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DECADE V. VOL. V.

JANUARY—DECEMBER, 1908.

THE

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OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., V.P.Z.S., F.G.S., F.R.M.S.,

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY; PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY;

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ASSISTED BY

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

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LONDON: DULAU & CO., 37, SOHO SQUARE.

Yours faithfully
John Evans

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. I.—JANUARY, 1908.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

Sir John Evans, K.C.B., D.C.L., LL.D., Sc.D., F.R.S., F.S.A., F.G.S., F.C.S., F.L.S., F.Z.S.;

Assoc. Inst. C.E., late V.P. and Treas. R.S., For. Sec. Geol. Soc., Pres. Roy. Num. Soc., Trust. Brit. Mus., Hon. M.R.I. Acad., Hon. F.S.A. Scot., Corr. Inst. France and of the Acad. of Sciences of Bologna, Comm. Ord. St. Thiago, Port., Officer of the Order of St. Charles of Monaco, etc., etc.

(WITH A PORTRAIT, PLATE I.)

FEW men who have engaged successfully in commerce for nearly half a century have achieved so distinguished a position in the world of science as Sir John Evans. Indeed, it may be said that his keen intellect, which enabled him to excel in business affairs, also gave him enormous advantages in pursuing those branches of natural knowledge to the investigation of which he has devoted his long life and his remarkable abilities, ever combining "science with practice." His powers of observation have always been singularly acute, and the writer recalls vividly a walk across the open country in Hertfordshire years ago, in his company, with Professor Boyd Dawkins and the late W. Ayshford Sanford, and being struck with the rapidity with which John Evans's well-trained eye detected a flint implement on the stony surface of a stubble-field, overlooked by the rest of the party.

John Evans, son of the late Rev. Arthur Benoni Evans, D.D., was born at Britwell Court, Burnham, Bucks, 17th November, 1823, and moved as a child with his parents to Market Bosworth, Leicestershire, on his father's appointment as Head Master of the Grammar School, in which he at once commenced to study. His first introduction to Geology was at the early age of 9, when hammer in hand he paid a visit, in June, 1832, to the famous "Wren's Nest" and Wenlock Limestone quarries at Dudley; there he found his first fossils, and returned home rejoicing and laden with spoils. In 1839 he was sent by his father to Germany for seven months to study the language, and in 1840 he left school and entered upon a business career at Nash Mills, Hemel Hempstead, where he was initiated into the art of paper-making under the firm of John Dickinson & Co., of which his uncle, the late J. Dickinson, F.R.S., was senior partner. It can easily be imagined that in such a business mathematical, mechanical, chemical, and geological knowledge might all be most valuable aids, and so it proved, for in 1851, when but 28 years of age, John Evans became a partner in the firm. About this time a celebrated lawsuit, Dickinson *v.* The Grand Junction Canal Co., turning on the question of water-supply, led him to pay still more special attention to geology than heretofore, and in this inquiry he had the good fortune to establish a warm personal friendship with Mr. (afterwards Sir) Joseph Prestwich, which lasted to the end of the latter's life.

Besides the question of water-supply and the Tertiary and Chalk formations, in which Prestwich was from an early period the great authority, and to which from that time forward John Evans also devoted most earnest attention, they had a common interest in collecting and studying flint implements from the gravels and other superficial deposits, in which, following the late Joshua Trimmer, Prestwich undertook the task of classifying and synchronising the strata, named by him 'Quaternary,' as Evans did with regard to the flint implements contained in them, and Falconer in respect to their associated mammalian remains.

In 1852 John Evans became a Fellow of the Society of Antiquaries, of which Society 33 years later he was elected President, holding the chair for seven years (1885–92).

In 1841 M. Boucher de Perthes began to collect, and in 1847 to publish his researches in the gravel deposits of the Valley of the Somme around Abbeville, and the sight of his collection incited Dr. Rigollot to search the gravel-pits around Amiens, which also yielded abundant evidence, in palæolithic flint implements, of the former presence of prehistoric man. It was the part taken in 1858–9 by Falconer, Prestwich, Evans, Lubbock, and others which at length secured for Boucher de Perthes the recognition that he deserved for his labour in the field of prehistoric archæology, which heretofore had been denied him by his countrymen in France. Then old records were unearthed, and it was ascertained by John Evans that about the year 1700 bones of the Mammoth (*E. primigenius*) had been found together with a flint weapon made by primitive man in Gray's Inn Lane, London.[1] He also recalled and republished Mr. Frere's account of the finding of flint implements with remains of Elephant, Rhinoceros, and Hippopotamus, in the Valley of the Waveney, at Hoxne, 1797.[2] So long ago as 1824 the Rev. Dr. John Fleming in an article in the Edinburgh Philosophical Journal (vol. xi) advocated the contemporaneity of the human and animal remains found in cave-deposits; and the exploration of Kent's Cavern before Pengelly's days by the Rev. J. McEnery, in 1824, led to the discovery of flint implements of undoubted human workmanship, with bones and teeth of the Mammoth, the Machærodus, Rhinoceros, Cave Bear, and other mammals, but McEnery distrusted his own discoveries at that time as being doubtfully contemporaneous.[3]

[1] Evans, "Stone Implements," 1872, pp. 521–2.
[2] See "Flint Implements from the Drift," 1859; also *Geologist*, 1861, vol. iv, pp. 20–1.
[3] Geol. Mag., 1902, pp. 116–117.

The change in public opinion in this country was no doubt largely due to the results obtained by the systematic investigation of Brixham Cave, near Torquay, commenced in 1858 under the direction of a Committee of the Geological Society, upon which John Evans served, with Prestwich, Falconer, Ramsay, and Busk, the actual carrying out of the work in the cave being entrusted to William Pengelly.

His subsequent exploration of Kent's Cavern, Torquay, initiated by Sir Charles Lyell, when President of the British Association in Bath (1864), and carried on for years by a powerful committee on which John Evans served as an active member, assisted largely to justify the conclusions arrived at by men of science generally, that prehistoric man was living in Britain and in France contemporaneously with the large extinct Mammalia, the Mammoth, the Machærodus, the Rhinoceros, Hippopotamus, Cave Lion, Bear, and Hyæna, and such now existing northern forms as the Reindeer, Musk Sheep, and the Asiatic Saiga Antelope.

Most valuable, among Mr. Evans' many services to science, has been his endeavour to tide over the gap between the Prehistoric and Historic periods of mankind, and to emphasize the importance of the Quaternary period in geology. He has also established for us a correct chronological succession of periods of time represented by the various discoveries of the implements and objects made by prehistoric man, which clearly indicate that gradual progress from the most barbaric savage whose weapons of stone were rudely chipped, and neither ground nor polished; until, as he advanced in intelligence and skill, we meet with a class of implements which after being fashioned by chipping have been ground or polished at their edges only, and again still further with those which are more or less ground or polished, not only at the edge, but over the entire surface.

The rudest forms of implements are classed as belonging to the "River-drift Period," the Palæolithic age, and are associated with the Mammoth and the Tichorhine Rhinoceros. Following on these we have the men of the Reindeer and Cave Period, with implements rather better finished, and, as a hunter-people, largely using harpoons and arrowheads of bone skilfully carved. Later, in the Neolithic Period, we find the makers of polished stone weapons with ground edges. Even in the subsequent Bronze Period that valuable alloy was also accompanied by highly finished stone axes, many being perforated and made in graceful forms.[1]

[1] The discussion of the various discoveries relating to prehistoric times, and the antiquity of the human race and the evidence bearing upon it, will be found in a long series of admirable Presidential Addresses to the British Association, Ethnological Section, Liverpool, 1870; to the Geological Section, Dublin, 1878; to the Anthropological Section, Leeds, 1890; as President of the British Association, Toronto, 1897–98; in 1861 in a lecture to working men at the Southampton Meeting; in an address to the Watford Natural History Society, 8th February, 1877; and as President of the Geological Society, 19th February, 1875. For an account of the flint implements in the Drift, see *Archæologia*, 1860 and 1862. There is an admirable paper on Bone and Cave-deposits of the Reindeer Period in the Quart. Journ. Geol. Soc., 1864, p. 444 (abstract), and Reliquiæ Aquitanicæ, 1875, p. 161 seq., and the subject is fully treated in Sir John Evans's "Ancient Stone Implements, Weapons, and Ornaments of Great Britain," 8vo (1872, and 2nd edition, 1897).

On February 20th, 1880, the Council of the Geological Society conferred upon Mr. John Evans the Lyell Medal, "in recognition of his distinguished services to geological science, especially in the department of Post-Tertiary Geology." In presenting it, Dr. H. C. Sorby, the President, said: "I can well remember the time when there appeared to be an almost impassable gulf between antiquaries and geologists, but you and your fellow-workers have so completely bridged over the gulf that we now can scarcely say where archæology ends and geology begins, nor whether to rank or value you most as an antiquary or a geologist" (Geol. Mag., 1880, p. 180).

The announcement in the *Annals and Magazine of Natural History* for April, 1862, of the discovery made by Dr. Haberlein, in the Lithographic Stone of Bavaria, of "a fossil reptile clothed in feathers," which Professor Wagner named *Griphornis longicaudatus*, attracted much attention. This was followed by a notice by Professor H. von Meyer a month later, giving an account of the same fossil and naming it *Archæopteryx lithographica*. The specimen was acquired for the British Museum in 1862, and Mr. John Evans was greatly interested in it as possibly affording evidence of a form intermediate between Birds and Reptiles. The suggested reptilian-like characters were based upon the free-clawed phalanges of the wings, and the long lizard-like tail, composed of 20 free unanchylosed vertebræ, but the head was wanting. Owen, in describing it, adhered to the fossil being a true bird by the fact that it was clothed in feathers and appeared to have the foot of a true perching bird, and he insisted that the feathers proved the existence of a *beak* for preening its plumage.

Mr. Evans drew attention to a rounded body which in the counterpart slab was represented by a hollow lined by a thin brown bony layer (apparently the cranial cavity). In order to elucidate this he proceeded to procure the heads of a very large number of wild birds, such as the Magpie, Rook, Crow, Gull, Jay, Woodcock, Snipe, etc. Casts were made by him of the brain cavities of these, and the skulls bisected so as to expose the cast of the upper surface of the two hemispheres of the brain and to show the hollow of the cranium. He also called attention to a small broken and detached jaw bearing five teeth upon its dentary border, resting on the same slab. Professor Owen refers to the first as "a concretionary nodule, which *may be*, as suggested by Mr. John Evans, part of the cranium with the cast of the brain of *Archæopteryx*" (Phil. Trans., 1863, p. 46). But he dismisses the jaw as a "premaxillary bone and impression of same, resembling that of a fish."

Mr. John Evans laid his case by letter with drawings before Professor Dr. Hermann von Meyer in 1863, who replied: "I hazard no opinion on the cast of the skull; much more important is the jaw." "Teeth of this sort I do not know in the Lithographic Stone. They are *not* like the teeth of Pterodactyles. The nearest likeness is to *Acrosaurus Frischmanni*, Meyer, a reptile from the Lithographic Stone of Bavaria." He goes on to compare the teeth with *Pleurosaurus Meyeri* and with *Geosaurus Soemmeringi*, Meyer, which he says are much longer, and ends by observing "From this it would appear that the jaw really belongs to *Archæopteryx*."

Mr. John Evans's paper on "A Cranium and Jaw in the Slab containing the *Archæopteryx*" was published in the *Natural History Review* for July, 1865, but it was not until 1884[1] that Dr. Dames described the second specimen of long-tailed *Archæopteryx* (obtained for the Berlin Museum), in which the head and neck of the bird are preserved with the jaws furnished with numerous pointed teeth, fully confirming Sir John Evans's observations on the *Archæopteryx* in the British Museum made twenty years earlier. Already in 1881 Evans had inspected the specimen in the Berlin Museum and reprinted the article of 1865 with some prefatory remarks on the peculiarities of the Berlin specimen.

Another subject which engaged Mr. John Evans's attention as early as 1866 was the consideration of a possible cause of climatal changes. We are all aware that great changes of climate have taken place in the northern hemisphere, and we have every reason to assume that corresponding changes have in all probability taken place in the southern hemisphere; also periods of glaciation may account for accession of cold, but it may be doubted if by any rearrangement of land surfaces or of warm currents, like the Gulf Stream flowing north, a sub-tropical, or a warm temperate climate even, could be forced up towards the Poles. Nevertheless, such a condition seems needed to explain the fossil vegetation in Tertiary times met with in Greenland, Arctic America, and Spitzbergen. Mr. Evans suggested that if the earth's crust were composed of solid material of equal density and thickness, and the interior were filled with fluid matter over which the shell could freely move, and the whole were in uniform rotation upon an axis, the hollow sphere being in perfect equilibrium, its axis and that of its fluid contents would perpetually coincide. If, however, the equilibrium of the shell or crust be destroyed by the addition of a mass of matter, midway between the pole and the equator, the centrifugal force of the mass of matter so added would gradually draw over the shell towards the equator; thus, though the whole sphere continued to revolve around its original axis, yet the position of the pole of the hollow shell would be changed by 45° and the whole surface would have shifted from its original position to the same extent. The axis of the hollow sphere would again coincide, and would continue to do so until a fresh disturbance took place. If instead of the addition of fresh matter a portion of the shell were removed, a reverse movement would result, and that part of the shell excavated would eventually find its way to the Pole. An ingenious model to exhibit this was shown before the Royal Society (March 15th, 1866); it illustrated the changes produced on a moving wheel by the alteration in the adjustment of the weights around its rim. The subject was ably discussed at the time and subsequently at the Geological Society on February 21st, 1877.[2]

In 1892 Sir John Evans gave evidence before the Royal Commission on Metropolitan Water Supply. He then put in a statement with

[1] See Geol. Mag., 1884, Professor Dames on *Archæopteryx*, pp. 418–424, Pl. XIV.

[2] Geol. Mag., 1866, pp. 171–174, 183–185; 1877, p. 219.

regard to the rain-gauges and the percolation gauges which had been started at Nash Mills in 1836 by his uncle John Dickinson, and had been in continuous operation under his own direction since 1853. Sir John Evans brought the subject before the Institution of Civil Engineers in 1885 in a lecture on "Physiography," one of a series, given by distinguished observers, on "The Theory and Practice of Hydro-mechanics."

In his evidence in 1892 he stated that the average percolation for thirty-seven years through 3 feet of soil, on which grass was allowed to grow, was 7·55 inches, and through 3 feet of chalk 10·71 inches; the yearly average rainfall being 27·42 inches. He felt it unsafe, however, to calculate on a certain supply of more than 4 inches of the rainfall, whether from the springs or streams of such a district as the Chalk of Hertfordshire, because many vegetable roots penetrate the earth to a far greater depth and absorb moisture, and in dry seasons moisture can be brought from a greater depth in Chalk by means of capillary attraction. Sir John Evans also dealt with the effect on the streams of pumping water from the Chalk.[1]

Sir John Evans has on several occasions acted as a guide to the Geologists' Association, having conducted or taken part in the conducting of excursions since 1875 to Watford, Tyler's Hill, Chesham, and Berkhamsted.

He has an extensive knowledge, not only of prehistoric archæology, but also of ancient, especially British gold coins, and of engraved gems. More than this, though he left school so early, he is a really good classical scholar, besides being well versed in at least three modern languages. Few men have shown more conspicuous ability in transacting the business of societies. His experience of life and affairs, as manager of an important commercial undertaking, as a county magistrate, as member or chairman of committees of different kinds, make him invaluable in any official position. He was three times a member of the Council of the Royal Society—on the last occasion for a period of twenty years as its Treasurer. In that office he rendered great service to the Society in bringing its financial affairs into a satisfactory condition, and his advice on the various and sometimes difficult questions brought year by year in increasing numbers before the Society was always of the highest value. In 1884, in consequence of the illness of Professor Huxley, P.R.S., he delivered the Anniversary Address. Of the Geological Society he was Secretary from 1866 to 1874, President from 1874 to 1876, and Foreign Secretary from 1895 to the present date, besides being a member of the Council and Vice-President on other occasions. Of Sir John Evans's long connection with the Society of Antiquaries and his communications to that body on subjects which have no bearing on geology this is not the place to speak. With regard to the Royal Numismatic Society, which he joined in 1849, it may be mentioned that he has been since 1860 one of the Editors of the *Numismatic Chronicle*, which is now completing its 47th volume. In 1878–9 he was President of the Anthropological Institute. In 1893 he was Chairman of the Society of Chemical

[1] See his second Presidential Address to the Geological Society (Geol. Mag., 1876, pp. 185–186).

Industry, delivering an address at Liverpool, and in 1900 Chairman of the Society of Arts. For many years he has been President of the Paper Manufacturers' Association.

He received the honour of being created K.C.B. in 1892. His services to the County of Herts as Chairman of Quarter Sessions and of the County Council, and in other capacities, were recognised in 1905 by the presentation of his portrait and of a magnificent silver-gilt cup. For seven years he was President of the Egypt Exploration Fund, and he has from its inception been Chairman of the Lawes Agricultural Trust Committee. His knowledge of affairs and of men, his courtesy, tact, and clearness of view, his happy gift of expression and facility in drafting a resolution, his readiness to yield on matters of minor importance and his firmness on those of principle, will make one so witty and yet so wise, so strong and yet so conciliatory, sorely missed when he disappears from the ranks of those who have worked for the good of science and learning.

Sir John Evans married, first, Harriet Ann, daughter of John Dickinson, F.R.S.; second, Frances, daughter of Joseph Phelps; third, Maria Millington, daughter of Charles C. Lathbury, Wimbledon, 1892. He has two sons and two daughters surviving. His eldest son, Arthur John Evans, D.Litt. Oxford, Hon. LL.D. Edin., Hon. Litt.D. Dublin, M.A., F.R.S., F.S.A., has been Keeper of the Ashmolean Museum, Oxford, since 1884, and is a Fellow of Brasenose College, Oxford; was born 1851. Sir John Evans celebrated his 84th birthday on the 17th November last, and was warmly congratulated upon the auspicious event by the Press and by a wide circle of friends and scientific colleagues.

His ardour in the pursuit of his favourite study of Geological Anthropology remains unabated. So lately as the 18th December last he communicated to the Geological Society of London an important paper on some recent discoveries of palæolithic implements on the southern borders of Bedfordshire and in the north-western part of Hertfordshire, obtained by Mr. Worthington Smith, of Dunstable. In addition to the discovery of a palæolithic floor at Caddington brickfield, at between 550 and 590 feet above sea-level, implements have since been found on the surface of the ground at 600 and 760 feet respectively; while a good ovate implement was found in thin, water-laid material, at 651 feet O.D. In Hertfordshire palæolithic implements have been found at Great Gaddesden, at a brickfield about 1½ mile north-east of Hemel Hempstead, and at Bedmont, 2 to 2¼ miles south-east of the last locality. The drifts which cap the hills in North-West Hertfordshire seem to be of very variable origin, and a great part of the material is derived from clay-deposits of Eocene age, but little remanié. It seems to Sir John that it is safest not to invoke river-action for the formation of the high-level deposits, which extend over a wide area and are in the main argillaceous and not gravelly or sandy in character, but to adopt Mr. Worthington Smith's view, that in early times lakes or marshes existed in these implementiferous spots, the borders of which were inhabited by Palæolithic Man. The evidence that he has brought forward as to the implements having, in some of the Caddington pits, been manufactured on the spot, most fully corroborates this view.

The meeting was a very large one, and the paper was cordially received and discussed by a great number of eminent geologists acquainted with the country and with palæolithic implements, of which a fine series was exhibited.

WORKS BY SIR JOHN EVANS, K.C.B., F.R.S.

1860. "Flint Implements in the Drift; being an account of their discovery on the Continent and in England": Archæologia, vol. xxxviii, p. 280, pp. 28, 2 pls.

1862. "Flint Implements in the Drift; being an account of further discoveries on the Continent and in England": Archæologia, vol. xxxix, p. 57, pp. 28, 4 pls.

1864. "The Coins of the Ancient Britons": arranged and described by J. E. and engraved by F. W. Fairholt. 8vo; pp. 424, 26 pls.; London. Supplement, 1890.

"On some Recent Discoveries of Flint Implements in Drift-deposits in Hants and Wilts": Quart. Journ. Geol. Soc., vol. xx, pp. 188–194; Phil. Mag., vol. xxvii, p. 544.

"On some Bone and Cave-deposits of the Reindeer Period in the South of France": Quart. Journ. Geol. Soc., vol. xx, p. 444; Phil. Mag., vol. xxviii, pp. 321–322; Geol. Mag., p. 85; Reliq. Aquit. (1875), p. 161.

1865. "On portions of a Cranium and of a Jaw in the Slab containing the Fossil Remains of the *Archæopteryx*": Nat. Hist. Review, pp. 415–421. Reprinted 1881.

1866. "On some Flint-cores from the Indus, Upper Scinde": Geol. Mag., Vol. III, pp. 433–435.

"On a possible Geological Cause of Changes in the Position of the Axis of the Earth's Crust" [1866]: Proc. Roy. Soc., vol. xv (1867), pp. 46–54; Amer. Journ. Sci., vol. xliii (1867), pp. 230–239; Phil. Mag., vol. xxxi, pp. 537–545; Geol. Mag., Vol. III, pp. 171–174.

1868. "On some Discoveries of Stone Implements in Lough Neagh, Ireland": Archæologia, vol. xli, pp. 397–408, 1 pl.

"On some Cavities in the Gravel of the Valley of the Little Ouse in Norfolk": Geol. Mag., Vol. V, pp. 443–447.

1872. "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain": 8vo; pp. xvi, 640; London.

"On the Flint Implements of Brixham Cave": Proc. Roy. Soc., vol. xx, pp. 514–524; Phil. Trans., vol. clxiii (1873), pp. 549–552.

Friday evening Lecture at the Royal Institution: "On the Alphabet and its Origin."

1875. Anniversary Address [to the Geological Society of London, February 19th, 1875]: Quart. Journ. Geol. Soc., vol. xxxi, pp. xxxvii–lxxvi.

1876. "Note on a proposed International Code of Symbols for use on Archæological Maps" [1875]: Journ. Anthrop. Inst., vol. v, pp. 427–435.

Anniversary Address [to the Geological Society of London, February 18th, 1876]: Quart. Journ. Geol. Soc., vol. xxxii (Proc.), pp. 53–121.

"On the Percolation of the Rainfall on Absorbent Soils": Proc. Inst. Civ. Eng., vol. xlv, pp. 203–216.

"Petit Album de l'Age du Bronze de la Grande Bretagne": small 4to; Londres.

1878. "On some Palæolithic Implements found in the Axe Valley": Rep. Brit. Assoc., 1877 (Sect.), p. 116; Journ. Anthrop. Inst., vol. vii, pp. 499–501.

"Les Ages de la Pierre": traduit par E. Barbier, Paris.

Opening Address to the Geological Section of the British Association, Dublin, August, 1878: Rep. Brit. Assoc., pp. 519–527; Nature, vol. xviii, pp. 415–419.

"The Hertfordshire Bourne": Trans. Watford Nat. Hist. Soc., vol. i, pp. 137–140.

Anniversary Address delivered at the Annual Meeting, 8th February, 1877, "Archæology and the Antiquity of Man": Trans. Watford Nat. Hist. Soc., vol. i, pp. 187–200.

1881. "The Ancient Bronze Implements, Weapons, and Ornaments of Great Britain and Ireland": 8vo; pp. xix, 509; London.

1882. "L'Age du Bronze" . . . Traduit de l'anglais par W. Battier . . . corrigé par l'auteur: 8vo; pp. viii, 551; Paris.

"Unwritten History, and how to read it": Nature, vol. xxvi, pp. 513–516, 531–533; Revue Scientif., vol. iv, pp. 449–458.

"A few words on Tertiary Man" [1880]: Trans. Herts Nat. Hist. Soc., vol. i, pp. 145–150.

1885. "Physiography." Opening Lecture of a course on Hydrodynamics delivered before the Institute of Civil Engineers: Proc. Inst. C.E.

"The Coins of Ancient Britons and Natural Selection": Trans. Herts Nat. Hist. Soc., vol. iii.

1892. "Posy-rings," a Friday evening discourse at the Royal Institution . . . . 1892: 8vo; pp. 30; London.

1893. "On the Forgery of Antiquities."

"Hydriotaphia, Urn Burial," by Sir T. Browne, with introduction and notes by Sir J. Evans. 8vo. Chiswick Press.

1896. [Anniversary Address, "The Stone Age in Hertfordshire"]: Trans. Herts Nat. Hist. Soc., vol. viii, pp. 169–187, 6 pls.

"On some Palæolithic Implements found in Somaliland by Mr. H. W. Seton-Karr": Proc. Roy. Soc., vol. lx, pp. 19–21.

Obituary Notice of Sir Joseph Prestwich: Proc. Roy. Soc., vol. lx, pp. xii–xvi.

1897. "Les premiers Ages de l'Humanité": Rev. Sci. Paris [4], vol. viii, pp. 355–360.

"The Ancient Stone Implements, Weapons, and Ornaments of Great Britain": 2nd edition, pp. xviii, 747. 8vo; London.

Presidential Address to the British Association at Toronto, August 18th, 1897: Rep. Brit. Assoc., pp. 3–20; Canada Rec. Sci., vol. vii (1898), pp. 390–426; Geol. Mag. [4], Vol. IV, pp. 457–465.

1899. "Il y a Quarante Ans": Assoc. Franc. Adv. Sci., pp. 296–298.

"The Antiquity of Man, with especial reference to the Stone Age in Egypt" [a presidential address delivered to the Birmingham and Midland Institute]: 8vo; pp. 1–15; London.

1900. "The Origin, Development, and Aims of our Scientific Societies": Address to Society of Arts.

1906. "On Formation of Pipes in Chalk": Quart. Journ. Geol. Soc., vol. lxii, p. 490.

"On a recent Palæolithic Discovery near Rickmansworth": Trans. Herts Nat. Hist. Soc., vol. xiii, pp. 65–66.

1907. "Some Recent Discoveries of Palæolithic Implements": Geol. Soc., Dec. 18th.

LIST OF HONOURS CONFERRED ON AND OFFICES HELD BY SIR JOHN EVANS, K.C.B.

1849. Member of the Numismatic Society, Secretary 1854–74, President 1874 till now; Medal in gold 1887; one of the Editors of the *Numismatic Chronicle* from 1860 onwards.

1852. Fellow of the Society of Antiquaries, President 1885–92.

1857. Fellow of the Geological Society, Secretary 1866–74, President 1874–76, Foreign Secretary.

1859. Associate of the Institution of Civil Engineers.

1861. Joined British Association. Presided over Ethnological Department, Liverpool, 1870; over Geological Section, Dublin, 1878; over Anthropological Section, Leeds, 1890; President, Toronto, 1897–8.

Joined Ethnological Society, subsequently Anthropological Society and Anthropological Institute; President 1877–9.

1864. Fellow Royal Society, Vice-President 1876, Treasurer 1878–98. Delivered Anniversary Address 1884 in absence of Professor Huxley.

1865. Elected to Athenæum Club under Rule II.

Assisted in founding and President of the Watford Natural History Society (afterwards the Herts Natural History Society).

1900. Chairman of the Society of Arts.

1892. Created Knight Commander of the Bath (Civil Division).

DEGREES, ETC.

D.C.L. Oxford, 1877; LL.D. Dublin, 1878; Sc.D. Cambridge, 1890; D.C.L. Toronto, 1897; LL.D. Trinity College, Toronto, 1897.
Hon. Fellow, Brasenose College, Oxford, 1903.
Hon. Member Royal Irish Academy.
J.P. Herts, 1870; Deputy Lieutenant, 1876; Sheriff, 1881; Deputy-Chairman Quarter Sessions, St. Albans, 1887; Chairman, 1889; Deputy-Chairman Herts County Council, 1889–98; Chairman, 1898–1905.

Trustee of the British Museum since 1885.

FOREIGN HONOURS.

1851. Hon. Member Société royale de Luxembourg.
1859. Mem. corr. Soc. d'Emulation, Abbeville.
1865. Hon. Memb. Instituto di correspondenza archeologica di Roma.
1874. Corr. Memb. Berliner Gesellschaft für Anthropologie.
1877. For. Memb. Société d'Anthropologie de Paris.
1881. Hon. Memb. American Philosophical Society, Philadelphia.
Knight Commander of the Order of St. Thiago of Portugal.
1887. Correspondant de l'Institut (Acad. Inscr. and Belles Lettres) Prix de Numismatique, 1865.
1888. For. Hon. Memb. American Academy of Arts and Sciences.
1891. Memb. hon. de la Société Géologique de Belgique.
1897. Corr. Memb. Academy of Sciences of Bologna.
1905. Officer of the Order of St. Charles of Monaco.

II.—NOTES ON THE DRIFT AND UNDERLYING DEPOSITS AT NEWQUAY, CORNWALL.

By B. B. WOODWARD, F.L.S., F.G.S., etc.

(PLATES II AND III.)

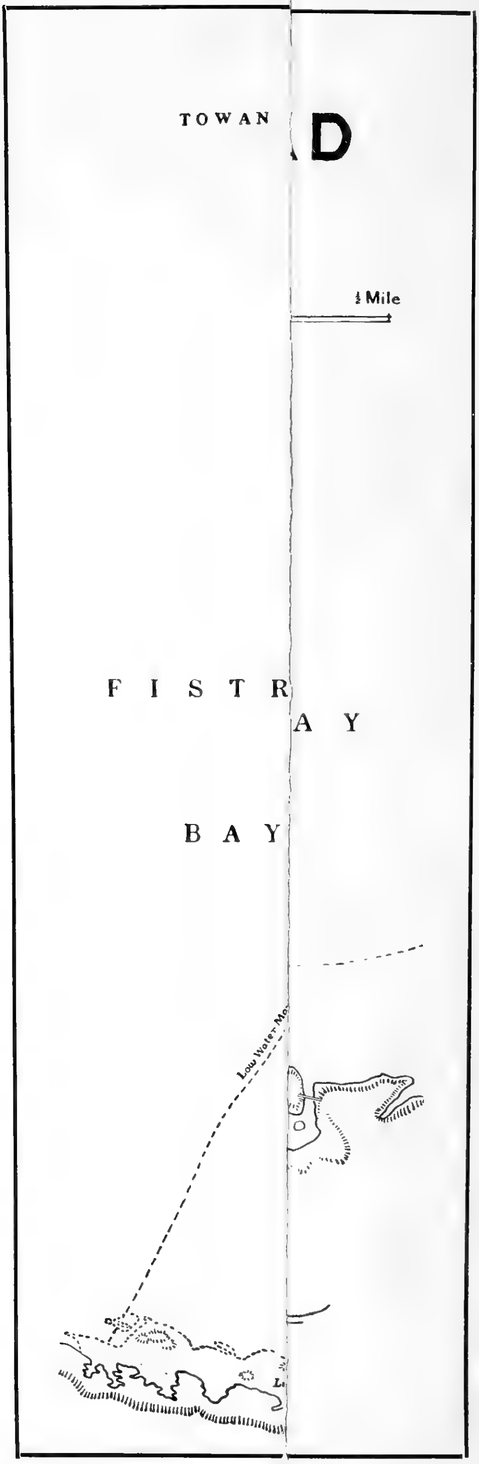
IN the Summer of 1900 the present writer on a visit to Newquay casually observed a deposit containing land shells near the Lifeboat House by Towan Head. The description of the little section was included in a joint paper by Mr. A. S. Kennard and himself on the "Post-Pliocene Non-marine Mollusca of the South of England"[1] and fortunately assigned in error to the Pleistocene period.

Fortunately, because the mistake elicited a very interesting and important communication on the series of deposits at that locality by Mr. S. Hazzledine Warren, with determinations of the shells and notes by Mr. A. S. Kennard.[2]

A holiday lately spent on the spot afforded the chance for making further observations, which supplement those of Mr. Warren in some respects, but differ from his in a few points, owing probably to some change in the sections in the interval. The list of mollusca has also been increased by the addition of several more species.

Opportunity was further taken of noting the sections of all the beds above the Killas, and since these seem largely to have been misunderstood, and vary under the destructive influence of Winter storms, it may be useful to place on record their present aspect.

[1] Proc. Geol. Assoc., vol. xvii (1901), p. 247.
[2] GEOL. MAG., 1903, pp. 19–25.


TOWAN
D
½ Mile
F I S T R
A Y
B A Y
Low Water Ma

The early literature on the subject has been so well summarised by Mr. W. A. E. Ussher in his far too little-known paper on the "Post-Tertiary Geology of Cornwall"[1] that further allusion to it is unnecessary.

The geological sequence of the beds in question is in reality very simple, but there has been so much slipping in the cliffs that it forms a veritable geological booby-trap for the casual visitant, or the hurried geological surveyor. The latter, to whom this class of deposit is caviare,[2] having under a misguided system so many square miles to cover in the day, cannot spare time for any but the most superficial glance as he sketches from the beach what really requires careful investigation to properly elucidate. On this account some very remarkable misreadings have found their way into print.

Briefly put, the sequence of the beds above the killas and their history is as follows:—

To begin with, at the commencement of their deposition, while the rocky headlands were much the same as they are to-day, the sea occupying the old Fistral Bay stood relatively higher and extended some distance over the site of the present golf links in the direction of the harbour—how far, in the absence of sections, it is impossible to say. On the denuded upturned edges of the killas in this tidal bay were laid down, first a pebbly beach full of boulders and then a thick deposit of marine sand exactly comparable to that occupying the present bay. This sand attained at the sides of the bay a thickness of as much as 20 feet, but shelved down to what was then the deepest point of the bay and is now the depression (miniature dry valley) in the golf links.

To this succeeded the period marked by the deposition of the well-known 'Head,' or remarkable clayey deposit full of angular fragments and occasional boulders of rock.

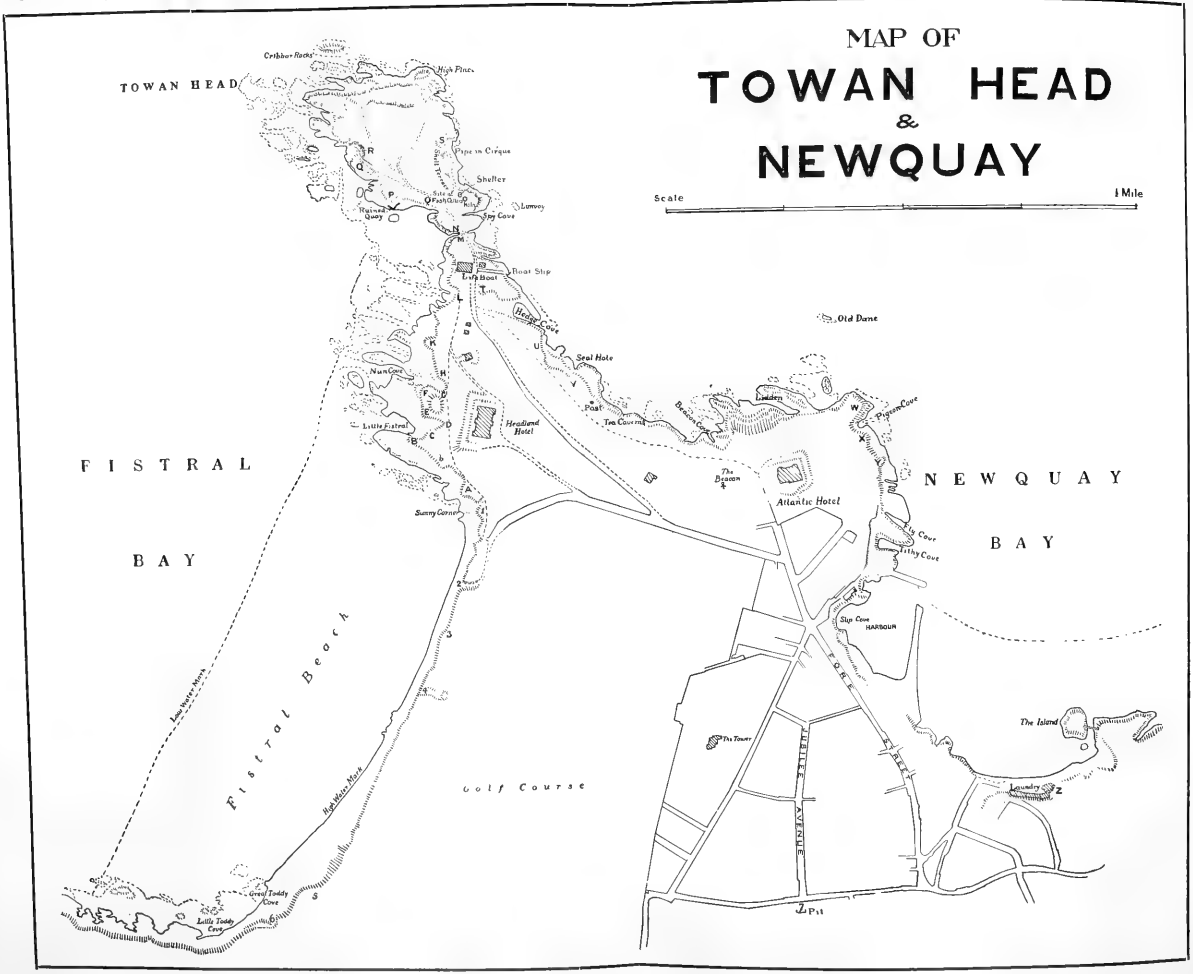
The exact time in the history of the bay when the recession of the sea took place is not clear, but there are indications that this event may have preceded the formation of the 'head,' the marine sands having in places obviously suffered previous denudation. At all events, the 'head' spread out over and partly filled up the trough of the old bay and quite probably extended partly up the flanks of the hills. This 'head' has frequently been described, and it seems pretty commonly agreed that it was due to minor local glacial conditions entailing a heavy snowfall and the formation of névé. The melting of this snow in warm Summers would release considerable volumes of water, which sinking through the underlying marine sands would erode in their indurated portions those remarkable vertical cylindrical pipes commented on and figured by Mr. Clement Reid.[3]

Whether, as suggested by Mr. Reid, this deposit will yield remains of Arctic plants or animals is problematical. No sign of life has as

[1] Geol. Mag., 1879, pp. 206–7.

[2] The terms for these beds in what may be styled the pre-glacial days of the Geological Survey seems to have been "Extraneous Rubbish" ("History of the Geological Society," p. 134).

[3] Geology of the Country near Newquay (Geol. Surv. Mem., Sheet 346), p. 67, pl. v.


MAP OF
TOWAN HEAD
&
NEWQUAY
Scale
¼ Mile
TOWAN HEAD
Cribbar Rocks
High Place
Pipe in Cirque
Shelter
Ruined Quay
Spy Cove
Boat Slip
Life Boat
Hedge Cove
Seal Hole
Nun Cove
Little Fistral
Headland Hotel
Post
Tea Caverns
Beacon Cove
Old Dane
Pigeon Cove
The Beacon
Atlantic Hotel
Sunny Corner
FISTRAL
BAY
NEWQUAY
BAY
Fly Cove
Tithy Cove
Slip Cove
HARBOUR
Fistral Beach
Low Water Mark
High Water Mark
Golf Course
FORE STREET
JUBILEE AVENUE
The Tower
The Island
Laundry
Pit
Great Toddy Cove
Little Toddy Cove

yet been extracted from it, whereas in the succeeding epoch molluscan life at all events was abundant, while man occupied the area.

It is usual to speak of these overlying latest deposits as 'blown sand.' This, however, is inaccurate: when investigated they prove to contain a large amount of soil, and are in reality composed of hill-wash with a large admixture of calcareous sand blown up off the beach. Consequently they may more correctly be termed 'hill-wash-dunes.' Of true 'blown sand' dunes there are a few examples in the lower part of the links near the road down to the beach and possibly a few towards the centre of that ground where less hill-wash would be brought down.

This dune period is divisible into two stages. An earlier layer present in the vicinity of the Headland Hotel, which is characterised by a molluscan fauna of a more woodland facies than that of the later period, and probably connotes a time when the sea had not re-excavated the bay to anything like its present extent. It is in this lower layer that the chief human remains occur. The later and more predominant hill-wash-dunes that overlie this suggest by their fossil contents the gradual coming on of the present open heath-like conditions and the nearer vicinity of the sea.

The first observer to give the correct reading of the sequence of these beds was Dr. H. S. Boase,[1] who is at great pains to point out the two series of sands, one above and the other below the 'head,' and he corrects De la Beche's error of considering the lower series with its consolidated portions to be blown sand. Dr. Boase's paper is worthy of more attention than it appears to have received: even Mr. Ussher has failed to notice this portion of his paper.

Turning to the actual sections and taking Fistral Bay first, we find in the northern angle of the bay (1 on the map, Plate II), next the Headland Hotel, as all along the bay, 1–2 feet of hill-wash surface soil. Under this there is 4 or 5 feet of 'head' resting in turn on the indurated old marine sands that pass down into the old pebble beach at the base; these two last having a total of 10 feet to the killas, of which all along the bay about 10 feet is exposed.

Proceeding southwards, the old marine sands become less indurated, while the pebble beach is less pronounced. About 50 yards south from the first point there has manifestly been some erosion of the old marine deposits and a corresponding thickening of the 'head,' the section showing from 4 to 5 feet of 'head,' then a sand seam 5 feet (which has nothing to do with the indurated series, though it may have been derived from the destruction of beds thereof that lie higher up on the slopes of the hills), and another layer of 'head' 3 feet thick, beneath which there is a trace only of the old sand and beach. This spot appears to represent the lowest point in the tideway of the old bay.

When the road down to the beach (2) is reached the 'head' is found to be only some 6–8 feet, resting on about 5 feet of the old beach, which here consists of layers of sand and pebbles passing down into the coarse pebbly beach at the base. Judging from his

[1] Trans. Roy. Geol. Soc. Cornwall, vol. iv (1832), pp. 468–9.

description, this must have been the section described by S. R. Pattison,[1] and the spot whence he obtained the shells identified by Crouch to be "*Modiola vulgaris*, *Cytherea chione*, *Patella*, *Ostrea*." It is, of course, impossible to pronounce definitely in the absence of the specimens themselves, but judging from what can be obtained on the spot to-day it seems more probable that the first two should read *Mytilus edulis* and *Venus verrucosa*.

By the path from the golf links to the beach (3) only about two feet of 'head' is to be seen resting on the old beach. The upper layers of the latter, which is altogether 5 feet in thickness, are far less pebbly than at the last section, while there is the usual coarse pebbly base.

Under the old lead-mine tip (4) the 'head' is very sandy and contains few of the characteristic angular fragments of rock, which come in again, however, a few yards further to the south, the old marine sands with pebble seams passing down into the bouldery base, while laterally they once more become indurated and stand out from the cliff face in miniature bluffs.

Still passing southward these indurated sands are seen to rise in places nearly as high as the top of the 'head,' while in others they appear to have been denuded, and the 'head' extends downwards till it attains as much as 10 feet in thickness.

Where the cliff rises towards the south end of the bay the 'head' is about 3 feet thick, while there is about 20 feet of indurated sand between it and the layer of coarse pebbles at the base.

In the southern angle of the bay, by the first path down (6), where the cliff is from 40 to 50 feet high, the indurated sands are last seen projecting out from among the talus about half-way up. Thence eastward along the East Pentire headland coastline no vestige of them was observed, the 'head,' as shown in the cliff lately scarped in the formation of a promenade, coming right down, full 30 feet in thickness, and resting at first on the old coarse pebble beach and afterwards on the killas itself.

Although all along the bay only about 2 feet of top stuff shows in the cliff face, there are plenty of hill-wash-dunes just inland containing abundance of shells belonging to the latest phase in their history. One of these (5), close to the edge of the cliffs near their highest point, has been cut into alongside the path and shows a section over 4 feet thick. An example of *Helix aspersa* occurred at 3 feet from the surface, and there were a few small fragments of *Mytilus*. A list of the shells obtained from this spot is given in the table at end. Nowhere were any traces observed of the older phase as in the more interesting sections close round the Headland Hotel, to which attention may now be directed.

