solidified before the granophyre was injected into it. The injection of granophyre has been of the most searching character, and the rock can be traced from the parent mass through dykes of all gradations in size down to the minutest films and specks which fill cracks and cavities in and amongst the constituent minerals of the gabbro. The gabbro has thus become converted locally into the quartz gabbro of authors, and it is suggested that in other cases, as that of Carrock Fell, this rock has had a similar origin. The granophyre, on the other hand, contains fragments of the gabbro, ranging from great blocks down to mere crystal dust of its constituent minerals, labradorite and augite. It thus passes into hornblendic granophyre, the "syenite" of the Survey. There is no evidence here, as has been erroneously supposed, of the differentiation of an originally homogeneous magma, and the minute granophyric dykes are neither contemporaneous nor segregation products. On the contrary, rocks of intermediate character have been produced from already differentiated and opposed types solely by admixture.

VI.—On the Discovery of a Concealed Ridge of pre-Carboniferous Rocks under the Trias of Netherseal, Leicestershire. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

IT is now generally recognised that the Leicestershire and Warwickshire Coal-measures were deposited along the borders of a land surface of older Palæozoic rocks, of which the visible representatives occur at Charnwood Forest and Atherstone. The attenuated condition of the Lower Carboniferous beds at Calke Abbey on the north of the Leicestershire Coalfield, and their entire absence below the Coal-measures of Warwickshire, show that these older rocks remained unsubmerged till the commencement of the Upper Carboniferous period, when they were gradually overspread, as the land became depressed, by successive deposits of the Coal period. The general north-westerly trend of these old foundation rocks, both at Charnwood Forest and Atherstone, appears to indicate that this old land was composed of a succession of ridges and furrows running in N.W. and S.E. directions; but as the country is for the most part covered by Triassic strata the position of such ridges and hollows can only be determined by experiment. One of these ridges appears to have been in this manner determined at Netherseal Colliery in a boring put down for the purpose of determining the extension of "the main coal." Having been invited by Mr. G. J. Binns, F.G.S., the manager of the colliery, to give my opinion regarding the age of the beds passed through in the lower part of the boring, I visited the colliery and inspected the cores which were brought up and were arranged in their order of relative depth at the works. The following is an abstract of the strata passed through:—

Trias . .	{ *Bunter Sandstone*; light reddish-brown, pebbly sandstone; 262 feet.
Coal-measures	{ Grey and black shales and sandstones, with coal and ironstone; plants abundant; 514 feet.
Pre-Carboniferous	{ Reddish, purple and grey grit, sandstone and micaceous quartzite; 19 feet.

The interest attaches to the beds called "pre-Carboniferous." They consist of sandstones, grits, and quartzites, of purple and yellowish tints, occasionally shaly. They contrast strongly with the Coal-measures, not only in the absence of beds of coal, grey and black shale, and ironstone, but also in the complete absence of plant remains with which the overlying Coal-measures are crowded; not one solitary instance of any plant-form having been found amongst all the cores after careful examination. It became clear that the beds were not of Carboniferous age, yet it was very difficult to determine with certainty to what period they were to be referred. Such sandstones, grits, and quartzites might be found in several pre-Carboniferous formations, either the Old Red Sandstone, the Upper Silurian, Lower Silurian (Ordovician), or Cambrian. A reference to the Old Red Sandstone was considered out of the question, as this formation is not found anywhere in this part of England; nor did it seem probable that they were referable to the Upper or Lower Silurian period, though this is possible. On the other hand, we could not forget that at no great distance to the south of the boring Lower Cambrian beds form the floor of the Coal-measures, and, although the cores at Netherseal boring did not show a very strong resemblance to those of the Hartshill ridge, there was no good reason why they might not be referable to the same general period, and consist of beds not visible in that locality. For these reasons I am disposed with some hesitation to regard the cores as of Lower Cambrian age, a view in which I am supported by Professor Lapworth, who was kind enough to examine the specimens of the cores which I brought away with me from Netherseal Colliery. I will only add that no conclusion could be gathered regarding the question of unconformity of these beds with the overlying Coal-measures, as the dip of both series appeared to be very slight. A strong discordance could have been immediately detected.

Since the above was written No. 2 boring has entered these old rocks, and the specimens brought up confirm the conclusion arrived at from the results of boring No. 1. The rock entered at a depth of about 760 feet consists of reddish vitreous quartzite, slightly micaceous, and very similar to the Hartshill stone of Warwickshire.