Returning to the northern angle of the bay (A on the map), and proceeding westwards along the first promontory, the indurated sands of the old marine series are again observed, from 10 to 15 feet thick according to circumstances, since they rest on an irregular surface of killas to which, when the coarse pebbly base is wanting, they are

[1] Trans. Roy. Geol. Soc. Cornwall, vol. vii (1848), p. 50.

firmly adherent. At this point the vertical cylindrical piping begins to be noticeable. Over these sands there is 3 to 5 feet of 'head,' whose upper surface slopes westwards, and the western two-thirds of the promontory is capped by the remains of a big hill-wash-dune. The base of this is formed by the *Helix nemoralis* zone, as the earlier phase may be conveniently termed, and at first this is at the top of the cliff just under the surface soil.

Further on the later phase is represented.

At one point (*b*), viewed from the beach, it looks as if there were two layers of 'head' separated by a thick seam of sand. A close inspection, however, shows that the upper is a lenticular mass of remade 'head,' that had somehow been washed down from the higher ground behind and become incorporated in the upper part of the hill-wash-dune The section reads as follows:—

		ft.	in.
1.	Top soil with land shells (where it rests on 2)	1	0
2.	Lenticular mass of remade 'head': at its thickest	1	6
3.	Sand with few land shells...	2	0
4.	Shell seam with plentiful remains of *Mytilus*	0	2
5.	Sand with *Helix nemoralis*	1	0
6.	'Head.'		

Nearer the head of the promontory (B on map) the section is:—

		ft.	in.
1.	Sand with land shells	4	0
2.	Seam of numerous land shells	0	6
3.	Sand with few land shells thinning out eastwards and disappearing	0	9
4.	Seam of land shells with *Mytilus*...	0	4
5.	Sand with *Helix nemoralis*	1	6
6.	'Head.'		

More examples of *Littorina obtusata* were obtained from the upper sands here than at any other spot on the headland.

The end of the promontory itself is much stepped by slipping and weathering, the exposed margins of the hill-wash-dune bearing no relation to the mass of it that lies behind on the promontory itself.

Turning round the northern face and going towards the steps at C, the cut-away edge of a dune gives some 4 feet of sand with land shells, that is reduced to 2 feet at the steps. In neither spot, however, were traces of the *Helix nemoralis* zone observable.

At the head of the little cove, however, where the public path comes near the edge at D (see also Fig. 1), a little section of about a foot or so by the side of the path, where a dune is just cut into, shows masses of broken slate mixed at one point with sand and containing *Helix nemoralis* and other shells (see table at end).

Turning westwards again along the northern side of the cove, the 'head' is found at the top of the section, and just behind, inland, there is a large dune. Seawards the top of the 'head' slopes down again slightly, and the *Helix nemoralis* zone comes on with 1 foot or 1 ft. 6 in. of upper sands over it at the corner, E.

The next small piece of cliff is practically parallel with the sea front and about 50 yards in length. It affords almost, if not quite, the most interesting section in the district (Fig. 1). A big hill-wash-dune has been cut into, the highest point of which is towards the northern end (F), and the section is better read from north to south.

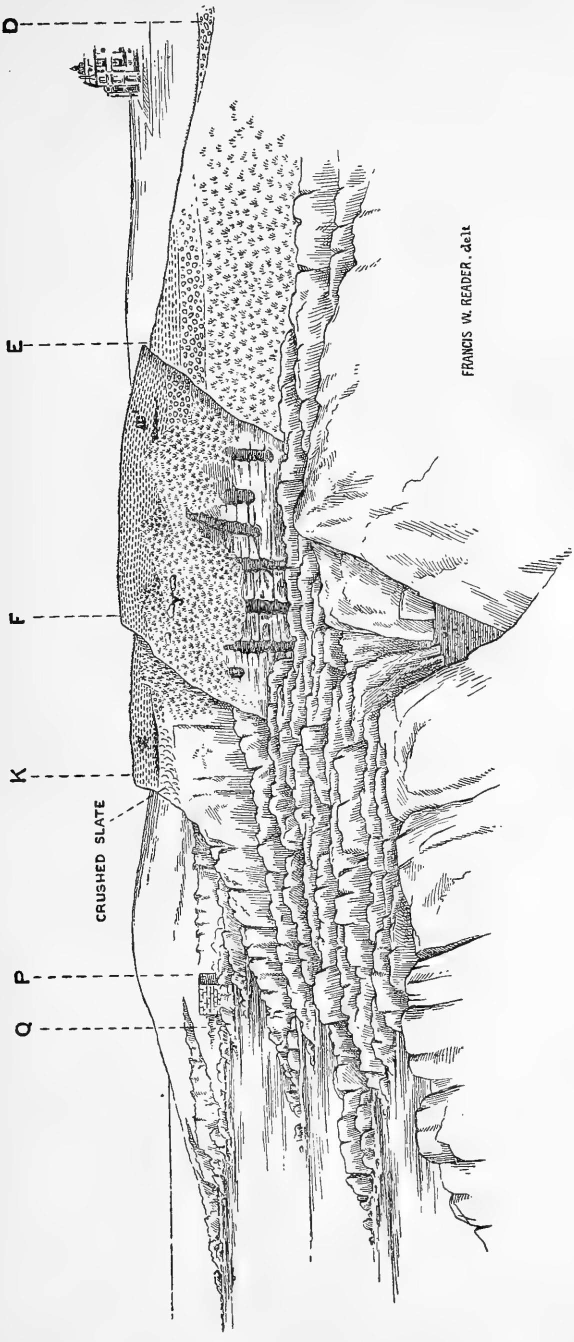


FIG. 1.—Diagrammatic view, from the point B on the Map, looking northwards, and showing the positions of the two prehistoric cooking sites (x, x') and the tabular masses of Indurated Sand in the *Helix nemoralis* zone at y, etc. The capital letters correspond to those on the Map, Plate II.

At the point F, then, helped by the return section shown between F and G, we find:—

		ft.	in.
1.	Very sandy top layer with land shells, resting on a thin seam of broken slates	1	0
2.	Darker sand (? peaty) with land shells	2	9
3.	Seam of land shells with some *Mytilus*	0	3
4.	Lighter sand with fewer shells	1	6
5.	*Mytilus* layer overlying a seam with land shells passing down into 6	0	6
6.	Sand with few shells, the basal portion being the *Helix nemoralis* zone	3	0

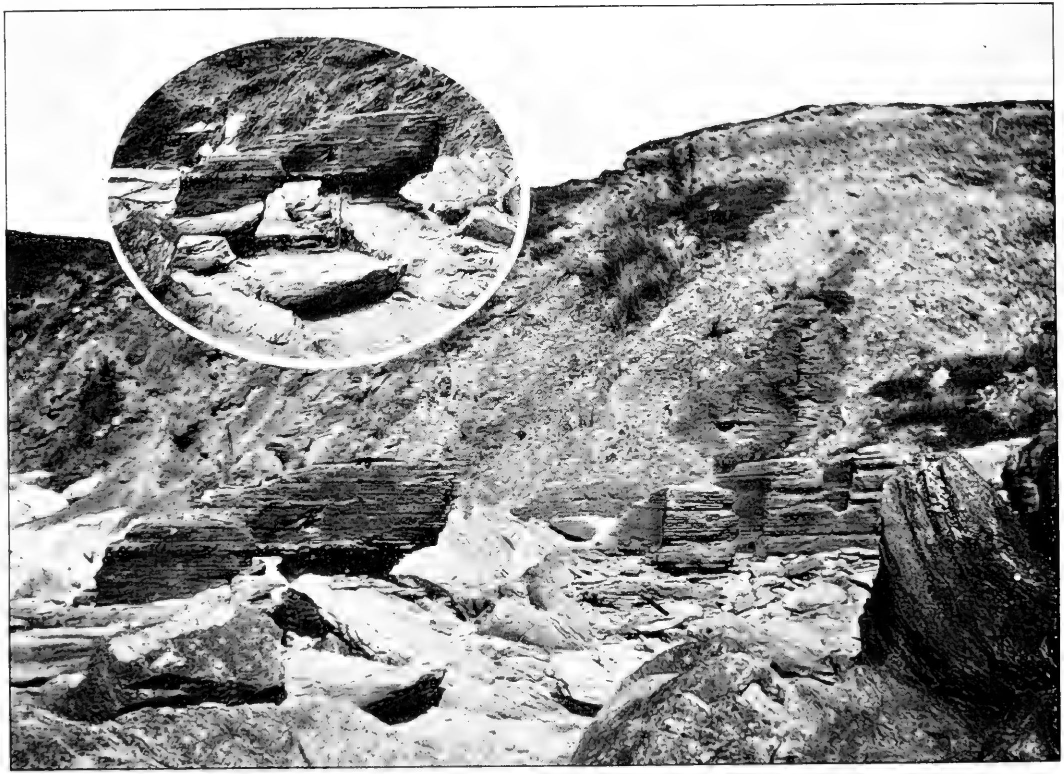
This last is obscured at the point F by talus. Projecting from the talus in several places for the first few yards southward of F is a sort of ledge (*y*, Fig. 1), which at a distance looks as if it were the top of the 'head.' Close inspection, however, shows that this layer consists of tabular masses of the indurated sands placed side by side and resting on the true *Helix nemoralis* zone, which is here of a reddish ochreous colour. Specimens of *Helix nemoralis* and *Pomatias elegans* were found beneath these sandstone masses, which are thus separated by the thickness of the *Helix nemoralis* zone and the whole of the 'head' from the parent rock. In view of the presence of other indications close by, and presently to be mentioned, of the existence of man on the spot at this period, one is constrained to believe that these tabular masses were carried up by man and arranged to form a sort of platform as flooring for a hut or some other purpose. A boulder about the size of a man's head also lay there and appeared to have been similarly carried up from the beach.

A few yards from F another slip obscures the section, and passing it it is seen that the lower *Mytilus* band has split into two, and so continues till at a point about midway in the length of the section the following reading was taken:—

		ft.	in.
1.	Top soil and sand with land shells	2	0
2.	Seam of numerous land shells and *Mytilus*	0	1
3.	Sand with land shells	1	3
4.	Thick seam of *Mytilus* shells	0	2
5.	Sand with land shells	0	9
6.	Seam of *Mytilus* with few land shells	0	1
7.	Sand with land shells, depth not seen.		

A few feet to the south, while the surface trends downward, the *Mytilus* bands rise in the dune, and the uppermost one dies out near the top, while the second and third nearly reach to it, re-unite, and then dip down again as they pass to the south. At this point the section is again obscured by grass-covered talus, and directly past this there is a most interesting section:—

		ft.	in.
1.	Sand with land shells	5	0
2.	*Mytilus* seam with *Patella* and land shells	0	3
3.	Seam of sand with few shells	0	6
4.	Blackened sand with charcoal and *Mytilus* shells	0	4
5.	Stones arranged to form a hearth	0	2
6.	More blackened sand and charcoal	0	3
7.	Broken slates arranged to form a rough hearth }	0	3
8.	Seam of *Mytilus* shells ... ... }		
9.	Sand with land shells (*Helix nemoralis* zone)	2	0
10.	'Head.'		



View at the Head of Nun Cove, showing weathered masses of the Indurated Sands (under point G and H on the Map).
The Inset gives a clearer view of the miniature arch.

Layers 4 to 8 (x' in Fig. 1) form the second of the two true kitchen middens mentioned by Mr. Warren. How far it extends northward could not be determined, since it passed behind the grass-covered talus slope. It appears to occupy a slight depression in the surface of the head. The discovery of a regular hearth is of interest, while the state of preservation of the whole is remarkable, the fragments of charcoal being as fresh as if newly burned. Besides *Mytilus*, shells of *Glycimeris* [= *Pectunculus*], *Patella*, and *Purpura* were found in it with a single burnt *Helix nemoralis* and three or four *Helicella barbara*. The latter must have been accidentally introduced among the embers, for they could not have served as articles of diet.

The two *Mytilus* layers of the kitchen midden speedily unite southwards, and at the point E blend with the upper layer (No. 2 of the section).

As Mr. Warren notes, the dune sands appear in places here to pass down into the 'head,' but this is probably a false rather than a true junction.

The return section from F to G into the next miniature cove to the north is practically the same as at the point F.

At G there is an easy way down to the beach, and at the foot of the descent the indurated sands are well seen, not only in the cliff, capped by the 'head,' but also in masses on the foreshore. These last are apparently the subject of Mr. Reid's plate v in his Survey Memoir on the Newquay district. They must, however, have suffered considerable further denudation since he photographed them, for he could not have failed to see and record the interesting miniature natural arch shown in the accompanying view most kindly taken for me by the Rev. A. E. Oldfield (Plate III). The illustration shows the old marine platform of killas with its boulder-strewn surface, and the way in which the old marine sands, when there is no coarse pebble bed at the base, fit in between and around the boulders and are firmly cemented to them, the layers preserving their horizontality everywhere as only water-deposited strata can do. Some of the curious vertical pipes in the indurated sands, partly cut through, are also conspicuous in the mass in front of the cliff.

Round the rest of the cove the 'head' comes nearly to the top of the cliff, and no dune deposits worth recording are seen till the northern point K is reached. Here the killas rises at the point to 2 ft. 6 in. from the surface, and is much broken and crushed at the top (see Fig. 1). From the point eastwards its surface is slightly depressed, and a little further on the 'head,' almost wanting at the very point, comes on and rises to about two feet from the surface.

The hill-wash-dune that caps the point gives at its thickest the following section:—

		ft.	in.
1.	Top soil with land shells, resting on a seam of broken slates ...	1	0
2.	Sand with a seam of pebbles at the base	0	9
3.	Sand	0	8
4.	Sand with land shells	0	6
5.	Sand	1	0
6.	Layer of closely packed *Mytilus* shells with fragments of slate	0	2
7.	Sand	0	6
8.	Masses of charred *Mytilus* shells, burnt earth, charcoal, and burnt stones (x in Fig. 1)	0	6
9.	Traces of 'head,' resting on killas.		

Layer No. 6 corresponds to the lower *Mytilus* band in the sections F to G and again at L. It is the upper kitchen midden of Mr. Warren, and contains some stones that appear to show the action of fire, but no burnt earth. Land shells occur plentifully just above, in, and immediately below it.

Both this band and No. 8 are limited in extent, covering about 9 feet. The latter much resembles the true kitchen midden at E, only no trace of a regular hearth is seen, and though quite as black when first dug out its contents, except the charcoal, dry paler. Besides *Mytilus* it yielded shells of *Patella* and *Purpura lapillus*, but no traces of land molluscs.

It is rather remarkable that no mention of these two interesting cooking sites is made in the Geological Survey Memoir, although Mr. Warren pointed out their existence three years before that work appeared. Judging, however, from the scant notice of Mr. Warren's paper, obviously inserted after the memoir had been written, the compiler not only was unacquainted with it at the time he visited the spot, but did not even make himself properly acquainted with it afterwards.

(To be concluded in our February Number.)

III.—The Sudbury Nickel-Ores.

By Professor A. P. Coleman, of the University of Toronto.

IN Professor Gregory's interesting presidential address contained in your journal for October, there is a reference to the origin of the Sudbury ores, in which he expresses the opinion that they were deposited from solution long after the first consolidation of the rocks with which they are associated. As the Sudbury ore deposits are perhaps the best examples in the world of the magmatic segregation of sulphide ores it seems a pity that the weight of Professor Gregory's authority should be given against the correct view. Probably he has not read the reports on the region by Dr. Barlow and myself in which incontrovertible proof of the magmatic origin of these ores has recently been given.[1] In the report prepared by myself it is shown that all the ore bodies are found at the lower edge of a laccolithic sheet of norite, blending upwards into micropegmatite, or on dike-like projections from this sheet. The laccolithic sheet is 37 miles long, 17 miles wide, and has dozens of ore bodies connected with its basic edge. The adjoining rock may be granite, gneiss, green schists, graywacke, etc., without affecting in any way the monotonous character of the ore. The ore bodies may contain fragments of the adjoining rocks and sometimes also of the norite, for some crushing and faulting has taken place; but everywhere the solid ore passes into pyrrhotite-norite, and then into norite spotted with blebs of ore. The sulphides have sharp boundaries against the adjoining rocks, but blend into the norite. The blebs of pyrrhotite may be found hundreds of yards from the ore bodies and completely enclosed in the norite with no fissure or

[1] Barlow, Ann. Rep. Geol. Surv. Canada, part II; Coleman, The Sudbury Nickel Field, Bur. Mines, Ontario, vol. xiv, part 3.

channel by which they could have reached that position by the aid of circulating water. The freshest norite of the region is found close to ore bodies and enclosing parts of the ore. Even so susceptible a mineral as hypersthene stands unchanged beside inclusions of pyrrhotite and chalcopyrite. In thin sections of the freshest specimens the sulphides are found embedded in original rock-forming minerals, such as hypersthene, augite, biotite, and even titaniferous magnetite, with no decomposition products between.

It is noteworthy that the ores, the heaviest parts of the original magma, everywhere occupy the lowest points in the eruptive sheet, bays projecting into the country rock, or long and sometimes interrupted offsets from the basic edge of the sheet, showing that gravity was an important segregative force. Even in the narrowest offsets, however, there is always some norite to show the connection with the main body of that rock.

Ore bodies never occur at a distance from the norite-micropegmatite sheet, and not one has been discovered elsewhere in northern Ontario after long and careful prospecting. That this eruptive mass was the source of the ore is evident, and it is equally evident that ore and rock reached their present position in a molten condition. It should be added, however, that a certain amount of later rearrangement of the sulphides has taken place, though there has not been sufficient water action to cause any banding or 'crustification' nor to introduce any appreciable amount of gangue minerals, such as quartz or calcite.

Practically every geologist who has visited the Sudbury ore deposits agrees with Dr. Barlow and myself as to their magmatic origin, and the only objections made to the theory have come from those who have studied specimens apart from their field relationships, or who have drawn inferences from the present arrangement of the ores as shown on polished surfaces. To determine the present arrangement of the ores throws very little light on their origin, for we are all agreed that a certain amount of solution and redeposition has gone on, especially in offset deposits, like the Copper Cliff mine. Any theory of original deposition of the ores from circulating waters must give a reason for the constant association of the ore with a single sheet of eruptive rock, for its presence only at the lowest points on its edge, for its blending upwards into the eruptive, and for the isolated blebs and masses enclosed in the fresh eruptive. All these relationships are easily explained by the magmatic theory, but very difficult to account for by any other.

IV.—Oceanic 'Deeps.'

By T. Mellard Reade, F.G.S., F.R.I.B.A., A.M.I.C.E.

One of the most characteristic features of the great oceans is the presence of what have been aptly termed 'deeps,' enormous depressions in the ocean bottoms. Having in my "Evolution of Earth Structure"[1] discussed their distribution and probable origin, I was

[1] Longmans, 1903.

naturally attracted by the notice in *Nature* of the surveys of the vessel "Edi" and the cable-ship "Stephan" during 1903 and 1905 in the western and south-western parts of the Pacific Ocean. Drs. G. Shott and P. Perlewitz, in a paper recently issued in the *Archiv der deutschen Seewarte*, taking into consideration previous work by U.S. ship "Hero" and of the German vessel "Planet," consider that these soundings throw a great deal of new light on the configuration of the sea bottom in those regions. They state that the troughs forming the deeps are usually about 10 miles wide, excepting the Guam deep, which is as much as 20 across. The most interesting statement to me is that in their opinion the troughs are the result of subsidence occurring on an enormous scale along lines of fracture, and that it is probable the *disturbances which produced these structures are comparatively recent.*

In p. 316, "Evolution of Earth Structure," I have said that the 'deeps' in "my view are produced by a *sagging* of the earth's crust similar to that which originated the Mediterranean basin," and further, "They may not be very old and necessarily more lasting than the deep basins in continental land such as the Black Sea and Lake Baikal."

It is pleasant to find that these later investigations by practical men tend to confirm my views and lead independently to similar conclusions, especially as the explanation involves the origin of other features of the sea bottom and the vexed question of the permanence of the larger features of the oceanic areas.

The narrowness of the troughs, if the figures are reliable, is striking, and points to vertical subsidence rather than lateral pressure. The subsidence in so narrow an area would doubtless be accompanied by fracture, but whether it is so or not we may legitimately infer, as I have done, that the originating cause is a local shrinkage of the magma under and beyond the area of the trough and deep down in or below the lithosphere.

The attainment of a reliable knowledge of the configuration of the ocean bed can only be of slow growth. Thanks largely to telegraph cable requirements, we have been adding to the facts in a fairly liberal manner of late years. Let us hope that the good work will continue notwithstanding the wireless phase of electrical development.

V.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

Introduction.

More than sixty years have now elapsed since the publication of the classical monograph of MM. Milne-Edwards and Jules Haime, "Les Polypes Fossiles des Terrains Palæozoïques." It can only be expected that many of the original descriptions of species in that work have for long been in need of amplification and revision. This applies with added force to the corals of the Carboniferous Limestone, in view of the impetus given to the palæontological study

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.

of that formation, by the vigorous revival of zonal work witnessed in the last few years. Those species in most urgent need of revision belong to the lower, or Tournaisian division of the Limestone, since their satisfactory determination affords a basis for evolutionary studies on the succeeding faunas, and an attempt is here made to deal with a few of these forms.

The great French actinologists were compelled, in the absence of opportunities for slicing and microscopic investigation, to confine their attention to the external characters of their specimens, assisted occasionally by such rough vertical sections as could be obtained by fracture. This also was the case in what appears to be the only authoritative re-description of their species, published in 1870 by M. de Koninck, in his well-known volume entitled "Nouvelles Recherches sur les Animaux Fossiles du Terrain Carbonifère de la Belgique." Indeed, in the introduction to that work, M. de Koninck expresses regret at his inability to take advantage of the newer methods of research then being inaugurated. The older authors were not enabled, therefore, to completely define their species; for obviously the internal, as well as the external, structures must be determined before an adequate idea of the nature and relationships of these corals can be gained. Indeed, of the two, the internal structures are the more important, since, until they are known, the meaning and value of the chief external feature, the calyx, cannot be duly appreciated.

For the elucidation of these internal structures, great use has been made, in the present investigation, of serial transverse sections. Such treatment is entirely necessary, if reliable conceptions on these points are to be gained; by this means the progressive changes occurring during the growth of the coral are ascertained, specific differences are more correctly gauged, and, most important of all, the phylogenetic nature of various structures realised. It is true that the exigencies of space can rarely permit of such sections being illustrated in their entirety; that is, indeed, the case in the present instance, but the results obtained can, at any rate, be embodied in the text.

For a re-description of species to be of any value, it is evident that if paratypes are not available (i.e. examples named by the authors themselves), then, at any rate, the specimens used should resemble the originals in nature and preservation as closely as possible, and should be derived from the same locality (i.e. they should be topotypes); these conditions are fulfilled in the present case.

The holotypes of the species to be immediately described were collected from Tournai and sent by de Koninck[1] to Milne-Edwards and Haime for description in their "Polypes Fossiles." In his own work (the "Nouvelles Recherches"), published thirty years later, de Koninck dealt with similar material from this locality, whence also the specimens on which the present account is based (the majority forming the Piret Collection at the British Museum) have also been derived. These corals are silicified; the exquisite preservation of most of their calices resembles that of recent corals far more than those of Palæozoic age.

[1] With the exception of Michelin's *Caninia cornucopiæ* and *Caninia cornu-bovis*, which, however, also came from Tournai.

The corals in the Piret Collection were first of all compared with those in the Musée Royale d'Histoire Naturelle at Brussels, to ensure their identity with de Koninck's figured specimens. A certain number were then cut, the transverse sections serially and at right angles to the axis of the coral, the vertical sections mostly down the centre of the cardinal fossula, a few also being cut in a vertical plane, between the fossular depressions.

Both internal and external characters of the various species being then known, it was possible to recognise and examine further examples in other collections, and make some notes on variation and distribution. These latter observations, however, cannot pretend to have any great value or completeness. Very much more work requires to be done before the zonal value of these small corals can be ascertained. The evidence at present available is so scanty, and the districts that have been thoroughly searched are so few, that it must be some time before definite conclusions on this point can be stated. Some general observation on the results so far attained will be found at the conclusion of the paper.

My indebtedness to many sources of information and assistance is great. First of all, my sincere thanks are due to the authorities at the British Museum (Natural History) for permission to examine and cut the very beautiful corals in the Piret Collection, and to the Geological Survey for facilities in the investigation; without such aid this work could not have been undertaken. I also wish to thank MM. Dupont and Rutot, of the Musée Royale d'Histoire Naturelle, Brussels, for their courtesy in allowing me to examine the collections there preserved.

It is hardly possible to adequately acknowledge the kindness of Dr. A. Vaughan in allowing me to make the freest use of his extensive collections from the Bristol district, for a constant supply of fresh material, and for the most generous and ungrudging assistance throughout. I am also indebted to Dr. Matley and Dr. Vaughan for material from the Rush area (co. Dublin), and similarly to Professor E. J. Garwood, and to the members of the Yorkshire Geological Society, for material collected in the Arnside and Colne–Clitheroe districts respectively. Finally, I wish to sincerely thank the Trustees of the Sladen Fund for a grant in furtherance of this work, without which the accompanying illustrations could not have been so numerous or complete.

Septal Formation and Terminology.

Before proceeding to the description of the species, it may be of assistance to the general reader that attention should here be drawn to the peculiar mode of septal formation, so characteristic of Rugose corals, since an acquaintance with the facts concerned explains many difficulties and apparent anomalies met with during an examination of these corals, especially with regard to the fossulæ.

As it was not till 1870 that Kunth[1] first established his law of growth, many years after the appearance of MM. Milne-Edwards and

[1] Zeit. Deut. Geol. Ges., vol. xxi (1869).

Haime's publications, and as these latter still remain to many English readers the chief work on Palæozoic corals, it must be said that, although found in the larger palæontological textbooks, Kunth's work has not, perhaps, received in this country the attention it deserves. According to this law, the insertion of new septa in a Rugose coral takes place at three points in the circumference of the corallum, approximately 80° apart, the chief of these being at the *cardinal septum,* with the remaining two points on each side at the *alar septa.* New septa are successively added on each side of the cardinal septum, the youngest being always next to that septum. On one side only of each of the two alar septa new septa are also added, the youngest always next to those septa, on the side remote from the cardinal septum. Since these young septa are necessarily short, there is consequently, in transverse sections, a break in the grouping of the septa at each of these three points. These breaks form the *fossulæ,* the largest being naturally at the cardinal septum; this is called the *cardinal fossula,* or more simply '*the fossula.*' The other two breaks, comparatively inconspicuous, are similarly referred to as the '*alar fossulæ.*' Occasionally a fourth fossula is developed immediately opposite the cardinal septum, and is called, from the primary septum dividing it, the *counter fossula.* No new septa are ever developed here, although the minor septa flanking the counter septum are occasionally more elongated than the others. These fossulæ are further marked by depressions of the tabulæ, varying in degree in different specimens.

The development of new septa according to Kunth's law may also be seen on the exterior of any rugose coral with good longitudinal ribbing, since each alternate groove corresponds to the position of a major septum; in any case, the arrangement can be seen on removing the epitheca by acid or filing, so as to display the septa within.

Fig. 1.

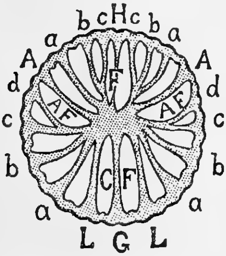


Fig. 2.

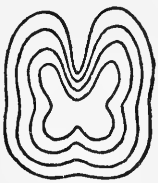


Fig. 1, Diagram A.—Transverse section of *Zaphrentis omaliusi.* Primary septa: H, cardinal septum; G, counter septum; A, A, alar septa; L, L, counter-lateral septa. a–c, the remaining major septa are lettered in the order of their formation. The minor septa are indicated by the ridges at the bases of the interseptal chambers. F, cardinal fossula; A–F, A–F, alar fossulæ; C–F, counter fossula.

Fig. 2, Diagram B.—Tabula of *Z. omaliusi,* represented by contours (after Vaughan). The deep depression is at the cardinal fossula, the three smaller ones at the alar and counter fossulæ. (See *infra,* p. 26.)

A diagram, Fig. 1, is appended as a key to the terminology used in this paper. In this connection the work of Kunth is followed, with two exceptions. The first, not of any importance for our present purpose, is the recognition of two more primary septa (the *counter-lateral* septa) in addition to the four enumerated by the German author. The second point concerns us more nearly. Previously most figures of the calyx and of cross-sections of rugose corals were so arranged that the cardinal fossula, if it occurred on the convex side of curvature of the coral, was shown on the upper side of the figure; if, on the other hand, the cardinal fossula occurred on the concave side of the coral, it was shown on the lower side of the figure. In the illustrations accompanying the present paper the cardinal fossula is in all cases shown on the upper side of the figure, since it is believed that recent work [1] enables us to extend to rugose corals the orientation adopted by common consent for other Anthozoa.

The terms 'major' and 'minor' septa are here used instead of the commoner terms 'primary' and 'secondary.' Since only the first six septa to be developed can properly be regarded as primary, the small intermediate septa should, if the common nomenclature be retained, be called tertiary septa, as has indeed been sometimes done. To avoid any confusion, it seems better to adopt some non-committal terms for the long septa and their intermediates, and therefore the terms 'major' and 'minor' septa are here used.

Genus ZAPHRENTIS, Rafinesque & Clifford.

Corallum simple, turbinate, conical or cylindro-conical, usually more or less curved. *Major septa* well developed, reaching quite, or very nearly, to the centre of the corallum. *Minor septa* may or may not be present; they are usually short. No columella is developed.

The conspicuous *cardinal fossula* is variable in position, and is completely enclosed and surrounded by septa, which fold round and form its walls. The *tabulæ*, though variable in character, are always a prominent feature, and are in direct connection with the wall; convex vesicles may arise on their upper surfaces, especially towards the circumference of the corallum; but these never assume a vertical alignment, and consequently in no case is there any trace of an external dissepimental zone of the nature of that found in *Campophyllum* and similar genera.

The above definition of the genus *Zaphrentis* is largely taken from that given by Messrs. Nicholson & Thomson (Ann. & Mag. Nat. Hist., ser. IV, vol. xvi, 1875, p. 426). In that article the nature of the cardinal fossula is for the first time regarded as "a character of primary importance in the definition of the genus." A restriction of this kind is necessary if the genus is not to attain unwieldy proportions, and although the above definition does not pretend to be founded on the specimens from which the original diagnosis was prepared, it undoubtedly represents the genus as understood at the present time. I have been unable to gather from the original description of MM. Rafinesque and Clifford any clear idea as to the nature of their specimens, and for the present, therefore, have retained the conventional definition in common use.

[1] Ann. & Mag. Nat. Hist., ser. VII, vol. xviii (1906), p. 362.

Zaphrentis omaliusi, M.-Ed. & H. (Plate IV, Figs. 1–4.)[1]

1851. *Zaphrentis omaliusi*, M.-Edwards & Haime: Pol. Foss. d. Terr. Pal., p. 337, pl. v, figs. 3, 3*a*.
1860. ,, ,, M.-Edwards: Hist. Nat. d. Corall., t. iii, p. 344.
1861. ,, ,, de Fromentel: Int. à l'et. polyp. foss., p. 289.
1872. ,, ,, de Koninck: Nouv. Recher. sur Anim. Foss. d. Terr. Carb. d. l. Belg., p. 94, pl. ix, figs. 4, 4*a*.
Hadrophyllum Edwardsianum, ibid., p. 52, pl. iv, figs. 2, 2*a*.
1905. *Zaphrentis* aff. *Phillipsi* (pars), Vaughan: Q.J.G.S., vol. lxi, p. 269, pl. xxii, figs. 2*c–e*.

External Characters.

Corallum gently curved and conical, in the adult portion much less so, sometimes becoming almost cylindrical. There is longitudinal ribbing on the epitheca, more strongly marked towards the tip of the coral; round the calyx this may be supplemented by fine annular striations (Pl. IV, Fig. 2). Slight constrictions of growth are present, but 'rejuvenescence,' in the sense of an interruption in the continuity of the epitheca, never occurs. Excellent figures are given both by Milne-Edwards & Haime and by de Koninck.

Calyx deep, with abruptly descending sides. In young specimens a quadrate division of the septa within is well seen, four fossulæ being visible (*Hadrophyllum Edwardsianum*, de Kon.), but in the adult the septa usually have a very radial arrangement, with only one break, due to the shortness of the cardinal septum. Frequently, however, both cardinal and counter fossulæ are visible even in the adult; the former always lies on the convex side of curvature of the corallum. A good figure is given by Milne-Edwards & Haime. That of de Koninck is poor in perspective.

The *major septa* are strong, reaching to the centre of the calicinal floor, where they are slightly flexuous, thickened, and fused together, though still distinct from each other. They taper quite gradually up to the rim of the calyx.

The *minor septa* are entirely rudimentary, only appearing as low ridges between the thickened bases of the major septa.

Average dimensions.

Height of an adult specimen, 2–3 cm.; diameter of calicinal rim, 1·2–1·5 cm.; depth of calyx, 1–1·3 cm.

Internal Characters.

(a) *Transverse Sections.*—The disposition of the *major septa* is far more readily seen in cross sections than in the calyx. They are seen to characteristically possess a curvature concave to the cardinal fossula. In sections across the adult portions of a corallum this curvature is sometimes not so marked, and occasionally a certain number of the septa may even be bent in the opposite direction for a portion of their length (Pl. IV, Fig. 4). The lobing and close interfusion of their inner ends gives rise to a dense mass in the centre of the section. This feature is not constant, however; examples may be found where the septal ends are not thickened and only join in the very centre of the coral.

The rudimentary *minor septa* only appear in sections across the

[1] Plates IV and V will appear in February.

adult portions of a corallum; they are never well developed, and are often barely perceptible.

The *cardinal fossula* is very generally a marked feature. Always completely surrounded by the major septa, in the lower part of the coral, it is broad and expanded at the inner end, but has a tendency to narrow higher up in the corallum, and though in typical examples a slight expansion of the central part is retained up to the floor of the calyx (Pl. IV, Figs. 1 and 4), continuous narrowing usually sets in beyond that point. The cardinal septum completely divides this fossula almost to the floor of the calyx, but latterly becomes much thinner than its neighbours. In extent the cardinal fossula never seems to reach beyond the centre of the coral, and usually falls short of it, often to a considerable degree; it would appear that sections cut across the more strongly curved parts of the coral show a short, broad fossula, and *vice versâ*.

A common and remarkable feature is the development of a *counter fossula* through a slight enlargement of the two interseptal chambers on each side of the counter septum. This character is almost always present in some degree in the young stage of growth of a normal example of the species (Pl. IV, Figs. 1*a* and 4*a*), and is often persistent throughout. This counter fossula is proportionately longer than the cardinal fossula, but, unlike the latter, of course never shows any appearance of young septa at its base. The counter septum may be either longer or shorter than its neighbours; when longer it is usually more markedly lobed at its inner end, thus approaching the distinctive character of the genus *Lophophyllum* (Pl. IV, Fig. 1*a*).

There is a tendency for the septa in each of the four quadrants to fuse together at their inner ends, the fused ends meeting in the centre of the coral. From this tendency arises the prominence of the fossulæ.

Dr. Vaughan's best figure is 2*e* (see Q.J.G.S., 1905, p. 269, pl. xxii).

(b) *Vertical Sections.*—The arched *tabulæ*, with their convex upper surfaces, are of an essentially simple type. They lie from 1 to 2 mm. apart, having depressions at each of the fossulæ, the extent of these depressions varying with the degree of development of the fossulæ. This being the case, the appearance of the tabulæ varies according to the direction of the section. Consequently, their nature is more clearly shown, not by the usual vertical section, but by a contoured figure of one of their number, as has been done by Dr. Vaughan, with whose kind permission the accompanying text-figure is reproduced. (See *ante*, p. 23, Fig. 2.)

Localities.

Millstone Grit: Greenfoot Quarry, near Glenboig, Lanarkshire (rare).

Upper (?) Visean: Hollins Delf, and other quarries near Colne; Horrocksford Quarry, near Clitheroe (D ?).

Tournaisian: Big Weston Wood Quarry, Portishead, near Bristol, Clevedon, Failand, Woodspring (Weston), and other localities in the Z_2 subzone of the South-Western Province; Burrington, near Bristol (Z_1 subzone, rare); Rush Slates, co. Dublin (especially R 4 *a*, the position of which is given in Q.J.G.S., 1906, p. 276, fig. 1).

Remarks.

Under the name of *Hadrophyllum Edwardsianum*, de Koninck described (Nouv. Recher., p. 52, pl. iv, figs. 2, 2*a*), in my opinion, a young specimen of *Z. omaliusi*. He carefully described the strongly quadrate arrangement of the septa in the calyx, and the development of a counter fossula (on account of the latter character he referred the specimen to the genus *Hadrophyllum*), features which are seen to be characteristic of the young stages of growth of *Z. omaliusi*, though obscured in adult calices, and I have no hesitation in referring the specimen to that species. An examination of his figured specimen showed that it was much weathered; to this fact the unusual depth of the epithecal ribbing is due, as also the presence of a small median groove down the centre of each of the ribs, a fact to which de Koninck drew attention in his description. This latter character is not, however, of any specific value, but may be found in any much weathered Zaphrentid corals.

Z. omaliusi can, as a rule, be readily separated from other Zaphrentids. *Z. phillipsi*, M.-Ed. & H., has a certain resemblance, but according to the authors' account possesses very thin major septa, with a curvature (according to the figure in the "British Fossil Corals," pl. xxxiv, fig. 2*b*) convex, instead of concave, to the large fossula, which also has a long dividing septum in the calyx. Radical differences are also shown in the epitheca, which in *Z. phillipsi* does not seem to have longitudinal ribbing, and above all is frequently so affected by rejuvenescence as to have its continuity interrupted (see Polyp. Foss. d. Terr. Pal., pl. v, fig. 1). The differences from *Z. delanouei* will be referred to presently when dealing with that species.

Some resemblance to *Z. omaliusi* is occasionally displayed in the calyx of a young specimen of *Caninia cornucopiæ*, Mich. (*non* M.-Ed. & H.). But besides other differences the fossula in this latter species is deeper and longer, and in transverse sections is seen to be of a totally different character, being open at its inner end with the flanking septa usually disconnected, while in transverse sections the septa in the two cardinal quadrants are always affected by accessory thickening, a feature never seen in *L. omaliusi*.

With the exception of the two varieties to be immediately described the nearest corals to *Z. omaliusi* seem to be Densiphyllids, especially *D. charlestonensis*, Thom. These are, however, fundamentally distinguished by the possession of a most inconspicuous cardinal fossula, narrowing continuously to the centre of the corallum, and the major septa are almost purely radial in disposition, altogether lacking the characteristic curvature of those in *Z. omaliusi*.

Distribution.

The species seems quite local in its occurrence. Dr. Vaughan has kindly supplied an account of its distribution in the South-Western Province, but as it will be more convenient to insert these notes after the description of *Z. delanouei*, it is sufficient to mention that in that region *Z. omaliusi* attains its maximum in the Upper Tournaisian subzone Z_2, while it is again common in the Upper Tournaisian Rush

Slates of co. Dublin, correlated by Dr. Vaughan with subzone Z_2. But in other areas the species is found on different horizons. For instance, in the Colne–Clitheroe district it is found in limestones very probably of Upper Visean age, and is there rather common and quite typically developed. Again, in Scotland good examples seem very rare, but almost the only specimens yet obtained were found in the Millstone Grit near Glenboig, in a band of cement lying not far below the junction of the Upper and Lower Carboniferous floras. Nevertheless, no really typical examples have so far been found in the underlying and richly fossiliferous Lower Limestone group (Visean) and not one in the Tournaisian Cement Stones, where other small Zaphrentids are not uncommon in certain localities.

With the evidence at present before us the conclusion seems justifiable, therefore, that *Z. omaliusi* has an extensive vertical range, but may be locally confined to definite horizons.

Zaphrentis omaliusi, var. *ambigua*, var. nov. (Plate IV, Figs. 5 and 6.)

External Characters.

Dr. Vaughan has noticed the occurrence of this variety in the Rush Slates, and has drawn attention to the chief distinction from the Rush Zaphrentids (see Q.J.G.S., vol. lxii, 1906, p. 314, first paragraph on "variants of the Rush *Zaphrentis*").

Corallum similar in shape and external ornamentation to *Z. omaliusi*. The *calyx* is also similar to that seen in *Z. omaliusi*, save for the large size of the *counter fossula* lying on the concave side of curvature of the coral.

Internal Characters.

(a) *Transverse Sections.*—The chief characteristic of this variety is at once seen to lie in the *counter fossula*. This is developed to an extraordinary degree, more so than in any coral with which I am acquainted. Though initially small, for sections taken near the tip of the coral are essentially the same as similar ones in the normal species (compare Fig. 5*a* with Fig. 1*a*, Pl. IV), this counter fossula becomes increasingly apparent during the growth of the coral. The two septa forming the sides become more or less parallel, and in the final stages of growth an expansion occurs at the inner end, varying in degree with different specimens, and giving, in sections cut just under the calyx of an adult, a broad club-shaped outline to the counter fossula (Pl. IV, Fig. 6). The counter septum extends down the centre of this fossula throughout, and never becomes shortened to any appreciable extent, even in the calyx itself.

The *cardinal fossula*, on the other hand, is comparatively small and inconspicuous. The septa forming the sides also show a tendency to parallelism, though this appearance is naturally modified if the section happens to show the incoming of new septa (a feature never seen in the counter fossula).

In accordance with the extreme development of the counter fossula, the fusion of the septa of each of the four quadrants is very marked, and takes place further from the centre than in the normal species;

the fused ends meet in the centre of the coral. Apart from this fact the septa are certainly less flexuous and more uniformly curved than in the normal species.

A majority of the specimens I have examined also show decidedly thinner, and sometimes more closely packed, septa than in *Z. omaliusi.* This does not, however, seem at present to be a character of any great value. Exceptions certainly exist with strong septa fusing to a dense mass in the centre of the coral.

(b) *Vertical Sections.*—As in *Z. omaliusi,* though the depression of the tabulæ at the counter fossula is proportionately greater.

Localities.

Upper (?) Visean: Horrocksford Quarry, Clitheroe (common).
Tournaisian: Rush Slates (R 4 *a*, R 8 *a*, and especially R 6 *b*, for position of which see Q.J.G.S., vol. lxii (1906), p. 276, fig. 1).

Remarks.

The differentiation of this variety from *Z. omaliusi,* lying chiefly in the character of the cardinal and counter fossulæ, has been sufficiently dealt with in the foregoing description. In the possession of a prominent fossula, divided even in the calyx by a long septum, *Z. omaliusi,* var. *ambigua* resembles *Z. phillipsi,* as described by Milne-Edwards & Haime; but the latter has its prominent fossula on the convex instead of the concave side of the corallum, while the epithecal characters are very different. It also seems probable that the prominent fossula of *Z. phillipsi* is a cardinal rather than a counter fossula, and the same distinction immediately separates *Z. delanouei* from *Z. omaliusi,* var. *ambigua,* to which it otherwise has a great resemblance.

At both of the known localities the variety is found in association with normal examples of *Z. omaliusi,* and although the two are easily separable in typical examples they are united by intermediate forms whose reference to one or the other of the two corals is often no easy matter; and, indeed, it will be seen on comparing Figs. 1*a* and 5*a* on Pl. IV that the young stages of the species and its variety are essentially identical.

Distribution.

I am at present acquainted with only two localities for this curious variety. These seem, however, to lie on very different horizons. That in the Rush Slates has been correlated by Dr. Vaughan with the Upper Tournaisian subzone Z_2 of the South-Western Province. The other locality is Horrocksford Quarry, Clitheroe, where examples are abundant in certain shaly partings between beds of massive limestone containing a brachiopod fauna, indicating, according to Dr. Wheelton Hind, an Upper Visean horizon somewhere about the base of D or the top of S. These correlations, therefore, if correct, indicate a considerable vertical range for the coral.

Z. OMALIUSI, var. *DENSA*, var. nov. (Plate IV, Figs. 7 and 8.)

Shape, dimensions, and *epithecal characters* as in *Z. omaliusi.* The *calyx* also is very similar, save that the radial disposition of the septa is more pronounced, the *cardinal fossula* only being denoted by the shortness of the cardinal septum.

In *transverse sections* the distinctive characters of the variety are well expressed. Here the curvature of the *major septa* is seen to be extremely even and regular throughout. The counter septum and its neighbours are prominent, being generally longer (Pl. IV, Figs. 7, 7*a*), though sometimes shorter (Pl. IV, Fig. 8) than the rest. Nevertheless, the interseptal chambers on each side of the counter septum rarely enlarge to form a counter fossula, though one, or both, may be so elongated as to reach the centre of the dense mass of fused septa lying in the centre of the corallum; this dense central area is of somewhat greater size than that observed in *Z. omaliusi*.

The inconspicuous *cardinal fossula* has a characteristic shape, narrowing inwardly, instead of slightly expanding as it does in the normal species. This occurs even in the young stages of growth, though sometimes masked by the insertion of young major septa.

Vertical sections show that the *tabulæ* are essentially of the same simple type as those in the normal species, but there is only one depression on their surfaces, corresponding to the single fossula usually present in this variety.

Localities.

Upper Visean: Crosshouse (Lower Limestone Group of Scotland) (D); Thornton and other quarries near Colne, Lancashire (D ?); Warsaw Knoll, near Clitheroe (D ?); middle and upper part of horizon Y, Burrington, Mendips.

Tournaisian: Big Weston Wood Quarry, Portishead, near Bristol (Z_2 subzone), very rare; coast at Malahide, co. Dublin (loc. I), and Rush Slates, R 4 *a*, R 6 *a*, and R 8 *a*.

Remarks.

The points of difference between this variety and *Z. omaliusi* proper are certainly not great. Nevertheless, these differences are so constant and are so readily detected in a hand-specimen that in my opinion they clearly merit varietal distinction. The variety forms an intermediate link between *Z. omaliusi* and Densiphyllids of the type of *D. charlestonensis*, Thom.[1] When the septal curvature is but slightly developed it becomes a most difficult and often, so far as I can see, an impossible matter to separate the two corals. Such cases must, however, be expected in dealing with considerable assemblages of similar forms.

It is tempting to suppose that *Z. omaliusi*, *Z. omaliusi* var *densa*, and *D. charlestonensis* represent so many stages in one line of evolution, more especially when it is remembered that in the Bristol district var. *densa* is chiefly found just above the maximum of *Z. omaliusi*, and *D. charlestonensis* occurs much higher up in D_2–D_3 of the neighbouring district of the Gower and Oystermouth, and is common on a probably similar horizon in Scotland and is again found in the shales overlying the Derbyshire Limestone. Nevertheless,

[1] J. Thomson, "Corals Carb. Syst. Scot.": Proc. Phil. Soc. Glasgow, p. 152, pl. vi, figs. 21, 22, etc. (1883).

when other areas are examined difficulties present themselves. For in the Colne–Clitheroe district, in limestones which at present we have every reason to regard as lying in the Upper Visean or D zone, we find *Z. omaliusi* and especially *Z. omaliusi*, var. *densa*, freely developed, and *D. charlestonensis* scarce, although from the above line of reasoning it might be expected that the latter would easily be the dominant form. And, further, in the Cement Stones (Tournaisian) of Liddisdale, where *Z. delanouei* is so (comparatively) abundant, only one of these corals has so far been found, and that, contrary to expectation, is an undoubted *D. charlestonensis*. It may be said that the evolution from *Z. omaliusi* was accelerated or retarded, as the case may be, in various districts. Such an hypothesis would certainly present an easy way out of the difficulty, though not a very acceptable one to the zonal investigator. All we can say at present is that while there can be no doubt of the genetic affinity of *Z. omaliusi* and *Z. omaliusi*, var. *densa*, on the other hand it is not certain that the affinity extends to *D. charlestonensis*, the latter being possibly a homœomorphic form.

(*To be concluded in our next Number.*)

VI.—Facts observed by Lieut. Damant, R.N., at the Sea-bottom.

By Arthur R. Hunt, M.A., F.G.S.

TAKING into consideration the apparently hopeless tangle in which the ripplemark and submarine erosion questions had become involved, I submitted to the Devonshire Association in July last a paper entitled "The Ripplemark Controversy," in which I attempted to bequeath the subject to posterity in such a form that anyone interested in the enquiry could pick it up where it had been dropped. It was, at any rate, my own farewell, or was so intended to be.

Last summer, however, in the progress of night manœuvres, the torpedo boat No. 99 was—fortunately, in the interests of science—sunk in 25 fathoms off Torbay. The vessel was recovered, and beached in Torbay. My curiosity was excited as to whether the divers could elucidate any of the submarine problems; but naturally, men only incidentally employed about the salvage could give me no information, and I hesitated to trouble the officers, besides being uncertain to whom I might apply. However, when Lieut. Damant, R.N., was appointed as a special officer to instruct divers, and as I knew he had been engaged in the salvage of No. 99, I finally deicded to lay the case before him. The result has been that, instead of my taking leave of ripplemark and the physics of the sea-floor, ripplemark has abruptly taken leave of me.

Lieut. Damant has scarcely appreciated the importance of his evidence, and as he has never contemplated publishing anything on the subject, I am going to ask the hospitality of the Geological Magazine to secure for our distinguished diver national priority for his observations.

I may observe that in the Blue-book on Marine Erosion, just published, Mr. Aubrey Strahan, on being requested to furnish information on submarine disturbance, could find nothing better than two conflicting authorities, derived, one from an old provincial paper of my own, and the other from "The Sea Coast" of my friend Mr. W. H. Wheeler, M. Inst. C. E.

Mr. Wheeler declares that "when there is considerable wave-motion on the surface of the sea at a depth at which divers are able to work the water is found to be motionless" ("The Sea Coast," p. 15). But he further asserts that "wind-wave action extends a very little way below the surface" (Coast Erosion, Question 4290). The formula given me by Lord Rayleigh, in the paper referred to, enables anyone to calculate what submarine disturbance is caused by any wave of known dimensions, and the depth to which it extends. I have myself been collecting information on this general subject since 1871, and have often pointed out the apparent certainty that the bottom down to about 50 fathoms must be appreciably disturbed by wave-currents if the records of the lengths and heights of waves are correct. My own collected evidence stopped short at a sounding which by the chart is somewhere between 36 and 41 fathoms. The evidence was a rolled and partially incrusted soda-water bottle, which was exhibited to Section C at Southampton in 1882, and has since been exhibited at a professional meeting of engineers to illustrate a professional paper.

The facts on which I have chiefly insisted have been the influence of alternate wave-currents on the marine fauna, and on erosion and deposition; also the independent and combined effects of tidal currents. My arguments were necessarily based on experiment, on sea and river observation, and on the authority of physicists. As Lieut. Damant has been down to 35 fathoms, and assures me that there is no difficulty in 30 fathoms, the physics of the shallow seas will obviously become a subject of ordinary observation, freed from the perils of induction, speculation, and conjecture. As a matter of fact, my own work of 36 years has been superannuated before it has even been accepted as sound. The following observations tell their own tale:—

"H.M.S. 'Excellent,' Portsmouth.

"I have seen sharp, well-defined ripplemarks upon sand at from 8 to 10 fathoms . . . .

"On the theory of the adaptation of certain gasteropodous shells in shape and arrangement of spines to a form difficult to capsize on a flat surface being due to the necessity of providing against fairly violent water movements, I have often watched the state of affairs down below; a gentle rhythmical swaying movement (in the vertical plane) of shreds of weed, sprigs of polyzoa on stones, and the flexible tubes of various worms is always noticeable at 12 fathoms and perhaps more. . . . (Signed) "G. C. C. Damant.

"*12th October*, 1907."

"H.M.S. 'Excellent,' Portsmouth.

". . . . the tide on the bottom certainly is not a steady horizontal sweep; it seems to come curling and twisting along in 'gusts,' but this is only an impression. When hanging on, prone on the bottom to prevent being swept away by a too strong tide, one is accustomed to hear the sharp pattering on one's helmet of a regular hailstorm of shingle and *small* stones; this is not continuous, but occasionally gusts of it come along, probably associated with upward currents.

"In Loch Striven, a deep narrow inlet on west coast of Scotland, near Kyles of Bute, specially chosen for deep diving experiments owing to the absence of perceptible tide, I found impalpable mud, not 'set' but almost in suspension on the bottom at 35 fathoms. It flew up in a cloud when one set foot on the ground, and altogether cut off what little light there was. (Signed) "G. C. C. DAMANT.

"*27th November*, 1907."

"Island Sailing Club, Cowes.

". . . Yes, I and another, a gunner, went down to 35 fathoms as a maximum at Loch Striven. I have often been at 30. . . .

"The sand round No. 99 torpedo boat the other day—you know where she lay—seemed utterly bare and lifeless. I saw one 'whelk,' and he looked absurdly lonely. . . .

". . . on that occasion of seeing ripplemarks in sand at about 12 fathoms, I remember being very much struck by the isolated chunks of rock, of about 10 lbs. I should judge, with weed on them, which stood on, rather than stuck up out of, the sand. There was a fair sea on, too much for our targets to stand. . . . shot were to be seen *on* the bottom, but, of course, they may have only just been fired. (Signed) "G. C. C. DAMANT.

"*29th November*, 1907."

In these conversational records of incidental observations Lieutenant Damant has unconsciously decided some hotly debated questions, and suggested several topics that might occupy the minds of physicists, geologists, zoologists, and engineers. My own feelings may be better imagined than described. They are analogous with what, I presume, those of an astronomer would be who had chanced upon a celestial visitant from comet and nebula, who just incidentally mentioned all the facts concerning those bodies which had perplexed and divided astronomers for generations. What has greatly astonished myself is that Lieut. Damant's attention should have been called to some of my own special puzzles, e.g. that of blocks lying on sand. Blocks of half a ton or more lie on the sandy bed of the English Channel off the coast of South Devon, and the trawlers occasionally take them in their nets. (See an example in the Museum of the Torquay Natural History Society.)

I should esteem it a great favour if this article were published, for otherwise the foreigners are sure to cut us all out, as they did in the case of the evidence of Kent's Cavern and the Antiquity of Man. That great fact was decisively proved in 1846 by the Torquay Natural History Society, following up the earlier researches of the Rev. J. McEnery, but the report of the explorers could find no publication except in the columns of a local visitors' directory, of which publication, I believe, there are but two copies in existence, though I have reprinted the report at my own charges.

So far as I can at present see, Lieut. Damant's observations have confirmed rather than disproved induction by tank and formula.

REVIEWS.

I.—Royal Commission on Coast Erosion.

Minutes of Evidence and Appendices thereto accompanying the First Report of the Royal Commission appointed to inquire into and to report on certain questions affecting Coast Erosion and the Reclamation of Tidal Lands in the United Kingdom. Vol. i, parts 1 and 2. 1907.

THE Commission was appointed on July 9th, 1906, and its first meeting was held on July 24th. The members comprise the Hon. Ivor C. Guest, M.P. (Chairman), Sir William H. B. ffolkes, Bart., Sir Leonard Lyell, Bart., Sir William Matthews, K.C.M.G., W. P. Beale, Esq., K.C., M.P., F.G.S., Commander G. C. Frederic, R.N., H. Rider Haggard, Esq., Professor T. J. Jehu, M.D., A. L. Lever, Esq., M.P., R. B. Nicholson, Esq. (Town Clerk of Lowestoft), P. O'Brien, Esq., M.P., T. Summerbell, Esq., M.P., and A. S. Wilson, Esq., M.P.

The Terms of Reference were as follows:—

To inquire and report—

(*a*) As to the encroachment of the sea on various parts of the Coast of the United Kingdom, and the damage which has been or is likely to be caused thereby; and what measures are desirable for the prevention of such damage:

(*b*) Whether any further powers should be conferred upon Local Authorities and owners of property with a view to the adoption of effective and systematic schemes for the protection of the Coast and the banks of tidal rivers:

(*c*) Whether any alteration of the law is desirable as regards the management and control of the foreshore:

(*d*) Whether further facilities should be given for the reclamation of tidal lands.

Part 1 of the First Report (5 pp., price 1*d.*) merely gives the notification of the issue of the Commission, and a statement that 27 meetings had been held and 56 witnesses examined. Part 2 contains Minutes of Evidence, with Index, 504 pp.; and Appendices with Index, 516 pp. (price 8*s.* 9*d.*). Here, indeed, is abundant, nay voluminous, material for study in the form of 11,367 questions and answers, and copious appendices.

Officers of the Board of Trade, of H.M. Woods and Forests, the Duchies of Lancaster and Cornwall, the Board of Agriculture and Ordnance Survey, the Local Government Board, and the Geological Survey were examined; likewise sundry local officials, other professional geologists and engineers.

There is no doubt that great and serious erosion is taking place along certain portions of the coast of England, notably between Bridlington and Kilnsea in Holderness; at Cromer, Happisburgh, and Caistor in north-east Norfolk; at Lowestoft, Kessingland, Pakefield, and Southwold in Suffolk; in Essex and Kent; at Rottingdean in Sussex; at Freshwater in the Isle of Wight; by Poole Harbour and at Lyme Regis in Dorset; and at Watchet in Somerset.

Remarkable evidence was, however, given by Colonel R. C. Hellard, Director General of the Ordnance Survey, to the effect that during the past 20 to 25 years there has been an actual gain of land of rateable value to England and Wales of 30,752 acres; the total gain being 31,171 acres, and the net loss 419 acres. In this estimate the foreshore, or the area between ordinary tide-marks, is not reckoned as part of the land; but the loss in the amount of foreshore, principally due to artificial reclamation, is estimated at 31,000 acres.

Among the particulars given in reference to the gain and loss of acreage in counties during about 35 years, the following are of special interest :—

	Loss.	*Gain.*		*Loss.*	*Gain.*
Yorkshire	774	2178	Kent	526	519
Lincolnshire	400	9106	Sussex	374	1018
Norfolk	339	3480	Hampshire	198	852
Suffolk	518	151	Dorset	35	52
Essex	168	562	Somerset	33	256

It was admitted that a certain amount of the reclaimed land is still under water at high-tide spring-tides.

Suffolk has suffered the greatest loss of any county in England and Wales, and Southwold in particular has been a great sufferer in recent years.

The Board of Trade have no power to construct works to protect the coast; all they can do is to prevent, if necessary, the removal of shingle or other beach materials.

It is admitted that land protected in one place may mean loss in another. Individual rights may thus be opposed to the general benefit. There is thus need of general control on the coasts with regard to the removal of shingle or stone from foreshore, and to the erection of groynes and sea-walls. There is much information regarding groynes constructed of wood, ferro-concrete, chain-cable, and sheet-iron. The utilization of chain-cable is interesting, as possibly it may act as a nucleus for the formation of a protective iron-pan or conglomerate.

Much interesting information was given on the movements of beach material, as influenced mainly by wave action due to prevailing winds, and partly by flood-tides. Each district, however, has to be studied independently in connection with local circumstances, for on parts of the Cumberland coast the beach material is moved by the flood-tide from N. to S., in a direction contrary to the prevailing wind. In heavy gales, of course, the movement is in the direction of wind and sea.

In the Channel the drift is mainly from west to east, but the strength of the ebb-tide is said to be, if anything, greater than that of the flood-tide. On the west side of Selsea Bill the shingle is moved from east to west.

The influence of the lateral movement of water manifested by the breaking of waves is said to extend to a depth of at least 40 fathoms.

There is considerable travel of heavy shingle in moderately deep water of 5 to 10 fathoms, where there are strong bottom-currents. Indeed, material is said to be moved in depths up to 40 fathoms, but the enormous displacements in shoals off the eastern coasts do not appear to take place below 5 fathoms. It is clear that we have much yet to learn of the transport of shingle, etc., along the sea-bed below low-tide.

Thus the material of the foreshore was considered rightly to be not wholly derived from the waste of adjacent cliffs, but opinions differed as to the amount of material that is thrown up from the bed of sea below low-water.

It was admitted that much scouring takes place off shore and that shingle travels below low-water mark. It was said to pass Beachy Head on to Dungeness, and the opinion was even expressed that no natural headland in the country completely arrests the travel of shingle.

On the other hand, it was asserted that stones in bays do not get out, that the shingle was retained in compartments between headlands. Here the Chesil Bank came in for discussion, and the old question was revived whether the Budleigh Salterton pebbles, which form a small portion of the material, came direct from the Devonshire cliffs, or were derived from a former raised beach of which tiny remnants still exist. Here it may be observed that no Budleigh pebbles are known to occur in the Tertiary (Eocene) gravels.

Incidentally other questions of geological interest arose, with regard to the warp of the Humber, and "Is clay a mineral?"

Geological evidence on the waste of particular portions of the coastline in England and Wales was given in order as follows, by W. Whitaker, Clement Reid, H. B. Woodward, C. Fox-Strangways, G. A. Lebour, A. Strahan, J. R. Ainsworth Davis, S. H. Reynolds, R. H. Worth, T. V. Holmes, and T. Mellard Reade (by Memorandum).

We look forward with interest to further information on the important subject of Coast Erosion, and to the conclusions at which the members of the Royal Commission after their long and patient labours will arrive.

II.—Geological Survey of Ireland.

The Geology of the Country around Limerick. By G. W. Lamplugh, F.R.S., S. B. Wilkinson, J. R. Kilroe, A. McHenry, H. J. Seymour, and W. B. Wright. Dublin: printed for H.M. Stationery Office by Alex. Thom & Co., 1907. 8vo: pp. vi, 119, with 7 plates and 11 text-illustrations, price 2*s.*; with colour-printed map, price 1*s.* 6*d.*

We have received from the Board of Agriculture and Fisheries, Whitehall, the above memoir, which has been prepared by the Geological Survey of Ireland under the Department of Agriculture and Technical Instruction for Ireland. It is the last of four memoirs, the result of field-work carried out under the superintendence of Mr. Lamplugh, prior to the severance of the Geological Survey of Ireland from that of Great Britain. The preface is therefore written conjointly by Dr. Teall and Professor Grenville Cole.

The value of a detailed Drift map is amply shown in the colour-printed sheet which accompanies this memoir. Nevertheless, it must be admitted that in an area where the 'solid' rocks appear only in comparatively small and isolated tracts, it would be difficult to grasp the underground structure without the aid of the section at the foot of the map, or without the earlier hand-coloured sheets on which the 'solid' rocks were distinctly shown. The section shows how the dominant features of the country were pre-Glacial.

The older rocks include Silurian, referred to the Llandovery division; also Upper Old Red Sandstone, conformably overlain by the Carboniferous, with which are included sundry volcanic rocks. The greater portion of the area is underlain by the several divisions of the Carboniferous Limestone series, comprising shales and limestones, the latter in places oolitic, cherty, and dolomitic. The highest shale division is grouped with the Yoredale Beds, and the overlying flagstone series with the Millstone Grit. These strata were originally classed as Coal-measures, but no coal appears ever to have been found in them. The igneous rocks in the Limestone series are due to contemporaneous volcanic action, and, although interbedded, Mr. Kilroe believes that many of the lavas are intrusive in the tuffs and ashes associated with them. Petrological notes are contributed by Mr. Seymour. With regard to the physical features, it may be mentioned that the Old Red Sandstone of the Cratloe Hills on the north rises to a height of a little more than 1,000 feet, and the volcanic rocks of Knockroe in the south rise to 672 feet.

More detailed accounts are given of the superficial deposits, which include Boulder-clay, Glacial Sand and Gravel, and Alluvial deposits. To these descriptions Mr. Lamplugh contributes a general introduction, and it may be safely averred that much of the work of his colleagues is due to his inspiration. He has in fact left indelible traces of his wide experience on Glacial phenomena in the several Irish memoirs with which he has been connected. We learn that the Boulder-clay is the direct product of an ice-sheet which invaded the country in a general direction from north-west to south-east; and that while most of the included rock-fragments are local, yet with them are occasional boulders of granite which may be traced to a parent source on the north side of Galway Bay.

The position and arrangement of the stratified glacial gravel and sand is shown to be incompatible with marine agency, and it is held to represent the material of the ice-sheet modified by fluvio-glacial action. The greater part, if not the whole of the area, appears to have undergone glaciation, but only the minor features have resulted from this and subsequent action. Thus the Basin of the Shannon, which, in the area of the map, extends from Castleconnell to Bunratty and Mellon Point below Limerick, occupies a course that must be regarded as essentially post-Glacial. Any pre-existing channels in this area are concealed by the covering of Drifts.

An interesting feature on the map is the indication of the general characters of the soils on each subdivision, whether solid or drift. To this subject Mr. Kilroe has given special attention, and it is necessary to qualify the indications above given by his observations. Thus he mentions that the boulder-clay, "represented by one tint on the map, is present in at least five distinguishable varieties, which yield correspondingly different soils and subsoils." It would obviously be impossible to indicate such minor changes on a one-inch map. Other topics of economic interest are duly discussed, and the work concludes with a useful bibliography.

III.—A Text-book of Palæontology.

Einführung in die Paläontologie, von Dr. Gustav Steinmann, Ord. Professor der Geologie und Paläontologie an der Universität Bonn. Zweite, vermehrte und neubearbeitete Auflage, mit 902 Textabbildungen. Leipzig: Wilhelm Engelmann, 1907. Price, marks 15.20, bound.

THE first edition of this work (not to be confounded with Steinmann and Döderlein's "Elemente der Paläontologie," 1890) appeared in 1903, and consisted of 466 octavo pages with 818 figures. The second edition consists of 542 pages ($9\frac{1}{2} \times 6\frac{1}{2}$ inches) with 902 figures. In the new edition 62 pages are devoted to Palæobotany, of which 7 deal with Dicotyledons, which occupied half a page in the first edition. Insecta, to which only two-thirds of a page were allotted previously, are now described by A. Handlirsch, of Vienna, in 14 pages; Reptilia occupy 29 as compared with 23, and Mammalia 53 as compared with $38\frac{1}{2}$ pages.

Since the late Professor Karl A. von Zittel wrote his great "Handbuch" and his smaller "Grundzüge der Paläontologie," the fault of most text-books of palæontology has been that they are often little better than systematically arranged descriptive catalogues of fossils, written with very little reference to evolution, by drawing attention to which the dry bones may have some living interest imparted to them. The distinguishing feature of the present work is the attention which the author draws to the probable phylogeny of the forms described, although the arrangement remains systematic for facility of reference. Whether one agrees with the author or not, his views on the relationship of genera (and higher groups) to their supposed ancestors and descendants are always interesting. Perhaps the most remarkable of his suggestions is that the Tertiary marine mammalia are descended from the Secondary marine reptilia, viz., the Delphinidæ from the Ichthyosauria, the Physeteridæ from the Plesiosauria, and the Mystacoceti from the Thalattosauria (Pythonomorpha). Professor Steinmann read a paper on this subject before the Seventh International Zoological Congress at Boston in August last. In a final summary (in his book) Professor Steinmann draws attention to the supposed frequent sudden extinction and equally sudden first appearance of some of the important groups of animals, and arrives at the conclusion that the usual systematic arrangement of plants and animals has nothing to do with the phylogenetic connection between the separate forms, but rather obscures it, because the systematic do not coincide with the genetic lines, but cut across them.

Among fossil plants, he says, if we regard the mode of reproduction on which the systematic arrangement is based as a feature which may undergo change, and the purely morphological characters of mode of branching, form, venation, and arrangement of leaves as relatively persistent characters, groups are arrived at which are much less forced than those based on systematic arrangement. So also, if the four classes of quadrupeds Amphibia (+ Stegocephalia), Reptilia, Aves, and Mammalia are regarded, not as phylogenetic units, but as different stages of organization which have been reached or passed through in more or less similarly directed progress by numerous series of phyletic stems already existing at the end of Palæozoic times, their evolution presents itself as a relatively simple and clear process of metamorphosis in which there is no space for large groups to either appear or become extinct abruptly. B. HOBSON.

IV.—GEOLOGICAL GUIDE TO THE NEIGHBOURHOOD OF VIENNA.

GEOLOGISCHER FÜHRER FÜR EXKURSIONEN IM INNERALPINEN BECKEN DER NÄCHSTEN UMGEBUNG VON WIEN. Von Dr. FRANZ X. SCHAFFER. Sammlung geologischer Führer XII. Sm. 8vo; 11 Abbildungen im Text. Gebrüder Bornträger, Berlin, 1907.

THIS is another of the excellent little Geological Guides issued by the Brothers Bornträger. The idea of writing this one occurred to the author when he was preparing for the excursions in the neighbourhood of Vienna in connection with the meeting of the Geological Congress in that city in 1902. The material for the work was already in the author's possession in his "Geologie von Wien" (part ii). Naturally only a few of the most important of the excursions could be dealt with in the small work under review.

Beginning with a brief bibliography of the subject, the author continues by giving the geological history of the Vienna Basin, which he calls the concluding episode in the formation of the Alps; that great chapter in the shaping of the physical contour of Europe, which has always had a particular attraction for students.

Let us depict in brief terms its past history as the author gives it, though but few traces remain by which the picture may be clearly presented to the mind's eye.

The Mediterranean had entered with its rich fauna into the sinking region, and in this area fresh-water beds were deposited before it had sunk below the level of the sea. The shore lay at a somewhat higher level than that at which its shore formations now stand. An immense portion of this inland sea was cut off from the ocean, and under the influence of inflowing fresh water a brackish-water fauna came into existence, and this can be traced up to the highest beds deposited near Vienna. While the transition from the marine to the Sarmatian stage is marked by a discordance or break in the succession of the beds connected with the retreat of the sea, the Sarmatian beds merged gradually into the Pontian, and the sea-level reached the same height as at the Mediterranean stage. The very thick beds of at least 500 metres (1,640 feet) in thickness mostly indicate a medium depth of water, the deposit having taken place on a slowly sinking sea-bottom. During the Pontian period a sinking of the water-level is noticeable, and at the same time a stream coming from the north-west finds its way into the basin. In Vienna its traces are not only seen in the high-level terraces, but also in the thick 'schotter' (conglomeratic deposits) which the stream has brought down here to the margin of the sea. The terraces can be traced near Vienna at heights ranging from 50 to 200 metres above the present level of the Danube, and they stretch still farther south of this area. Loess and also fresh-water limestone were deposited at about this period at the edge of the basin. The smaller watercourses coming from the marginal hills blended their schotter with the fresh-water limestone, and the transition to the present time is so gradual that the dividing-line cannot be recognized. While in the more central part of the basin immense masses of sediment have been deposited, those of the margin are very much thinner. Erosion alone can have created the present geological conformation.

This little work is well illustrated by means of natural sections, reproduced from photographs, and by numerous diagrammatic sections in the text. There are also many tables of characteristic fossils.

A. H. F.

V.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1906. 8vo; pp. 181, with three text-illustrations and one plate. London, 1907. Price 1*s*.

THIS number of the "Summary of Progress," which was issued in the autumn, is less in bulk than its predecessor by more than twenty pages: a reduction due not to the fact that the publication is for the first time notified as "of Great Britain," instead "of the United Kingdom," but to the shorter record of field-work in Scotland. Progress has been made with the mapping of the Highland Schists, but at present "the difficulties of interpretation and correlation appear to increase rather than diminish," and "no general theory as to the structure or sequence of rocks has been formed on which all officers are agreed." The rocks of the Lizard area have been undergoing detailed examination, and they too have presented problems not yet solved, as their relations with the Devonian and earlier sedimentary strata on the north have yet to be demonstrated. Elsewhere in Cornwall, as also in the coal-fields of South Wales, Derbyshire, and Scotland, and in the adjacent tracts of older and newer strata, the work has proceeded in areas often of much difficulty, but without those conflicting opinions which beset the crystalline schists. The zonal distribution of fossils has received special attention in the Ordovician, Silurian, and Carboniferous rocks of Pembrokeshire, and in the Carboniferous of Scotland, and has not been neglected in other regions. Economic geology rightly occupies some space—in the details of coal-bearing strata in England, Wales, and Scotland, in remarks on the eastern extension of the Nottinghamshire coal-field, in the account of the fluor-spar of Derbyshire, and in the suggestion made that bordering Cornwall "There must be a large amount of detrital tin-ore at the bottom of certain of the bays margined by rich tin-lodes."

In the Appendix there is an essay on "The Scapolite-bearing Rocks of Scotland," by Dr. J. S. Flett; a statement of the "Total quantity of Tin, Copper, and other Minerals produced in Cornwall, particularly with regard to the Quantities raised from each Parish," by D. A. MacAlister; and detailed records of "Some Well-sections in Middlesex," by W. Whitaker and George Barrow.

VI.—The Cotteswold Naturalists' Field Club.

THE Proceedings for September, 1907, being part 1 of vol. xvi, contain a record of the excursions of this Club during 1906, and of the Winter meetings of 1906–7. An interesting excursion to the Lickey Hills was made under the direction of Professor Lapworth, and another notable excursion, in celebration of the 60th Anniversary of the Club, was made to Bourton-on-the-Water and Burford. Among the papers published is one by Mr. S. S. Buckman on "Some species of the genus *Cincta.*" Of these the genotype is *Terebratula numismalis*, Valenciennes, afterwards known as *Waldheimia numismalis*. Two plates are given to illustrate this and nineteen other forms of *Cincta*. Another paper of considerable interest is by Professor C. G. Cullis and Mr. L. Richardson, entitled "Some remarks on the Old Red Sandstone Conglomerate of the Forest of Dean and the Auriferous Deposits of Africa." During the course of last year some stir was made in the newspapers about a discovery of gold in a locality about 200 miles distant from London. The locality is in the Old Red Conglomerate about one and a half miles south-west of Mitcheldean Road Station. The authors report that a small amount of both gold and silver do occur, "but it still remains to be proved that the gold occurs in any part of the rock, either at or below the surface, in sufficient quantity to be workable with profit."

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*November* 20*th*, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Glacial Beds of Cambrian Age in South Australia." By the Rev. Walter Howchin, F.G.S., Lecturer in the University of Adelaide.

The known extension of the beds in question is 460 miles from north to south (Onkaparenga River to Willouran Range). The greatest width across the strata between Port Augusta, at the head of Spencer's Gulf, in an easterly direction to the Barrier Ranges of New South Wales, is about 250 miles. The beds occur as part of a great conformable series, in the upper part of which Cambrian fossils have been found. The rocks above the glacial beds are mainly purple slates and limestones; below they are quartzites, clay-slates, and phyllites, passing into basal grits and conglomerates, resting on a pre-Cambrian complex. The beds consist of a groundmass of unstratified indurated mudstone, more or less gritty, carrying angular, subangular, and rounded boulders, up to 11 feet in diameter. In most sections there are more or less regularly stratified bands. The thickness of the glacial series has been proved up to 1,500 feet. The commonest rock-type among the boulders is a close-grained quartzite; but gneiss, porphyry, granite, schistose quartz, basic rocks, graphic granite, mica-schist, and siliceous limestone occur. The discovery of ice-scratched boulders has placed the origin of the beds, according to the author, beyond doubt. The striæ are often as distinct and fresh-looking as those occurring in a Pleistocene boulder-clay. Up to the present eighty definitely glaciated boulders have been secured, besides the known occurrence of other erratics too large for removal. Under strong pressure and movement in their bed, some of the boulders exhibit evidences of abrasion; but this produces features which cannot well be confounded with those due to glaciation. The pressure that has induced cleavage has caused the elongated boulders to revolve partly in their bed and place their long axes parallel to the cleavage-planes. In this movement some of the stones have become slightly distorted, and many show the effect of fracture in the form of pseudo-striation on exposed surfaces. The lines, however, are of equal size and depth, and parallel to each other over wide surfaces; while the glacial striæ are generally patchy in their occurrence, of varying intensity, and divergent in direction. A series of illustrative sections are described. It is considered that Mr. H. P. Woodward's suggestion, that the 'boulder-clay' had its origin from 'floating ice,' appears to be most in accordance with facts. The interbedded slates and limestones may possibly indicate the occurrence of interglacial conditions.

2. "On a Formation known as 'Glacial Beds of Cambrian Age' in South Australia." By H. Basedow and J. D. Iliffe. (Communicated by Dr. J. Malcolm Maclaren, F.G.S.)

Some 8 miles south of Adelaide a typical exposure of the conglomerate is bounded to the east by a series of alternating quartzitic and argillaceous bands of rock, comprising the central and western portions of a fan-fold, partly cut off by a fault. Further evidence of stress in this margin is given in the fissility, pseudo-ripplemarks, contortion and fracture, and obliteration of bedding in the quartzite bands, and in the pinching-out of them into lenticles and false pebbles. On the west side the conglomerate is bounded by the "Tapley's Hill Clay-Slates," and there is evidence from the nature of the junction beds that the conglomerate itself is isoclinally folded. In that portion of the conglomerate which is adjacent to its confines, 'boulders' of quartzite are apparently disrupted portions of quartzite bands, since these are in alignment with the truncated portions of bands still existing, and are of similar composition. The authors are not at present in a position to account for the presence in the conglomerate of boulders of rocks foreign to the beds that border the conglomerate, or of such as possess markings comparable to glacial striæ, by their theory of differential earth-movements; but they consider that a boulder-bed subjected to lateral pressure would probably lend itself to the production of 'false pebbles,' through the disruption of intercalated hard bands within itself or on its boundaries.

II.—*December 4th,* 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Faunal Succession in the Carboniferous Limestone (Upper Avonian) of the Midland Area (North Derbyshire and North Staffordshire)." By Thomas Franklin Sibly, B.Sc., F.G.S.

The area dealt with is the irregularly-shaped periclinal mass forming the southern end of the Pennine anticline, with a few small outliers. The base of the limestone is not shown, and the whole series exposed constitutes a greatly expanded development of the uppermost zone of the typical Avonian succession of the South-Western Province, namely, the *Dibunophyllum*-zone. The most extensive section—that along the Midland Railway, between Longstone and Buxton—shows a thickness of about 1,500 feet. Three subzonal divisions are distinguished, as follows:—

D_3. Subzone of *Cyathaxonia rushiana*: represented in the South-Western Province by horizon ε and the lower part of the Millstone Grit.

D_2. Subzone of *Lonsdalia floriformis*: correlated with the Upper *Dibunophyllum* zone (D_2) of the South-West.

D_1. Subzone of *Dibunophyllum θ*: correlated with the Lower *Dibunophyllum* zone (D_1) of the South-West.

An abnormal development of the *Lonsdalia*-subzone, consisting of richly fossiliferous Brachiopod beds, in which the typical coral fauna has very little representation, forms a conspicuous local feature in various parts of the western half of the area. The passage-beds between the Carboniferous Limestone and the Pendleside Series are included in the *Cyathaxonia*-subzone. Locally, these passage-beds attain a thick development. A local unconformity between the Carboniferous Limestone and the Pendleside Series, indicating contemporaneous elevation and erosion, occurs in the eastern part of the area. A close general similarity exists between the *Dibunophyllum*-zone of the Midland area and that of North Wales. These two areas should be regarded as constituting a Midland Province. A comparison of the *Dibunophyllum*-zone of the Midland with that of the South-Western Province brings out the following more important differences:—(*a*) The Brachiopod fauna of the *Lonsdalia*-subzone of the Midland Province is considerably richer than that of the equivalent part of the South-Western sequence. (*b*) The *Cyathaxonia*-subzone of the Midland Province, which attains a maximum development in Derbyshire and North Staffordshire, is practically undeveloped in the South-Western Province.

The paper concludes with a description of certain corals and Brachiopods from the Midland area, some species and varieties being new.

2. "Brachiopod Homœomorphy: '*Spirifer glaber.*'" By S. S. Buckman, F.G.S.

The smooth, catagenetic, stage of shells may have been attained by the loss of different distinctive features, pointing to polygenetic origins. The series of shells figured by Davidson as *Spirifera glabra* do not all agree in being smooth; some are radially costate, some have a pronounced mesial fold, others hardly any, some are very transverse, others are narrow. There is good evidence that several of the forms ranged under this species are *Reticulariæ* (M'Coy), more or less smooth. Thus *Sp. obtusus*, regarded by Davidson as a synonym of *Sp. glabra*, shows faint reticulation, has the dental plates, and must be classed as a *Reticularia*; while quite smooth forms with similar plates also occur (*Sp. lata*, Brown, and *Sp. glaberrimus*, de Koninck). But other forms called *Sp. glabra* seem to have been derived from radially costate ancestors. The use of the generic name *Martinia* for various smooth Spiriferids of the Devonian and Carboniferous thus becomes wholly unjustifiable, as it simply denotes a stage of catagenetic development at which several different stocks of Spirifers arrive. As the outcome of this study the author restricts the genus *Spirifer*, and allocates several British and foreign species among the genera *Fusella*, *Choristites*, *Trigonotreta*, *Brachythyris*, *Martinia*, and *Reticularia*. He also gives in an appendix a revised explanation of Davidson's plates xi and xii of the Monograph of Carboniferous Brachiopods.

CORRESPONDENCE.

GLACIATION OF THE USK AND WYE VALLEYS.

Sir,—At the meeting of the British Association at York in 1906 a paper on the Glaciation of the Usk and Wye Valleys was read by the Rev. W. Lower Carter, and was printed in abstract in the Report (pp. 579–580). An abstract appeared also in the Geological Magazine (for 1906, pp. 521, 522). The author there records several interesting and important glacial phenomena, and it is to be hoped that he will find occasion to continue his researches. There is, however, one point on which it is necessary to register a *corrigendum*. After speaking of the purely local drift in the region (an Old Red Sandstone district) he calls attention to certain "erratics of volcanic ash and brecciated limestone" (B.A. Report), or "volcanic ash and breccia" (Geol. Mag.), which overlie the local drift; and he supposes them to be derived from distant Ordovician sources.

A recent visit—unofficial and connected with quite other matters—to the district enables me to say that the erratics of 'volcanic ash' and 'breccia' or 'brecciated limestone' to be seen in the village of Trecastle and on the neighbouring hillsides, and again at Talgarth and along the course of the river Enig above the town are, in fact, boulders of *cornstone*, of both the conglomeratic and the non-conglomeratic variety; and that instead of being derived from distant Ordovician sources they are traceable to quite local outcrops of that rock in the valleys in which they occur. No doubt ice had much to do with their transport, but their journeys to their present resting-places were not so romantic as a derivation from Ordovician sources would involve.

T. C. Cantrill.

Geological Survey, Jermyn Street, S.W.
7th December, 1907.

RE SPELLING OF PLACE-NAMES.

Sir,—The slight demurrer offered by your reviewer of the Geological Survey Memoir on "The Geology of the Country around Ammanford" in the November number of this Magazine (1907, p. 515), as to the alteration of the spelling of the place-name 'Llandeilo' to 'Llandilo,' reminds me of an intention I had of enquiring, through the medium of your Magazine, the views of some of your readers as to the desirability of altering the specific names of fossils derived from place-names so as to accord with the present rendering upon the Ordnance Survey Maps. The well-known Rhætic fossil *Pleuromya crowcombeia* (Moore) is given as *Pleuromya crocombeia*—the *w* is omitted—in the Geological Survey Memoir on "The Geology of the Country between Wellington and Chard" (1906, p. 27).

L. Richardson.

Cheltenham.
14th December, 1907.

NORTH DEVON ATHENÆUM: GIFT OF THE PARTRIDGE COLLECTION.

Sir,—This institution has recently received a most valuable gift, the large collection (Partridge Collection) of Devonian and Culm fossils made by Mrs. Coomaraswamy in North and South Devon, and by Dr. Coomaraswamy on the Continent. Included in the Partridge Collection are fourteen specimens figured in the Rev. G. F. Whidborne's Monograph of Devonian Fauna (Palæontographical Society) and the Geological Magazine, five of them type-specimens. This, added to T. M. Hall's already there, makes the North Devon Athenæum Collection one of the most complete of its kind in the kingdom. The specimens being too numerous to be all displayed, Dr. Coomaraswamy has made a selection, for the exhibition of which special cases have been provided; the remainder have been placed in drawers, and, like all the specimens in this Museum, are available for purposes of study.

Devonshire, even prior to this most liberal gift, was rich in local geological collections. It may now be said without exaggeration that the Museums at Exeter, Plymouth, Torquay, and Barnstaple, between them contain practically a complete collection of the fossils and rocks (so far recorded) of the county. J. G. Hamling.

The Close, Barnstaple.

OBITUARY.

THE RT. HON. WILLIAM THOMSON, BARON KELVIN,

P.C., O.M., G.C.V.O., LL.D., D.C.L.,

Past President of the Royal Society, etc.

Born June 26, 1824. Died December 17, 1907.

In the death of Lord Kelvin geologists have lost one who took keen interest in the physical and astronomical aspects of their science, and aided perhaps more than any other philosopher in this country to place the subject of Cosmogony on a scientific basis. He dealt with the evolution of the heavenly bodies, with changes in the position of the earth's axis of rotation, with the probable condition of the earth's interior, and with the thermal conductivity of rocks. In one respect his views regarding the earth found little support. His calculations on the increase of temperature beneath the surface and the rate of loss of heat from the earth led him in 1862 to argue that the age of the earth must be restricted to about one hundred million years; and he subsequently reduced the estimate to between twenty and forty million years.[1] Huxley, in one of his famous addresses to the Geological Society (1869), showed that while geologists had no reason to be greatly concerned at an estimate of 100,000,000 years, yet the data on which the restriction was based were insufficient and inconclusive. Further researches have not tended to modify this judgment.

William Thomson, Lord Kelvin, was the second son of James Thomson, Professor of Mathematics in the University of Glasgow, and the son became Professor of Natural Philosophy in the same University during the lifetime of his father.

Regarded as the foremost man of science in Britain, it was fitting that a final resting-place in Westminster Abbey should be selected, near the tombs of Newton, Herschel, Darwin, and Lyell; and there he was buried in the presence of a large and distinguished gathering on the 24th December, 1907.

MISCELLANEOUS.

British Museum Model of *Eurypterus*.[2]

In the Upper Silurian rocks of the island of Oesel, in the Baltic, are found the fossil remains of an Arthropod called *Eurypterus Fischeri*. This animal is of interest as one of an extinct group of Arthropods that appear to have been allied to the modern *Limulus* or king-crab, as well as to the Scorpions. These particular fossils have a further interest in that the chitinous substance of the outer coat of the animal has been preserved unaltered in chemical and physical composition. Thus Professor G. Holm, of Stockholm, has been able to dissolve the remains out from the rock by means of acid, and to mount them on glass slides in Canada balsam. On the preparations thus obtained he based an elaborate description, published in the Memoirs of the Academy of Science, St. Petersburg (ser. VIII, vol. viii, No. 2, 1898). It can now be said that the structure of this species is known better than that of any other extinct arthropod. Several of Professor Holm's preparations preserved in the Geological Department of the British Museum are quite marvellous, and it is difficult to believe that one is looking at a fossil at all, still more one dating from the Silurian epoch.

The perfection of these specimens and the interest of the animal suggested to members of the staff of the British Museum (Natural History) the advisability of preparing a complete model of it, and such a model in coloured wax, of about twice the natural size, has now been made under the direction of Dr. W. T. Calman and Dr. F. A. Bather by Mrs Vernon Blackman, whose beautiful models of plants, of the parasite of malaria, and of the tsetse fly are well known to all visitors to the Natural History Museum in the Cromwell Road.

[1] See Sir A. Geikie's Text-Book of Geology, 4th ed., vol. i, 1903, p. 79.
[2] From *Science*, November 15th, 1907, pp. 679–680.

The model was first placed on exhibition on the occasion of the visit of foreign geologists at the Centenary of the Geological Society of London and evoked their enthusiastic admiration. It measures 23 × 15 cm. The wax of which it is made will stand any extremes of temperature likely to be met with in a museum, and the colours are believed to be quite permanent; they are based upon those of the recent *Limulus*, and Sir Ray Lankester has shown great interest in their selection. The model, which, it may be mentioned, has been subjected to the careful scrutiny of Professor Holm himself, certainly looks quite as natural and lifelike as any specimen of a recent Arthropod exhibited in the museum.