VII.—Notes on the Water-bearing Capacity of the New Red Sandstone of Nottingham. By Professor Edward Hull, LL.D., F.R.S., F.G.S.

About half a century ago, before the problems of sanitation were generally understood, the town of Nottingham was placed in a most unfavourable position as regards drainage and water-supply. As regards the former the drainage of the houses

for the most part was run off into cesspools sunk in the sandstone rock on which the town is built; and as regards the latter the water-supply was drawn from wells sunk through the same formation down to the water-level, so that often the cesspools and wells were in proximity to each other. The result of such a state of affairs may easily be surmised. However excellent as a filter may be the sandstone rock, it must assuredly become clogged with fæcal matter when filtration of water is carried on for an indefinite period, subject to such contamination as is here referred to, and in course of time the water from the wells becomes unfit for drinking and household purposes.

Now all this is changed: the cesspools have been closed or filled up, and the water-supply is drawn from large and deep wells far removed from possibility of contamination.

Few towns in central England are more favourably situated for purposes of water-supply than Nottingham. Built on a foundation of New Red Sandstone and conglomerate, which rises at the Castle in a precipitous cliff above the valley of the Trent, the formation on which the city stands in its prolongation northwards is a source of water-supply of the highest excellence, and yields several millions of gallons per day of pure water from three or four wells situated within a few miles of the city.

The conditions which render this formation so well adapted for water-supply may be briefly explained. The succession and character of the strata all combine towards this end.

In descending order the succession is as follows:—

Trias	*Keuper Marls* . . .	Red and variegated marl, shaly and gypseous (slightly permeable).
	Waterstones and Lower Keuper Sandstone	Laminated micaceous sandstones alternating with marls and shales.
	Bunter Sandstone . .	Soft yellow and reddish sandstone and conglomerate (permeable).
Permian	*Red Calcareous Marls* .	These are the strata separating the Upper and Lower limestones of the Worksop district to the north (impervious).
	Lower Magnesian Limestone	Sandy magnesian limestones.

From the above succession it will be seen that the permeable beds of the Bunter Sandstone, about 300 feet in thickness, are underlain by impervious marls of the Permian series, which thus form a water-tight floor, effectually preventing the water which percolates downwards from the surface to escape into the magnesian limestone; and, as the beds dip eastwards at a small angle from the western margin of the formation, an underground reservoir is thus formed with a naturally permanent level corresponding to that of the springs which break out at the junction of the sandstone with the marl along the western outcrop.

The proportion of the rainfall, taken at an average of 30 inches, which sinks down into the Bunter Sandstone north of Nottingham must be very large, owing to the absence of drift deposits and the sandy character of the ground. As there is no surface drainage

the percolation cannot be less than about 20 inches per annum, giving a supply of about 1,000,000 gallons to every 3 square miles. Taking the area of the formation between Nottingham and Worksop at 120 square miles, the amount of water which annually percolates into the rock and becomes a reservoir of supply may be estimated at about 40,000,000 gallons per day.

This large quantity of water tends to flow eastwards, following the dip of the beds; and that it has permanently saturated the Bunter Sandstone under an extensive area occupied by the overlying formations is proved by the result of the boring at Scarle, near Lincoln, which, commencing in the Lower Lias, passed down through the Keuper marls into the Bunter, when the water came up with force and flowed over the surface.[1] This boring is at a minimum distance of 20 miles from the margin of the Bunter Sandstone. From these considerations it may be inferred that Nottingham is most favourably situated as regards its water-supply for a long period to come—a circumstance of great importance at a time when so many large manufacturing towns are looking forward with anxiety to the future as regards this prime necessary of progress and prosperity.

Since the above was written I have been favoured by Mr. L. T. Godfrey Evans, the Borough Engineer, with information, of which the following is a summary:—

There are four pumping stations, of which one, the Park, Zion Hill, is not now in use. The others are:—

1. Basford or Bagthorpe, yielding 12,800,000 gallons per week.
2. Bestwood, yielding 11,800,000 ,, ,,
3. Papplewick, yielding 12,190,000 ,, ,,

In all 36,790,000 gallons per week, or *5,257,143* gallons per day.