The Geological Department hopes to have a limited number of copies of this model, which it will be prepared to exchange with other museums. Naturally a model of this nature, which has taken a very long time to make, demands an exchange of considerable value, but for information on this matter inquiries should be addressed to Dr. A. Smith Woodward, F.R.S., the Keeper of the Geological Department, Natural History Museum, Cromwell Road, London, S.W.

Royal Medal to Dr. R. H. Traquair, F.R.S., F.G.S.

In the Anniversary Address to the Royal Society by Lord Rayleigh on November 30th, 1907, the President said His Majesty has approved the award of a Royal Medal to Dr. Ramsay H. Traquair, F.R.S. Dr. Traquair is honoured on the ground of his long-continued researches on the fossil fishes of Palæozoic strata, which have culminated, within the past 10 years, in his discovery of new groups of Silurian and Devonian fishes, and in his complete exposition of the structure of *Drepanaspis*, *Phlyctenaspis*, and other remarkable forms. For nearly forty years Dr. Traquair has been busy with the description of fossil fishes, mostly from the Palæozoic rocks of Scotland, and he is deservedly held to be one of the most eminent palæontologists of the day. He has been highly successful in the interpretation of the often very obscure and fragmentary remains which he has had to elucidate, and his restorations of fishes have won such credit as to appear in all modern text-books of Palæontology. It may be said that his work, notwithstanding the great difficulties of the subject, has well stood the test of time. Dr. Traquair has done much to advance our knowledge of the osteology of fishes generally. His earliest memoirs on the asymmetrical skull of flat-fishes and on the skull of *Polypterus* remain models of exactness. His acquaintance with osteology enabled him to show how former superficial examination of the Palæozoic fishes had led to wrong interpretations. He demonstrated that *Chirolepis* was not an Acanthodian, as previously supposed, but a true Palæoniscid. In 1877 he satisfactorily defined the Palæoniscidæ and their genera for the first time, and conclusively proved them to be more nearly related to the Sturgeons than to any of the other modern Ganoids with which they had been associated. He thus made an entirely new departure in the interpretation of extinct fishes, replacing an artificial classification by one based on phylogenetic relationship. His later memoir on the Platysomidæ was equally fundamental and of the same nature. All subsequent discoveries, many made by Traquair himself, have confirmed these conclusions, which are now universally accepted. In 1878 Dr. Traquair demonstrated the Dipneustan nature of the Devonian *Dipterus*, and somewhat later he began the detailed study of the Devonian fishes. His latest researches on the Upper Silurian fishes of Scotland are equally important, and provide a mass of new knowledge for which we are indebted to his exceptional skill and judgment in unravelling the mysteries of early Vertebrate life.

Award by the Academy of Sciences, Paris, for researches in Petrography.—The Academy of Sciences, Paris, has awarded the Delesse prize to Dr. J. J. H. Teall, F.R.S., Director of the Geological Survey of Great Britain, for his researches in petrography.

The Royal Geological Society of Cornwall.—The annual meeting of the Royal Geological Society of Cornwall was held at the Camborne School of Mines in October, Mr. A. K. Barnett, F.G.S., Mayor of Penzance, presiding. The event of the meeting was the presentation of the William Bolitho medal for the year to Mr. Upfield Green, F.G.S., whose excellent work in connection with the geology of Cornwall had, in the words of the report of the Council, "fully merited the highest distinction in their power."—*Mining Journal*, Nov. 2nd.

Sedgwick Museum, Cambridge.—Dr. T. G. Bonney, F.R.S., who two years ago presented to the Sedgwick Museum his valuable collection of rocks, has now presented also the whole of his collection of rock-slices, consisting of some two thousand seven hundred specimens. Professor T. McKenny Hughes says the gift is one of great scientific value.—*Morning Post*, November 20th, 1907.

Museum of Practical Geology.—After a service of thirty years Mr. Alexander Pringle, M.A., has retired from the post of Assistant-Curator, which he has held to the great advantage of the institution and of the public. To the numerous enquirers in reference to minerals and ore-deposits, to gems and precious stones, he was ever ready to give sound information, for like the late Thomas Davies he had acquired great experience and eye-knowledge of minerals. He is succeeded by Mr. W. F. P. McLintock, B.Sc. (Edin.).

Erratum.—In Professor J. W. Spencer's article, published in the Geological Magazine for October, 1907, p. 441, on the "Recession of Niagara Falls," three words were accidentally dropped out in line 4 from foot of page. Instead of "Almost all of the physical changes in," etc., please add the three words in italics, viz., "Almost all of the *discoveries in the* physical changes in," etc.

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HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., Dr. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

FEBRUARY, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. II.—FEBRUARY, 1908.

ORIGINAL ARTICLES.

I.—Flowing Wells and Sub-Surface Water in Kharga Oasis.

By Hugh John Llewellyn Beadnell, Assoc.R.S.M., F.G.S.

WITH the exception of an article written by me for Sir William Willcocks and published in his "Nile in 1904,"[1] and a reference to the relations of the Eocene and Cretaceous in the oasis of Kharga in a paper read before the Geological Society in 1905,[2] nothing has, I believe, been published on the water-supply and geology of this district since Dr. Ball's report in 1900.[3]

Since my first acquaintance with the Libyan desert oases, where from time immemorial a considerable population (at the present day exceeding 30,000) has flourished, the origin of the underlying artesian water, on which the very existence of the inhabitants depends, has always appealed to me as one of the most interesting problems of Egyptian geology. It was not, however, until two years ago, when I took up more or less continued residence in the oases, that I was able to pay special attention to the subject and make a commencement of attacking the problem by undertaking a detailed study of the geology and water-supply of a definite district, the northern part of Kharga oasis.

Before proceeding to a description of the actual district in question it may be well to briefly remark on the chief characteristics of the surrounding country as a whole, a more detailed account of which I hope shortly to give in a separate publication.

The Libyan desert is the easternmost and most inhospitable portion of the Sahara, or Great Desert of Africa. On the north and east its boundaries are clearly defined by the Mediterranean Sea and the highly cultivated valley of the Nile; on the south it is bounded by the Darfur and Kordofan regions of the Egyptian Sudan; south-eastwards its limits may be regarded as coterminous with the elevated

[1] "The Oases and the Geology of the Nile Valley," being Chapter 5 of "The Nile in 1904," by Sir William Willcocks, K.C.M.G., Cairo, 1904.

[2] "The Relations of the Eocene and Cretaceous Systems in the Esna-Aswan Reach of the Nile Valley": Quart. Journ. Geol. Soc., vol. lxi (1905), pp. 667–678.

[3] "Kharga Oasis: its topography and geology": Egypt. Geol. Surv. Report, Cairo, 1900.

district of Tibesti, while on the east it stretches to the outlying oases of Fezzan and Tripoli. Its area is approximately equivalent to that of the British Isles.

Except for a narrow belt fringing the Mediterranean the region is practically rainless, so that unlike the more elevated deserts on the other side of the Nile, where the rains are of sufficiently frequent occurrence to maintain a water-supply in the isolated water-holes and valley springs, and to allow of the growth of a fairly permanent though scanty herbage in the more favoured areas, the greater portion of the Libyan desert is quite devoid of vegetation, and is uninhabited even by nomad tribes. The extreme barrenness of the region as a whole, however, is in great measure counterbalanced by a number of isolated highly fertile oases, in which there is a permanent resident population.

The chief groups of oases are the Siwan on the north, that of Kufra on the west, and the Egyptian, including the four large oases of Baharia, Farafra, Dakla, and Kharga, on the east.

The Egyptian oases occupy extensive depressions cut down nearly to sea-level through the generally horizontal rocks forming the Libyan desert plateaux. These depressions owe their origin in great measure to the differential effect of subaerial denudation acting on rock masses of varying hardness and composition. Variation in the original conditions of deposition has resulted in a preponderant development in some areas of soft argillaceous beds, and subsequent folding has raised these beds in some districts and depressed them in others. Wherever during the general denudation of the country these soft deposits have become exposed, weathering has proceeded at an increased rate and gradually produced deep and broad depressions separated by elevated plateaux.

Geological Sequence in Northern Kharga.

The geological succession (excluding Pleistocene and Recent superficial deposits) in the northern part of the oasis of Kharga, determined by actual measurement of the different stages exposed on the floor and in the cliffs of the depression, and from numerous bores put down within the last two years, is as follows:—

			Average thickness in metres.
LOWER EOCENE	Lower Libyan ...	1. Plateau Limestone ...	115
	Passage Beds ...	2. Esna Shales and Marls	55
UPPER CRETACEOUS	Danian	3. White Chalk	70 (3 and 4)
		4. Ash-grey Shales	
		5. Exogyra Beds	30
	Campanian (Nubian Series)	6. Phosphate Series	70
		7. Red Shales	50
		8. Surface-water sandstones	45
		9. Impermeable Grey Shales	75
		10. Artesian-water Sandstones	120
			630

See Map, Fig. 1, p. 51. The numbers 1–10 correspond with section (Fig. 2) given on p. 55.

For the Eocene limestone, which everywhere caps the plateau between the oasis and the Nile Valley and also the northern bounding

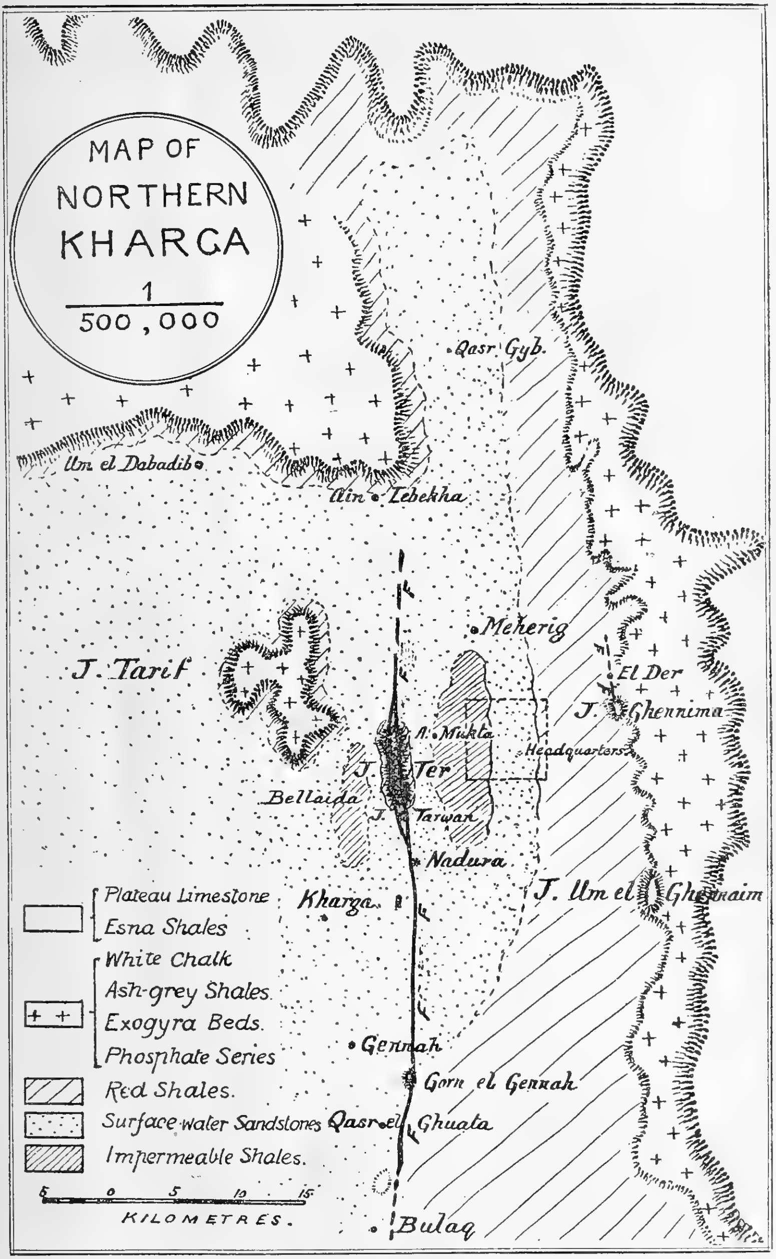

MAP OF
NORTHERN
KHARGA
1
500,000
Qasr Gyb.
Um el Dabadib
Ain Tebekha
Meherig
J. Tarif
El Der
J. Ghennima
A. Mukta
Headquarters
J. Ter
Bellaida
J. Tarwan
Nadura
Kharga
J. Um el Ghennaim
Gennah
Gorn el Gennah
Qasr el Ghuata
Bulaq
Plateau Limestone
Esna Shales
White Chalk
Ash-grey Shales
Exogyra Beds
Phosphate Series
Red Shales.
Surface water Sandstones
Impermeable Shales.
5
0
5
10
15
KILOMETRES.

Fig. 1.

wall of the depression, I have adopted the convenient term of "Plateau Limestone." Between it and the White Chalk of the Upper Cretaceous come the Esna Shales and Marls, which, as I have shown in a former paper, are to be regarded as passage beds between the Cretaceous and Eocene systems.[1] It is true that in the lower layers fossils with typical Cretaceous affinities occur, but on the other hand forms of equally pronounced Eocene character are found in the upper bands. Lithologically there is nothing to distinguish one part of the band from another; typically it is made up of laminated shales, which by increase of carbonate of lime pass insensibly both upwards and downwards into the limestones above and below. The total thickness of the stage varies greatly in different parts of the oasis; this variation was regarded by Ball[2] as indicating an unconformity between the Eocene and Cretaceous, whereas it is due solely to the fact that varying thicknesses of the upper and lower portions become in places so markedly calcareous as to be indistinguishable from the limestones above and below. In some cases practically the whole, as a band of laminated shale, has disappeared, and then the Cretaceous limestones merge directly into those of the Eocene above.

Although the shales below the White Chalk differ little in colour from the Esna Shales above or from the shales of the *Exogyra* series below, I have retained Zittel's term "ash-grey shales"—though ash-grey is by no means their usual tint—to avoid the possibility of confusion. They are grouped most naturally with the White Chalk, which nearly everywhere forms a marked band at their summit; other less conspicuous bands of chalk or chalky marl sometimes occur intercalated in the shales on a lower horizon.

With regard to the *Exogyra* beds, it is only necessary to remark here that they are almost everywhere marked by hard bands made up of the shells of fossil oysters. Below comes a group of shales containing a number of prominent intercalated bands composed of fish-bones, coprolites, and phosphatic nodules; the series is so well marked in northern Kharga that it is difficult to understand how it had until recently escaped notice, yet that such was the case is evident, as Ball makes no mention of the beds in his report nor are they shown in the published sections. Considering the great development of phosphatic beds in the neighbouring oasis of Dakhla, the extension and thickness of which had been fully mapped and reported on by me in 1898,[3] it was no surprise to find similar beds in Kharga when I made a casual examination of the succession at one or two points in the early months of 1905. Since then I have traced the beds over a large area of northern Kharga, and found them to consist as a rule of an upper brown coloured series, individual beds of which in places exceed two metres in thickness, and a lower division consisting of three or four bands of harder and lighter-coloured rock, in which the nodules are sometimes cemented by iron pyrites. These bone-beds mark the

[1] Op. cit.: Q.J.G.S., vol. lxi (1905), p. 675.
[2] Op. cit., p. 94.
[3] "Dakhla Oasis: its topography and geology": Egypt. Geol. Surv. Report, Cairo, 1901.

invasion of the area by the Cretaceous sea, the underlying shales and sandstones being as far as known devoid of all fossil remains except vegetable impressions and silicified wood, having in all probability been accumulated in an immense inland lake.

Underlying the phosphates is a great thickness of an almost homogeneous red or purple shale, below which occurs the first water-bearing sandstone; this will presently be described in detail. Between this sandstone, which for purposes of easy reference I have designated the "surface-water sandstone," and the underground sandstone from which the flowing wells of the oasis derive their water, is a 75 metre band of grey shale or clay; it is this bed which forms the confining and impervious cover, and prevents the water in the beds below from reaching the surface except when provided with such means of escape as artificial boreholes. To all intents and purposes these shales are impermeable, at any rate over the district in question, and may therefore be referred to as the "impermeable grey shales." The upper layers of this division are visible on the floor of the depression in some parts of the oasis, notably in the Bellaida district west of Jebel Têr, and in the neighbourhood of Ain Mukta to the east of the same range. Their thickness has been determined from the results of about twenty bores put down on the area about midway between Jebel Têr and Jebel Ghennima near the eastern scarp of the depression.[1]

The Longitudinal Monoclinal Flexure.

Although over the Libyan desert as a whole the general dip of the different sedimentary deposits is steadily northwards, we find considerable local variations, especially in the oasis-depressions. In northern Kharga there is a difference of level of over 200 metres between the same beds on either side of the depression, the dip being in fact eastwards, as will be seen from the accompanying section across the oasis from the summit of Jebel Tarif to the top of the eastern plateau in the neighbourhood of El Dêr. The dip appears to markedly decrease, if not die out altogether, on either side, and the structure of the area might therefore be regarded as a simple monocline were it not for the dominant line of disturbance which runs in a north and south direction along the centre of the oasis parallel to the longer axis of the depression. This line of folding and faulting is most marked in Jebel Têr, a hill range bounded by faults and formed of beds let down through a vertical distance of over a hundred metres. Southwards the line of disturbance—in some places a fault, in others a monoclinal fold—can be traced past Jebel Tarwan, Nadura, and Kharga village to the conspicuous highly inclined beds of Gorn el Gennah, and thence passed the old ruined temple known as Qasr el Ghuâta, immediately

[1] The localities referred to in this paper are shown on the accompanying map, p. 51, the topography of which is based on the maps of the Survey Departmental Report. The scale (1 : 500,000) is of course too small to show each division of the Eocene and Cretaceous, and the boundaries of such as are indicated must only be taken as approximate. On the Survey maps the names of the two prominent outliers of the plateau on the east side of the depression have their names reversed; the most northerly is Jebel el Ghennima, the other to the south Jebel Um el Ghennaim.

south of which the White Chalk is let down some 300 metres on to the floor-level of the oasis, it and the underlying shales being bent into an almost symmetrical oval basin or centroclinal fold. In all probability the isolated eminences near Bulâq, Gala, and Girm Meshim mark the prolongation of the line of fault southwards, and it may quite possibly continue throughout the depression.

The difference in level on either side of the line of disturbance is as a rule very marked, the floor of the depression on the downthrow side being very considerably lower than that on the west or upthrow side. As might be expected, the line of partial or complete fracture directly affects the water-supply, and one of the most noteworthy features of the country south of Jebel Têr is the grouping of all the most important wells near but on the upthrow side of the fault, in spite of the ground on this side being at a considerably higher level. Probably the sandstones rise gently to the west, in which case the underground flow in this neighbourhood may be from west to east, which would account for the best yields being obtained from bores put down near but to the west of the fault; on the other side, although the actual surface level is lower, the water-bearing sandstones occur at a deeper level, and possibly the line of fracture in great measure cuts off the supply.[1]

Ball reported that the most striking evidence of faulting in the oasis was between Jebel Têr and Jebel Tarif, but although the possibility of this fault being connected with and causing the tilted strata of the Gorn el Gennah is referred to, he finally appears to have abandoned this view, as his map shows the fault as extending over only a comparatively short distance lying midway between Jebel Têr and Jebel Tarif and running in a N.N.E. and S.S.W. direction. This misplacing of the line of fracture led Ball to believe that the majority of the wells were on the east or downthrow side of the fault, whereas, as I have shown, they are in reality on the opposite or west side, the actual line of flexure passing almost direct from Jebel Têr through the Gorn el Gennah.

Surface-water Sandstone.

The stratigraphical position of the beds of this division will be seen by reference to the section. They have an average thickness of 45 metres, and consist almost entirely of sandstones of varying degrees of coarseness, often highly ferruginous, and containing occasional beds of aluminium and magnesium sulphates. Bands of shale are met with here and there, but as a rule are confined to the upper and lower portions of the series. Members of the group outcrop on the nearly level floor of the oasis over large areas to the east of the line of disturbance, while to the west, where, as I have shown, the general elevation of the beds is higher, they form the foothills of Jebel Tarif, Jebel Têr, and the high cliffs which rise to the north of Um el Dabâdib and Ain Lebekha. Probably the sandstones which form the surface of the desert between Kharga and Dakhla and cover large areas to the south of these oases, also belong to this group.

[1] Op. cit., pp. 95–97.

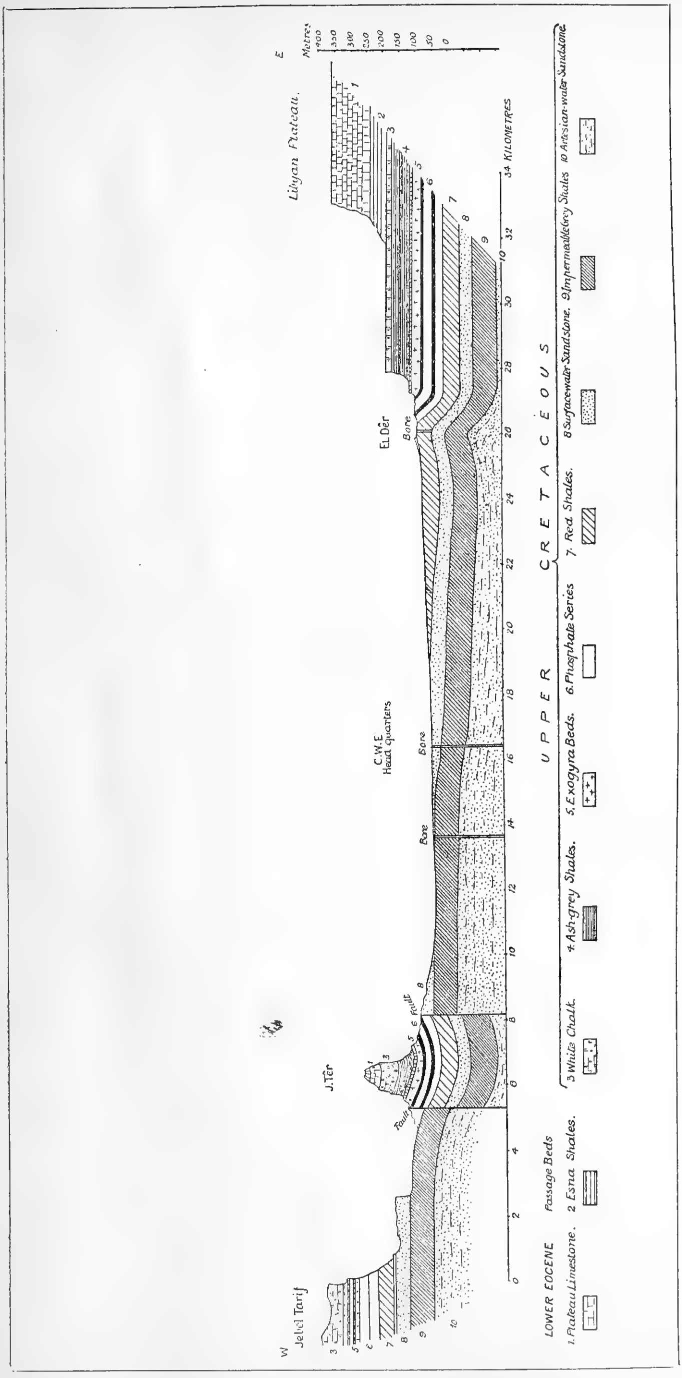


FIG. 2.—Kharga Oasis: detailed section across the Depression through Jebel Tarif, Jebel Têr, C.W.E. Headquarters, and El Dêr.

The sandstones of this series form the highest water-bearing horizon in the oasis, and one quite distinct from the artesian-water sandstone, the two being separated by a thick impervious series of dense grey shales. In the district round headquarters the water is as a rule met with at a depth of from five to six metres below the ground surface, is not under pressure, and does not rise appreciably in boreholes, so that to become available for irrigation it has to be lifted by power. An ordinary borehole or small pit is, however, useless, as the inflow of water through the pores of the sandstone is too slow to yield a pumping supply; in a large pit a number of small fissures are usually struck, and it is through these that most of the water is obtained. Provided a sufficiently large collecting tank is excavated—say 5 × 4 metres and sunk to from one to one and a half metres below the standing water-level—a supply sufficient to yield a continual discharge of eight gallons a minute (or 11,500 gallons per day of twenty-four hours) can usually be obtained. In especially favourable localities a pit of the dimensions given above will yield 15 or even 20 gallons per minute, and the pumping capacity can as a rule be still further increased by deepening. The extent to which this supply can be drawn on without appreciably lowering the water-level has not, of course, yet been determined, though in one pit alongside Bore No. 2, where a 'sakia' has been working more or less continuously for over a year, the water-level has not appreciably changed.

Unfortunately the quality of this water, at any rate in the headquarters area,[1] is not uniform, in some places being quite sweet while in others, only a few hundred metres distant, it is highly ferruginous and more or less charged with salts. For instance, the water of a pit put down at a point 570 metres E.S.E. of headquarters was found on analysis to contain 63 grains of dissolved solids per gallon, the salts consisting of iron, potash, and soda, with traces of lime and magnesia, mostly in the form of sulphates and chlorides.[2] The utilisation of this water for purposes of irrigation would, at the rate of three gallons a minute per acre, mean an annual deposition of over three tons of sulphate of potash and common salt on each acre of land, an amount which would of course spell ruin to its agricultural value in a very short time.

In many parts of the oasis, however, perfectly sweet water is obtainable from the sandstones of this series, and that this source, as an auxiliary to the artesian supplies obtained from deep borings, was taken full advantage of by the ancients, is testified by the wonderful systems of underground aqueducts which penetrate the sandstones in many parts of the oasis, but more especially in the districts round Um el Dabâdib, Ain Lebekha, and Qasr Gyb. They were especially applicable to districts where the bulk of the sandstones, as in the first two localities mentioned, form extensive hills above the general level of the neighbouring cultivable ground. The method was probably

[1] The headquarters of the Corporation of Western Egypt, Ltd.; the area over which the boring operations referred to in this paper extend is shown on the accompanying map (Fig. 1, p. 51) by a dotted line.

[2] For the analyses quoted in this paper I am indebted to Mr. William Garsed, formerly of the Oasis Headquarters Staff.

introduced into the oases from Persia, where underground aqueducts or 'kareez,' for the transference of water from one locality to another, have from an early date been extensively employed. The immense amount of time and labour which must have been expended can hardly be realised without actually exploring the excavations themselves, but it may be remarked that at Um el Dabâdib the two main carrying channels, with their subsidiary branches, measure several kilometres in length, and are cut almost throughout in hard sandstone rock, the tunnels being moreover connected at frequent intervals with the ground surface above by vertical air shafts, likewise excavated in the solid rock; one of the latter which I descended measured 130 feet in depth.

It is difficult to believe that the supplies of water obtained from these sandstones were commensurate with the time and labour involved in the construction of the necessary collecting tunnels, but that enough water was obtained to enable fairly large colonies to exist is evident from the traces of former villages and cultivated areas. After the withdrawal of the Romans these outlying districts were abandoned and the subterranean aqueducts gradually silted up. Some few years ago one of the main tunnels at Um el Dabâdib was completely cleaned out, and when I visited the place in 1905 the discharge at the mouth of the aqueduct was about 30 or 35 gallons a minute.[1]

(*To be concluded in the March Number.*)

II.—Notes on the Geology of Basutoland.

By the Rev. S. S. Dornan.

THE rocks composing Basutoland belong to the Stormberg Series of the Karroo System. They cover a much larger area than Basutoland, extending into the Orange River Colony on the west and north, on the south and east into Cape Colony and Natal, and, I am informed, across the Vaal into the Transvaal. The area is thus not less than 45,000 square miles. The whole of that part of the Orange River Colony known as "the Conquered Territory," east of a line drawn from Thaba 'Nchu to Vrede, is occupied by the whole or portions of these rocks.

The average thickness of the rocks is as follows:—

	Designation.	*Thickness of feet.*
	Recent and superficial accumulations	20–40
Stormberg Series.	(1) Volcanic Beds	600–4000
	(2) Cave Sandstone	150–400
	(3) Red Beds	300–500
	(4) Molteno Beds (base not seen)	600 exposed.

[1] Ball visited the locality in 1898 before the tunnel described above had been cleaned out, and is responsible for the rather fantastic theory that it led to another inhabited oasis to the north of the escarpment (op. cit., pp. 31 and 76). The same writer further remarks (p. 82): "It is worthy of note that, with the exception of the Roman work near Ain Um Dabadib and a line of bricked manholes near Gennah, no traces of underground watercourses, such as occur so abundantly in Baharia Oasis, are to be seen in Kharga." As a matter of fact, however, there is hardly a district in northern Kharga where extensive underground aqueducts do not occur, and they far exceed in magnitude anything found in the oasis of Baharia.

The rocks are, as a rule, well exposed, owing to the great denudation the country has undergone. The thickness is very uniform all over the country from north to south, as at Qalo, near Botha-Bothe :

	feet.
Volcanic Beds	400
Cave Sandstone	250
Red Beds	350
Molteno Beds	450

and at Sebapala in the extreme south-east :

	feet.
Volcanic Beds	1000
Cave Sandstone	200
Red Beds	400
Molteno Beds	150 exposed in places.

As one advances farther into the hills the Volcanic Beds become much more prominent rock features, as they compose the highest ranges of mountains, termed Maluti in Sesuto. In addition to these rocks there is a vast network of intrusive sheets and dykes traversing the various members of the Stormberg Series.

(4) The Molteno Beds are composed of sandstones, shales, and mudstones, usually grey or greenish in colour, with occasional bands of conglomerate. When freshly fractured the sandstone presents a highly glittering appearance. Nodules of mud are of frequent occurrence, and most of the sandstone is of a loose texture. The rocks weather very fast. At Morija the shales contain numerous plant-remains referable to *Thinnfeldia* and *Stenopteris.* Fragmentary reptilian remains occur in the sandstones. The largest portion I have yet found is the upper part of the humerus of a Dinosaur ; the species to which it belongs has not been determined. The cast of a Cephalopodous shell was found by the writer in the Molteno Sandstones close to Morija, and I have heard of a similar discovery near Ficksburg. The Molteno Beds contain thin seams of coal, varying in thickness from 1 inch up to 6 inches. Usually the seams only extend a short distance and then break up into pockets. The coal is soft and of indifferent quality, but occasional seams of good quality are to be found, as for example at Mohale's Hoek, where a seam 6 inches thick exists of most excellent quality. It is worked to some extent by the natives. The plants composing the coal seem to have grown, generally speaking, in marshy depressions, as the presence of occasional trunks of trees in the sandstones indicates an old land surface. I am aware that this is not the usual view held of the origin of the coal, but from observations at widely different places I have come to the conclusion that the drift origin of the coal-beds is not generally true. These seams of coal are widespread over the country, being found at places as far apart as 70 or 80 miles. The Basutos do not usually dig this coal. They try to conceal its whereabouts as much as possible, for fear of the white man seizing the country, and, with the example of other parts of South Africa before their eyes, one cannot wonder at their action.

About 50 feet above the horizon upon which the coal is found there is a bed of deep red conglomerate, containing pebbles of quartzite, evidently derived from Cape or pre-Cape rocks, varying in size from a pea up to masses six or eight inches in diameter. The presence of these blocks must imply a considerable distance in transportation, as no rocks of this character occur nearer, I understand, than Pondoland, Griqualand West, or the Transvaal. As most of the ripple-marks in the sandstones indicate a current with an east to west direction, it is more likely they came from the first-mentioned place. This conglomerate is highly charged with ferruginous matter, so that its appearance is very characteristic. The thickness of the bed varies from three to five feet. This bed is usually taken as indicating coal beneath in Cape Colony, and I can confirm this from personal observation in Basutoland. It seems to be the higher of the two horizons upon which coal is found in the Molteno Beds. The lower is not exposed in Basutoland. The conglomerate is remarkably uniform and persistent all over the country, just a little above the plain, and in every exposure I have found indications of the presence of coal beneath. Good exposures of the Molteno Beds are difficult to obtain in Basutoland owing to the amount of detritus, which covers the slopes of the hills where they lie. This does not apply to the Red Beds and Cave Sandstone, splendid exposures of which occur everywhere.

Fossils,[1] except plants, are not plentiful, principally owing to the absence of good exposures, and also owing to the jealousy of the natives, which prevents any systematic search. Scattered bones occur, but I have seen no skulls or complete skeletons. The species to which these bones belong have not been determined. Large fossilised trunks of trees as much as 2 feet in diameter are not uncommon. These would indicate a land surface, at no great distance, or they may have been floated down by a river.

(3) The Red Beds lie conformably upon the Molteno Beds without any distinct line of separation, so that it is difficult to say where the one ends and the other begins. The name is an unfortunate one, and as the rocks are so characteristic and so persistent all over the country, the name could be very well changed in favour of some other designation. They are composed of red sandstones, blue, green, and chocolate-coloured mudstones and shales, the mudstones as a rule predominating. It is noteworthy that most of the green mudstones weather red, which gives the red portions of the beds an apparent thickness much greater than they really have. Ripple-marks and false bedding are extremely common, and nearly always indicate a current from an easterly and north-easterly direction. No plants have been found so far. Fossil wood is rather plentiful, and, of late, reptilian bones have been found in the Orange River Colony and North Basutoland in considerable numbers, indicating large and small Dinosaurs. The largest thigh-bone I have seen measures 19½ inches

[1] Since this was written footprints of reptiles have been discovered in Molteno Beds near the Tsuaieng River about 1½ hour's ride from Morija. They are four-toed and about 6 inches square, and belonged to some heavy-footed animal similar to a *Pareiasaurus*, but certainly not this animal. They strongly resemble Labyrinthodont tracks. I am also informed by Mr. H. C. Sloley, Resident Commissioner of Maseru, that a skeleton of a Dinosaur of large size was found in the bed of the Tebetebeng River, and curiously enough was lying alongside of a doleritic dyke.

in circumference at the upper extremity of the shaft. Near the Caledon River outside of Ficksburg a large quantity of bones was recently found belonging to individuals of various sizes, and presumably of different species. The bones are broken and mixed up together as if they had been swept down into their present position by a flood. They are embedded in chocolate-coloured mudstone. So plentiful are they that a farmer has built the walls of his cattle kraal of blocks of stone containing fragments of bones.[1] In this band of mudstone are curious circular bombs of clay, filled with fine glassy sand, with a central nucleus of limestone, so that they look like howitzer shells. The diameter of these concretions is usually about 10 or 12 inches, and the thickness of the clay layers about 8 inches. The local name for them is "Basuto pots," and the term is certainly not inapplicable, as on breaking in the top the whole of the contents can be emptied out. Nodules are of frequent occurrence all through the Red Beds, and are more or less common through the whole of the Molteno Red Beds and Cave Sandstone. Silicified wood is fairly plentiful in the Red Beds, but the remains are mostly fragmentary; the largest portion of a tree I have seen measures 4 feet in length and 1 ft. 10 in. in diameter. It occurs between Cana and Hlotse. The Red Beds in many places must have been deposited in shoal water, as ripple-marked sandstone is very common, so much so in fact that the Rev. D. F. Ellenberger, of Masitisi, has built one of his outhouses and flagged all his floors with slabs of the most beautifully ripple-marked sandstone belonging to the upper members of the Red Beds. Fossil fishes have been found in the bed of the Telle River said to belong to the genus *Semionotus*, but I am not able to vouch for the accuracy of this. I understand these fish eventually found their way to the British Museum. Spines of a small carnivorous Dinosaur, *Massospondylus*, have also been found in the neighbourhood of Masitisi. The Red Beds are remarkably uniform in thickness and appearance all over the country. They have been traced for nearly 100 miles in practically a straight line without any marked difference, the average thickness being about 300 feet. In some places in South Basutoland they are 400 feet thick. They lie nearly horizontally on the Molteno Beds, partaking of their general easterly dip.

(2) The Cave Sandstone is extremely difficult to separate from the underlying Red Beds, which pass up into it without any marked difference. Thus there is no definite line of demarcation; Red Beds occur in what I consider Lower Cave Sandstone, but the Cave Sandstone is distinguished, especially in its upper members, by its greater massiveness, and also by its prevailing grey colour. It forms precipices round the tops of the hills, in many cases overhanging. The individual beds are very thick, and the rock does not readily split into laminæ. The Cave Sandstone weathers into huge pillars, or breaks off in immense blocks hundreds of tons in weight. These

[1] The Rev. H. Dieterlen, of Leribe, has a vertebra of a Dinosaur, 6 inches in length, which is said to have come from Red Beds, and also near his station there is a portion of an arm-bone, embedded in grey mudstone, just at the base of the Red Beds.

strew the hillsides everywhere, so that one can always tell when one is in the neighbourhood of this rock by the character of the fallen blocks on a slope. A good example of the pillar formation is to be seen at the station of Thaba Bosin. A small hill named Qiloane, evidently at one time connected with Thaba Bosin mountain, but now separated by a valley a mile wide and over 600 feet deep, is crowned by a pillar of Cave Sandstone some 100 feet high. It is about 15 feet broad on top, and is composed of three immense steps gradually tapering to a point. The precipices of the Cave Sandstone are usually covered with a blackish glaze, the effects of sun and rain, which renders them very slippery. The rock is perforated with openings, especially near the crests of the hills, but though these openings have given the rock its present name they are not true caves, being usually due to the more rapid erosion of the bands of blue clay with which the rock is interstratified, especially in its lower members. They are merely shelters with overhanging ledges. Instances of true caves do occur, but they are uncommon. The Bushmen inhabited these caves in former times, and also cannibals—the remnants of tribes broken up by Chaka and Umsilikazi in their sanguinary raids and driven to cannibalism by fear and starvation.[1] One very large cave near the station of Cana is still called the Cannibals' Cave, and the people point out the ledge upon which the cannibals slaughtered their victims, appealing to the blood-stains on it in proof of their assertion. Needless to say, the ledge is nothing more than green mudstone, which has weathered red. The Bushmen have left traces of their occupation of the country in the paintings on the walls of these rock shelters. Many of these paintings are remarkable for their finish and accuracy of delineation. One of the largest series of paintings is to be found two hours from the station of Thaba Bosin. On the rock face are hundreds of paintings of elands, some of them 24 inches long and 9 inches high, hartebeest, 'gnu, storks, and jackals, all in the natural colours of the animals. The bodies of the elands are painted brown, while the neck, head, and belly are white. Mixed with these are scores of men in rows with bows and arrows, evidently fighting. At one place a Bushman is stealing up to a hartebeest grazing in rather long grass, with his arrow on the string. At another place we can see the hunter charged and knocked over by the infuriated animal he has just shot. On another part of the rock lions are depicted in their tawny colour, some leaping upon game, others on the *qui vive*. Then there are jackals and curious drawings representing snakes or perhaps mythological signs. Unfortunately most of the paintings have been spoiled by the fires made by the Basuto herd boys. The Basuto see no beauty in and put no value upon these paintings, and their wanton destruction is very often encouraged by the chiefs themselves, in order to prevent Europeans from visiting the country. Other beautiful sets of paintings occur at Sehonghong on the Upper Orange River, the finest set in the country, at Hermon, Thabana, Morena, Masitisi, Kolo, Qeme, Teyateyaneng, Qalo, and many other places. Those at Masitisi are remarkably good, but the figures are small. They are

[1] Voyage d'exploration, par M. Arbousset, 1836.

comparatively recent, certainly within 70 years or so, as horses and riders are depicted upon them, and these animals were not brought into Basutoland till the early part of last century.

Fossils are comparatively rare in the Cave Sandstone, but although the actual remains of the animals are seldom met with their footprints are fairly common. The remains of the forearm and part of the shoulders of a Dinosaur, species undetermined, occur at Sebapala.[1] The footprints of Dinosaurs of large size occur at the following places, all in a band of green mud about 18 inches thick, viz., Tsikuane, Qalo, Morija, and Teyateyaneng. Those at Qalo are most distinct, showing the corrugations of the skin. The largest prints are 14½ inches long by 10 wide. Other impressions are shown in relief on the roof near by. The animals walked from west to east up-stream, over the bed of a river, as indicated by the ripple-marks, similar to what one sees every day in the beds of all the large rivers. This green mudstone is interesting as it lies on a jagged surface of coarse sandstone, and points to some denudation having previously taken place.

At Tsikuane, 25 miles further south-west, a magnificent series of dinosaurian footprints are to be seen in the same green mud, on the underside of an overhanging cliff. They are all in relief. The huge block which has broken off, with the impressions in their natural state, lies below. There are more than 50 of these prints all with the same general direction from west to east, but crossing and recrossing each other in the most extraordinary fashion. Large and small are mixed up together, but the great bulk of them are small prints. There are two sets of very large prints most conspicuous, evidently belonging to two large individuals. The length of these tracks is not less than 15 inches (middle toe). They are all of the three-toed variety. A study of these footprints, which ramble about a great deal, shows that they were probably not all made at one time, as some have been imprinted on the others subsequently, when they had to some extent hardened, for if they had all been formed at the same time the first would have obliterated the second. One is irresistibly driven to the conclusion that these prints belong to a single family of Dinosaurs. This would imply that Dinosaurs were rather prolific, or that their families remained with them a long time. Another and more probable suggestion is that the animals were gregarious.[2]

At Morija, 75 miles further south-west, there are two slabs containing dinosaurian tracks. The smaller contains one large and a few small impressions. The larger slab is many tons in weight, and in falling has split into two, showing the tracks in reverse. It contains three different sets of impressions large and small, belonging to individuals of different sizes and possibly of different species. Here the same crossing of prints occurs as at Tsikuane. The middle toe of the largest track is 15 inches long, and the stride 3 ft. 3 ins. to 5 feet. Besides these impressions it contains well-preserved sun-cracks, showing

[1] Part of a jaw was found near Morija; it probably belongs to *Hortalotarsus*.

[2] Since writing this, further study of these footprints has convinced me that what I took to be footprints partially obliterated by others made long subsequently were only the partial obliteration made by the hind-feet of animals following the others immediately.

that the animals walked over the muddy flats of a lake or river before they were dry. These tracks occur in the same band of green mud as at Tsikuane and Qalo, with ripple-marks and sun-cracks, just what one sees on the muddy bottoms of many of the large rivers to-day.

(*To be concluded in the March Number.*)

III.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

(PLATES IV AND V.)

(*Continued from the January Number, page* 31.)

Zaphrentis delanouei, M.-Ed. & H. (Plate V, Figs. 5–7.)

1851. *Zaphrentis delanouei*, M.-Edwards & Haime: Pol. Foss. d. Terr. Pal., p. 332, pl. v, figs. 2–2c (*syn. exclusâ*).
1860. ,, ,, M.-Edwards: Hist. nat. d. Corall., t. iii, p. 339.
1861. ,, ,, de Fromentel: Int. à l'et. polyp. foss., p. 288.
1869. ,, ,, Kunth: Zeit. d. deut. Geol. Gesell., vol. xxi, p. 665, pl. xviii, fig. 6.
1872. ,, ,, de Koninck: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. l. Belg., p. 101, pl. x, figs. 6, 6*a*.
,, *Cliffordana*? ibid., p. 105, pl. x, figs. 9, 9*a*.
1905. ,, aff. *phillipsi* (pars), Vaughan: Q.J.G.S., vol. lxi, pl. xxii, figs. 2, 2*a*.

External Characters.

Corallum conical and, as a rule, gently curved, though often straight; a short broad outline is not uncommon.[2] The *epitheca* has well-marked longitudinal ribbing, sometimes obscured by fine annular striations in the neighbourhood of the calyx; slight constrictions of growth may occur, but there is never an interruption in the continuity of the epitheca. Good figures are given both by Milne-Edwards & Haime and by de Koninck.