The supply at Bestwood is decreasing, owing probably to mining operations in the neighbourhood. The yield at the Park Station is about 5½ millions of gallons per week. The water is excellent.

VIII.—On the Reptilia of the British Trias. By E. T. Newton, F.R.S., F.G.S.

THIS communication is a review of our knowledge of the reptiles which have been recorded from the Triassic strata of Britain. In the first place attention is called to the teeth from Durdham Down, Bristol, described by Riley and Stutchbury, in 1836, under the generic name of *Palæosaurus* and *Thecodontosaurus*, which, with additional specimens, were further described by Professor Huxley in 1869, he regarding them both as dinosaurian. The two genera are distinguished by the form of their teeth. Closely allied to *Palæosaurus* is the tooth described by Murchison and Strickland in 1837 as *Megalosaurus*, but subsequently named *Cladyodon* by Owen. Another and still larger tooth, from the same neighbourhood, has been referred by Professor Huxley to *Teratosaurus* (=*Zanclodon*): it is very

[1] Two feeders of water were struck—one at a depth of 917 feet in the Lower Keuper Sandstone, and the other at 1,250 feet in the Bunter Sandstone.

similar to that of *Cladyodon*, but is more compressed and has both anterior and posterior edges serrated to the base.

Rhynchosaurus articeps, from the Keuper of Grinshill, Shropshire, was described by Owen in 1841 from a skull, but was further illustrated by additional specimens, including other parts of the skeleton, by Professor Huxley in 1887. This form, which is allied to the recent *Sphenodon*, is also near to the *Hyperodapedon*, remains of which have been found in the Elgin Sandstone and also in the Trias of Warwick and Devon. *Hyperodapedon* was first made known by Professor Huxley in 1858, who described it in 1869, but more fully in 1887, from a fine example preserved in the British Museum.

Telerpeton Elginense, the celebrated lizard of the Elgin Sandstone, was found in 1850 by Mr. Patrick Duff, and described by Dr. Mantell in 1851 as having amphibian affinities. Additional examples were, however, described by Professor Huxley in 1867, who showed that its affinities were with the lacertilia, and not with the amphibia. *Telerpeton* is probably closely related to the living *Sphenodon*. *Stagonolepis Robertsoni* was really the first reptile found in the Elgin Sandstone; a series of scutes from Lossiemouth being thus named by Agassiz just fifty years ago (1843), but were thought by him to be the scales of a fish. The reptilian nature of this fossil was shown by Professor Huxley in 1858, and more abundant material has been described by the same writer in 1875 and 1877, which has established the crocodilian affinities of this Triassic reptile.

Dasygnathus longidens is the name suggested by Professor Huxley for a jaw with long teeth from the Elgin Sandstone, which had at first been referred to *Stagonolepis*. This form Professor Huxley thought might be dinosaurian, but additional information is much wanted to establish its true affinities.

The dicynodont remains noticed by the present writer at the meeting of this Association last year at Edinburgh have now been worked out, and the results, fully illustrated, will shortly appear in the Phil. Trans. of the Royal Society. Four forms nearly allied to *Dicynodon* have been named *Gordonia Traquairi*, *G. Huxleyi*, *G. Duffiana*, and *G. Juddiana*. Another dicynodont more nearly related to the *Ptychognathus* of Owen, but with a short muzzle and no teeth, has been named *Geikia Elginensis*.

The peculiar horned reptile, resembling the Moloch lizard, but apparently most nearly related to the South African *Pareiasaurus*, has been named *Elginia mirabilis*.

Work among the Elgin reptiles is still going on, and two entirely new forms are now made known for the first time. One of these was found by Mr. James Grant, of Lossiemouth; and, although the exact locality is uncertain, there is no doubt as to its being from the sandstone of the Elgin area. This specimen, which includes the skull (about three inches long) and the fore part of the trunk, is evidently related to *Stagonolepis*.

The second new form was obtained by the Rev. Dr. Gordon from the Elgin Sandstone of Spynie Quarry, and will eventually be

preserved in the British Museum. With the exception of the fore limbs and neck, nearly the whole of the skeleton has been preserved. Much of the skull has been very successfully cleared from the matrix by Mr. Richard Hall, of the British Museum, and was exhibited at a soirée of the Royal Society, when its resemblance to *Aëtosaurus* was pointed out by Mr. Arthur Smith Woodward. This reptile is of much interest, as it seems to be an intermediate form between crocodiles and dinosaurs, being, apparently, related on the one hand to the *Parasuchia* and on the other to the theropodous dinosaurs. The skull is, in fact, that of a miniature megalosaur.

IX.—Note on some Molluscan Remains lately discovered in the English Keuper. By R. Bullen Newton, F.G.S. British Museum (Natural History).

THIS communication directs attention to the discovery, by the Rev. P. B. Brodie and Mr. E. P. Richards, of some obscure impressions of lamellibranch shells in the green gritty marls of the Upper Keuper Sandstone of Shrewley, Warwickshire, which form the first evidence of a molluscan fauna from these beds as developed in this county. The matrix appears to be so peculiarly unfavourable for the retention of shell structure that it is doubtful whether any better material than the present will ever be forthcoming. The specimens indicate truly marine types, though on account of bad preservation only three of them could be selected for description as exhibiting certain characters in their contours and sculpturing, which might be of service in ascertaining their probable generic positions. *Estheria minuta* is the one invertebrate form hitherto recorded from the British Keuper; that is, excluding the Foraminifera described by Professor T. R. Jones and W. K. Parker,[1] which came from an alabaster pit at Chellaston, near Derby, and which were doubtfully referred by the authors to an Upper Triassic age. The very modern facies of the Foraminifera has suggested the highly probable idea that they were derived from superficial deposits.

Associated in the matrix containing these molluscan impressions are fragments of Cestraciont spines and teeth (*Acrodus Keuperinus*) and a part of a carapace of the small phyllopodous crustacean, *Estheria minuta*.

The specimens described are identified as—

(1) *Thracia* (?) *Brodiei* (n. sp.).
(2) *Goniomya Keuperina* (n. sp.).
(3) *Pholadomya* (?) *Richardsi* (n. sp.).

Such generic forms as are represented here have not apparently been reported from rocks of a similar period on the Continent or elsewhere.

[1] "On some Fossil Foraminifera from Chellaston, near Derby," Quart. Journ. Geol. Soc., 1860, vol. xvi. pls. 19, 20, pp. 452—458.

X.—On the Radiolarian Cherts of Cornwall. By Howard Fox, F.G.S.

THE Mullion Island Radiolarian cherts were first recognized by Mr. J. J. H. Teall, F.R.S., in rocks sent to him by the author last autumn, and a joint paper was read at the Geological Society's meeting, February 8 last, describing the manner in which they occur. Dr. Hinde accompanied the paper with a description of the species recognized and with micro-photographs of the individual organisms.

Last Easter Mr. Teall, Professor Lapworth, and the author traced these cherts for about 650 yards in the cliffs and on the foreshore from the south end of Nelly's Cove, near Porthallow, Meneage, to near Ligarath Point, south of the Nore Point. Subsequently the author has examined the coast and some inland districts between Helford River and Fowey, and has found other exposures in the following places:—

Pendoner Beach, Veryan (for about 1000 yards).—Beds many feet thick at the west end of this beach, on which the raised beach rests. Angular fragments of chert are enclosed in the raised beach, and in one place a mass of chert and slate cliff has been thrust over it, and thus the chert appears both above and below as well as in the raised beach. Towards the eastern end of this beach the chert beds become thicker and more numerous.

Portloe Point, Veryan.—Here several beds, varying from one to six inches in thickness, are seen for 20 yards in the volcanic breccia (or "trappean conglomerate" of De la Beche) associated with some small amount of shale and grit, more or less decomposing from the presence of iron. Two small exposures are traced inland, one of which is 500 yards west of Portloe Point.

Pecunnen Cove, Gerran.—North-west of the Dodman beds of chert are seen in perpendicular thinly laminated crushed-dark slates for 60 yards, accompanied by numerous lenticules and bands of black quartzite and yellowish-grey limestone.

Inland exposures are traced at intervals in a line extending for five miles inland from Pendoner Beach in a north-east direction through the village of Veryan to Tolcarne Mill, north of St. Michael Caerhays. These cherts on the mainland are less pure than those in Mullion Island, and the structure of the individual organism is destroyed. Some specimens show signs of great shearing and crushing, and have no traces of Radiolaria; others show shearing with slight traces of Radiolaria, whilst others show no signs of crushing, and have clear round spaces, evidently due to Radiolaria. In many of the specimens examined a considerable amount of ferric oxide has been formed by the decomposition and oxidation of pyrites, and possibly also of ferriferous carbonate. At Portloe Point the chert appears to pass into quartz.