Calyx deep, with a thin rim and steep sides. The *major septa* are strong, well separated, and very regularly arranged, with a characteristic curvature convex to the fossula. This curvature is not so apparent in adult calices (Pl. V, Fig. 5*a*); it is best seen in young specimens, where also the septa in the two cardinal quadrants are arranged as if overlapping those in the counter quadrants (see de Koninck's figure of *Z. Cliffordana*, Pl. x, fig. 9*a*, Nouv. Recher.). The inner ends of the major septa are, as a rule, slightly thickened,

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.

[2] In a few rare cases the coral may become cylindrical in the final growth stages and the septa then become amplexoid, retreating from the upper surface of successive tabulæ. The commencement of such a stage is indicated in Pl. V, Fig. 6. A unique specimen from Tournai, now in the Survey collection (R.C. 330), shows this habit. It is 4·5 cm. in length, and the cylindrical distal portion measures 2·5 by 1·3 cm. No trace of marginal dissepiments appears, either in the longitudinal section or in the calyx. In other species amplexoid septa accompany the acquisition of a cylindrical habit, and fuller reference to the matter will subsequently be given under *Caninia cornucopiæ*, Mich.

and are intimately fused together. They do not quite reach the centre of the calicinal floor, where there is consequently a small tabular area about 2 mm. in diameter, forming the inner end of the fossula. This small tabula is, however, not often found preserved, and in that case the centre of the calyx presents a smooth-walled tubular space (see Pl. V, Figs. 5, 5*a*).

The *minor septa* are entirely rudimentary. They are seen around the interior of the calyx as low ridges between the thickened bases of the major septa; those on either side of the counter septum are sometimes longer than the others.

The (cardinal) *fossula*, unlike that of most rugose corals, lies on the concave side of the corallum;[1] it is always very distinct, extending to the centre of the calyx, and, especially in young specimens, often beyond. The outline is continuous and even, becoming sometimes slightly narrower midway in its length, and having a marked expansion at the inner end (Pl. V, Fig. 5*a*); although so smooth, the bounding walls are purely septal, and there does not seem to be any accessory thickening, as in *Z. konincki*. Good figures of the calyx are given both by Milne-Edwards & Haime and by de Koninck, although in that of the latter the perspective is somewhat faulty. Both figure specimens in which the central tabular area is preserved, so that the fossula appears much narrower and shorter than it does in Pl. V, Fig. 5*a* (where the tabular area has been destroyed), or than it does in transverse sections.

Average dimensions.

Height of an adult specimen, 2·5 cm.; diameter of calicinal rim, 1·3 cm.; number of major septa with above diameter of calyx, 27; depth of calyx, 1 cm.

INTERNAL CHARACTERS.

(a) *Transverse Sections.*—The mode of septal arrangement does not differ greatly from that seen in the calyx, though the curvature of the septa convex to the fossula is more clearly shown. In the lower part of the coral it is common to find the fossula relatively wider and larger in every way than in the upper sections, and expanding continuously from the wall to the centre of the coral (Pl. V, Figs. 6*b* and 7). The cardinal septum is long and thin, completely dividing the fossula till just below the calyx, where it rapidly dwindles in length. There is never any indication of a counter fossula, nor is the counter septum of itself in any way differentiated from its neighbours.

The *minor septa* are extremely rudimentary. They may be barely perceptible, even in calicinal sections of a mature individual, but occasionally those on each side of the counter septum are more prominent than the rest, affording useful evidence in the identification of that septum.

(b) *Vertical Sections.*—The simple tabulæ, arched in the centre, from 1 to 2 mm. apart, and with a strong depression at the fossula, call for no special remark. A text-figure (Diagram C) is given to illustrate their nature.

[1] It is, however, sometimes laterally disposed, and in one or two rare instances lies distinctly on the convex side of curvature.

Localities.

Visean: Ashfell Beds (S). Thorlieshope and other quarries in the Cement Stone Series of Liddelsdale.[1]

Tournaisian: Z_1 subzone and horizon β; Avon Gorge, Walton Castle (Clevedon), Abbotsleigh, and Burrington (especially at Goatchurch Cave).

Remarks.

The enlarged figures on Pl. x of de Koninck's "Nouvelles Recherches" of a coral doubtfully ascribed by the Belgian author to *Z. Cliffordana*, M.-Ed. & H., represents a young example of *Z. delanouei*. Such was apparent on an inspection of the figured specimen; two similar ones are represented in the Piret Collection. These, on slicing, afforded sections identical with those cut near the tip of a typical example of the species.

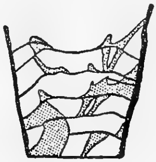


Diagram C.—*Zaphrentis delanouei*, M.-Ed. & H. Cement Stones, Liddelsdale. M. 289*f*. Geol. Surv. Scot. Vertical section in a plane at right angles to the cardinal fossula, showing the tabulæ; the shaded parts represent intersections of septa in the plane of section. × 2.

Z. delanouei is a well-marked species. Though often identical with *Z. omaliusi* in size, shape, and epithecal characters, marked differences of septal arrangement are displayed in the calyx and in transverse sections. The curvature of the septa convex, instead of concave, to the cardinal fossula, the large size, the extent, and position relative to the curvature of the corallum, of the cardinal fossula, and the entire absence, at any period of growth, of a counter fossula, are all characters which at once distinguish *Z. delanouei* from *Z. omaliusi*. When any doubt occurs, a section in the lower part of the coral should dispose of the difficulty, since it is here that the septal grouping in these two species is most characteristically shown.

The only other Tournaisian coral with which, so far as I am aware, the species could be confused, is perhaps *Caninia cornucopiæ*, Mich. M. de Koninck noticed that there is a resemblance in the calyx of these two corals. The differences (which are very apparent in transverse sections) will be dealt with in the description of the latter species.

Certain Visean Zaphrentids show considerable resemblance to *Z. delanouei*, though, as will be noticed later, the species itself does not seem to occur in that division of the Carboniferous Limestone, or at any rate, only in the lower part. Of these, a mutation, as yet undescribed, though extremely abundant in the Carboniferous Limestone Series of Scotland, only differs in the constricted shape of the fossula, which

[1] Ranging probably from the Upper Tournaisian to the Lower Visean.

narrows rapidly from the outer to the inner end instead of expanding, and in the shortening of the cardinal septum very early in the growth of the coral. Intermediate forms also exist, where the sides of the fossula are parallel from end to end. These mutational forms will be dealt with in a future paper on the evolution of the species. Meanwhile, in my opinion, the name *Z. delanouei* should be restricted to those corals where the fossula, in a section cut just below the calyx, is clearly more expanded at its inner than its outer end, and where, of course, the other characters of the species are present. Another somewhat similar Visean Zaphrentid is *Z. enniskilleni*. This may be distinguished from *Z. delanouei* by its larger size, a more irregular outline of the fossula, and by an absence of the thickening and intimate fusion of the inner ends of the major septa, so well seen in the latter species, while the septa are more irregular in their disposition, and are often discontinuous.

It has, unfortunately, not been possible to obtain serial sections of this beautiful species, suitable for reproduction, in an unbroken condition, at any rate so far as fully grown forms are concerned; the large fossula and simple tabulæ make the coral peculiarly liable to fracture. The partially restored sections on Pl. V, however, represent the average of a considerable number of specimens, and it is hoped that they will serve as accurate delineations of the mature coral.

Distribution.

Dr. Vaughan has kindly contributed some notes on the distribution of *Z. omaliusi* and *Z. delanouei* in the South-Western Province. After referring to the separation of *Z.* aff. *phillipsi* into these two species,[1] he says:—

"Being convinced of the justification for this separation, I have assiduously collected[2] from the *Zaphrentis*-zone in the Bristol, N. Mendip and Weston areas, with the view of determining the distribution of these two species. The results of this revision are highly satisfactory in their definiteness, viz.:—*Z. delanouei* is practically confined to Z_1, being only doubtfully recorded from Z_2 of Portishead. It is prolific at the base (Horizon β), but rare in Upper Z_2. *Z. omaliusi* teems in Z_2 and at several levels in the lower part of C. It is practically unknown from Z_1, being very doubtfully recorded from β of Burrington. In the Gower the resolution of *Z.* aff. *phillipsi* into its component species has yet to be studied, but the results of such revision will, however, in no way affect the zonal sub-divisions established in the [Bristol] paper from the consideration of broad faunal assemblages, in terms of which the distribution of the components will have to be expressed. Since the distribution and structural characters of the *Zaphrentes* and *Campophylla* in County Dublin have an important bearing upon the correlation of the beds, and since the Densiphyllid Zaphrentes are practically unknown except as rare

[1] As Dr. Vaughan informs me, the description of *Z.* aff. *phillipsi* in his original paper (Q.J.G.S., vol. lxi, p. 270) is only applicable in its entirety to *Z. omaliusi*.

[2] "In this work I have received very valuable assistance from Mr. W. H. Wickes, Professor S. H. Reynolds, and Mr. H. F. Barke; Mr. Carruthers has uncomplainingly checked the identification of almost every specimen."

unstable sports in the South-Western Province, a discussion of the Irish material must be deferred, and will accompany Dr. Matley's forthcoming account of the Rush to Skerries section."[1]

The range of *Z. delanouei* seems more extensive in Scotland than in the South-Western Province. A large number of specimens have recently rewarded the diligent search of Mr. A. Macconochie; these were found at several horizons in the Cement Stones of Liddelsdale, up to the base of the Fells Sandstone. The great majority were dwarfed forms, in common with the associated fossils; conditions in these deposits seem to have been quite unfavourable to a free development of marine life. The species also seems to occur at a somewhat high level in the North of England. Some small corals in Professor Garwood's collection from the Ashfell Beds, provisionally correlated by him with the lower Visean level S_1–S_2, seem clearly referable to *Z. delanouei*; it is noteworthy that one or two associated forms are intermediate in type between *Z. delanouei* and the characteristic Visean coral *Z. enniskilleni*.

Zaphrentis konincki, M.-Ed. & H. (Plate V, Figs. 1–4.)

1851.	*Zaphrentis*	*konincki*,	M.-Edwards & Haime: Pol. Foss. d. Terr. Pal., p. 331, pl. v, figs. 5, 5*a*.
—	,,	*cornucopiæ*,	ibid., p. 331, pl. v, figs. 4, 4*a*.
—	,,	,,	Bronn u. F. Roemer: Lethæa geogn., Th. ii, p. 192, pl. vi, fig. 17.
1852.	,,	,,	M.-Edwards & Haime: Brit. Foss. Cor. (Pal. Soc.), p. 167.
1860.	,,	,,	M.-Edwards: Hist. nat. d. Corall., t. iii, p. 338.
1861.	,,	,,	de Fromentel: Int. à l'et. polyp. foss., p. 287.
—	,,	*konincki*,	ibid., p. 287.
1872.	,,	,,	de Koninck: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. Belg., p. 98, pl. x, figs. 3, 3*a*.
—	,,	*intermedia*,	ibid., p. 99, pl. x, figs. 4, 4*a*.
—	,,	*le Honiana*,	ibid., p. 106, pl. x, figs. 10, 10*a*.
1905.	,,	aff. *cornucopiæ*,	Vaughan: Q.J.G.S., vol. lxi, p. 271, pl. xxii, figs. 3–3*d*.

External Characters.

Corallum conical, slender, and gently curved. The *epitheca* is smooth without longitudinal ribbing, but usually with annular striations and constrictions of growth, while an interruption of the continuity of the epitheca through rejuvenescence is by no means uncommon (see outline of Fig. 2, Pl. V). Good figures of small specimens are given both by Milne-Edwards & Haime and by de Koninck.

Calyx of moderate depth, bell-shaped in vertical section, with closely-packed septa.

The *major septa* are usually thin, always thickened at their outer ends and usually also at their inner ends, which are fused together in the centre of the coral. This may give rise to more or less elevation in the centre of the calicinal floor; but since the inner ends of the counter septum and its neighbours are often not so affected, this

[1] This refers to the recent discovery of *Z. delanouei* and Densiphyllid Zaphrentids in conjunction at Malahide, co. Dublin.

elevation may disappear at that point of the calyx, while in many examples of this species it is not present at all. The feature is commonest in the calices of young specimens.

The (cardinal) *fossula*, lying on the convex side of the corallum, is very deep and distinct, extending to, or beyond, the centre of the calicinal floor, and with a characteristically smooth, even outline, due to the presence of a distinct and continuous stereoplasmic lining; as a rule the fossula is long and narrow, with an expansion at the inner end of varying degree (Pl. V, Fig. 4*a*); it may, however, be widely expanded internally, especially in young specimens.

The *minor septa* are almost always well developed, although at first sight this would not seem to be the case, since they are fused with the major septa for the greater part of their length, and so give rise to a broad and more or less solid rim inside the top of the calyx, beyond which they project but slightly (Pl. V, Fig. 4*a*). They taper to a thin point in the interseptal chambers.

Milne-Edwards & Haime and de Koninck both give good figures of the calyx, but the perspective does not express the peculiar bell-shaped cup very well.

Average dimensions.

Height of an adult specimen, 2·5 cm.; diameter of calicinal rim, 1·3 cm.; depth of calyx, ·8 cm.

Internal Characters.

Transverse Sections.—The *major septa* show similar characters to those seen in the calyx. They are more or less straight, while the thickening at their outer and inner ends is well shown, being generally rather more apparent in the two cardinal quadrants (Pl. V, Fig. 3). As a rule those septa at the counter end of the section show less thickening at their inner ends, and often become subparallel, especially in sections across the younger parts of a corallum.

The (cardinal) *fossula* shows great variation in shape, but is always very prominent. As a rule in the young parts of a corallum it is more expanded than in the mature portions (Pl. V, Figs. 1*a* and 3*a*–3*c*); but the open portion may be very small if the stereoplasmic lining is greatly developed (Pl. V, Figs. 1*a* and 3*c*). The fusion of the inner ends of the major septa with this lining is very complete.

The cardinal septum only extends down the middle of the fossula to the centre of the section in the very young stages of growth. It rapidly shortens higher up the corallum, so that in sections across the more adult portions it is similar in size and shape to the minor septa. These latter are usually well developed,[1] and being fused with the sides of the major septa to a great extent, give the appearance of a very thick wall to the coral (Pl. V, Fig. 1, etc.). The thin pointed ends are sometimes joined with a major septum. They appear very early in the life of the coral, and are seen even in the young stages of growth.

[1] I would regard the minor septa seen in Pl. V, Fig. 1, as having the greatest length attained in *Z. konincki*, as here defined.

Vertical Sections.—The *tabulæ* are numerous, decidedly irregular and vesicular in character, and are strongly arched in the centre of the coral, with a well-marked depression at the fossula (Pl. V, Fig. 2). Vertical sections cut clear of the fossula show a similar arrangement of the tabulæ to that seen in fossular sections, although the strong upward bending in the middle of the coral is naturally not so apparent. There are no dissepiments.

Localities.

Visean (C_2–S): Hazelback (Caninia bed) and Arnside, apparently rare at both localities.

Tournaisian (Z_2 & Y): many localities in the Bristol district (see Dr. Vaughan's paper, Q.J.G.S. 1905), but especially at Big Weston Wood Quarry, Portishead (Z_2), Cromhall (Z_2 & Y), and Strawberry Hill, E. Clevedon (Z_2).

The material at hand was not sufficient to adequately examine the variation of this species, though the facts ascertained may not be without interest.

As regards shape, a definite division into three main groups seems justifiable. These are sufficiently distinct to warrant separation, although they do not merit varietal rank, for the septal characters and arrangement in all three divisions are identical. They may conveniently be referred to as (1) *forma typica*, (2) *forma α*, and (3) *forma β* (see Diagram D).

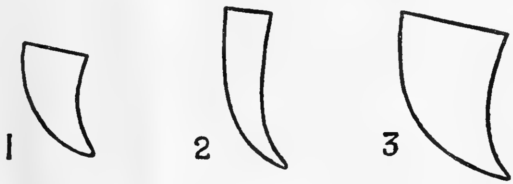


Diagram D.—Outlines of *Z. konincki*, M.-Ed. & H. All half natural size. 1, forma typica; 2, forma *α*; 3, forma *β*.

The first group (*forma typica*) exemplified in those specimens on which the species were founded, is well represented in the Piret Collection, and seems the common form at Tournai (an example is given in Pl. V, Fig. 4), and may also be seen in specimens from the Upper Tournaisian of the Bristol district, and from the lower Visean at Arnside; the second group (*forma α*) is, as Dr. Vaughan has noticed, the dominant form in the Bristol district,[1] while the third group (*forma β*) is found chiefly at Cromhall, near Bristol, and at Arnside also. These growth forms do not seem to be of evolutionary value, and may perhaps be due to environment.

As regards internal structure, some curious features are displayed in a specimen from Tournai, in the Piret Collection (R. 11,677). Externally, this specimen is of large size, with abundant strongly marked constrictions of growth, giving a very corrugated aspect to the coral. When sliced in serial transverse sections, it was apparent that

[1] Dr. Vaughan has figured an example in his Bristol paper (Q.J.G.S., vol. lxi, pl. xxii, fig. 3).

in the upper portion of the coral the septa are impersistent, many of them only reaching the centre of the coral as lines on the surface of the tabulæ; consequently there is a bare tabular area of considerable size in the centre of some of the upper sections, while in the calyx itself the bare tabular floor amounts to two-thirds the diameter of the coral.

A few fragments of a similar form have been found by Dr. Vaughan at Cromhall, in association with more normal examples of the species, including some of large size, but the evidence at present forthcoming does not warrant the establishment of a distinct variety.

A mutation of *Z. konincki* has been briefly described by Mr. Sibly.[1] The chief difference from the normal species appears to lie in the large size of the coral and the more elongated minor septa. Similar forms have been collected by Professor Garwood from Arnside (where the normal species seems rare) together with a further mutation, noticed by Dr. Vaughan, who has kindly supplied the following notes on the form[2]:—

"*Z. konincki*, mut. C_2.—This mutation exhibits a marked convergence with *Cyathophyllum* ϕ, the dominant coral of the C_2 beds. The form is continuously conical and cornute, and the dimensions are large compared with those of typical representatives of the species (the average length is nearly 9 cm.). The septal plan is essentially that of *Z. konincki*, but differs in the conspicuous elongation and distinctness of the secondary [minor] septa. All the septa are attached to the wall by short thickened bases, and the fossula has the elongated parallel-sided section of that in most forms of *Z. konincki*. The striking resemblance to *Cyathophyllum* ϕ is caused by: (1) the external zone radiated by primaries and secondaries" [major and minor septa]; "(2) the apparent development of vesicles in the internal area (as seen in horizontal sections); (3) the type of fossula. The differences are: (1) the apparent absence of vesicles in the external area; (2) the attachment of the septa to the wall by markedly thickened bases."

Remarks.

MM. Milne-Edwards & Haime, in establishing the above species, notice its similarity to the coral erroneously ascribed by them to Michelin's *Caninia cornucopiæ*. In separating the two, they notice that *Z. konincki* has (1) a circular instead of an oval calyx; (2) thirty instead of thirty-two septa, which are (3) thicker at their outer ends and form a prominent lobe near the septal fossula; (4) a fossula more enlarged in the middle and not extending so far across the calyx, and finally (5) 'altogether rudimentary' minor septa.

M. de Koninck's description (Nouvelles Recherches, etc., p. 99) also agrees with theirs, but after showing that the French authors were mistaken in their diagnosis of *Caninia cornucopiæ* he gives a new name, *Zaphrentis intermedia*, to the coral they considered referable to Michelin's species.

[1] F. Sibly, "Carboniferous Limestone of the Mendip Area": Q.J.G.S., vol. lxii (1906), p. 366.

[2] In these notes it should be understood that *Z. konincki* is equivalent to *Z.* aff. *cornucopiæ* of Dr. Vaughan's earlier papers.

The differences between *Z. konincki* and *Z. intermedia* above noted, appear at first sight quite sufficient to justify the relegation of the two corals to different species. But a close examination of several well-preserved examples of these corals from Tournai, and especially of serial transverse sections from them, in my opinion show that the two are essentially identical. The differences are, in the main, a matter of preservation and form of growth. The first two points, i.e., the shape of the calyx and the number of septa, are not of value unless dimensions are given, since they depend on the age and growth of the coral. MM. Edwards & Haime do not give the dimensions of *Z. konincki*; according to M. de Koninck they are about the same as those of *Z. intermedia*; a very slight difference in size would account for the septa being a little different in number.

The last three points, concerning the character of the septa and the fossula, are, however, of greater importance. Serial transverse sections show them to depend to a great extent on the amount of stereoplasmic thickening present. If this is considerable, the lobing of the major septa at their inner and outer ends is emphasized, causing a close fusion of the outer ends with the inner septa; the latter consequently project very slightly into the interseptal chambers, and so have a rudimentary appearance in the calyx, but in the absence of thickening seem long and prominent. At the same time the fusion of the inner ends of the major septa with themselves and with the fossular lining becomes more intimate than usual; this, in the calyx (and it was on the aspect of the calyx that the species were founded) gives rise to more or less elevation in the centre of the calicinal floor, which is otherwise flat. The most striking difference, however, between the figured specimens of these two 'species,' lies in the shape of the fossula. But this, in serial transverse sections of specimens similar to those figured by de Koninck, is seen to vary to a remarkable degree during the growth of the coral, and, further, like the septa, to be affected by the presence or absence of accessory thickening. This is very well exhibited in a typical example of one of these corals from Tournai, part of which is here figured (Pl. V, Figs. 3–3*c*). An examination of these transverse sections shows that in its young stages there is a widely expanded fossula, largely filled up by a stereoplasmic deposit (Pl. V, Figs. 3*a*–3*c*). In successively higher sections this lessens, the fossula then becomes constricted (Pl. V, Fig. 3), while in the last section (not figured) it expands again internally, but finally in the calyx again assumes a constricted and elongated form. These sections show further that the thickening of the inner ends of the major septa is quite as variable at various points of the coral's growth.

These facts clearly show that if the calyx of this particular example could have been examined at various periods of growth, the coral would be referred at one time to *Z. konincki*, at another to *Z. intermedia*.

Precisely similar appearances were afforded by similar serial sections of a large number of these corals collected by Dr. Vaughan in the Bristol district. It was found impossible to draw any valid distinction between *Z. intermedia* and *Z. konincki*; the latter name having considerable priority has therefore been retained.

No doubt examples can be found that have the characters of one of these so-called species throughout its growth. In particular, I have noticed a few small specimens (e.g., R. 11,676) which possess a short enlarged fossula throughout and short minor septa, corresponding to *Z. konincki* as originally defined. But the great majority of these corals which I have examined, are in accordance with the description and figures accompanying the present paper.

It is not surprising that the French and Belgian authors employed two names for this coral. Such a course was indeed a perfectly natural one, since their observations were of necessity confined to the calyx; in such circumstances it was impossible for them to be certain that they were concerned with a single species.

One other point in connection with the synonymy of this species remains to be considered. *Zaph. le Honiana*, de Kon., was a species founded on a single specimen; according to the author, it differed from *Z. konincki* in the greater development of the septa, and in the less elongated shape of the fossula, and from *Z. intermedia* in the number and length of the septa.

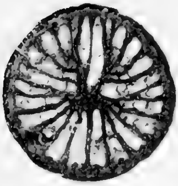
An inspection of the type-specimen showed that it was in reality an unusually large example of *Z. konincki*. This accounted for the number of the septa (40 instead of 32, the diameter of the calyx being 1·5 cm. instead of the 1 cm. of the ordinary *Z. konincki*). The shape of the fossula and the development of the septa (i.e., their prominence in the calyx) we have seen to be unreliable in these corals. Although the central portion of the calicinal floor is broken away in the type (the interior was destroyed during silicification and is now quite hollow), nevertheless the nature and arrangement of the septa around the calyx are clearly seen to be identical with those in *Z. konincki*, as here defined, and to the latter species, in my opinion, the coral must undoubtedly be referred.

One small point concerning the figure of the calyx of *Z. le Honiana* (Nouv. Recher., Pl. x, fig. 10*a*) may be mentioned. The epitheca in that figure seems unusually thick. In reality it is of medium thickness, and the appearance is due to a constriction of growth having taken place at the very top of the calyx.

Distribution.

Z. konincki appears to have a distinct zonal value, although it must be confessed that our knowledge of its distribution outside the South-Western Province is as yet very scanty, since the only district outside that region from which the species has been reported is that of Arnside in the North of England. Concerning the occurrence of the species in the South-Western Province, Dr. Vaughan has supplied the following notes, while he has also added a few words on the Arnside specimens:—

"As I have already pointed out in the Bristol paper, our form is conspicuously elongate when compared with the figure of *Z. cornucopiæ* given by Edwards & Haime (referred above to *Z. konincki*). The recent revision of the Z fauna has added nothing to our previous knowledge of the range of this species; its entrance may be conveniently taken as marking the base of Z_2, its maximum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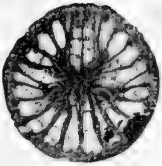
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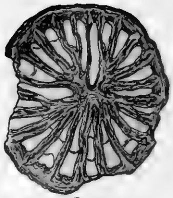
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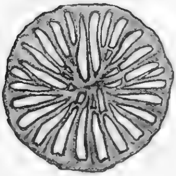
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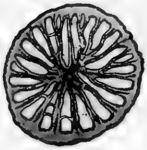
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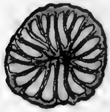
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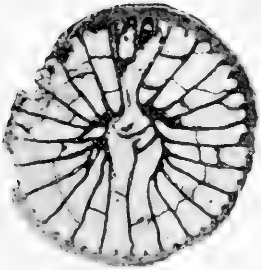
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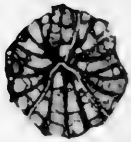
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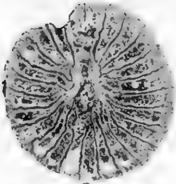
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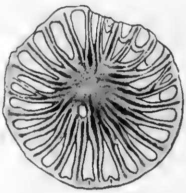
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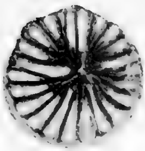
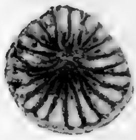

7a


7b

Bemrose, Collo., Derby.

Figs. 1-4.—*Zaphrentis omaliusi*, Edw. & H.; and Figs. 5 to 8.—Varieties.

CARBONIFEROUS LIMESTONE.

occurs immediately below γ, and it diminishes in numbers in C_1. In the Gower the typical species is not uncommon at Threecliff Bay (the base of C_2), but in Upper C_2 it is replaced by the C_2 mutation (for description see notes on the species previously given). From Arnside (Lakesland) in beds which he correlates with C_2–S, of the South-Western Province, Professor E. T. Garwood cites *Z. cornucopiæ*[1]; the specimens belong to this mutation, and are apparently not uncommon."

Professor Garwood has kindly allowed me to examine his material; while most of the specimens clearly belong to the C_2 mutation above referred to by Dr. Vaughan, one specimen (Arnside) with minor septa of moderate length, I would refer to *Z. konincki* as here defined, as also a further specimen from the *Caninia* bed at Hazelback. The Arnside specimen, in outline, agreed with *Z. konincki*, forma β, as opposed to the forma a commonly found in the Bristol district, but was otherwise similar to the specimens figured on Pl. V. The shape of the Hazelback example could not be ascertained as it was embedded in the limestone. The section agreed very closely with that on Pl. V, Fig. 1.

Some further specimens collected from Arnside by Dr. Wheelton Hind and forwarded to me by Dr. Vaughan, also yielded a good example of *Z. konincki*, forma typica, but the remainder belonged to the C_2 mutation.

Summarising the evidence, therefore, it seems that in the Bristol district *Z. konincki* characterises the uppermost Tournaisian beds, while in the Gower it occurs at a somewhat higher level, in the lower Visean, and in the North of England, at Arnside, probably on a still higher horizon, but at both of these last localities a mutational form becomes predominant.

EXPLANATION OF PLATES.

Plate IV.

The register numbers refer to specimens in the British Museum (Natural History) unless otherwise stated.

Zaphrentis omaliusi, M.-Ed. & H.

Figs. 1–1*a*.—Transverse sections from a typical individual, that in Fig. 1 cut just below the calyx floor. Indications of a counter fossula are shown. × 3. Tournaisian (Z_2 subzone): Woodspring, near Bristol. Vaughan Collection.

Fig. 2.—Profile of a young example. × $\frac{3}{2}$. Tournai. R. 11,658.

Fig. 3.—Another transverse section, cut just below the calyx floor. × 3. Waulsort. Mus. Roy. d'Hist. Nat. Brussels.

Figs. 4–4*b*.—Serial transverse sections of another example. × 3. The calyx agrees well with those figured by MM. Milne-Edwards & Haime and de Koninck. Tournai. R. 11,675. (Camera lucida drawings.)

Var. ambigua, var. nov.

Figs. 5–5*a*.—Transverse sections from a typical example. × 3. Upper (?) Visean: Horrocksford Quarry, near Clitheroe.

Fig. 6.—Transverse section just below the calyx of an unusually large specimen, lower sections of which agree with those in Figs. 5–5*a*. × 3. Tournaisian (Z zone): coast at Rush, co. Dublin. Matley Collection.

[1] Geol. Mag., 1907, p. 73.

Var. DENSA, var. nov.

FIGS. 7–7*b*.—Serial transverse sections (type-specimen). × 3. The septa in the highest section (Fig. 7) were partly silicified, and a camera lucida drawing was necessary to show their disposition clearly. Tournaisian: coast at Malahide (locality i), co. Dublin. Vaughan Collection.

FIG. 8.—Transverse section of another example. × 3. The section is cut just above the floor of the calyx; the cardinal septum is therefore very short and some of the septa disconnected. Tournaisian (Z_2 subzone): Big Weston Wood Quarry, Portishead, near Bristol. Vaughan Collection.

PLATE V.

The register numbers refer to specimens in the British Museum (Natural History).

ZAPHRENTIS KONINCKI, M.-Ed. & H.

FIG. 1.—Transverse section of a mature individual, cut just below the floor of the calyx. × 3. Tournaisian (Z_2 subzone): Strawberry Hill, East Clevedon, near Bristol. Vaughan Collection.

FIG. 1*a*.—A further section cut 1·3 cm. below preceding. × 3.

FIG. 2.—Vertical section cut down the cardinal fossula. Nat. size. The thick black line represents the wall, and the shaded parts the intersections of septa in the plane of section. The vesicular tabulæ, depressed in the fossula (to right-hand side of figure), are shown, and also the interruption in the epitheca through rejuvenescence. The calyx of this specimen was identical with that shown in Fig. 4*a*. Tournai. R. 11,678. Camera lucida drawing.

FIGS. 3–3*c*.—Serial transverse sections of a typical example. × 3. Parts of the wall have been destroyed by silicification, as also some of the tips of the minor septa. Tournai. R. 11,661. Camera lucida drawings.

FIG. 4.—Profile (*forma typica*). × $\frac{3}{2}$. Tournai. R. 11,660.

FIG. 4*a*.—Calyx of preceding.

ZAPHRENTIS DELANOUEI, M.-Ed. & H.

FIG. 5.—Front view of a typical example. Half of the calicinal wall is broken away, displaying the septal arrangements within. The central tabular area is destroyed. × $\frac{3}{2}$. Tournai. R. 11,682.

FIG. 5*a*.—The same, seen from above.

FIGS. 6–6*b*.—Serial transverse sections from a mature individual. Camera lucida drawings; the parts without detail are restored. × 3. Tournaisian (horizon β): Avon Gorge, Bristol. Vaughan Collection.

FIG. 7.—Transverse section of a young individual. × 3. Tournaisian: coast at Malahide, co. Dublin (locality i). Vaughan Collection.

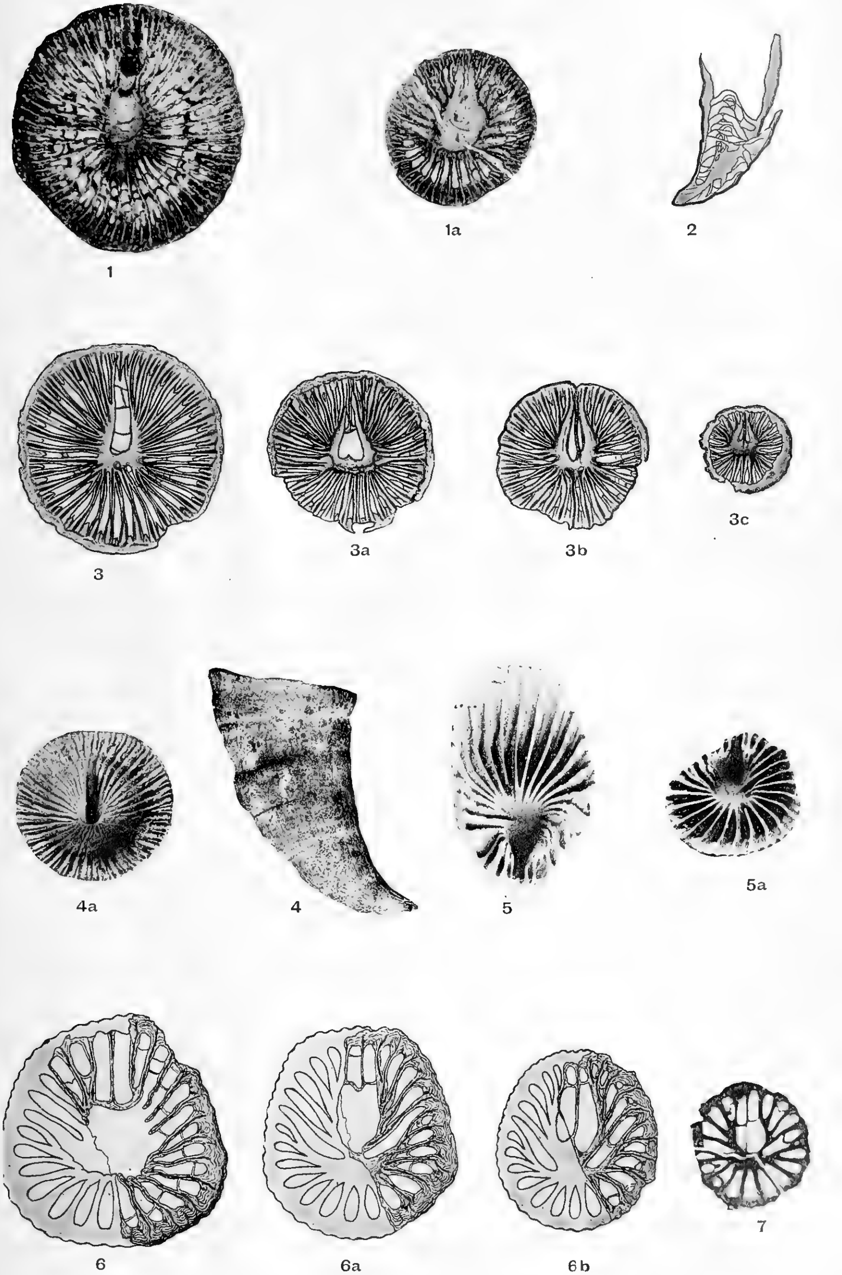
(To be concluded in the next Number.)

IV.—*UINTACRINUS* IN THE RINGWOULD AREA, NEAR DOVER.

By Dr. ARTHUR W. ROWE, F.G.S.

WHEN we were gathering material and data for that portion of the paper on Kent and Sussex[1] dealing with the Dover section we made careful search for *Uintacrinus* both on the top of the cliff, north of St. Margaret's Bay, and on the high ground immediately to the westward of the cliff. We failed to find it in either situation, and there were no quarries close to the coast. A thick tabular band of

[1] "The Zones of the White Chalk of the English Coast"; Part 1, Kent and Sussex: Proc. Geol. Assoc., vol. xvi, part 6 (1900).



Bemrose, Collo., Derby.

Figs 1-4.—*Zaphrentis konincki*, Edw. & H.; Figs. 5-7.—*Z. delanouei*, Edw. & H.

CARBONIFEROUS LIMESTONE.

flint is seen at the top of the cliff at the north side of St. Margaret's Bay, and this we believe to be the same table of flint which we have called in Thanet the "Whitaker 3-inch tabular band." If our inference be correct, we are here within 21 feet of the "Barrois sponge-bed," which forms the basement-bed of the *Uintacrinus*-band in Thanet.

In the Autumn of 1902 we determined to examine all the pits in this area which were situated on sufficiently high ground to afford a chance of finding this crinoid. In walking from Dover to Walmer we passed through Ringwould, which is 1½ miles south of Walmer and the same distance west of the coast, and decided that, as it was on the highest ground in the district, on the 200 feet contour-line, and sufficiently far from the coast to bring up the bed in question, it was here that our quest should begin. We found *Uintacrinus* in the pit called The Hooketts, at Ringwould (Pit No. 8 of this paper), but had no time to follow up the search on that occasion. However, we took characteristic body-plates and brachials to General C. F. Cockburn, of Dover, and asked him to continue the examination of this limited area. This he did with such good success that he was able to add the pits at Appleton Farm, Court Lodge Farm, as well as those north-west of Longclose Wood and north of Ripple Cross, to the list.

Standing on the high ground at Ringwould, it is clear that we are on a ridge, and that the ground falls away in all directions save that on the south-west, where the village of Martin is situated. Parallel with the Ringwould ridge, and between it and the sea, is another ridge, the northern extremity of which is called Wood Hill, and the centre of which is known as Free Down. A glance at the map (Ordnance Survey, 6 inch, Sheets 58 S.E. and 58ᵃ S.W.) will show that both these ridges are surrounded by the 200 feet contour-line. It is obvious, then, that our work lies along these two ridges.

A large number of pits have been examined between Walmer and Dover by General Cockburn and ourselves, and the numbers given simply indicate the order in our notebooks in which the quarries were examined. The two pits in the valley separating the Ringwould and Free Down ridges are situated in the zone of *Micraster cor-anguinum*.

We now give the pits in the *Uintacrinus*-chalk and the list of fossils obtained in them.

No. 1. We have here three small roadside exposures on the hill leading from Martin Mill Station to the village of Martin. The flints are in the form of rather small scattered nodules, mostly with thin cortices, but a few have thicker cortices. Between us we have examined these little exposures four times, and the only indication of *Uintacrinus* is a single body-plate found by General Cockburn. The other noteworthy occurrences are *Actinocamax verus*, *Conulus conicus*, and *Rhynchonella plicatilis*. The thick cortex of some of the flints is suggestive of the zone of *Micraster cor-anguinum*, and but for the plate of *Uintacrinus* we might possibly have felt inclined, on purely lithological grounds, to have placed the lowest of these little sections in the upper limit of that zone. Those who are familiar with the coast-section at Kingsgate in Thanet, however, will remember that

Uintacrinus and *Actinocamax verus*[1] extend to within a few feet of the base of the *Uintacrinus*-band, and that there *Rhynchonella plicatilis* is limited to the base of the sub-zone in question. It is reasonable, therefore, to suppose that we have here the base of the *Uintacrinus*-band exposed, and not the top of the zone of *Micraster cor-anguinum*. We saw no evidence of the "Barrois sponge-bed" which divides the two zones in Thanet. The three fossils quoted above are of the twelve species collected here alone of zonal value.

No. 2. A pit in a coppice about 300 yards west of the northern end of Longclose Wood. It is near a trigonometrical station on the 240 feet level. Of the thirteen species collected here *Uintacrinus* and *Actinocamax verus* are alone useful for zonal purposes, and the former was found in abundance.

No. 3. This is a pit of fair size north of Appleton Farm, one-third of a mile north of the village of Martin. It is in a flintless area of *Uintacrinus*-chalk, and the name-fossil is abundant. We obtained a list of nineteen species here, but the only forms characteristic of the sub-zone are *Actinocamax verus*, the nipple-shaped head of *Bourgueticrinus*, the large form of *Porosphæra globularis*, and *Infulaster rostratus*. A rostrum of the last-named rare echinid was found by General Cockburn.

No. 4. There is no pit here, but only a few inches of broken-up chalk exposed on the eastern side of the road, which runs by the eastern side of the reservoir at Martin. Here we were fortunate enough to find *Uintacrinus*.

No. 5. An old pit on the western side of Leeze Wood, Martin, is certainly in the same horizon, but it is now covered by grass and bushes. A few pieces of chalk were lying on the grass, and in these we found fragments of *Echinocorys*, as well as *Cidaris perornata*, *Terebratulina striata*, and *Ostrea vesicularis*; but *Uintacrinus* could not be seen. There can be no doubt, however, as to the age of this chalk.

No. 6. A very small, badly exposed pit at Court Lodge Farm. This also yielded *Uintacrinus* in fair abundance, but we found no other zonal fossils.

No. 7. In a pine plantation, 300 yards north-east of Ripple Cross, there is a small pit in flintless chalk which gave us nine species. Of these *Uintacrinus* and *Actinocamax verus* are alone worth quoting.

No. 8. An old pit at a place called "The Hooketts," one-fourth of a mile south of Ringwould, with seven small square caves hewn in the surface. A few nodular flints are seen here. This exposure gave us our longest list (27 species); it is the place where we originally found *Uintacrinus* in this area. The crinoid is abundant and *Actinocamax verus* not uncommon. In addition we found two examples of the nipple-shaped head of *Bourgueticrinus*, and Mr. Sherborn obtained no less than three rostra of *Infulaster rostratus* in one day. Such a stroke of good fortune can hardly have occurred before to any other collector in this sub-zone in the South of England. The large form of *Porosphæra globularis* was found; and an example of *Lima decussata* is from its comparative rarity sufficiently interesting to be worthy of notice.

[1] Op. cit., pp. 296–300.

No. 9. This is a small and much obscured pit behind the Wheat Sheaf Inn at Martin. The flints are in the form of large and smooth nodules, and they do not run in courses. We were quite content to find *Uintacrinus* and the large *Porosphæra globularis* in a list of only six species.

This completes the workable exposures surrounded by the 200 feet contour-line on the Ringwould ridge. It will be seen that every pit is in the *Uintacrinus*-chalk.

We now cross the valley between the Ringwould and Free Down ridges, passing on the way two poor exposures in the *Micraster cor-anguinum*-zone at Great Coombe. The flints here are quite different, being in courses, more rugged in shape, and with thicker cortices. Moreover, the scanty fauna was that of the zone just mentioned.

No. 22. Ascending the Free Down ridge, we make for the east side of Wood Hill to examine an old chalk-pit, and find that it is completely overgrown with vegetation. By good fortune a new estate is being laid out on the southern slope of this ridge, and in Victoria Road a pit has been opened for the purpose of road-making. The flints are here in the form of large smooth nodules, like huge potatoes, and we found not a few plates and brachials of *Uintacrinus* on them, as well as in the chalk itself. Out of seventeen species obtained here only the name-fossil and *Actinocamax verus* were of zonal value.

No. 18. The railway made by the contractors to the new Harbour Works, for the purpose of bringing ballast from Stonor, skirts the northern edge of Langdon Hole, which is a deep coombe situated midway between the east side of Dover and the South Foreland light-house. Above the north-eastern corner of Langdon Hole the line emerges through a short and shallow cutting which exhibits the usual broken-up surface chalk. Knowing that a considerable thickness of the *Micraster cor-anguinum* zone is exposed in Langdon Stairs, and that the railway cutting through the top of the cliff called the Cobbler passes through the same chalk, it occurred to General Cockburn that this insignificant little exposure at the north-eastern corner of Langdon Hole was at a sufficient elevation to bring in the *Uintacrinus*-band. He examined it and found the crinoid in abundance.

We visited this section with General Cockburn at a later date, with the result that our combined collecting furnished a list of 36 species, among which we record the nipple-shaped head and barrel-shaped columnar of *Bourgueticrinus*, the pyramidal shape-variation of *Echinocorys scutatus*, *Infulaster rostratus*, *Micraster cor-anguinum*, *Conulus conicus*, *Cyphosoma corollare*, *Terebratulina rowei*, *Kingena lima*, *Terebratulina striata*, *Rhynchonella plicatilis*, *Actinocamax verus*, *Pecten cretosus*, *Pecten quinque-costatus*, *Ostrea vesicularis*, *Ostrea wegmanniana*, *Spondylus latus*, *Inoceramus cuvieri*, *Lima hoperi*, *Lima decussata*, *Porosphæra globularis*, *P. pileolus*, *P. patelliformis*, *P. arrecta*, and *Spinopora dixoni*. We give the more important fossils found here, as this list is characteristic of the fauna found in the other pits.