The Meneage and Veryan cherts are associated with the well-known Ordovician quartzites of those districts, and appear to lie immediately under them; but the sequence is not absolutely clear, and no typical fossils have yet been found in the shales and slates with which the cherts are interbanded.

XI.—On the Derbyshire Toadstone. By H. H. Arnold-Bemrose, M.A., F.G.S.

TOADSTONE is a local name for the igneous rocks interbedded with the Carboniferous limestones of Derbyshire. It occurs in a district of 25 by 20 miles. The upper and lower portions of a bed are sometimes amygdaloidal. The spheroidal structure is often well marked, the columnar more seldom and less perfectly. Toadstone varies very much in the amount of weathering it has undergone. It often decomposes to a sort of clay containing nodules of less altered rock, so that it has been supposed that toadstone in some localities "replaces" a bed of clay in others. For this reason, and also because of the loose way in which the word is used by miners, statements as to the number of beds of toadstone and of the presence or absence of ore in it must be accepted with reserve. Careful mapping over the whole district will be necessary to ascertain the actual number of beds. Two at least may be seen exposed in several places, and there may be three or even four beds. The Black Hillock shaft has been supposed to be one of the vents through which the toadstone came up to the surface, because the bottom of the rock was not reached. Farey, however, maintains that this bed was sunk through, and a careful examination of the mine heap and shaft shows that the dolerite is not coarse-grained, and that there is no trace of agglomerate or tuff. An occurrence of lead-ore in the toadstone of the Wakebridge mine was next described. The rock in which the ore occurred, when examined under the microscope, proved to be a decomposed olivine-dolerite. The ore was as good in the toadstone as in the limestone. That the toadstone is contemporaneous with the limestone is proved by its being interbedded with the latter, by the occurrence of stratified tuffs in various parts of the district, and by the non-alteration of the beds immediately above the igneous rock, though in one or two places a clay bed below it has been caused to assume a columnar structure.

Very many specimens have been collected from all the outcrops of toadstone, which are some fifty in number, and many of them have been examined under the microscope. The lavas consist mainly of olivine-dolerite, the augite being both in ophitic plates and in irregularly shaped grains. The rock is much more fresh and less amygdaloidal than has been generally supposed. The tuffs are in some cases well preserved, and the outlines of the lapilli very clearly defined.

XII.—The Dissected Volcano of Crandall Basin, Wyoming. By Professor Joseph Paxson Iddings.

THE writer, in exploring the north-eastern corner of the Yellowstone National Park and the country east of it, came upon evidences of a great volcano which had been eroded in such a manner as to expose the geological structure of its basal portion.

The work was carried on as a part of the survey of this region

under the charge of Mr. Arnold Hague, of the United States Geological Survey. This paper is an extract from a chapter of the final report on the Yellowstone National Park, in process of completion, and the writer is indebted to Major J. W. Powell, Director of the Survey, and to Mr. Hague, chief of the division, for permission to present it at this time in anticipation of the publication of the final report.

The area of volcanic rocks described is but a small portion of the great belt of igneous material that forms the mountains of the Absaroka range, lying along the eastern margin of the Yellowstone Park. The volcano of Crandall Basin is one of a chain of volcanic centres situated along the northern and eastern borders of the Yellowstone Park, which are all distinguished by a greater or less development of radiating dykes, and by a crystalline core eroded to a variable extent.

The Palæozoic and Mesozoic strata, which formed an almost continuous series to the coal-bearing Laramie, had been greatly disturbed, and almost completely eroded in places, before the volcanic ejectamenta in this vicinity were thrown upon them. The period of their eruption is therefore post-Laramie, presumably early Tertiary.

The first eruptions of andesite were followed by those of basalt in great quantities, and these by others of andesite and basalt, like the first. This was succeeded by a period of extensive erosion, reducing the country to nearly its present form. Then came the eruption of a vast flood of rhyolite, constituting the Park Plateau, which was followed, in this region, by smaller outbreaks of basalt. The last phase of volcanic activity is found in the geysers and fumaroles which have rendered the region famous.

The volcano of Crandall Basin consists chiefly of the first series of basic andesites and basalts. The earliest acid andesite which occurs beneath these rocks appears to be the remnant of eruptions from neighbouring centres.

Nothing remains of the original outline of the volcano. The district is now covered by systems of valleys and ridges of mountain peaks that rise 2,000 to 5,000 feet above the valley bottoms. The geological structure of the country, however, makes its original character evident.

The outlying portions of the district to the south, west, and north consist of nearly horizontally bedded tuffs and subaërial breccias of basic andesite and basalt. With these are intercalated some massive lava-flows, which are scarce in the lower parts of the breccia, but predominate in the highest parts above an altitude of 10,000 feet. Here they constitute the summits of the highest peaks.

In contrast to the well-bedded breccias around the margin of the district the central portion consists of chaotic and orderless accumulations of scoriaceous breccia with some massive flows. These breccias carry larger fragments of rock and exhibit greater uniformity in petrographical character.

A still more noticeable feature of the central portion of the district

is the occurrence of dykes, which form prominent walls, and may be traced for long distances across the country.

The greater number of them converge towards a centre in the highest ridge in the middle of the drainage basin of Crandall Creek. A small number converge towards a second centre three or four miles east of the first. In the southern part of the district there are many dykes trending towards a centre near the head of Sunlight Basin, about fifteen miles south of the Crandall centre.

The centre towards which the Crandall dykes converge is a large body of granular gabbro graduating into diorite. It is about a mile wide, and consists of numerous intrusions penetrating one another, and extending out into the surrounding breccia, which is highly indurated and metamorphosed in the immediate vicinity of the core. Within the area of indurated breccia the dyke-rocks become rapidly coarser-grained as they approach the gabbro core. This was undoubtedly the central conduit of an ancient volcano, the upper portion of which has been eroded away.

Upon comparing the geological structure of this region with that of an active volcano like Etna it is apparent that the lava-flows which form the summits of the outlying peaks must have been derived from lateral cones fed by dykes radiating from the central conduit; and, assuming that the volcano of Crandall Basin was similar in type to that of Etna, an idea of its original proportions is derived by constructing, upon profile sections through the Crandall core, the outline of Etna. If the erosion of the summits of the highest peaks is neglected the resulting height of the ancient volcano above the limestone floor is estimated at 13,400 feet. This is undoubtedly too low, and is well within the limits of present active volcanoes.

Erosion has removed at least 10,000 feet from the summit of the mountain to the top of the high central ridge in which the granular core is situated, and has cut 4,000 feet deeper into the valleys on either side. It has prepared for study a dissected volcano, which, it is hoped, will in time reveal some of the obscurer relationships existing between various phases of igneous rocks.

XIII.—Geological Sketch of Central East Africa. By Walcot Gibson, F.G.S.

THE tract of country described in this paper is situated in Equatorial East Africa. It extends from the coast inland to the N.W. borders of Victoria Nyanza.

The small island of Mombasa, the starting-point of the expedition, lies fifty miles north of the island of Pemba. A narrow creek, fordable at low water, separates the island from the mainland.

The sea cliffs are composed of coral rock, which also forms an inland belt about two miles broad, with a general elevation of 50 feet, which sometimes rises to 100 feet. A fringing reef borders the coast. The shore sand consists of comminuted corals and shells mixed with rounded fragments of quartz, orthoclase, garnets, and splinters of clear blue cyanite. These constituents appear to be

derived from a submerged ridge, of which the Seychelles Islands are a remnant.

The coral rock rests on a sedimentary series consisting of shales, limestones, flaggy sandstones, grits, and conglomerates in descending order. The beds dip gently to the east. They extend inland to the borders of the Taru Plain, a distance of about forty-seven miles.

The beds are of marine origin, Ammonites and Ichthyosaurian remains having been found near Rabai and other localities.

It is impossible to correlate these beds with any occurring in South Africa, but they appear to form a belt running many miles north and south of Mombasa.

The sedimentary beds rest unconformably on a metamorphic series, consisting of gneisses, schists, and intrusive granites. The strike is N.N.W. and S.S.E., and the dip is generally high. The beds are often intensely folded (Ndange River). Biotite is the commonest mica, and orthoclase the predominant felspar. The schists contain much cyanite, full of iron inclusions. Common garnets are plentiful. Hornblendic rocks are remarkably scarce, the main mass being micaceous. Graphite schists occur, and the Bura Hills are largely composed of a crystalline limestone containing scales of graphite. No fossils could be detected. Quartz veins and quartzites are only feebly developed. They form gently undulating country or else nearly level plains (Taru, Serengeti) through which low isolated hills of gneiss and granite protrude.