No. 11. In 1906 General Cockburn and Mr. Sherborn examined a recently cut trench, 30 feet deep and 400 yards long, at the site of the Duke of York's Schools, between Lone Tree on the Deal Road and Frith Farm on the Guston Road, Dover. No contour-line is given, as this spot is in the neighbourhood of a fortress. There is here a section in the *Micraster cor-anguinum*-zone, with a thin capping of the *Uintacrinus*-band. Three brachials of this crinoid, but no body-plates, were found, and out of a list of 15 species we mention *Actinocamax verus*, the large dome-shaped form of *Echinocorys scutatus*, *Conulus conicus*, *Micraster cor-anguinum*, *Rhynchonella plicatilis*, *Pecten cretosus*, and *Pinna decussata*. The last-named rare fossil came from the lower zone and is a new record for the district.

We may mention incidentally that in visiting the estate called Higham, on the high ground to the east of Bridge, we found *Uintacrinus* abundantly in a little pit in the private grounds. It is clear, therefore, that the stretch of country lying between Ringwould and Higham would be worth searching for this crinoid wherever the ground stands sufficiently high to make the quest possible.

Not only are the foregoing observations useful as a record of an occurrence of the *Uintacrinus*-band, hitherto unknown, but they afford some interesting information in relation with the lithological and zoological conditions in that sub-zone.

In Thanet, with the exception of the 'Bedwell-line,' which is a scattered band of smooth nodular flints dividing the *Uintacrinus*-band from the *Marsupites*-band, flints are notably rare. In the *Uintacrinus*-chalk of the Ringwould area, however, flints are nearly always present, and often of considerable size. Though they are rather irregular in shape, they are generally smooth nodules with practically no cortex, and no tendency to run in courses, thus affording a marked and useful contrast to the notably irregular flints of the zone below, where the flint courses succeed one another at regular intervals and the cortices are quite thick.

This variation of the flints in the *Uintacrinus*-band is but another instance of lithological change in a relatively short distance, for Ringwould is only 10 miles from Pegwell Bay. We have pointed out these local variations in every county with which we have dealt, and are more than ever convinced of the unwisdom of relying on lithological data alone.

Zoologically, the chief point of interest lies in the fact that the fauna of the two districts is identical. For, as in Thanet, we found *Actinocamax verus*, the nipple-shaped head of *Bourgueticrinus*, the pyramidal shape-variation of *Echinocorys scutatus*, *Terebratulina rowei*, and the large form of *Porosphæra globularis*. The shape-variations in *Conulus* seem also to be the same as those in the Island. We found no fragment of *Ammonites leptophyllus*, but obtained four examples of *Infulaster rostratus*, which is a notably rare fossil in Thanet. This echinid must be not uncommon in the Ringwould Chalk, for it is only on these grounds that we can explain the discovery of four minute rostra in sections so poor and obscured by rainwash.

Not one of these sections presented a clean surface, and most of them were very small. In spite of these difficulties we were able to obtain a list of 60 species for the whole area.

V.—*Actinocamax verus* in the Upper Part of the *Micraster cor-anguinum* Zone at Walmer and St. Margaret at Cliffe.

By Dr. Arthur W. Rowe, F.G.S.

THE known occurrences of *Actinocamax verus* in this zone are comparatively few. Northfleet in Kent, Micheldever in Hampshire, and Great Fimber in Yorkshire are our only records.

When we were examining the cliff between Kingsdown and St. Margaret's Bay we searched for it in vain. In November, 1901, however, General Cockburn showed us several examples which he had obtained in the pits by the waterworks at Walmer, together with the fossils associated with them. From an inspection of the latter we had no doubt that they were derived from the upper part of the *Micraster cor-anguinum*-zone rather than from the *Uintacrinus*-band. However, to place the matter beyond doubt, we went to Walmer and found that the pits were hewn in massive chalk, with regular bands of compact black flints, corresponding in every way to those on the coast at Kingsdown.

From these pits we obtained two examples of *Actinocamax verus*, the characteristic shape-variation of *Echinocorys scutatus*, *Micraster cor-anguinum* and the var. *latior*, *Conulus conicus* and *C. albogalerus*, the characteristic head and columnars of *Bourgueticrinus*, and *Cidaris perornata*.

There is a pit at East Valley Farm, on the 200 feet contour-line, and a mile north of St. Margaret at Cliffe. The flints are in bands, and not very numerous, but they are more irregular than those found in the *Uintacrinus*-band, and have thick white cortices. From the lithological standpoint we should infer that we were in the highest part of the *Micraster cor-anguinum* zone, and at a higher level than the Walmer pits. A long and careful search failed to demonstrate the presence of *Uintacrinus*. We found *Actinocamax verus*, the characteristic shape-variations of *Echinocorys* and *Bourgueticrinus*, *Conulus conicus*, *Micraster cor-anguinum*, *Cyphosoma Königi*, *Cidaris perornata*, *C. clavigera*, *C. hirudo*, *C. sceptrifera*, *Kingena lima*, *Notidanus microdon*, and *Porosphæra globularis*, of the size associated with the zone in question. There was no sign of the "Whitaker 3-inch band" or of the "Barrois sponge-bed."

It may be of interest to those who follow the distribution of Cephalopoda in this zone to mention that since the publication of the paper on Kent and Sussex we have found four Ammonites of the *leptophyllus* group in falls from the *Micraster cor-anguinum*-zone on this coast. We have also seen one *in situ* at Joss Bay, Kingsgate, Thanet, 10 feet below the "Whitaker 3-inch tabular band," and therefore 21 feet below the junction with the *Uintacrinus*-band. We know also of four examples in the Northfleet pits.

We put on record these zonal notes in the hope that those resident in the Dover area will extend our obviously sketchy and imperfect examination of the district. Indeed, the work was done in a few brief hours snatched from the more important examination of the cliffs, and but for the able assistance of General Cockburn would not have been worth publishing.

VI.—Notes on the Drift and Underlying Deposits at Newquay, Cornwall.

By B. B. Woodward, F.L.S., F.G.S., etc.

(*Concluded from the January Number, page* 18.)

FROM the point K northward to the stile leading to the road on to the Towan Head the killas comes to the top, but just short of the stile there is a section of another hill-wash-dune showing about 5 feet, but not exposing the base. Land shells are abundant towards the top, especially at 1 ft. 3 in. and 2 feet from the surface, but the lower portion contains very few. The *Helix nemoralis* zone lies just below. This section yielded the flint flake found by Mr. Warren.

Immediately on crossing the stile a deep narrow cove comes right up to the path on the left-hand side, and on the top of a thin layer of 'head' which caps the killas the base of the *Helix nemoralis* zone can be seen. It consists of reddish ochreous earth, with fragments of *Mytilus*, shells of *Patella*, and burnt (?) stones, passing up into sand with land shells. The greater portion of the zone, however, forms the floor of the path. Between the latter and the head of Hedge Cove on the east side of the neck of land (where is the quarry section noted by the writer in 1900) is a big hill-wash-dune divided by the road. The section on the east side (T), which was clear in 1900, is now nearly all talus. A small patch of *Mytilus*, 1 foot from the top, appears at one point.

The floor of the ledge by which this section is approached is formed by the *Helix nemoralis* zone, which is perfectly visible in the cutting leading down into the cove as well as in the edge of the ledge, and it is separated from the killas by only about 6 inches of 'head.' It consists at the base of reddish ochreous loam passing up into somewhat firm yellow sand that contains many shells common to the later phase, notably some very fine *Helicella barbara*. In this it resembles the section at E. The zone was also traceable round the seaward face of the dune.

Opposite the Lifeboat House in the sides of the cutting for the lifeboat slip, the zone is again shown, reddish ochreous in colour, but containing no shells, while there are but few molluscan remains in the 2 to 3 feet of overlying, later-date sands.

Just north of the Lifeboat House a deep gully cut right down to the old platform (?) runs right athwart the neck of land, and is crossed by a narrow bridge. The *Helix nemoralis* zone crops out on both sides of this gully and is of reddish ochreous colour, about 1 foot thick. On the west side of the bridge (M) it was full of shells (see table, p. 84), but on the east side was barren. This is Mr. Warren's point 'D.'

On the west side next the Lifeboat House the zone is overlain by masses of broken slate, probably the result of building operations, for on the east side about 2 feet of hill-wash-dune caps it.

Immediately on crossing the bridge the zone is seen on the surface just where a slope leads down into the gully; here one type shell occurred. Three yards on, the zone appears in the side of the path to the beach (N), and is about 9 inches thick, but contains no shells, being full of rock-fragments and looking as if composed, as it probably is, of re-made 'head.' It is capped by 15 inches of hill-wash-dune with land shells, and at the base *Patella*. Over all is a layer of slate fragments 4 to 6 inches thick immediately succeeded by the turf.

This is Mr. Warren's furthest north and his starting-point.

Careful search, however, did not result in the finding of any more pieces of pottery.

On either side of the path to the top of the headland are further remains of hill-wash-dunes with land shells, but they cease in a few yards, and all over the headland the surface soil, which is about 9 inches thick, resting directly on the killas, contains no remains of shells whatever, though snails live on the spot. The same is the case on East Pentire headland.

Following round the west side of the Towan Head the next section is beside the path (O) leading to the ruin of the old quay. Here there is a sandy seam resting on the killas and overlain in places, especially at the point P, by slate rubble. At the top of this seam at one spot were some burnt slates and a few shells of *Purpura* and *Mytilus*. A deep fissure in the killas was filled as follows:—

		ft.	in.
1.	Sand seam	0	9
2.	Sand with fragments of slate and rock: the equivalent, seemingly, of the 'Head'	6	0
3.	Indurated sands, showing current bedding	15	0

These rest on an old platform of killas rising 8 to 10 feet from a second platform of the same that is raised 10 to 15 feet above the beach below.

Yet a little further north a sloping path (Q) leads into an old quarry in the cliff. Between P and Q, under about 2 feet of top soil, there appears to be about 4 feet of 'head,' or its equivalent, and beneath this some 20 feet of indurated sands, deposited over and between projecting reefs of killas.

Where the path begins to descend the upper portion of the section is obscured by a talus of slate rubble, and similar rubble caps the killas in the quarry (R).

Under the path the indurated sands are extensively piped. Most of these are filled with ordinary earth, but three or four contiguous pipes contained a purer sand than seen elsewhere, full of land shells, the wrecks of some deposit of which no trace now remains above. The molluscan fauna gathered here differed markedly from collections made elsewhere in the neighbourhood, as will be seen from the list given in the table (p. 85). The bulk is made up of a high-spired variety of *Helicella virgata*, having a single peripheral band. Of these 1,186 specimens were counted, while there are only 16 having more than one band and 127 without any.

No dune deposits exist over the northern part of the Head, but on the eastern side at a point (S) nearly exactly opposite to Q, there is a small cirque sloping down to the sea. By the edge of the path that runs round it about half-way up, the soil exposed is seen to consist for the most part of slaty rubble, but almost in the centre of the cirque there is an inlet, or pipe, of sandy material with land shells.

Except for the presence of *Helicella barbara* and the absence of *Jaminia cylindracea*, the fauna bears a resemblance to that found at Q. The former species may indeed be only adventitious, for the mollusc lives on the spot and has a quaint habit of rolling down into places where it has no business.

On the rocks below, traces of the coarse pebble beach, but no indurated sands, were observed.

Retracing one's steps southwards past the Lifeboat House and going down the eastern side of the headland, the quarry (U) over Seal Hole is reached. Here a foot or so of 'head' is covered by a like amount of hill-wash-dune with shells, including a stray *Helix nemoralis*.

At the south end of the quarry where the path leads down (V) another hill-wash-dune is cut into. This contains a few land shells of the species most characteristic of the upper series (see table, p. 85).

Descending to the base of the cove, the old marine platform is found exposed with the coarse pebble beach resting on it, while projecting through the talus of tumbled top soil that curtains the steep slope, masses of the indurated sands are seen, and round the corner of the south end of this section a big mass of these sands showing current bedding is visible, stacked between two reefs of killas, in a position impossible for a blown sand to assume (Fig. 2).

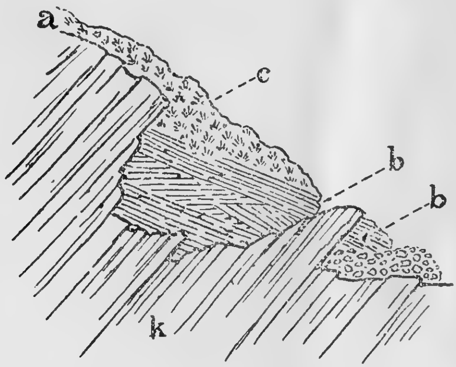


Fig. 2.—Diagrammatic sketch of the south end of the Raised Beach by the Seal Hole. *k*, killas, rising to near the surface at *a*, where it is overlain by a hill-wash-dune. *b*, *b*, denuded masses of the indurated marine sands, resting to the right on the remains of the coarse pebble beach. *c*, curtain-like talus of top soil.

Judging from the species of shells found in the base of the talus (see table, p. 84), the *Helix nemoralis* zone would seem to have been represented on the spot.

No further sections were noted till the cliff to the east of the Atlantic Hotel by Pigeon Cove was reached. On the north side of the Cove (W) the old platform is some 15 feet above the sea with the coarse pebble bed resting on it, capped by about 15 feet of indurated sands. Above these, again, there is a very coarse, hard, solid breccia, 2–3 feet thick, which seems to have escaped the notice of previous observers. It is quite different from any other rock in the vicinity, though it may be the local equivalent of the 'head.'

On the south side of the Cove (X) the pebble beach is again met with on the platform, while the indurated sands above seem partly eroded, but mostly masked by slips of the top soil. The southern ascent from this spot to the projecting point (Y) is capped by a hill-wash-dune containing a few land shells of the modern type. The talus, which stretches right down the face of the cliff here, is derived from this dune. The platform is again well seen at the base of the cliff on the south side of this point.

Just beyond to the south is an inaccessible shelf-like promontory, reaching half-way up the cliff and covered with bracken and ferns. Save for a few stunted examples by the wall of the ruined fish cellars on Towan Head, this is the only spot on the headland where the bracken can be seen.

No shell-bearing beds occur to the south of this, but there is a patch of 'head' to be seen filling a hollow in the killas above the eastern end of the recess in Town Beach occupied by the Laundry (Z).

One other locality remains to be mentioned. On the slope of the hill rising from the town to the top of the golf links on the south side of Crantock Street and just opposite the opening of Jubilee Avenue, a pit (7) in a field shows 6 feet of sand with land shells belonging to the last phase of the hill-wash-dunes. The bottom of this deposit is not shown, while the surface simply forms part of the general hill slope and gives no indication of its probable extent. The source of this sand is presumably Fistral Bay: it shows but little hill-wash soil in its composition.

A word as to the age of these deposits. The hill-wash-dunes are mainly, if not altogether Holocene. Whether any portion of the *Helix nemoralis* zone at their base be Pleistocene is not clear, though if the human vestiges should prove to belong to the Palæolithic period some part would be. The molluscan remains shed no light on this question.

The 'head' is manifestly the local representative of the cold period known in other parts of the country as Glacial.

Then as to the old marine (mostly indurated) sands that underlie the 'head.' These are nowhere, as some have asserted, interstratified with the 'head.' Nor are they 'blown sands.' They compare in composition very closely with the existing sands of the foreshore of Fistral Bay,[1] and are coarser than the sands found in the hill-wash-dunes, or than those at Perranzabuloe, judging from specimens kindly sent me by Mr. G. Earthy for comparison. Their bedding planes, except of course where current action is shown, slope seawards, just as the present beach does. Dr. Paris[2] aptly, so far as the rock is concerned, compares them to the celebrated Guadeloupe specimen containing the skeleton, and hunted in vain for human remains in them. Where these indurated sands rest directly on the irregular surface of the killas they are bedded in among the interstices as a water-deposited sand would be and as a blown sand deposit would

[1] I have to thank my young friend Miss Dorothy Joos for sending me on samples of these.

[2] Trans. Roy. Geol. Soc. Cornwall, vol. i (1818), p. 6.

TABLE SHOWING THE MOLLUSCAN FAUNA OF

Species.	Helix nemoralis Zone.				
	A–B	D	E–F	T	M
Milax Sowerbyi (Fér.)	...	...	...	...	...
Vitrina pellucida (Müll.)	...	...	...	...	...
Vitrea lucida (Drap.)	4	1	3	1	...
V. cellaria (Müll.)	3	...	...	...	...
V. nitidula (Drap.)	7	...	24	...	...
V. radiatula (Alder)	...	1	...	...	1
Arion ater (Linn.)	*	...	...	...	*
Pyramidula rotundata (Müll.)	18	3	34	...	10
Helicella virgata (Da C.)	5	...	12	...	...
H. itala (Linn.)	...	...	...	...	...
H. barbara (Linn.)	10	...	...	4	...
Hygromia granulata (Alder)	4	...	...	...	...
Acanthinula aculeata (Müll.)	1	...	...	...	...
Vallonia pulchella (Müll.)	4	...	8	...	...
Helix aspersa, Linn.	...	...	...	...	...
H. aspersa, spicula amoris	...	...	...	...	...
H. nemoralis, Linn.	32	12	92	18	81
H. nemoralis, spicula amoris	...	...	3	...	...
H. hortensis, Müll.	...	4	...	...	3
Cochlicopa lubrica (Müll.)	13	...	4	2	...
Jaminia cylindracea (Da C.)	...	...	...	...	...
J. muscorum (Linn.)	3	...	1	...	...
Vertigo pygmæa (Drap.)	1	...	...	...	...
Clausilia laminata (Mont.)	...	...	1	...	...
C. bidentata (Ström)	...	...	1	...	...
Carychium minimum, Müll.	2	...	3	...	2
Pomatias elegans (Müll.)	...	...	13	...	...
Total ... 25	107	21	199	25	97
Purpura lapillus (Linn.)	...	...	*	...	*
Turbonilla ?	...	...	...	...	...
Rissoia parva (Da C.)	...	...	...	...	1
Littorina obtusata (Linn.)	...	...	...	...	...
Gibbula umbilicata (Mont.) ?	...	...	...	...	...
Patella vulgata, Linn.	...	...	*	*	*
Venus verrucosa, Linn.	...	...	...	...	...
Lassæa rubra (Mont.)	...	...	...	...	1
Ostrea edulis, Linn.	...	...	...	...	...
Mytilus edulis, Linn.	...	...	*	...	...
Glycimeris glycimeris (Linn.)	...	...	*	...	...

THE HILL-WASH-DUNES NEAR NEWQUAY.

Age Doubtful.			Holocene.						
				F–L					
Q	S	V (base)	*Mytilus* band at K.	Below upper *Mytilus* layer.	Above upper *Mytilus* layer.	V (top)	A–B	5	Total.
...	...	...	...	...	...	...	...	1	1
...	...	1	...	...	...	...	...	...	1
...	...	...	...	...	...	...	...	...	9
...	...	1	...	...	...	...	...	...	4
...	...	...	...	...	...	...	...	...	31
...	...	...	...	...	5	...	...	...	7
...	...	...	*	*	*	...	*	*	*
...	...	...	...	...	...	...	...	...	65
1329	117	45	...	4	80	127	323	145	2187
...	...	23	91	869	923	46	454	134	2540
...	5	5	32	148	158	150	202	120	834
...	...	3	...	8	...	1	...	...	16
...	...	...	...	...	...	...	...	...	1
...	...	...	3	101	58	...	32	8	214
...	...	1	...	...	3	...	...	2	6
...	...	...	...	...	1	...	...	1	2
16	2	5	...	2	3	...	1	...	264
...	...	...	...	...	...	...	...	...	3
...	...	...	...	...	...	...	...	...	7
5	4	1	21	86	36	...	17	3	192
10	...	2	...	...	...	...	...	...	12
8	2	...	7	83	63	...	36	4	207
...	...	...	...	2	5	...	...	1	9
...	...	...	...	...	...	...	...	...	1
13	2	...	...	...	1	...	...	...	17
...	...	...	...	...	...	...	...	...	7
...	...	...	...	...	...	...	...	...	13
1381	132	87	154	1303	1336	324	1065	419	6650
...	...	...	*	...	...	...	*	...	...
2	...	...	...	...	...	...	...	...	...
1	...	...	...	...	...	...	...	...	...
*	...	...	...	...	*	...	*	...	...
1	...	...	...	...	...	...	...	...	...
*	...	*	*	*	*	...	...	...	...
...	...	...	...	1	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
...	...	*	...	...	...	...	...	...	...
...	...	*	*	*	*	*	*	*	...
...	...	...	...	...	...	...	...	...	...

not be. They contain no angular fragments of rock, all such large pebbles as they enclose being well rounded, while the few fossils that have been found genuinely embedded in them are marine.[1]

The coarse pebble beach at the base contains well-worn fragments of rock; the bulk, of vein quartz, is of local origin, but, according to Mr. Clement Reid, who has studied them, there is a considerable admixture of rocks not traceable in the immediate vicinity. Mr. Reid postulates ice for their transport, but has to invoke many hypotheses to buttress this contention, while he is obliged to admit that the fossils indicate a temperate period. He even refers to this raised beach a big greenstone boulder found on the beach at the southern end of Fistral Bay; had he searched the cliff above he would have found in the 'head,' a much more likely source, boulders to compare with it in size.

To the writer a more simple explanation, demanding but a single hypothesis, is that these fragments were derived from contiguous rocks that have been removed in the formation of the present coastline.

It is evident that a vast interval of time must have been consumed, first in the excavation of the old bay and the wearing down of the killas to form the old platform (possibly with the assistance of the pebbles that afterwards went to form the beach immediately lying thereon), then in the production and piling up of the marine sands to a depth of 20 feet before the 'head' period. Under these circumstances a greater age must be attributed to this set of deposits than has hitherto been granted, so that one would not be surprised if they ultimately were referred to the Pliocene. There is nothing in the few fossils they contain to disprove this.

With regard to the molluscan fauna of the hill-wash-dunes, the accompanying table speaks for itself. Twenty-five species are here recorded, as against seventeen in Mr. Warren's list.

Mr. A. S. Kennard has most kindly assisted in the case of critical specimens and undertook to search the material for slug remains: those given are all of his finding. To Mr. E. A. Smith, I.S.O., I am indebted for the determination of the smaller marine species.

No particular attention was given to the marine forms and no register kept of their number where more than a chance specimen was present: their occurrences are consequently marked in most cases solely by an *.

It is also impossible to attach a number for the calcareous grains that represent the shell in *Arion*, since they stand for an uncertain quantity, hence in their case too an * is employed to mark their occurrence.

The division of the species into 'woodland' and 'sand dune' is a matter of assemblage rather than an individual quality, and has not been attempted. If, however, the species recorded for the *Helix nemoralis* zone be scrutinized, it will be manifest at once that they as an assemblage differ from the group of forms from the upper beds and

[1] The ox bones cited by De la Beche (Rep. Geol. Cornwall, etc., pp. 427–8) obviously came out of one of the pipes, as also must the portion of red-deer's antler recorded and figured by Borlase, Nat. Hist. Cornwall, p. 281, pl. xxvii, fig. 5.

contain more of the sylvan and moisture loving species. As a matter of fact, the species taken as the type of the zone on account of its greater prominence is not confined to that period, but is still living on the spot, e.g. the grassy slope in the southern angle of Fistral Bay. Some examples of this species from the zone have the thickened shell so characteristic of those from Dog's Bay, Ireland.

The forms that so far appear restricted to the zone are *Vitrea lucida*, which has not hitherto been recorded fossil, *Pyramidula rotundata*, *Acanthinula aculeata*, *Helix hortensis*, *Clausilia laminata*, *Carychium minimum*, and *Pomatias elegans*. Those found only in the upper beds are *Milax Sowerbyi*, *Helicella itala*, and *Helix aspersa*; while peculiar to the beds of doubtful age are *Vitrina pellucida* and *Jaminia cylindracea*.

The mode of occurrence and recurrence of the layers of *Mytilus* shells calls for some further explanation than can at present be offered. They occur at such defined intervals, and, if synchronous in the several dunes, are spread over such a considerable area, that they appear to mark epochs of some sort. The thicker patches and, of course, the cooking sites indubitably speak of Man, but the persistent thin upper seams, and especially the top one in each section, even if those in the different dunes do not correspond in time, seem to suggest some other agency than Man needful to account for their being thus evenly spread out. Do they, perchance, indicate periods of dearth of other food during which crows and gulls were driven to subsist mainly on mussels and carried them up on the dunes to devour?

Another point of interest is the wonderful state of preservation of the molluscan shells in the dunes, wherein they occur quite perfect from the base right up to the turf, whereas when the slates come to the top, save for a foot of soil, that soil never contains the trace of a shell, though snails are living on the spot and must have done so for ages. This is the case both on Towan Head itself and on East Pentire Headland. The explanation seems to be that where the drainage is uniform and perfect the percolation of rain-water has little, if any, effect on the shells, whereas when there is no such complete drainage the soil retains the moisture longer and the shells are macerated and dissolved, just as they are when the drainage is diverted and concentrated in channels and pipes.

REVIEWS.

I.—Ancient Britain and the Invasions of Julius Caesar. By T. Rice Holmes, Hon. Litt. D. (Dublin). 8vo; pp. xvi, 764, with 3 maps and 44 text-illustrations. Oxford: at the Clarendon Press, 1907. Price 21*s*. net.

THE object of the present work is "to tell the story of man's life in our island from the earliest times"; and as the author has endeavoured "to treat it comprehensively from the beginning to the Roman invasion of A.D. 43," it has a direct bearing on the later chapters of geology. In his interesting introductory sketch of the progress of research, the author pays tribute to Sir Richard Colt Hoare and William Cunnington (sen.), with whose labours in Wiltshire "the era of scientific investigation may be said to have begun." From the materials since accumulated, by Prestwich, Pengelly, Sir John Evans, Lord Avebury, Canon Greenwell, Pitt-Rivers, Professor Boyd Dawkins, E. B. Tylor, and many others, it is considered that we know enough about sepulchres, skulls, coins, about implements, weapons, ornaments, urns, place-names, and folklore, "to justify an attempt to create a synthetical work, the aim of which shall be to portray in each successive stage and to trace the evolution of the culture—nay, in some sort even to construct a history—of prehistoric Britain." With this aim we are in full sympathy. A judicial summary of our knowledge is ever an advantage to progress, and we agree with the author that "Not only is the subject fascinating; it is an indispensable introduction to the history of England."

That much remains to be learnt is freely admitted by the author. Following the Introduction he deals with the Palæolithic age, and with "those who, in hard struggle with nature and with fierce beasts, were the unconscious founders of European civilization." Here we are brought face to face with many controverted questions, with the relations of man to the Glacial epoch and with his origin. Palæolithic implements identical in form and character with British specimens, fabricated perhaps at widely separated periods, but many of them of great antiquity, have been found in various regions of the world; but "the original home of the race is unknown."

The author gives a good account of the main features of the Ice Age as interpreted by geologists; a task by no means easy, considering the divergence of views on the extent of ice-sheets, on movements of upheaval and depression, and on interglacial periods. Here indeed, as elsewhere, we may compliment him on his impartial treatment, his laborious research, and the full references he gives to the views of others, whether or not he agrees with them.

When man first entered Britain the whole country may have stood at least 600 feet above its present level, or it may have been no more than 70 feet. Thus at the start the author calls attention to contradictory views expressed in different volumes of the Victoria History of England. In the latter case it is supposed that man entered across a narrow strait formed during an early stage in the Glacial epoch, the channel having been cut by overflow from the north European drainage that was then barred from escaping northward by the North Sea ice-sheet.[1] A greater elevation than 70 feet, perhaps a subsequent elevation, seems needed to explain the deeply eroded channels filled with Glacial Drift that have been found in East Anglia.

There is still diversity of opinion with regard to the relation of the Mammoth to the Glacial period. It has not, however, been definitely obtained in any Pliocene deposit; even in the Cromer Forest-bed, although some specimens, as Mr. E. T. Newton has remarked,

[1] Cf. C. Reid, "Origin of the British Flora," 1899, p. 39.

"approach the *E. primigenius* type of tooth, none are precisely like any undoubted example of the species."[1]

Glaciated remains of mammoth have, however, been found, and it is not to be questioned that this animal existed in Britain prior to the period of maximum glaciation. That man similarly existed there is no reason to doubt. Remains of mammoth and other Pleistocene mammals are abundant in the Dogger Bank and in the Thames Valley gravels; and when these remains were accumulated a large part of the North Sea, as the author remarks, could not have existed, and there was a 'land-bridge' at any rate in that part of the Palæolithic age.

He does not attempt to connect this stage with that when the Straits of Dover began to be cut by overflow; and in a footnote referring to Mr. Clement Reid's remarks on the re-extension of the old Rhine estuary, he confesses he does not understand how to reconcile them. There is, however, no necessary want of discord.

That caves were occupied by man and by Pleistocene mammalia before the climax of the Ice Age is now admitted from evidence obtained not only in North Wales, but also, as regards mammalia, more recently by Mr. Tiddeman in the Gower promontory.

With regard to Eoliths the author speaks with reserve, remarking that "he who reflects that they have been met with not only in Tertiary beds but in those immeasurably later deposits which were contemporary with or but little older than Palæolithic man will leave them for the present without regret to the consideration of enthusiasts." Nevertheless, among those noted to have accepted these rudely shaped stones as artificial are Canon Greenwell, Pitt-Rivers, and Prestwich.

A great deal has yet to be learned about the successive types of Palæolithic implements, a subject brought before our readers by Mr. S. Hazzledine Warren (Geol. Mag., 1902, p. 97); and we may add, much information is wanted also of the animal and other remains associated with them. Thus the Hoxne implements, regarded as of later date than the Chalky Boulder-clay, those of Caddington near Dunstable, and those found at various levels in the deposits of the Thames Valley, and elsewhere, have yet to be studied more particularly in reference to the sequence of Pleistocene events. Eoliths as well as palæoliths have been derived and re-deposited. As the author remarks, "the Palæolithic age was of such vast duration that before its close Britain may well have been invaded by new races"; but he admits that, despite some present difficulties, the French chronological classification of de Mortillet may "contain a measure of truth."

Comment is naturally made on the scanty evidence of human remains in Pleistocene deposits. Of the famous Neanderthal man, the author observes that the skull was capacious enough to lodge a brain as large as that of many a living savage; and trained observers have pointed out that skulls of like contour have belonged in modern times to men of considerable mental power." Quite recently Professor Sollas has remarked that "the Neandertal and Pithecanthropus skulls stand like the piers of a ruined bridge which once continuously

[1] "Vertebrata of the Pliocene Deposits of Britain": Mem. Geol. Survey, 1891, p. 47.

connected the kingdom of man with the rest of the animal world" (Phil. Trans., 1907, B, p. 337).

While there is much that is doubtful concerning the Palæolithic inhabitants of Britain, there are sufficient facts to enable the author to picture something of their mode of life and culture. He remarks that "the close of the British Palæolithic age is veiled in obscurity." Nevertheless, he is doubtful about any great break between that and Neolithic times; doubtful also as to the physical conditions, whether Britain was so upraised as to be almost connected with the Continent, as suggested by the depth of alluvium in many river-valleys and by the evidence of submerged forests. After reviewing the evidence he concludes—"Therefore those of us who cling to the belief that the Neolithic immigrants who first ventured to launch their frail canoes on the narrow Channel and ran them aground on the Kentish coast may have found the new-born island inhabited by men of an older race have some reason to show for our pious faith."

We do not propose to follow the author in detail in his accounts of the Neolithic and later ages. Nevertheless, his chapters are by no means devoid of geological interest in connexion with the physical features, the inhabitants, the flint-mines of Brandon and Cissbury, and the pit-dwellings.

In his account of the Bronze age he does not accept Sir Norman Lockyer's views regarding Stonehenge, nor does he agree in any respect with Mr. Clement Reid's views on the subject of Mictis, Ictis, and Vectis. Mr. Reid had assumed that they indicated but one island, the Isle of Wight; and that about 2,000 years ago the Isle of Wight, near Yarmouth, was connected with the mainland near Lymington by ledges of Bembridge limestone, which formed a natural stone-causeway, available at low-water for the transport of tin from Cornwall. Other observers on various grounds had previously suggested that Ictis, rather than St. Michael's Mount, was the Isle of Wight. Alfred Tylor, in 1884 (*Archæologia*, xlviii, pp. 230–6), had urged the claims of Bembridge and Brading Harbour as the port of Ictis. Our present author strongly condemns these suggestions, and, discussing the whole subject in considerable detail, maintains that the evidence favours the old view that St. Michael's Mount was the veritable Ictis. He agrees with Lyell, Pengelly, and Ussher, "that since the time when tin was shipped at Ictis, St. Michael's Mount has undergone no sensible change." Lyell had observed that "It still affords a good port, daily frequented by vessels, where cargoes of tin are sometimes taken on board, after having been transported, as in the olden time, at low tide across the isthmus." John Phillips, in a paper entitled "Thoughts on Ancient Metallurgy and Mining in Brigantia and other parts of Britain" (Proc. Yorksh. Phil. Soc. for March, 1848), concluded that at first "the only route for the tin of Cornwall to the Mediterranean was by sea to the western parts of Spain"; and that at a later period "the track by land through Gaul to Massilia was preferred." If we accept this view we need not disagree with the remarks of Alfred Tylor that tin was sometimes carried by coasting vessels from Cornwall to the Isle of Wight. This alternative method of transport from Cornwall to the Isle of Wight is indeed referred to by Mr. Reid, and it appears more reasonable than the idea of transport across country from Devonshire and Cornwall; moreover, there is no need to invoke a land-connection at that recent period between the Isle of Wight and the Hampshire coast, if we accept St. Michael's Mount as the island to which tin was conveyed by the people of Belerium in wagons at low tide.

Dene-holes are briefly dealt with, and the author agrees that they were used as granaries and places of refuge. Other excavations by shaft and tunnel were undoubtedly used simply to extract chalk, but they are not dene-holes. In some cases, however, it seems probable, as at Chislehurst, that excavations by tunnel for chalk were made in a tract previously utilized for dene-holes.

The author discusses the configuration of the coast of Kent in the time of Cæsar, the Goodwin Sands, and Romney Marsh.

He gives reasons for deciding that *Portus Itius*, whence Cæsar sailed on both of his expeditions to Britain, was Boulogne; and he claims to have demonstrated "that he did land both in 55 and in 54 B.C. in East Kent—in the former year between Walmer Castle and Deal Castle, in the latter north of Deal Castle."

One further conclusion may be mentioned with regard to the site of the great Metropolis:—

> "The very large number of Palæolithic implements which have been found in London and its environs prove that in the earliest times it was a centre of population; but it would hardly be safe to infer from the discoveries of bronze and iron tools and weapons and of British coins that the Romans found a town on the site. If there was such a town, it certainly had little political importance; for while numerous British coins issued from the mints of Verulamium and Camulodunum, not one has been discovered which bears the name of Londinium. Nevertheless, it may reasonably be affirmed that London existed before the Roman conquest: first, because the same advantages that attracted the traders of Rome would also have commended themselves to those of Britain; and secondly, I repeat, because it is improbable that a Celtic name would have been given to a town which the Romans had built upon a virgin site."

II.—Geology of Ontario.

In a paper on the "Grenville-Hastings Unconformity" (16th Report of Bureau of Mines, Ontario, 1907), Messrs. Willet G. Miller & Cyril W. Knight claim to have proved that the Keewatin of South-Eastern Ontario is the oldest series in the region. "An ancient Keewatin lava has, in places, been subjected to little denudation before the deposition of the Grenville limestone, which fills the cracks and openings in the ropy surface of the lava. Unconformably above the Grenville limestones and Keewatin lavas or greenstones rest the conglomerates and other sedimentary rocks, including limestones, which the present writers class as Huronian. These conglomerates contain not only ordinary fragments of the Grenville limestones but 'eozoon'-like boulders as well, thus showing that the limestone is much older than the conglomerate." They have further found in the conglomerates pebbles of cherty and ferruginous rocks resembling those of the iron-ranges of Lake Superior, and derived from layers or bands in the Grenville limestone. The Huronian in their classification stands for what heretofore has been called the Hastings Series. The Laurentian includes both the Keewatin and Grenville Series.[1]

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*December* 18*th*, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Some Recent Discoveries of Palæolithic Implements." By Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., For. Sec. G.S.

By the courtesy of Mr. Worthington Smith, the author is enabled to call attention to some recent discoveries of Palæolithic implements on the southern borders of Bedfordshire and in the north-western part of Hertfordshire. In addition to the discovery of a Palæolithic floor at Caddington brickfield, at between 550 and 590 feet above sea-level, implements have since been found on the surface of the ground at 600 and 760 feet respectively; while a good ovate implement was found in thin, water-laid material, at 651 feet O.D. In Hertfordshire, Palæolithic implements have been found at Great Gaddesden, at a brickfield about 1½ miles north-east of Hemel Hempstead, and at Bedmond, 2 to 2¼ miles south-east of the last locality. The drifts which cap the hills in North-West Hertfordshire seem to be of very variable origin; and a great part of the material is derived from clay deposits of Eocene age, but little *remanié*. It seems to the author that it is safest not to invoke river-action for the formation of the high-level deposits, which extend over a wide area and are in the main argillaceous and not gravelly or sandy in character, but to adopt Mr. Worthington Smith's view that in early times lakes or marshes existed in these implementiferous spots, the borders of which were inhabited by Palæolithic Man. The evidence that he has brought forward as to the implements having, in some of the Caddington pits, been manufactured on the spot, most fully corroborates this view.

2. "On a Deep Channel of Drift at Hitchin (Hertfordshire)." By William Hill, F.G.S.

Evidence is given, from nine borings running along a line slightly west of north from Langley through Hitchin, of the existence of a channel of considerable depth, now filled with Drift, occupying the centre of an old valley in the Chalk escarpment, which may be called the Hitchin Valley. For the first 3 miles it appears to be contained within narrow limits, persistent ridges of Chalk occurring on each side, and it might almost be compared to a Chalk combe. At Hitchin, after passing between two Chalk knolls, its confines become less clear, and there seems to be some evidence of broadening as it emerges on to the Lower Chalk plain and leaves the higher ground of the main

[1] In connection with the above see report of paper by Professor F. D. Adams, Geol. Mag., Dec., 1907, pp. 574, 575.

Chalk escarpment. The greatest depth to which the channel has been proved is at a boring in Hitchin, where the Gault was reached beneath Drift at a depth of 68 feet below sea-level. That the channel flowed northwards and belonged to a 'subsequent' stream seems to be proved by the fact that at Bragbury End, the only place where a southerly stream could pass, the space between bare Chalk exposures is but 450 yards, and in about the middle of the space Chalk has been reached within 50 feet of the surface (that is, about 200 feet above sea-level) in a well dug a few years back. The channel must be older than the Chalky Boulder-clay, which still partly fills it as far south as Langley, and may have blocked it to the southward and given rise to the features now presented in the drainage on the northern slope of the escarpment. But the author is inclined to suggest that either glacier ice or bay ice must have played no unimportant part in damming up the old valley. The author suggests the existence of another channel, in this case draining southwards, buried under the broad area of Boulder-clay and gravel which lies immediately south of Stevenage and to the north as far as Letchworth and Wilbury Hill. But a narrow space of bare Chalk, at an elevation of 240 feet O.D. connecting large areas east and west of it, precludes the occurrence of a channel farther north than Letchworth.

II.—*January 8th*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Chronology of the Glacial Epoch in North America." By Professor George Frederick Wright, F.G.S.A. (Communicated by Professor E. J. Garwood, M.A., Sec. G.S.)

In the case of Plum Creek, Lorain County (Ohio), the study of the activity of the stream and of the amount of work which it has done since a certain stage of the Glacial epoch has yielded important results. This stream began the erosion of its trough when the temporary lake, held up in front of the ice, was maintained for a considerable period at the level of its Fort Wayne outlet; it has never had anything more resistant than Till to act upon. From a given section, 5,000 feet long, it has excavated 34 million cubic feet of Boulder-clay, removing it from exposed banks 1,600 feet long. Twelve years' erosion of a 500 foot length of a part of the trough of the stream under observation, and from banks 1,000 feet long, gives a rate of 8,450 cubic feet per annum. Therefore, the removal of 34 million cubic feet from the 5,000 foot section would give a period of 2,505 years. Considerations tending to lengthen the estimate are the former afforestation of the area and the increased gradient in the artificial cut-off. Those tending to shorten the estimate are the present wider flood-plain, the time taken for forests to grow, and the probably greater former water-flow.

The erosion of the Niagara Gorge began considerably later than that of Plum Creek, and probably dates from midway between the disappearance of the ice from Northern Ohio and from Quebec. If conditions have been uniform, the age of the Gorge would be 7,000 years. As the Niagara Limestone is thinner at the mouth of the Gorge, and the Clinton Limestone has dipped out of sight at the Whirlpool, there is nothing in the stratigraphy to indicate a slower recession in the past than in the present. Moreover, nearly one-third of the erosion has been accomplished by two pre-Glacial streams, one from the south and a smaller one from the north. Therefore the author concludes with considerable confidence that the Gorge is less than 10,000 years old, and that the ice of the Glacial epoch continued down to that time, to such an extent over the lower St. Lawrence Valley and Central New York that it obstructed the entire eastern drainage of the Great Lakes.

There is nothing which would lead to a longer estimate of the time which has elapsed since the Kansan stage of the Glacial epoch than that approved by Professor Calvin, of Iowa, and agreed to by Professor Winchell. These assume 8,000 years as the limit for post-Glacial time, and that a multiple of this by 20, amounting to 160,000, would carry us back to Kansan time. This, however, would still leave as long a period still earlier, for the advance of the ice. The author's impression is that the whole epoch may well have been compassed within 200,000 years.

2. "On the Application of Quantitative Methods to the Study of the Structure and History of Rocks." By Henry Clifton Sorby, LL.D., F.R.S., F.L.S., F.G.S.

The knowledge of the final velocities of material subsiding in water is of fundamental importance; but the relation between size of particles and velocity is complex, and perhaps may be partly explained by a thin, adherent film of water. The angle of rest in the case of sand-grains of varying size and quality enables us to ascertain approximately the velocity of current necessary to keep such sand drifting, and that needed to move it when at rest. The comparison of this angle with that observed in sedimentary rocks made of similar materials may be used to determine the amount of vertical contraction of rocks since deposition, the average in cases studied in Tertiary and Secondary rocks being from 100 to 57. In studying the drifting of sand along the bottom by currents (on which the author experimented in a small stream many years ago), the results are found to vary, according to whether the water is depositing sand as well as drifting it, and according to whether ripples are or are not being formed on the bottom. The velocity of a current can be determined approximately in feet per second for different kinds of sand. The connection between the structure of 'ripple-drift' and time is discussed; and an equation is given, from which the rate of deposit in inches per minute can be deduced. The connection between the structure of a deposit and depth of water is found to be difficult to study quantitatively. From the occurrence of 'drift-bedding' the depth of water may probably be determined to within a few feet, and on this being applied to particular rocks some interesting results come out, including the separation of sandstones into several different groups. The deposition of fine deposits, like clay, is a most complex subject, varying according to the amount of mud present in the water, and according to whether the grains subside separately or cohere together. When no pressure is applied, even when no further contraction takes place on standing for a year, the amount of water included in the deposited clay may be 80 per cent., and when dry the minute empty spaces may still amount to 32 per cent. This leads to the conclusion that many of the older rocks must now be only 20 per cent. of their original thickness. In many cases there is produced by a gentle current a minute laminar structure from which probably the rate of deposition may be learned approximately, a common rate in the older rocks being from 9 to 18 inches per hour. But complex and difficult experiments are very desirable on this question. The rocks classed as clays differ very much in structure, and must have been formed under different conditions.

Applying these conclusions to various rocks, the author shows that in the green slates of Langdale there is good evidence that the volcanic eruptions sometimes occurred within a few weeks of one another, and at other times at more distant intervals. Now and then there were bottom currents, probably due to volcanic disturbances, gradually rising to a rate of about 1 foot per second and gradually subsiding, the entire period being a few minutes, and deposition taking place in different cases at from $\frac{1}{10}$ to 2 inches per minute. There is also good evidence that, when deposited, part of the rock was analogous to fine, loose sand, and part to semi-liquid mud. In the Coal-measure sandstones deposition at the rate of 1 inch per minute was common, with intervals of little or no deposit.

The volume of invisible cavities in rocks varies from 49 per cent. in some recent rocks to nearly 0 in the ancient slates. The packing of grains is discussed mathematically and experimentally, the latter with round and flattened shot; and experiments with sand of various qualities, rapidly deposited and also when well shaken, show a good agreement with calculation. The methods of determining the volume of minute cavities in rocks are given, followed by a number of examples from recent and older deposits. It is found that in some limestones the cavities have been reduced by pressure to close on the mathematical minimum, whereas in others, even of Silurian age, the cavities were filled with carbonate of lime, introduced from without, not long after deposition. Some oolites have had their cavities filled in a similar manner; in others most of the material of the original grain has been removed, and the present solidity is due to the filling up of the original cavities mainly by internal segregation. Among fine-grained rocks the Chalk probably was originally a sort of semi-liquid with fully 70 per cent. of its volume water, and in its present state is about 45 per cent. of its original thickness; the thickness of some clays must have diminished still more; while the amount of minute cavities in rocks with slaty cleavage is so small, that sometimes they are nearly solid.

By the measurement of green spots in slates it can be deduced that the rock before cleavage was somewhat more consolidated than rocks of the Coal-measures now are, and was then greatly compressed and the minute cavities almost completely squeezed up. The development of 'slip-surfaces' in cleaved rocks is very great, and furnishes an additional proof that the cleavage is of mechanical origin. 'Pressure-solution' is also dealt with.

In conclusion, the author discusses the volume of minute cavities in clay rocks and their analogues of various ages, and shows that there is a distinct relation between it and the probable pressure to which the rocks have been exposed. Tables are given of the pressures so calculated for rocks of various geological ages, the volume of empty spaces decreasing in older rocks from the 32 per cent. existing in recent clays. In the Moffat rocks, with very little or no slaty cleavage, the pressure is calculated at about 7 tons to the square inch, while the Welsh slates, with very perfect cleavage, indicate a pressure of about 120 tons to the square inch.

CORRESPONDENCE.

OPHTHALMOSAURUS: A CORRECTION.

Sir,—In the paper on the osteology of *Ophthalmosaurus* published in this Magazine last year (Vol. IV, p. 202) one or two errors occurred which should be corrected. The first of these is that the figure of the fore-paddle (Fig. 3) is not, as stated, a ventral view of the right limb, but a dorsal view of the left. Similarly, the hind-limb figured (Fig. 5) is that of the right side, not the left, Fig. 5 A being the ventral view and Fig. 5 B the dorsal. In consequence of these changes some of the reference letters will also be incorrect. The reason for these mistakes is that all the specimens examined were completely freed from the matrix, so that their position in relation to the skeleton as a whole could not be determined. Recently Mr. Leeds has carefully observed and marked some paddles before their removal from the clay, and the above corrections result from an examination of these specimens. C. W. Andrews.

RE SPELLING OF PLACE-NAMES.

Sir,—In the January Number of the Geological Magazine, p. 45, Mr. Linsdall Richardson calls attention to the spelling of the specific name *crowcombeia*. In the Geological Survey Memoir on "The Geology of the Country between Wellington and Chard" the Rhætic fossil *Pteromya crowcombeia* Moore, was by an oversight spelt *Pteromya* (not *Pleuromya*) *crocombeia*. This error arose from the change in spelling of Beer Crowcombe, which has been altered to Beer Crocombe on the new series Ordnance Map. Changes of this kind ought not, in my opinion, to affect either palæontological or stratigraphical terms. Thus I would adhere to the spelling of the Pabba Shales and Scalpa Beds for subdivisions of the Lias in the Inner Hebrides, despite the fact that the names of the islands on the Ordnance Map have been changed to Pabay and Scalpay.

Horace B. Woodward.

Hampstead.
January 20th, 1908.

MISCELLANEOUS.

Erratum.—p. 46 (January Number), end of notice of Lord Kelvin: for 24th read 23rd December.

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

MARCH, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. III.—MARCH, 1908.

ORIGINAL ARTICLES.

I.—A Giant Sub-Fossil Rat from Madagascar, *Myoryctes rapeto*,[1] gen. et sp. nov.

By Dr. C. I. Forsyth Major, F.Z.S.

AMONGST the vertebrate remains which I found in the marshes of Sirabé (Central Madagascar), a large Rodent is represented by two right ossa innominata, one of which (B.M. M 7085) is fairly complete, only the free portion of the pars dorsalis of the ischium being broken off.

The very elongate, comparatively narrow ilium, divided pretty equally by the crista lateralis into a dorsal and a ventral portion, shows that we have to deal with a muriform member of the Rodentia; it comes very near in its general form to the same bone of the Malagasy genera of rats *Nesomys*, *Gymnuromys*, *Eliurus*, and *Hypogeomys*; in *Brachyuromys* the long axis of the ilium is more straightened. The single tuberculum iliopectineum (iliopubicum) for the insertion of the psoas minor is enormous, and the spina ventralis posterior (anterior inferior of man) is likewise very strong.

The conformation of the os pubis, however, is markedly different from that of the genera above-mentioned; its pars anterior is very long and directed more decidedly backwards, and the symphysis is quite minute. This is the shape of a vole's pubis, and in a general way of all fossorial Muridæ and Rodents generally,[2] so that I do not hesitate in assigning the fossil to a highly fossorial Rodent.

The length of the fossil innominatum is 134·5 mm.; that of the bone in a *Nesomys rufus* = 41 mm.; the skull of the latter has a basal length of 39·5 mm., the absolute maximum length—front of nasals to occiput—being 49 mm. The approximate corresponding measurements of the cranium of the new genus may therefore be

[1] *rapeto* is the Malagasy word for 'giant, uncanny.'

[2] Cf. in Tullberg, "Über das System der Nagethiere" (1899), the figure of the innominatum of *Nesomys* (pl. 32, figs. 11, 12), and those of the genera of fossorial Rodents, viz., *Spalax* (figs. 13, 14), *Ellobius* (figs. 15, 16), *Arvicola amphibius* (figs. 17, 18), *Hesperomys* (figs. 19, 20), *Geomys* (figs. 27, 28), *Georychus* (pl. 31, figs. 1, 2), *Ctenomys* (figs. 19, 20), *Haplodon* (pl. 33, fig. 8), *Perodipus* (figs. 23, 24).

calculated at 129·5 and 160·7 mm. respectively. In the largest known recent Rat, the *Phlœomys* of the Philippines (B.M. No. 97.3.1.17), the skull has a basal length of 80 and maximum length of 90 mm.

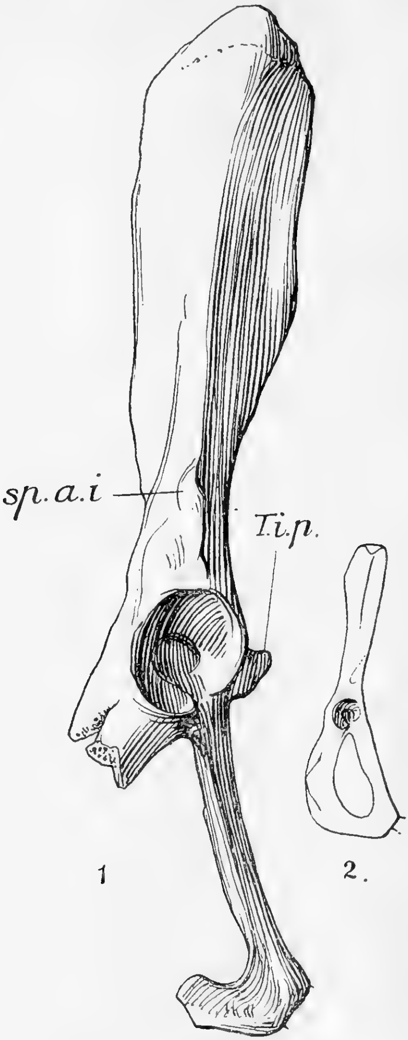

Fig. 1.—Right innominate bone of a giant sub-fossil Rat, from Sirabé, Central Madagascar, *Myoryctes rapeto*, gen. et sp. nov. *sp.a.i.* spina anterior inferior ilei; *T.i.p.* tuberculum iliopectineum.
Fig. 2.—The same bone of *Arvicola amphibia*.
Both figures are natural size.

II.—On the Age of the Reptile Faunas contained in the Magnesian Conglomerate at Bristol and in the Elgin Sandstone.

By Friedrich Baron Huene, D.Sc., Tübingen, Germany.

According to Etheridge (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pp. 174–192) the Magnesian Conglomerate at Bristol is of the same age as the German Muschelkalk, but Moore (Quart. Journ. Geol. Soc., vol. xxxvii, 1881, pp. 67–82) was of opinion that it was Rhætic. Since that time no special paper on the subject has been published, but now the present writer has been able to find some new evidence.

The reptilian remains of the Magnesian Conglomerate comprise four species—

Thecodontosaurus antiquus, Morris.
T. cylindrodon, Riley & Stutchbury.
Palæosaurus platyodon, Riley & Stutchbury.
Rileya bristolensis, Huene.

Thecodontosaurus antiquus and *T. cylindrodon* are very primitive theropodous dinosaurs (see Seeley, Ann. Mag. Nat. Hist., vol. xv, 1895, pp. 102–132, and Huene, Zeitschr. d. deutsch. geol. Ges., 1895, p. 349). A full description will soon appear in Huene, "Die Dinosaurier der europäischen Triasformation" (Pal. u. geol. Abh., suppl. Bd., G. Fischer, Jena). The tooth of *Palæosaurus platyodon* belongs probably to a Phytosaur. The name *Palæosaurus* is preoccupied by Geoffrey, 1831. The bones of *Rileya bristolensis* (Huene, Pal. u. geol. Abh., vol. vi (x), 1902, pp. 62–63) belong to a Phytosaur too. Now it seems to the writer not impossible that they came from the same animal, so that the tooth, if that be the case, should be named *Rileya platyodon*, R. & St., sp.

The small tooth figured by Murchison & Strickland, 1837 (Trans. Geol. Soc., vol. v, pl. xxviii, fig. 7*a*), is *Thecodontosaurus antiquus*; and the writer found a short time ago in the Warwick Museum that vertebræ figured by Huxley (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pl. iii, fig. 9) and Owen (Trans. Geol. Soc., vol. vi, 1842, pl. xlv), and some other bones from the Lower Keuper Sandstone of Coton End Quarry, near Warwick, belong to the same species. Moreover, the tooth of *Thecodontosaurus cylindrodon* figured by Huxley (Quart. Journ. Geol. Soc., vol. xxvi, 1870, pl. iii, fig. 4), and another one figured by Owen (Trans. Geol. Soc., vol. v, 1837 (1840), pl. xxiii, fig. 9), also from Coton End, really belong to that species. And as *T. antiquus* and *T. cylindrodon* occur in the Magnesian Conglomerate and in the Lower Keuper Sandstone both strata must be of the same age.

Concerning the Elgin Sandstone, the writer at first (Pal. u. geol. Abh., vol. vi (x), 1902, p. 74) divided it into the Permian *Elginia*-sandstone (Cuttie's Hillock) and the Triassic *Steganolepis*-sandstone (Lossiemouth, Spymie, and Firdrassie), according to their respective faunas. Two years later Boulenger adopted the same classification (Proc. Zool. Soc., 1904, vol. i, pt. 2, pp. 470–487) and applied the term *Gordonia*-sandstone to the Permian beds. The only reptile of the *Steganolepis*-sandstone occurring also elsewhere is *Hyperodapedon Gordoni*, Huxley. It is one of the characteristic fossils of the Lower

Keuper Sandstone, having been found at Warwick (Coton End), Bromsgrove, and Otter River, Devonshire. So the *Steganolepis*-sandstone of Elgin is also of the same age as the Lower Keuper Sandstone.

But now, what is the age of the Lower Keuper Sandstone? Two of its fossils are also found in the German Trias, namely, *Mastodonsaurus giganteus*, Jäger, in the German Lettenkohle, and *Equisetum arenaceum*, Jäger, in the German Lettenkohle and Schiefsandstein. The numerous other (autochthonous) Labyrinthodont species (seven) proves also the age of the Lower German Keuper. So we conclude that the fossiliferous parts of the Lower Keuper Sandstone (Upper [and Middle?]), the Magnesian Conglomerate of Bristol, and the *Steganolepis*-sandstone are of Lettenkohle age. Therefore the Upper Keuper of England is of the same age and extent as the German Keuper above the Lettenkohle; while the English Bunter and perhaps the lowest part of Lower Keuper Sandstone are deposits contemporaneous with the German Buntsandstein + Muschelkalk.

III.—Note on Two Sections in the Lower Keuper Sandstone of Guy's Cliff, Warwick.

By Friedrich Baron Huene, D.Sc., Tübingen, Germany.

In October, 1907, the Rev. J. Magens Mello, F.G.S., kindly took me to the Lower Keuper section on the bank of the Avon at Guy's Cliff, near Warwick. These sections are very instructive in a special sense.

It has been asserted more than once that the English Trias is a desert formation, but I am of opinion that neither the Bunter nor the Keuper can be thus explained. How could the presence of *Equisetum*, of Sharks and Ganoids, and of the many Labyrinthodonts and Rhynchosaurians in the Lower and Upper Keuper, in this case

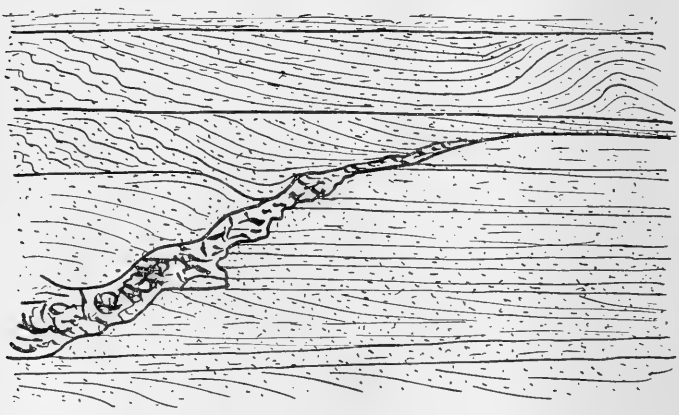

Fig. 1.—Section in the Lower Keuper Sandstone on the rocky bank of the Avon below Guy's Cliff House, Warwick. (The dotted spaces are sandstones, the breccia is strongly marked.) (Diagrams by the author.)

be explained? In considering the formation of the Keuper strata it should always be imagined that a great continent extended from England to America, but a brackish sea and swamp from England to Eastern Germany as far as the Scandinavian, East Prussian, and Bohemian borders, where another great northern continent began and extended eastwards. England was thus the western zone of gulfs and brackish swamps, but in the west was the great Atlantic continent, probably with great sand-masses from the weathered Armorican Alps.

In one of the outcrops of the Keuper Sandstone at Guy's Cliff, below the house of Lord Algernon Percy, on the bank of the Avon (Fig. 1), some horizontal laminated strata of sandstone have obviously been eroded and covered over by a conglomerated and brecciated mass, and after that this little valley was again filled up by cross-bedded sand.

The other section higher up and opposite the house (Fig. 2) shows several strata of sandstone, between which are thin layers of marl and conglomerate. It is very interesting to observe how the uppermost of these thin marl-layers is crushed. It cannot possibly be the natural bedding, but the marl is squeezed by the heavy overlying sand-mass, which was probably a dune with a moving line of the greatest heaviness (the vertical line of the dune).

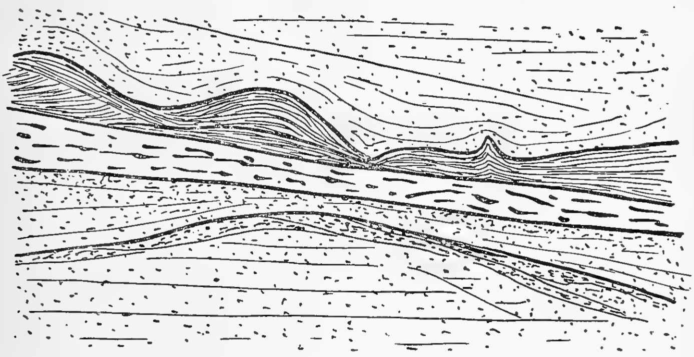

FIG. 2.—Small section in the Lower Keuper Sandstone on the rocky cliff opposite Guy's Cliff House, Warwick. (The dotted spaces are sandstones, the hatched ones are marls, the breccia is strongly marked.)

The same is still better visible in the largest quarry at Bromsgrove[1] (Fig. 3). There are overhanging folds of shale pressed into the thick masses of sandstone. This cannot be produced otherwise than by pressure in one direction, and that again can only be the result of advancing dunes, because it is, of course, not a tectonic pressure.

Dunes and strongly and quickly eroding waters are found together either in deserts or near the border of the sea. It cannot be the first in the case of the Lower Keuper Sandstone, because this sandstone contains *Acrodus*, *Hybodus*, *Semionotus*, and *Dictyopyge*. The sand-masses must therefore be dunes near the shore. In Coton End Quarry, near

[1] Mr. L. J. Wills, M.A., kindly guided me to this interesting section.

Warwick, a tooth of *Ceratodus lævissimus*, Miall, has been found, so that fresh water, probably a river, must have been there. The dunes were, perhaps, not only sea-dunes but also sand-waves advancing

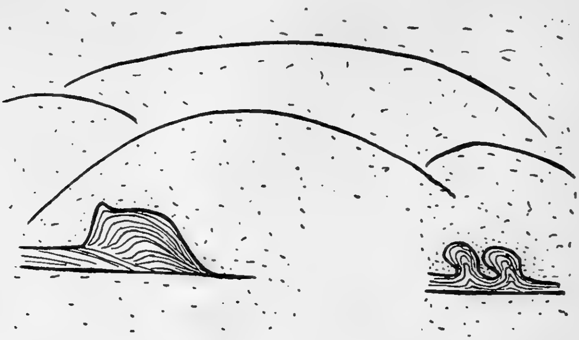

FIG. 3.—Large section (much reduced) in the largest of the quarries near Bromsgrove, Worcestershire. (The dotted spaces are fossil sand dunes, the hatched spaces are shales in two different corners of the same great cliff.)

eastwards from the great and perhaps partly desert-covered Atlantic continent to the border of the salt-swamps and brackish bays of the Anglo-German region.

IV.—Flowing Wells and Sub-Surface Water in Kharga Oasis.

By Hugh John Llewellyn Beadnell, Assoc.R.S.M., F.G.S.

(PLATE VII.)

(*Concluded from the February Number, page* 57.)

THE possibility of obtaining, under certain conditions, flowing wells from these sandstones[1] has been brought to my notice by the discovery that in the neighbourhood of El Dêr, on the east side of the depression, flowing water is obtainable from comparatively shallow wells sunk on the crest of the anticlinal fold, which runs north and south through that district, through the red shales to the underlying surface-water sandstone (see section).[2] I am unable to speak positively of the original depth of the ancient wells in this district, but when one of those to the north of El Dêr was taken in hand, cleaned out and cased, flowing water was met with at a depth of 65 metres, below which untouched ground was struck. The flow increased on drilling a few metres into the sandstone rock below, and the bore has now given a fairly steady discharge of about 40 gallons per minute for over twelve months.

The water appears to be derived from the surface-water sandstone, though here on a line of disturbance it would not be safe to disregard the possibility of the presence of fissures through which the water might rise directly from the artesian-water sandstones below. If, as appears to be the case from the depth of the bore and position of the

[1] See *ante*, p. 56.
[2] *Ante*, p. 55.

View of Flowing Well (Bore No. 39), Kharga Oasis, Libyan Desert, Egypt.

strata, the water is derived from the surface-water sandstones, the explanation may lie in the general east and west dip, resulting in a difference of level of the sandstones here and in adjacent districts—a difference which may be sufficient to furnish the necessary working head, which, as has been suggested by Cridler & Johnson, may be the only essential requirement for an artesian flow.[1]

Artesian-water Sandstones.

The source of the great majority, if not of all, the flowing wells of the oasis is the group of sandstones underlying the "impermeable grey shales." Needless to say, the beds of the series are nowhere visible to the eye, but judging by the samples obtained from the bores put down under my supervision during the last two years they do not differ in general characters from the sandstones just described. Throughout the area over which our operations have extended, no well-defined or persistent argillaceous bands have been met with, though the deepest bores have been carried to a depth of 122 metres (400 feet) below the junction of the sandstones, with the confining shales above. The beds vary considerably in coarseness and porosity, in hardness, and in the amount of cementing material between the individual grains of the rock, all of which characters have a marked influence on their capacity as water-carriers. Thin seams of lignite, frequently associated with bands of iron pyrites, testify to the conditions under which these beds were originally laid down.

The Artesian Wells.

As no very reliable data concerning the few native wells which have been sunk in recent times are available, it will be more satisfactory, in describing the wells themselves, to confine our attention to those which have been drilled on the headquarters area during the last two years and of which accurate and reliable records have been preserved.

The area around headquarters is one of the few large districts entirely devoid of old wells and traces of ancient cultivation. A combination of circumstances appears to have led the ancients to regard this area unfavourably: firstly, the general elevation is comparatively high, meaning small flows from wells of ordinary depth; secondly, the 'soil' is heavy, necessitating a considerable expenditure of time and labour to bring it into good growing condition; and thirdly, and probably most important of all, the presence of a copious supply of surface water, which would have greatly hampered, if not made impossible, the old system of well-sinking.

It may be assumed, therefore, that owing to the entire absence of both ancient and modern wells the water-sandstones of this district were practically fully charged at the time the first bore was sunk.

The junction of the artesian-water sandstone with the grey shales above is usually fairly abrupt, the first flowing water being obtained as soon as the bore strikes the top of the sandstone. Although

[1] A. F. Cridler & L. C. Johnson, "Underground Water Resources of Mississippi": Water Supply and Irrigation Paper No. 159, United States Geological Survey publications.

different layers of the sandstone vary greatly in water-holding capacity, there is almost certainly an intimate connection between all parts of it, as no definite bands of shale or other impervious strata have been met with. Where alternating shales and sandstones occur at or near the junction the latter are usually charged with water under feeble pressure, yielding flows at the surface of from one to five gallons a minute. On drilling into the sandstone proper, increments in the flow are generally obtained at fairly frequent but very irregular intervals of depth. At times the flow is seen to increase slowly but steadily, while a particularly porous bed is being passed through; at others the rate of increase is so rapid as to suggest that a fissure filled with freely flowing water has been struck. Hard bands of sandstone, acting locally as confining beds, frequently overlie the best water-carrying layers; while loose and uncemented sands, which continually 'cave,' that is, run in on all sides, and which form one of the greatest difficulties with which drillers have to contend, may be encountered at any time, though they do not seem, as might be expected, to coincide with marked increases of flow.

Of twenty bores finished in this district none have failed to strike water, though three have yielded such small flows that they must be regarded as comparative failures; of the remaining seventeen the average flow on completion was approximately 100 gallons per minute, the maximum being 350 and the minimum 65 gallons per minute.

By far the most important factor determining the volume of flow is the absolute ground-level at the mouth of the well. The floor of the oasis in the district under description lies between 53 and 61 metres above sea-level,[1] the general slope being to the west in the opposite direction to the dip of the water-bearing sandstones. Although the actual difference of level is so little, amounting only to 7 or 8 metres, the difference of flows from wells of equal depth on either side of the area averages fully 100 per cent. This indicates that we are on this area very near the static head or limit to which water will rise from bores of this depth, and this is borne out by the observed pressures, which even in one of the best wells when first completed and flowing about 217 gallons per minute only amounted to just over 8 lbs. to the square inch.

In the neighbouring oasis of Dakhla there are a number of wells whose temperatures are from 90° to 100° F.; some few even exceed the latter figure, the highest temperature recorded being 105° F. in Bir el Dinaria, a well sunk fifteen years ago and the deepest and most northerly bore in the oasis. The temperature of the Kharga wells average considerably less; of thirteen new bores measured in the headquarters district two have temperatures of 87° F., the remaining being one degree lower.

One of the most noticeable features of the wells is the highly effervescent character of the water as it reaches the surface. In some cases it resembles the contents of a newly opened bottle of aerated water, in others the gas reaches the surface in a slow continual

[1] The datum used being a point on the Western Oasis Railway, the value of which must be regarded as approximate only.

succession of large bubbles. Analysis shows the gas to consist almost entirely of nitrogen, only small quantities of oxygen and CO_2 being present. Mr. Garsed's results are as follows:—

Headquarters District: Bore No.	1	2	3	4	5	6
Carbon dioxide	1·6	1·6	3·6[1]	1·8	1·2	1·2
Oxygen	0·8	nil	0·8	0·6	0·3	nil
Ethylene and unsaturated hydrocarbon	nil	nil	nil	nil	nil	nil
Carbon monoxide	nil	nil	nil	nil	nil	nil
Residual gas—Nitrogen	97·6	98·4	95·6	97·6	98·5	98·8

It was estimated by rough experiment that the volume of gas issuing from Bore No. 1 (diameter of bore 4¼″) amounted to half a pint a minute.

The quality of the artesian water seems to be in all respects excellent, and when taken direct from the outlet of a cased well has for domestic purposes the advantage of being free from all danger of contamination. Analyses of the waters of four of our bores show the total dissolved solids to range from 43 to 47 parts per 100,000, equivalent to from 30 to 33 grains per gallon. The water is generally slightly ferruginous even in new bores, while in one or two of the ancient wells it is so highly charged with ferric oxide that thick deposits of ochre have been formed along the channels.

Analyses of Typical Artesian Water of Kharga Oasis.

Headquarters District: Bore No.	1	2	5	6
Total solids, grains per gallon	33	30	33	32
Composition of dissolved salts, per cent.				
Silica	4·2	4·5	4·6	3·4
Ferric oxide	1·7	0·8	1·2	1·3
Lime	6 5	7·0	5·4	5·6
Magnesia	2·9	3·1	2·7	3·8
Sulphuric anhydride...	4·5	4·9	4·4	4·4

[1] Mr. Garsed informs me that the CO_2 figure of Bore No. 3, which appears comparatively high, may be due to experimental error.

General Considerations of the Water-supply as a whole.

As I hope shortly to publish the results of experiments carried out to determine the mutual influence of wells, it need only be remarked here that the sensitiveness of any one well to its neighbours is far greater than has, I believe, been generally supposed. For instance, the shutting down of a flowing or the opening of a closed well will produce a most marked effect on a neighbouring well within the short space of sixty minutes, even when the intervening distance is over 500 metres. The degree of influence is especially dependent on the amount of difference between the depths, discharges, and surface-levels of the bores.

When drilling was first commenced in the headquarters district the bores were placed at an average distance apart of 500 metres; the circumstances of drilling, however, led to there being a great variation in the depths of the bores, with the result that those of comparatively shallow depth and those situated on comparatively high ground were adversely affected by the deeper and more favourably placed ones; to lessen the effects of this extreme sensitiveness the average distance between the bores has since been considerably increased.

All bores show a marked decline in discharge for some time after completion, when they settle down to a fairly steady flow, or at least to a flow which decreases at a constantly diminishing rate, except when affected by new bores subsequently sunk in the vicinity. The same point is brought out by observing the extent and rate to which the pressure and flow can be increased by the temporary closing of a bore. Experiments show that a flow may be augmented by as much as 75 per cent. as the result of closing a bore for five days, the increased discharge falling to its normal twelve hours after reopening.

Data are as yet far too insufficient to warrant an attempt to calculate the supply which can safely be drawn from a given area without unduly reducing the pressure and lowering the water-level. In some parts of the oasis there are bores many hundreds of years old still pouring forth their hundreds of gallons a minute; such wells are probably situated in particularly favourable positions or have been exceptionally fortunate in striking large fissures. There are at the same time hundreds of wells which have ceased running, either through local exhaustion of the sandstones or through failure to keep the channels open, or through a combination of both circumstances. In many instances new bores sunk in the immediate neighbourhood of old wells, some of which were completely extinct while others were yielding feeble flows only, have produced strong discharges of considerable volume.

At the present day there are about 230 native owned flowing wells in the oasis of Kharga, yielding a total discharge of some 295 'qirats.' The output of wells is for purposes of taxation determined in a very rough and ready manner by measuring the depth of water passing over a weir of definite breadth fixed in the stream. The discharge is reckoned in qirats, a qirat being a water-section of 64 square centimetres. As the velocity of the stream is not taken into account the qirat has a very variable value, low for small and high for large flows, the result being that the smaller wells are being taxed as much as 50 per cent. higher than the large ones. In order to obtain the average value of the qirat for streams of different size I had thirteen of our new bores, with discharges varying from 23 to 233 gallons a minute, measured by the local native measurers by their own methods, I myself making direct measurements immediately afterwards. It was found that below 2 the qirat has a value of 22 gallons per minute, from 2 to 4 of 26 gallons per minute, from 4 to 5 of 33 gallons per minute, and from 5 to 6 of 38 gallons per minute.

Applying these values as far as possible to the old wells and adding the known discharge of the score of new bores, we shall not be very far from the truth if we estimate the total discharge of the whole of the Kharga wells at 8,000 gallons a minute or 11½ million gallons (53,000 cubic metres) a day.

The numerous and often extensive remains of temples, forts, and villages in many parts of the oasis, the abundant traces of ancient cultivation, and the hundreds of old sanded-up wells have given rise to a widespread belief that the oasis was in olden times far more thickly populated and better watered than at the present day. That this was to some extent the case is not to be gainsaid, but it must not be forgotten that the remains in question belong to successive generations, and that there is as yet no evidence to enable us to determine how much of this land or how many of these wells were in use at one and the same time.

When one considers the vast areas under which the water-bearing sandstones are known to extend, and the comparatively small extent of country over which the existing wells occur; when it is remembered that as yet the deepest bores have only penetrated the water-bearing beds to a depth of 400 feet; that the existing total discharge is mostly made up of insignificant flows from a great number of very ancient and comparatively shallow wells, which for centuries have been subject to gradual decay; that so far as observed, the flows obtainable increase in volume as deeper beds are struck; it does not seem unreasonable to assume that the total discharge could be very much increased, though to what extent this could profitably be done is another question and one with which it is not the province of this article to deal.

Until such time as our knowledge of the region to the south of the oases enables us to do better than label the whole country "Nubian sandstone," and until more information is available as regards the relative levels of the oases and different parts of the Nile Valley and Libyan desert as far south as the more elevated regions of Kordofan, Darfur, and Tibesti, any attempt to explain the origin of the artesian waters of the oases must be regarded as little better than speculation. Possible sources of origin lie in the rainy districts of the Sudan, in the great swamps of the upper Nile, in the Nile river itself, in past accumulations of water absorbed from the extensive lakes which covered parts of the oases and Nile Valley depressions in the pluvial period which preceded the existing desert conditions. The water may be entirely of meteoric origin, derived from one or other of these sources, or it may be partly of magmatic or plutonic origin, derived from the deeper-seated rocks underlying the country.

It is not possible in the limits of this paper to adequately discuss questions which, as we know in the case of the artesian waters of Central Australia, have given rise to such diverse opinions among well-known professional geologists who have made long and special studies of the subject. It will readily be admitted that the ordinary explanation of the origin and flow of artesian wells in regions of moderate or abundant rainfall, situated in well-defined basins where the exact position, extent, and absorbing capacity of the water-table outcrop can be carefully determined, may be entirely inadequate to account for the flowing wells of vast arid regions like those of Australia and Africa.

It is moreover almost incredible that, where the outcrop of the water-bearing strata is so remote from the wells themselves and the dip over the intervening country so slight, the rise of the water could be due to direct pressure of water flowing downwards through the higher portions of the beds, unless on the supposition of the existence of large and continuous open fissures. Local pressure arising from variation in the level of the water-table in adjacent areas might, however, quite conceivably be adequate to account for the phenomenon, especially if assisted by the presence of large volumes of gas under compression. Much stress has been laid by Gregory and other writers on the pressure of the overlying strata,[1] but if this were sufficient to squeeze water from the pores and crevices of a bed and force it up through hundreds of feet to the surface as soon as a free passage was provided, surely the same pressure would have long ago obliterated all such pores and prevented water from ever having obtained access to the bed in question.

The points to which attention should be directed as likely to throw light on the origin of the oases artesian wells are: the area and position of the outcrops of the impermeable grey shales and the underlying sandstone, and their relations to possible sources of water, whether rain, river, or lake; the nature of the bed of the swamp region of the upper Nile; the amount and distribution of the rainfall of all surrounding regions; the amount of water lost in different reaches of the Nile over and above that which can be directly accounted for by evaporation and by water abstracted for purposes of irrigation; the total thickness of the water-bearing sandstones, and the presence or absence within them of impervious strata; and lastly, the relation of the water-bearing beds to the underlying crystalline rocks.

V.—Windings of Rivers.

By T. S. Ellis.

THE course of rivers cannot be properly understood if regarded as objects complete in themselves. In reality, a river is only a part of a system of channels serving to drain the whole of the area over which it extends, the breadth as well as the length. Of this system the tributaries are an essential part. So, too, valleys and combes

[1] J. W. Gregory: "The Dead Heart of Australia," London, 1906, pp. 288–289.

which still exist but no longer serve for streams, and others altogether effaced, have, in former times, been included in the system. I hold to my belief, recorded nearly twenty-six years ago, that only by taking into account the influence of tributary streams can river-windings be explained, and that the subject is important as "bearing on the formation of warths and the maintenance of navigation channels." [1]

The system of drainage as we see it, a principal channel with tributaries flowing in on either side, is the result of a long process of evolution. When the rainfall began its work of denudation, no turf, nor trees, nor verdure of any kind existed: the rain fell directly on to the surface. Now a very large proportion is either conducted gently down to and into the earth, or fails to reach it at all, passing off by evaporation. According to Reclus ("The Earth") "Becquerel's experiments prove that during heavy rain only $\frac{6}{10}$ of that which falls reaches the ground." At any rate, a much larger quantity of water would, with the same rainfall, have flowed off the surface than now does; and this, I think, fully explains dry valleys and combes, even those of the Chalk hills, such as are now seen.

Whatever the size of the early channels they would certainly be numerous, and, having regard to the uneven surface of an uplifted area, be diverted in different directions. Thus they would meet in loops and form a network which might continue even after a well-defined valley has been formed. Such loops are often seen in the present day. Out of the network the principal line of stream (the river) is selected. Which one this will be must depend on a number of circumstances. A tributary stream coming from a lateral valley would require a channel on that side. Into this, necessarily kept open, streams near the middle line of the valley may flow, and these may attract others, so that, finally, one might be continued in a channel adapted to the needs of the principal stream and of the tributary. Certainly, either the principal stream must be inclined towards the tributary, or the tributary must be extended to the principal stream. In fact, the two often meet in the form of a capital letter Y, as I illustrated in the paper mentioned by the case of the Severn and Avon at Tewkesbury. A diverted route of the principal stream, more or less circuitous, would render those in a more direct line unnecessary, except only for the area close to them. Denudation, therefore, would not go on in the same degree, and some of the channels would be effaced, wholly or in part.

The process of evolution is, in principle, the same, whether it be in a denudation area or in alluvial soil where the streams not only arrange their own channels but also build up their own banks. The process is well illustrated in the sketch-map taken from an old Baedeker's Guide to the Rhine, Fig. 2, p. 112. The river Ill, which occupies the same valley, is not shown; it is now at the margin on the left side, by the Vosges Mountains. Probably it was once part of the Rhine system which is seen inclining to the right side, that of the

[1] "On some Features in the Formation of the Severn Valley," a paper read before the School of Science Philosophical Society, at Gloucester, on February 7th, 1883. Printed for the Society.

Black Forest. Here, having received a stream coming down from Staufen, it has, in one case, settled into a single channel. The partially effaced loops are seen on the opposite side as streams serving to drain the local area. The river here does not form a sharp curve, it inclines to its tributary, the two resembling the letter Y. The faint upper stroke is, however, on the wrong side; the figure should be held up to the light and viewed from the back; then the resemblance is manifest. If the Rhine valley had been less wide and the country on the margin less mountainous a single river might have sufficed. Then it would have swung from side to side, taking in tributaries on the convexities of great curves. The curved double lines in the figure indicate an artificially regulated channel. The present condition may be seen in the "Karten des Deutschen Reiches," pp. 630 and 643. I discussed the influence which a tributary stream would have in diverting the course of the larger one, supposing it to be straight, in the Geological Magazine for August, 1903, pp. 350–354.

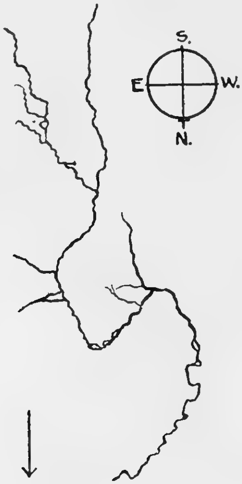

Fig. 1.—River-windings, a relic of an old figure-of-8 looping.

That some relation exists between river-windings and tributary streams seems to be indicated by such facts as the following:—On the Thames, near London, are four well-marked windings near together. Of these, three receive tributaries on their convexities: at Brentford, the Brent; at Hammersmith, the stream now only represented for a short distance by the creek; at Wandsworth, the Wandle. The convexity between Mortlake and Barnes receives no stream now, but a very short channel cut in the alluvium would connect the river with the Beverley brook which, directed due northward along the Combe Valley, turns to the east and falls into the river opposite Fulham. Assuming an old arm of a loop to have been partially effaced, why did the river prefer to "go by the bow" and not "by the cord"? Because the Hammersmith stream required a channel to be kept open for its use. Here the case differs from that of the 'Oxbows' on the Mississippi. The short route has been abandoned; the circuitous one remains. Mortlake does not mean dead lake in the modern meaning of the word 'lake,' but dead stream.

The Thames also supplies striking instances, on a larger scale, of river-windings, relics of old loopings. At Bray there is a tongue-shaped area of low-lying land bounded, as it projects westward to Waltham, by the 100 feet contour-line, so forming a shallow combe. This, although now occupied by only a small stream, suggests an old arm of the river between Bray and Sonning. Here again the river goes, not "by the cord"—it has deserted that line—but "by the bow" round by Henley and Marlow, receiving the streams which flow down the slopes of the Chiltern Hills, representatives, it may be, of larger ones at an earlier period. In my view, the river adopted for itself the line of channel necessarily kept open by these streams, and so the circuitous rather than the direct route became the permanent course of the river.

Only less manifest is the case of the Wey and Blackwater, separated at a point between Farnham and Aldershot by a slight 'sill' only. The former stream flows in a direction down the line of the Thames to Weybridge, and the latter in a direction up the line of it to join the Loddon in its course to the Thames near Shiplake. As I find, it is far easier to believe that the two streams, so curiously close to each other, were continuous when the river flowed at a higher level and occupied a wider valley, than it is to imagine that the approximation signifies a 'working' or 'eating backwards,' going on towards 'capture' of one by the other, as similar features have been explained. Elbows in two neighbouring streams pointed towards each other also suggest a former union, and, generally, the level of the ground between them does not forbid the supposition. An instance is seen in the Wey and the Mole south of St. George's Hill by Weybridge, and, again, in the Oak and the Childrey Brook by Abingdon. The Thames abounds, all along its course, in interesting features illustrating the Natural-history of rivers and, as I contend, showing the hopelessness of attempting to explain river-windings by theories of reciprocal curves or of relation between extent of curve and velocity or volume of stream.

On the other hand, appearances suggestive of old loopings as the explanation of river-windings are very common. No one accustomed to observe English rivers would be surprised to hear that Fig. 1 represented a mile or so in one of them. It really represents more than 500 miles of the Nile, and is taken from Dr. Budge's Guide to Egypt and the Soudan. It shows, at the upper part, the meeting of the Blue and White Nile by Khartoum. In imagination I filled in the lines so as to make a figure of 8, and then sought for evidence of an old arm of the river to complete the lower loop. The little upward curve at the foot is by Korosko at one end of a valley, 60 miles long, extending southwards up to Bab el (gate of) Korosko. This, with other valleys, seems to afford sufficient evidence of an old looping with the river at the prominence shown (Abu Hamed), 220 miles south from Korosko.

In estuaries the influence of tributary streams can be seen in operation. They divert the low-water channels and, therefore, the deep-water line. This is strikingly illustrated in the Exe, to be discussed in a future paper.

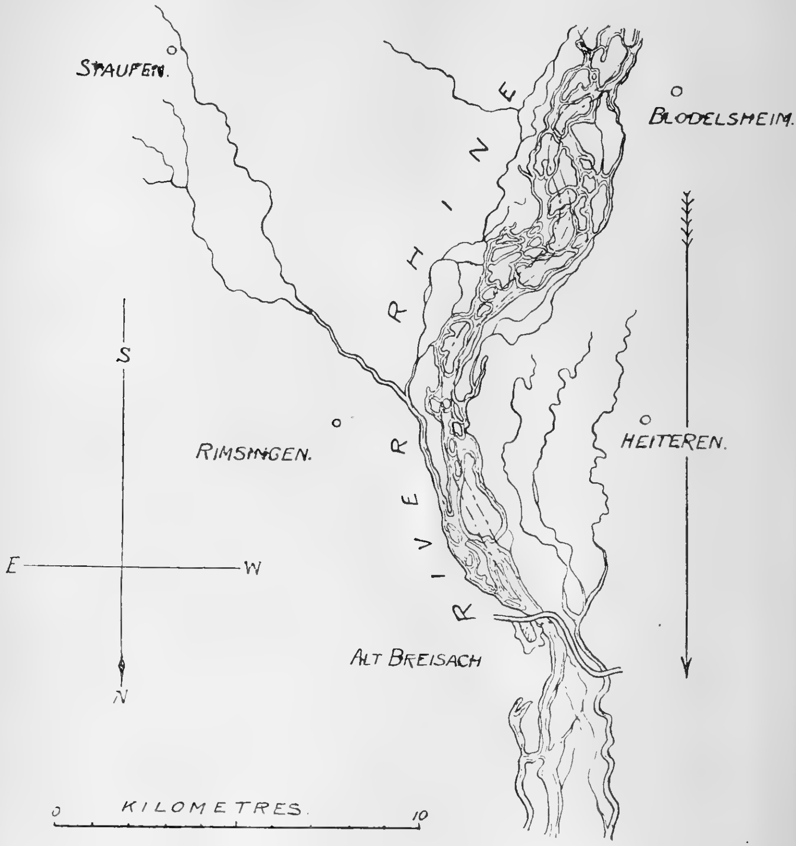

FIG. 2.—Deviation of a river towards a tributary; on the opposite side, streams formerly continuous with the network above.

VI.—NOTES ON THE GEOLOGY OF BASUTOLAND.

By the Rev. S. S. DORNAN.

(*Concluded from the February Number, page* 63.)

OF all the animals of the Stormberg Beds the Theriodonts are the most interesting, as they bear strong resemblances to mammals. Dr. Broom, of Stellenbosch, says they have practically solved the problem of the origin of mammals. Of these Theriodonts only two are said to have come from Basutoland, both of small size, viz. *Galesaurus* and *Tritylodon*. They are only known from their skulls. I have not been able to discover whether they came from Molteno Red Beds or Cave Sandstone, but I imagine most likely from the first. *Tritylodon* has a small and decidedly mammalian-like skull, and is said to have been found at Thaba Tsuen, a mountain 16 miles south-west of Morija. It was brought to England by Dr. Exton, Curator of the Bloemfontein Museum, and described by Sir Richard Owen at a meeting of the Geological Society in 1884.[1] Dr. Broom, who has recently discussed the affinities of the skull, inclines to the view that it is a mammal.