It is evident that they have suffered enormous denudation. They no doubt represent a complex metamorphosed series of sediments and intrusive rocks, but of what geological age or ages it is impossible to state.

The intrusive granites are generally pegmatites. Porphyritic granite covers a large area in Kavirondo. Biotite is the essential mica, and a pink orthoclase the predominant felspar. The relation of this large mass of granite to the gneisses and schists could not be ascertained.

The area covered by granite and metamorphic rocks is enormous. Fully two-thirds of Central East Africa are composed of these rocks. The remaining portion of the country, excepting the narrow coast belt of sedimentary rocks, is formed of recent volcanic rocks.

No traces of the fossiliferous sandstones and shales found by Professor Drummond near Lake Tanganyika, and quite recently by Mr. Joseph Thomson to the west of Lake Nyassa and around Lake Bangweolo, were detected. If further investigation proves their absence from East Africa to be a fact, then we have in the deposits around Lake Tanganyika the most northerly extension of the Karoo beds of South Africa.

Volcanic rocks form the grandest scenery in East Africa. They occur in two forms, giving rise to two distinct types of scenery. They have either built up tall isolated mountains like Kilimanjaro (19,718 ft.), Kenia (18,000 ft.), Elgon (14,000 ft.), Chibchangani (12,000 ft.), besides numerous other smaller hills, or they are arranged in lines running north and south. The lavas, tuffs, and

ashes composing the high central plateaux of Mau, Kamasia, and Lykipia have evidently issued from a north and south fissure. The site of this fissure is now occupied by the chain of lakes commencing with Naivasha on the south, and terminating northward in Lake Baringo. Along this line recent eruptions, some still giving out steam, have broken out, and it is the interception of the drainage by the material thrown out from these vents that forms the lakes Naivasha, Nakuru, and Elmeteita.

Highly acid and ultra-basic rocks are represented. Kilimanjaro and the Kyulu Mountains are chiefly built up of basic rocks, while the lavas of Lykipia and the Mau plateaux are chiefly acid. It appears that the latter localities have been the seat from which acid lavas have continued to be poured from times prior to the first eruptions of Kilimanjaro up to the present day.

The basic lavas of Kilimanjaro do not extend very far from the original point of issue. At least this is so to the north, for no lavas were found on the plains of Lytokitok, distant thirty miles north of Kilimanjaro. On the other hand the acid lavas of Mau and Lykipia extend for great distances. Eastwards they stretch as far as the Athé plain, about fifty miles, and westwards to near the shores of Victoria Nyanza, a distance of nearly one hundred miles.

Further westward, in Busoga and Buganda, basic igneous rocks pierce the metamorphic rocks, but without possessing any general trend.

With the exception of the still active volcanoes it is impossible to state even the approximate geological age of any of the eruptions. Some of the volcanoes are possibly only dormant, others are certainly extinct, but none appear to be of great geological antiquity. All that can be safely asserted is that they are long subsequent to the deposition of strata containing *Ammonites*, for, whereas the conglomerates of these sedimentary deposits contain pebbles of schist and gneiss, they nowhere yield fragments of igneous or volcanic rocks.

REVIEWS.

I.—Note sur les Gîtes de Phosphate de Chaux des environs de Fresnoy-le-Grand. Par M. Gosselet. Annales de la Soc. Géol. du Nord, vol. xxi. 1893, pp. 149–159.

IN this paper Prof. Gosselet describes the position and mode of occurrence of some newly opened deposits of phosphate of lime near Fresnoy-le-Grand, in the north of France. The workable deposits do not extend over areas of more than from five to ten acres in each locality, they occur in a zone of Gray Chalk of from 1½ to 2 metres in thickness, containing *Belemnitella quadrata*, *Ventriculites* and sharks' teeth. The phosphate is partly in the form of concretionary nodules, which are so numerous as to form a sort of conglomerate in the lower portion of the bed; the phosphate varies in amount from 9 per cent. to 27 per cent. The Gray Chalk rests on White Chalk with *Micraster coranguinum*, and the upper part