(1) The volcanic beds are by far the most typical rock features of the country. They are confined to the high ranges of the Malutis, which form the backbone of the country. The Malutis consist of at least two and in most places three or four parallel ranges of mountains. The average height is 7,500 feet. The necks seem to lie in three or four lines, roughly corresponding to the ranges which now form the Malutis and Drakensberg. A study of the present river system of the country bears out this view, as the Orange River and the Caledon run in approximately parallel courses, and this specially applies to the tributaries on the right or northern bank of the Orange River. The first range of necks builds up the great mountains known as Bitsolebe, Machache, Thaba Phutsoa, and Matelile. The next range, 25 miles to the south-west, contains the great necks known as Dikolobeng, Mokhele, and Thaba di Noha. To the north and east of this there is another composed of still higher summits, amongst them not only the highest in Basutoland but in the whole of South Africa, namely, Mount Hamilton 11,500 feet, Leteba's Nek 10,842 feet, Motar 10,400 feet, and Bukotabelo 10,000 feet. The last range composes the mighty wall known as the Drakensberg, and includes the Mont aux Sources 11,170 feet, Champagne Castle 10,357 feet, Giant's Castle 9,657 feet, and many others. Besides these well-defined ranges, there are many other smaller ones scattered around and between them. It must be remembered that many of these heights are not absolutely reliable, as no proper surveys have been made.

The volcanic beds consist of vast piles of lavas and ashes. Siliceous tuffs are not plentiful. I have seen two or three small examples. The thickness ranges from 500 to 4,000 feet. The lavas are amygdaloid and doleritic near the base of the group, often columnar near their junction with the Cave Sandstone. Higher up in the group truly vesicular and scoriaceous varieties occur, interbedded with thick deposits of ash purple in colour. The greater part of the lavas is amygdaloid, with the cavities filled with quartz or calcite. Weathered surfaces on the lavas indicated by bands of red clay are entirely absent. The thickness of the individual beds varies very much, from a few inches up to 20 feet or more. Many of the flows are full of pipe-like vesicles, usually from 4 to 6 inches in length and from $\frac{1}{3}$ to $\frac{2}{3}$ of an inch in diameter, filled with calcite. These vesicles are not quite perpendicular to the plane of the bed, but inclined towards the vent from which the flow took place. They are more or less spherical and often branch at the top. Occasionally the calcite is completely weathered out, leaving the pipes open, so that a bed of lava at its surface and along its fractured edges looks not unlike a honey-

[1] See Quart. Journ. Geol. Soc., vol. xl (1884), pp. 146–151, pl. vi.

comb. Most of the lavas are basalts, but andesites occur, not only intermingled with the others, but composing entire hills themselves, as at the magistracy of Mayeni in South Basutoland. Agglomerate necks are of frequent occurrence, filling up the great vents, and also in small isolated necks. Most of the indications presented by the lavas of Basutoland point to their deposition in water. This, however, is difficult to reconcile with the fact that in two instances where the junction of the lavas and the Cave Sandstone is exposed, the former rest on the eroded surface of the latter. The upper members of the Cave Sandstone seem also to have been removed by denudation prior to the deposition of the volcanic beds. In the lower flows of the group thin intercalated beds of sandstone occur, pointing to an interruption of volcanic activity, the thickest being 3½ feet. A short description of two of these volcanic peaks, Thaba 'Telle and Thaba di Noha, will serve as examples of all the rest.

Thaba 'Telle is a mountain about 7,800 feet high, rising abruptly from a platform of Cave Sandstone. Its lower slopes consist of doleritic lavas, alternating with vesicular varieties and beds of purple ash, and at the top of agglomerate, evidently the remains of the old throat. The lavas are just under 2,000 feet in thickness. The mountain is a kind of three-sided cone, with steep, often precipitous sides, and was once much more extensive than now. The summit is a plug of naked agglomerate standing up to a height of fully 100 feet, exceedingly steep and in some places overhanging. It can only be climbed at one point where there is a crack left by the weathering away of a doleritic dyke, and then only with considerable difficulty and risk. The top is convex and grass-grown about 30 square yards in area. The view from the summit is magnificent, as several prominent volcanic peaks can be seen in the distance. This plug is the resort of multitudes of vultures that make their homes in the cracks and fissures of the rock. The lavas of Thaba 'Telle are full of steam holes, more especially in the upper beds, and about the middle of the beds are two thick deposits of ash separated by a thin bed of amygdaloid lava. This alternation of beds can be made out at some distance, as the ash is light purple in colour, and the lava a deep shining black. The same phenomenon occurs elsewhere. Near the base of the mountain is a large intrusive sheet surrounding what was once a subsidiary cone, but what is now nothing more than a mere plug of doleritic lava and agglomerate. This sheet is of much later date than the surrounding lavas which it penetrates and overlies. From it spring two immense dykes that traverse the country for miles in practically straight lines.

Thaba di Noha. This mountain is about 50 miles, as the crow flies, from Thaba 'Telle, and rises immediately behind the magistracy of Mohale's Hoek. It is the extreme western point of the great Mokhele range. It is about 7,500 feet high. The bridle-path from Mohale's Hoek to Moyeni leads over the plateau from which the mountain rises, between the plug and what is presumably the old crater wall. It is a typical volcanic vent, and one can trace the outflow of the lavas on the north side of the hill. At one point where a stream has cut through, they are steeply inclined, glassy, and weather into coarse splintery fragments about 10 or 12 inches in length, not unlike spear-heads. At another place, a little higher up, they are ropy and scoriaceous. The whole crest of the mountain consists of doleritic amygdaloid lavas, interbedded with vesicular varieties and very thick beds of ash. The vesicles in the lavas are generally filled with calcite. An exposure of the junction of the lavas and the Cave Sandstone occurs in the bridle-path upon this mountain, and indicates that erosion of the Cave Sandstone had taken place before the deposition of the Volcanic Beds, but the evidence is not decisive. The erosion may be due to a subsequent and different cause. This does not apply to an exposure near Sefikeng, which plainly indicates erosion. Many of the highest summits, such as Mount Hamilton, Mont aux Sources, Bitsolebe, etc., contain a vertical thickness of over 4,000 feet of lavas and ashes. These mountains, with the exception of the last, are situated in very difficult and broken country, far from centres of population, and as I have not visited them personally I am unable to describe them in detail.

Connected with the lava beds are a great series of intrusive dykes and sheets. They cover a considerable extent of country, and traverse all the Stormberg Series. They are subsequent to the Volcanic Beds, and so far as I can make out are of the same age as the Karroo dolerites of the Cape Colony and of similar composition. Amongst the many scores of them that I have examined I cannot say that I have ever observed any decided characteristics of a lava-flow. Doleritic lava can be generally separated from doleritic intrusions, not only by its appearance but also by its mode of occurrence. A doleritic sheet weathers red, which doleritic lavas never do, at least so far as I have seen them. Some of the dykes are only a few inches wide, and upwards of 50 feet long, sending out side branches. By far the larger number are from 10 to 20 feet in thickness and several miles in length. They traverse the country in all directions like great roads running up and down the hills, and usually terminating in a large sheet. There are many examples of this kind, as for example at the mountain Thaba Tsuen. It crops out in the valley to the west of the cone; sends two parallel dykes up the mountain at very steep angles, and separated by rather less than a mile. These dykes traverse the lower lava beds, reappear on top as two shallow parallel trenches, and then pass into an immense sheet nine or ten miles in length by four in width, which attains in places a thickness of 400 feet. Near Mohale's Hoek two remarkable examples of intrusive dykes are to be seen. The first runs across the country with perpendicular sides like a huge wall for about seven miles, traversing the lavas of the Mokhele range. At one point where a stream has cut through the side of the dyke the dolerite assumes a columnar structure closely resembling basalt. The Molteno sandstones through which it has broken are much altered. The other dyke is a conspicuous feature of the landscape, and runs in an east and west direction for upwards of 15 miles from the volcano Mokhele to Raboroko. It is perfectly straight, 30 feet thick, and about the same in height, but more must be hidden by superficial accumulations. It stands up in the form of a huge causeway, and is much weathered at the top and sides, the nodules ranging in size from a marble up to masses two feet or more in diameter. The edges of the rent into which the molten dolerite has been injected are as clean-cut and straight as if laid out artificially. Small displacements of the neighbouring strata are characteristic features of these dykes. Occasional enclosures of sandstone occur in dykes, but they rarely exceed three feet in thickness. From observations made at widely separated places, I am convinced that these dykes and sheets were intruded into the lavas long after volcanic action had ceased, at least from the main centres of eruption, but before the earth-movements to which the country largely owes its present configuration had begun.

Recent and superficial deposits cover the low grounds, and consist of stratified clays, sands, and gravels. The pebbles of the gravels consist of fragments from all the Stormberg rocks. In many places these deposits are more than 30 feet thick. The rivers in the course of ages have cut their way through them, and, as they are loose and easily removed, the amount swept away by every storm is considerable. Large masses fall from the banks during the rains, with the result that a small stream becomes in a short time a huge gaping donga. These dongas everywhere intersect the country, and are a positive danger, especially during the rainy season. The destruction of the wood and bush of the country, together with the increase of cattle that eat off the grass, has powerfully assisted the formation of these dongas. They not only reduce the area of arable land, but also drain off the water and disfigure the country. If nothing be done to check their formation they will render the water problem a very serious one at no distant date. When the first missionaries came to Basutoland about 75 years ago multitudes of these dongas did not exist. A deep donga near Morija was forty years ago a small stream that one could step across; now it is a trench 15 feet deep and more than 20 feet wide. It is a pity that the Basuto cannot be induced to plant trees more extensively. They would at least do something towards checking denudation, besides being useful as fuel in a country where such a commodity is exceedingly scarce. The Government is trying to induce the natives to plant by the gift of trees, and they are slowly waking up to the necessity of it.

The most interesting of the superficial deposits are the sand dunes on Thaba Bosin mountain. They occupy the south-eastern portion of the plateau, and travel east or west according to the direction and strength of prevailing winds. These sand dunes are formed of disintegrated Cave Sandstone, the grains being chiefly quartz and felspar. They cover many acres in extent. Thaba Bosin is the necropolis of the Basuto chiefs, and every paramount chief, besides many sons and brothers of the ruling chiefs, have been buried there. The sand-hills have partially covered up the graves and appear to be slowly travelling towards the east, as some of the graves formerly hidden are now exposed. They never approach close to the precipitous edge of the plateau, as apparently the updraught of the wind in rushing round and over the plateau prevents the sand from falling over the precipice. They are also beautifully ripple-marked by the wind, and some of them are quite 20 feet in height. Not far from Morija there is the basin of an old lake, just as there are many such prehistoric lake basins over the surface of the country, in which there have been found Palæolithic flint implements. Some of the floors upon which these flint implements have been found are 60 and 70 feet above the present levels of the rivers. The lake basin referred to above is now quite filled up, and is only represented by a marsh, as the river which formerly drained it has cut a deep channel for itself, removing the surplus waters. It is about six square miles in area, and the beds of sand and gravel filling it up are well exposed in the bed of the stream. They are over 30 feet thick. This lake existed from a remote period until quite lately. It ought to be a likely place for fossils, but none have been found. A few fossils have been discovered in other gravels in various parts of the country, belonging, so far as is known, to species still living, but some of which no longer inhabit the country. The skull of a hippopotamus was obtained many years ago from the bank of the Caledon River near the station of Hermon, and I am informed the remainder of the skeleton is still there, as the people objected to its removal. Tusks of the warthog, together with scattered bones of other animals, have also been found. The warthog is quite extinct in Basutoland, and has been for a considerable time. It is probable from the age of some of the oldest of these deposits that recently extinct animals might also be found.

So far as can be seen it is probable that the drainage of the country, from the time of its elevation at the close of the Stormberg Period, has followed pretty much its present lines. A glance at the sectional map of the country, from Morija to the Natal border east and west, compiled by the Rev. R. H. Dyke from notes made by him in 1883 and 1884, will show this.[1] The Caledon River flows in a shallow syncline tending east-north-east, and there is no trace of any change in the direction in recent times. The same may be said of the Orange River and its tributaries, which have cut their way through the plateaux and formed steep-sided valleys nearly 2,000 feet deep, and in some places much deeper than that. On the Maletsunyane River, a tributary of the Orange, there is a magnificent waterfall 632 feet high, formed by the river cutting back its bed. Ages of denudation have hollowed out deep troughs, in the bottom of which the rivers now run with a general southerly direction, carving the volcanic beds into three and in some places four parallel ranges. This has been powerfully assisted by earth-movements subsequent to the cessation of volcanic activity. There have been two distinct thrusts. First one from east to west, giving the Stormberg Beds their general easterly dip, next one approximately at right angles to this. The first produced the series of synclinal folds, which the country presents on traversing it from the Caledon River to the Drakensberg; the second gave a gentle rise to the country from south to north, assisting the rivers to deepen their beds.

A good example of river erosion on a small scale is to be seen near the station of Hermon in the west of the country, where a small tributary of the Caledon has cut its way through a doleritic intrusive

[1] Published in "Papers read at the joint meeting of the British and South African Associations for the Advancement of Science, 1905," vol. ii, p. 129.

sheet 200 feet thick, and there is no indication that the stream ever followed any other course. The best examples of river erosion are to be seen in the gorges of the Malutis, but I have never had the good fortune to visit them. The scenery of these parts of the country is remarkably grand in places, and well merits the title bestowed upon it of the Switzerland of South Africa.

REVIEWS.

I.—Geology of the Panama Canal.

To the journal entitled "Economic Geology, with which is incorporated the American Geologist" (vol. ii, Oct.-Nov., 1907), Mr. Ernest Howe contributes an essay on "Isthmian Geology and the Panama Canal." He observes that the widespread decomposition to which all the rocks have been subjected, and the thick mantle of soil and vegetation, offer great obstacles to the study of the geology of the region; but he was fortunately able to examine numerous artificial excavations and records of borings. The oldest rocks along the Canal route, andesitic tuffs and breccias with associated flows, occur in the central and southern portions. Resting upon these on the Atlantic or northern side of the Isthmus are fossiliferous conglomerates, sandstones, and shales which dip at low angles toward the Caribbean Sea, so that in passing from the interior to Colon successively younger beds are encountered, the oldest carrying an Eocene fauna, and the youngest late Oligocene, according to Mr. W. H. Dall. On the Pacific or southern slope the Eocene strata extend for some distance and disappear beneath beds of acid pyroclastic rocks, which in turn are to be traced almost continuously to the shore near the Pacific end of the Canal. Ancon Hill, which dominates the city of Panama, consists of massive rhyolite porphyry, that is believed to mark the site of a volcanic vent, from which the acid tuffs and breccias of the neighbourhood were erupted. Tuffs of nearly the same composition are found on the Atlantic side in the vicinity of San Pablo and Tabernilla, and similar rocks occur at Gatun, interbedded with fossiliferous Oligocene sediments. The deposits on the Pacific side are believed to be contemporaneous with these. Cutting all these earlier Tertiary rocks are irregular dykes and stock-like masses of pyroxene-andesite and basalt, which are considered to be of Miocene age.

The general structure of the Canal route is therefore a broad flat anticline, having a nearly east-west axis; but there are many small folds and faults, and evidences of local unconformity, which show that differential movements of the land took place at intervals from the Eocene period onward.

The author deals with the origin of the present topographic features that have resulted from the erosion and deposition that attended three well-marked epeirogenic movements; and in connection with them a notable feature, discovered and located entirely by means of borings, is a buried Pleistocene valley, that has afforded not only great scientific interest, but also the most important problem with which the engineers of the Canal have had to deal.

II.—GEOLOGICAL SURVEY, WESTERN AUSTRALIA. BULLETIN NOS. 24, 25, 1906; NOS. 26, 30, 1907. A. GIBB MAITLAND, F.G.S., Government Geologist. 8vo; with maps, plates, and figures in the text. Perth, W. A.

BULLETIN No. 24 contains an account of the Laverton, Burtville, and Erlistoun auriferous belt of the Mount Margaret Goldfield, by Charles G. Gibson, Assistant Geologist. The report is one of the special series dealing with the mineral resources of the State, and it includes a brief summary of the work of other observers in the same area.

The boundaries of the Mount Margaret Goldfield embrace an area of 42,252 square miles. The formations met with constitute a complex of crystalline rocks, to which the general terms 'greenstone' and 'granite' are provisionally applied. The greenstones are essentially hornblende rocks, ranging through typical diorites to a fine-grained rock, consisting almost entirely of hornblende. The granitic rocks are in some places found to be intrusive in the greenstones in the shape of dykes and masses; in others their relations to the greenstones cannot be determined with certainty owing to the covering of recent deposits. They vary in character from a dark hornblende granite or quartz-diorite, to a light coloured quartz-porphyry. The group of rocks here called greenstones is the most important from the economic point of view, as it generally contains the auriferous ore bodies.

This report is illustrated with geological and mining maps and illustrations of geological phenomena.

Bulletin No. 25 is a report upon the "Prospects of obtaining Artesian Water in the Kimberley District," by R. Logan Jack, who was specially appointed to undertake the work. After referring to previous surveys made by E. T. Hardman, H. P. Woodward, and A. Gibb Maitland, which paved the way for later investigators, the writer takes the geological formations met with in the district as follows:—

Carboniferous Sandstone.
Carboniferous (?) Limestone.
Devonian Sandstone, Grit, and Limestone.
Metamorphic Rocks—Slates, Schists, Gneisses, etc. (Silurian, Cambro-Silurian, or Cambrian).
Granite.
Basalt.

These are briefly described from the author's observations while drawing special attention to the pioneer work of Hardman in this field. In summing up his results Dr. Jack refers to the nine distinct areas that he examined and in which he anticipates more or less success in the search for artesian water. He concludes that the latter is destined to play an important part in the pastoral industry of the Kimberley District. An appendix to this report gives an itinerary and notes on water. There is also a coloured geological map (scale 12 miles to 1 inch) with explanatory notes upon its face, and a full index.

Bulletin No. 26 includes a series of reports which were too short to be separately issued. They relate to the mineral and other resources of the country. The first, by Mr. Gibb Maitland, deals with the occurrence of artesian water; the second, by Mr. H. P. Woodward, refers to the same subject in connection with the Gascoyne area. The phosphatic deposits near Dandaraga are described by Mr. W. D. Campbell. A small meteorite (siderite) from the Nuleri district is described by Mr. E. S. Simpson, whose account of it is well illustrated from photographs. "The geology of Princess Royal Harbour, with reference to the occurrence of oil," and "Recent advances in the knowledge of the geology of Western Australia" form the subjects of two papers by Mr. Gibb Maitland. The second of these was Mr. Maitland's presidential address before the Section of Geology of the Australian Association for the Advancement of Science in 1907. This is of much interest as a comprehensive summary of the geology of the country. The writer devotes particular attention to the older rocks of the State, consisting of crystalline, schistose, and metamorphic rocks, considered to be possibly of Archæan age, though the term pre-Cambrian is used in preference to designate them. These rocks occupy about two-thirds of the total superficial area of the State, which comes to about 975,920 square miles. They consist of rocks of various types, many of them in a crystalline condition, forming coarse crystalline schists and gneiss, differing but little from granite and rocks of similar origin, as well as basic rocks which have been more or less crushed, foliated, and completely converted into greenstone schists. The sedimentary rocks are representative of the Cambrian, Devonian, Carboniferous, Jurassic, and Tertiary periods, and are all recognizable by their fossil contents. Finally, volcanic rocks occupied an important place in the geological history of Western Australia. They are to be found in the shape of lava-flows, ash beds, breccias, dykes, etc. Igneous activity took place, it appears, in three distinct periods, viz., in pre-Cambrian time prior to the deposition of beds holding an Olenellus fauna; early in Devonian time, but ceasing before the Carboniferous; after the deposition of the Jurassic beds, and finally in rocks believed to be of Tertiary age.

Two other papers are included in this report, viz., "Notes upon the geological map of the Greenough River District," by W. D. Campbell, and "Prevention of external corrosion of Goldfields water supply Pipes," by E. S. Simpson.

Bulletin No. 30 contains a report by E. S. Simpson and Charles G. Gibson on "The Distribution and Occurrence of the Baser Metals." In a prefatory note Mr. Harry P. Woodward explains the object of this bulletin to be for the purpose of aiding prospectors and persons interested in the search for metals other than gold. The metals dealt with are copper, tin, lead, zinc, antimony, bismuth, iron, nickel, cobalt, manganese, aluminium, tantalum, tungsten, and molybdenum. Particulars relating to the mining, yield, and value of these metals are set down in the report, to which a full index is appended.

A. H. F.

III.—Geology of India.

General Report of the Geological Survey of India for 1906, by T. H. Holland, F.R.S., F.G.S., Director. The Mineral Production of India during 1905, by T. D. Latouche, B.A., F.G.S. The Geology of the State of Panna, principally with reference to the Diamond-bearing Deposits, by E. Vredenburg, A.R.C.S., F.G.S.; also numerous papers on Indian Geology by the same author. A Preliminary Survey of certain Glaciers in the North-West Himálaya, by Officers of the Geological Survey of India.—All the above extracted from the "Records."

PARTLY in continuation of a review of the Geology of India which appeared in the Geological Magazine for July, 1907, we are now able to offer a few additional remarks on the progress of this far-reaching Survey. When we reflect that the area under consideration, though nominally India, extends from the crest of the Karakoram in Central Asia to the southernmost point of the Nicobar Islands, and from the confines of Persia on the west to those of Chinese Yunnan on the east, it must be admitted that this is a truly Imperial Survey, and that the variety of formations must afford a wide scope for official enterprise.

There are of necessity so many and such diverse subjects dealt with in this Report and the accompanying papers that it seems advisable, for the purposes of review, to alter somewhat the arrangement adopted by the Director, and to place the several subjects more or less on a chronological basis so far as this is practicable.

Existing phenomena.—There are two subjects dealt with in this category.

(1) "River action." Mr. Holland drew the attention of the Board of Scientific Advice to the unsatisfactory nature of our information regarding the data available as to the amounts of silt and dissolved salts carried by the large Indian rivers to the sea, and, on the recommendation of the Board, Government sanctioned the institution of systematic investigations. These, it is thought, will materially assist in the estimation of the amount of denudation going on, and be of much interest to geologists. Steps have been taken, notably in the case of the Indus, to determine the amounts systematically. This is for many reasons an excellent move, but the problems of denudation, which it is hoped to solve, must of necessity be complicated where the rivers drain such a rare and exceptional area as that occupied by the Himálayan system. The rivers of Central India might yield results of a more normal character.

(2) "Himálayan glaciers." The importance of determining the secular movements of these glaciers has been recognized, and a preliminary survey of the principal ones in the Kashmir, Lahaul, and Kumaon region instituted. Of all these glaciers plane-table sketches were made showing the exact positions of the 'ice-caves' with reference to points fixed on rocks in the valleys, as well as with reference to prominent and unmistakable peaks in the vicinity. In

Kashmir, so called, six glaciers belonging to Hunza, Nagir, and Bagrot have been visited, and sketch-maps, supplemented by photographs, of their 'snouts' have been prepared with a view to determine the direction and amount of their secular movements. The glaciers fall into two classes, viz., those which lie in troughs parallel to the mountain ranges, and those which flow at right angles to the ranges; the former longitudinal, the latter transverse glaciers. The Kashmir section of the Survey is illustrated by numerous photographs taken by Hayden and reproduced (collotype) by Bemrose of Derby. These pictures, regarded simply from an artistic point of view, are exquisite landscapes, in addition to their utility from a geological point of view. The photograph of the terminal ice-cave of the famous Hispar glacier, in conjunction with the explanatory sketch-map, affords a most instructive picture, whilst that of the Hassanabad glacier (already reproduced in *Nature*, January 2nd, 1908, p. 201) presents features of quite a different character. Moreover, this latter glacier has been increasing in length of late years, contrary to the general practice of Himálayan glaciers. The work on the glaciers of Lahaul and Kumaon is equally interesting and artistic, and as a result of the entire survey posterity will be able to form an accurate estimate of the movement of all these glaciers in future. How poor Marshall Hall would have rejoiced at this!

As might well be expected, the glaciers of the Hunza Valley and the Karakoram range generally descend to lower levels than those in the Lahaul and Kumaon regions. In the former the snouts of the glaciers proceed down to levels of 7,000 or 8,000 feet, whilst in the latter they melt before descending below about 11,000 feet. The second point most prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines at lower levels in the valleys. If we remember rightly, this seems to corroborate the experience of Hooker in Nepal during the fifties of the last century. Mr. Holland points out, however, that these results do not necessarily mean that the glaciers are now in retreat, and he gives two cases where a recent advance has been made. The evidence with regard to the erosive action of ice is said not to be conclusive.

Tertiary.—In this connection Mr. Vredenburg, who has recently been appointed Palæontologist, appears to have done good work, especially in Belúchistán. The Director remarks that Mr. Vredenburg has paid especial attention to the distribution of the foraminiferal genera *Orthophragmina* and *Lepidocyclina*, in view of the doubts that have been expressed as to their constant separation in European Tertiary strata. So far no instance has been noted in India where these two genera are in association with each other. *Lepidocyclina* has never been found below the Nari (Oligocene), whilst *Orthophragmina* has never been found above the lower zones of the Upper Khirthar (Eocene). Thus these two genera retain their distinctive stratigraphical value.

The general result of Mr. Vredenburg's work tends to emphasize the importance of the breaks in the Tertiary formations. In the Belúchistán area, where the beds are more disturbed, the unconformities are obvious from the stratigraphical evidence; whilst in Sind, where the only serious orogenic movements occurred in late Tertiary times, there is a general physical parallelism amongst the lower Tertiary strata, but the interruptions in deposition are, according to Mr. Vredenburg, none the less pronounced when the palæontological evidence is sifted. Thus there is found to be a conspicuous break, both stratigraphical and faunistic, throughout the regions under description, between beds of Eocene and those of Oligocene age, which latter pass upwards by gradation into the equivalents of the Lower Miocene. A break again occurs before the establishment of the Manchar (Siwalik) strata.

At the base of the Tertiary system itself there occurs an important break, separating it from the *Cardita Beaumonti*-beds of Cretaceous age, which are placed by Mr. Vredenburg as low as the Maestrichtian. It is concluded, therefore, that the uppermost Cretaceous beds of Western India are separated from the Tertiaries by a gap, occupied by the Thanetian and Montian stages in Europe.

Under the heading of "Tertiary" we must advert briefly to the geology of the Andaman Islands, which attracted the attention of Indian surveyors some years ago. According to a recent survey it would seem that beds of Tertiary age are largely represented in these islands. Mr. Tipper shows that beneath recent and sub-recent formations of no particular interest there are clays, foraminiferal limestones, sands, and shell-marls of Miocene age; also in North Andaman a large outcrop of coarse sands and conglomerates with *Nummulites atacica*, Leym., and *Assilina granulosa*, D'Arch., of Eocene age. In South Andaman the Eocene beds are represented by micaceous sandstones and shales with leaf impressions, etc. The underlying serpentines, gabbros, and diorites are probably of Upper Cretaceous age. A comparison with the rocks of the Aracan Yoma shows that the Andamans are a continuation of the same system.

Cretaceous.—As a further contribution to the probability of the Cretaceous age of the Deccan Trap, Mr. Vredenburg announces the recognition, amongst beds of Maestrichtian age in Belúchistán, of the characteristic Intertrappean fossil *Physa Prinsepii*, Sow. In Central India the examination of the Deccan Trap and Intertrappeans has continued, and some interesting facts with regard to the old soils and the fresh-water deposits have been noted. At one locality, where an Intertrappean bed is well developed, it was found to consist of 6–10 feet of cream-coloured marl and limestone, the upper layers of which were crowded with well-preserved specimens of *Physa*. It is of interest to note that the respective areas, where red clay bands and Intertrappean aqueous deposits are found, do not commingle, a fact which bears out the interpretation that the former represent old land surfaces and the latter areas more or less under water.

Triassic.—A special memoir on the Triassic fossils of the Central Himálayas appears in the *Palæontologia Indica*, and supplements the descriptions of older collections. There is a strong similarity between the Himálayan and the Alpine Muschelkalk. The upper beds are especially rich in Brachiopoda, whilst in the lower beds Cephalopoda predominate. Amongst the Cephalopoda described in the memoir twelve species are either closely related to or identical with those previously known in the Alpine Muschelkalk, whilst three characteristic species of Brachiopoda are common to both areas. Of the Cephalopoda 148 species belonging to 41 genera and subgenera are now known in the Himálayan Muschelkalk. The Triassic faunas of the Himálayan regions approximate more closely to the Alpine province than to the "Arctic-Pacific."

Permo-Carboniferous.—Certain limestones lying to the eastward of Mandalay in Burma, which were formerly regarded as Silurian, have been shown by Mr. Latouche to contain specimens of *Fusulina* and corals, indicating the presence of Permo-Carboniferous beds, whose occurrence in various parts of the Shan plateau had been previously announced.

But the most interesting intelligence in connection with this horizon comes from Kashmir, where evidence has been obtained which seems likely to set the almost everlasting Gondwana question at rest. It appears that, after considerable doubts as to the correct interpretation of a somewhat debatable section, Mr. Hayden discovered *Gangamopteris* and other plant-remains in Godwin-Austen's typical section near Zewan, about 9 miles south-east of Srinagar. The rest of the story should be told in the Director's own words:—

"In this section the trap-flows are covered with apparent physical conformity by an oolitic limestone, which has been made crystalline and largely converted into novaculite. Above the limestones are beds of siliceous shales covered conformably by the *Gangamopteris*-bearing beds, which pass up through a perfectly conformable series, about 150 feet thick, to limestones containing *Protoretepora ampla*, Londs., near the Zewan series of *Productus*-limestones. The *Protoretepora*-beds are without doubt the equivalent of the *Fenestella*-shales of Spiti, and are therefore of Upper Carboniferous age, giving the upper limit for the *Gangamopteris*-bearing beds. We have thus at last obtained positive proof of the existence of this characteristic Lower Gondwana plant in rocks that cannot be younger than the English Coal-measures, and are possibly even Middle Carboniferous in age. As *Gangamopteris* occurs in the lowermost beds of our Gondwana system the long-disputed contention of the Geological Survey of India as to the Palæozoic age of the Lower Gondwanas is finally settled by positive evidence; and, although other workers have been so near discovering the one link wanting, the honour of completing the chain of evidence belongs to Mr. Hayden."

Devonian.—Two Devonian horizons have been proved to exist in Burma on palæontological evidence, but their stratigraphical relations to beds believed to be Permo-Carboniferous are not as yet known. The most important fauna includes an abundance of Corals, Bryozoa, and Brachiopoda associated with a very small number of Crinoids, Molluscs, and Trilobites. This fauna is thought to resemble that of the Eifel: *Calceola sandalina* is especially abundant. It may be worth while mentioning that the small collection of Devonian fossils obtained by McMahon in Chitral appears to resemble this one in the relative abundance of Brachiopoda and Corals. Another Devonian collection from Burma, instead of resembling a European fauna of this age, is said to include many species related to or identical with the Hamilton Series in North America.

Pre-Cambrian.—The great unfossiliferous Vindhyan system, so important a feature in Central India, has attracted some attention of late from the Indian Survey, and Mr. Vredenburg has even suggested a new classification, though perhaps only provisional. Into these details we need not enter, but there is one subject in connection with the Vindhyans to which some allusion might be made, viz., the Diamantiferous Conglomerate occurring in the Rewa division of the Upper Vindhyans near Panna in Bundelkhand. The diamond industry in India at present is only a small affair, and therefore the subject is unimportant from an economic point of view. Yet the occurrence of the diamonds otherwise than in an ordinary alluvial gravel is interesting, as possibly tending to throw some light on the origin of the gem. For this purpose it will be necessary to study the geological conditions under which the Diamantiferous Conglomerate occurs. The Archæan base of the country is held by a Granite, which, even if newer than the Arávalli system, is the oldest rock in Bundelkhand. This Granite, where exposed, is seen to be seamed by quartz-reefs, and these again are cut, approximately at right angles, by linear dykes of basic igneous rock. These dykes appear to represent a period of volcanic activity contemporaneous with the Bijáwar system, an unfossiliferous sedimentary formation which, in places, intervenes between the Granite and the Lower Vindhyans. In Southern India similar dykes of the same age occur abundantly in the neighbourhood of diamond-bearing deposits like those of Bundelkhand, "an association which suggests some possible genetic relation." The Bijáwars were extensively disturbed before the deposition of the Vindhyans, which partly rest upon them quite unconformably. Their denudation supplied the Vindhyans with a vast amount of material, the bright-red pebbles derived from the bedded jaspers and fault-breccias being particularly conspicuous in some of the Vindhyan conglomerates, which likewise contain a peculiar jaspery sandstone of a greenish colour derived from the denudation of a portion of the Lower Vindhyans.

Having discussed the probable origin of the material, Mr. Vredenburg next proceeds to define the position and mode of occurrence of the diamond-bearing deposits. There are two thin conglomerates (seldom exceeding two feet) in each case capping sandstones and underlying shales, of which the lower one is the best known and the most important. The pebbles of the Lower Rewa conglomerate are derived partly from the quartz-reefs of the Bundelkhand Granite, partly from the Bijáwars and Lower Vindhyans. Fragments derived from these two sedimentary formations are absent from the Upper Rewa conglomerate, which only contains pebbles of vein-quartz. These quartz pebbles derived from the granite area are therefore the essential associates of the diamonds, "and the original home of the gem must be one of the rocks of the granitic region, either the Granite itself, or its quartz reefs, or the basic dykes." Further on, however, Mr. Vredenburg, commenting on the presumed absence of diamond workings in the Bijáwar conglomerates, both in Central and Southern India, suggests that the diamonds are not older than the Bijáwar, "which supposition, coupled with their evident derivation from the crystalline area, points to the basic dykes of Bijáwar age as their possible *nidus*." So far as we know at present, the almost invariable association of the diamond in South Africa with ultra-basic rocks inclines us to believe that its birthplace occurs in a magma of this character. Hence the basic dykes so often quoted by Mr. Vredenburg may really be the original home of the gem, though the basic material itself could never endure the attrition inevitable in the formation of a conglomerate.

To use a popular expression, these Panna diamonds are "small potatoes and few in a hill," whilst their derivative character helps us very little towards a recognition of the source whence they originally proceeded. The majority of the crystals are said to be small, yet of a good water and lustre, and very seldom clouded or flawed. Their commonest defect consists in the presence of 'spots,' which are black, opaque inclusions of jagged outline. Owing to this defect a large number of the stones are unfit for the European market.

(*To be concluded in our next number.*)

IV.—Système Silurien du Centre de la Bohême, par Joachim Barrande. 1e partie: Recherches Paléontologiques. Continuation éditée par le Musée Bohême. Vol. iv: Gastéropodes, par le Doct. Jaroslav Perner. Tome i, 1903; Tome ii, 1907. Traduit par A. S. Oudin.

THIS work supplies a need that has been long felt by palæontologists studying the Gasteropoda of the Palæozoic rocks. As is well known, Barrande succeeded not only in accumulating an immense amount of material connected with the ancient fauna of Bohemia, but he also wrote a considerable number of volumes thereon. He, however, died before accomplishing the part on the Gasteropoda, and in his will desired Professor W. Waagen to continue it. Illness and subsequent death prevented this. Therefore, in April, 1900, the Barrande Commission requested Dr. Perner to undertake the work, and all the materials collected by the eminent French refugee were placed in his hands.

After a careful study of these large quartos, with due consideration for the difficulties involved, we must congratulate the Commission on the result of their choice. Dr. Perner shows not only extensive knowledge of the Gasteropoda of his own country but also of other countries, and he brings to bear on the subject a great breadth of observation, as well as a faculty for minuteness of detail. The translation into fluent French renders the work easy of comprehension by foreigners.

In the prefaces to the two parts Perner describes the difficulties he has had to contend with, the mode he has thought best to meet them, as well as the scope of the work. The material consisted of specimens, notes, and sketches accumulated between 1847 and 1883—the year of Barrande's death—and also of some 247 lithographed plates. These plates contain a superabundance of figures, not merely of different families and genera of Gasteropoda (often mixed up unsystematically), but they even include various organisms belonging to other branches of the animal kingdom which he had mistaken for Gasteropoda. Barrande drew the figures as the material came to hand during successive years, a practice that involved much repetition. On the one hand he laid stress upon minute distinctions of little moment, while on the other hand important features of detail and ornament to which much value is now attached were sometimes overlooked. To compensate for this latter deficiency Perner has introduced numerous admirably executed drawings into the text. The indiscriminate mixture of figures has been much more difficult to cope with satisfactorily. Perner has considered it best to give the descriptions in zoological order, and has in the main followed the classification of Pilsbry in the Text-book of Palæontology by K. A. von Zittel, translated by C. R. Eastman, vol. i, 1900.

Though tome i contains the descriptions of the families Patellidæ, Carpenter, and Bellerophontidæ, M'Coy, only, the plates of necessity contain in addition the figures of species belonging to many other families. To render these plates comprehensible before their detailed description can be published more than usually full explanations and notes are given. Tome ii also comprises figures of species which cannot be described before the publication of tome iii. Though Perner has used Barrande's plates, he has not been able to adopt his explanations and descriptions, as the real structure of the fossils and their phylogeny were then imperfectly known. He has been obliged to change many both generic and specific names, while adhering as far as possible to Barrande's nomenclature. This was all the more advisable as Barrande made out preparatory tables of genera and species which he named provisionally, and he also presented specimens to many European collections with his manuscript names attached.

In chapter 1 (tome i) Perner gives a chronological list of some forty-three works in which Bohemian species of Gasteropoda have been quoted. Amongst them is Bigsby's "Thesaurus Siluricus," 1868, where about 244 species are recorded whose names were transmitted by Barrande. Perner considers the Gasteropod fauna of the Bohemian basin more or less peculiar to that area, with the exception of there being an almost complete connection between the Gasteropoda of f2 (Devonian) and those of the calcareous deposits of Lower Devonian age in other countries. As Barrande's title "Système Silurien" is somewhat misleading, it may be well here to give a reminder that his étages, D, E, F, G, whose Gasteropoda are described in the volumes before us, include not only the Silurian formation as now understood but also the Ordovician and the Lower and Middle Devonian.

Perner divides the families into groups usually differentiated as genera and subgenera, the exact value of which cannot at present be accurately determined owing to the lack of sufficient material. He has, however, found it advisable to divide the family Bellerophontidæ, M'Coy, into two larger groups in the first instance, and then to subdivide these into genera, laying great stress on the presence or absence of a dorsal band, the first group, *Cyrtolitoidea*, being devoid of it, while the other, *Bucanioidea*, possesses it. This family and the Patellidæ, Carpenter, contain respectively 20 and 8 genera and subgenera (some of them new), comprising 153 species and varieties.

Tome ii describes many of the most interesting families, which are 13 in number and contain 105 genera, comprising 326 species and varieties. Thus we have a total in the two volumes of 133 genera and 479 species. In addition 147 other Gasteropoda are mentioned whose state of preservation does not admit of their being referred with certainty to any species or even genus.

Tome iii will contain the descriptions of five more families, comprising among others many species already figured in tome ii. The Capulidæ may be mentioned as an instance of this, 52 plates in tome ii being exclusively devoted to that family. The same volume will also furnish more particulars about the relationships between the Gasteropoda of Bohemia and those of other countries.

The families described in tome ii are the Pleurotomariidæ, Murchisoniidæ, Euomphalidæ, Trochoturbinidæ, Delphinulidæ, Neritopsidæ, Solariidæ, Scalaridæ, Littorinidæ, Loxonematidæ, Turritellidæ, Chemnitziidæ, Subulitidæ. Of these the Pleurotomariidæ ought by rights to have been described in tome i as the first family of the Rhipidoglossa, but as the plates destined for that part contained but few members of the family Perner thought it better to give the Bellerophontidæ the precedence.

There is considerable difference of opinion among palæontologists with regard to the respective limits of the families Pleurotomariidæ and Murchisoniidæ, Koken. Perner considers the form of the aperture the most important feature to be taken into account. Thus shells with more or less rounded aperture he places in the former family, and those with an oval aperture prolonged into a short canal in the latter. The possession of a nacreous inner layer, or of an elongated form, he regards merely of generic value. Both the *Murchisonia*, d'Arch. & de Vern., and *Pleurotomaria*, Sow., should strictly possess a slit in the outer lip, the filling up of which during growth gives rise to the formation of a band on all the whorls. Perner states that if *Pleurotomaria* be restricted to forms agreeing with the Mesozoic types, *P. anglica*, Sowerby, and *P. tuberculosa*, Defrance, it is not represented in the Palæozoic rocks of Bohemia. But he nevertheless considers that there exist several groups with certain features in common which may be placed with *Pleurotomaria* (taken in a more extended sense) in the family Pleurotomariidæ, and many of these have merely a sinus and not a slit in the outer lip. These groups he regards as constituting genera and subgenera; they number twenty-five, twelve of which are new, and most of the species are also new. Some of the old genera are extended so as to include more species, while others are restricted. Among the latter is *Lophospira*, of which the types given by Whitfield are *L. bicincta*, Hall, and *L. helicteres*, Whitfield. Ulrich considerably extended this genus, dividing it into numerous sections; Perner, however, restricts it to the *perangulata* section of Ulrich, of which *L. perangulata*, Hall, is the type. He includes some of Ulrich's species of *Lophospira* in *Worthenia*, de Kon., and he creates a new genus, *Coronilla*, for the *robusta* section of Ulrich, of which *P. robusta*, Lindstr., is the type. In the latter genus he gives four new species, all from the Upper Silurian (e2). In *Worthenia* he has also four new species from the same horizon. *Lophospira* is represented by six species, all from the Ordovician (d4 and d5). Two of these are identified with the American *L. medialis*, Ulrich & Scofield, and *L. tropidophora*, Meek.

Only two species of the Pleurotomariidæ are mentioned as common to Britain. One of these from the Silurian (e2) is referred to *P. Lloydii*, Sow., which occurs also in Gothland, and is placed in the genus *Phanerotrema*, Fischer, by Perner. It shows a different structure above the band, but seems too badly preserved for accurate determination. The other is referred with a query to *P.* (*Bembexia*?) *Champernowni* (?), Whidborne, sp. It is merely an internal mould, so there can be still less certainty about its identification.

Perner also places in the family Pleurotomariidæ the genera *Stenoloron*, Œhlert, *Catanostoma*, Sandberger, and *Agnesia*, de Koninck, though he does not regard them as belonging to *Pleurotomaria*, s.l.

Stenoloron contains two new species, *S. pollens*, Barr. (f2), and *S. ambigena*, Barr. (e2), which are especially interesting for showing distinct traces of the very narrow grooved band, which had evidently possessed orifices along it at unequal distances represented by a row of elongated tubercles.

The Murchisoniidæ are divided by Perner into four genera, viz., *Pseudomurchisonia*, Koken, *Murchisonia*, d'Arch. & de Vern., s.l., *Sinuspira*, n.g., and *Ectomaria*, Koken. *Murchisonia*, s.l., he subdivides into eleven subgenera, of which five are new. The other three genera are distinguished from *Murchisonia*, s.str., by having a sinus and not a slit in the outer lip, and by not possessing a distinct band on all the whorls; indeed, the two last-named have no band, and *Pseudomurchisonia* (which is represented by one species) has a band on the later whorls only.

The new genus *Sinuspira* (which is also represented by only one species) is particularly interesting in that it apparently forms a link between *Murchisonia* and *Loxonema*; the lines of growth make a deep tongue-shaped sinus without any interruption in their course to form a band. Thus it comes near those species of *Loxonema* which have very sharply sinuated lines of growth, but it may be distinguished by the sinus being of greater depth, and the whorls being more convex and not adpressed at the suture.

Among the new subgenera *Leptorima* may be mentioned as remarkable for having a narrow deep band situated between two swellings high up on the whorl just below the upper suture. *Donaldiella*, Cossmann (*Goniospira*, Donald), is but doubtfully represented by two species, neither of which has so prominent a band as the type. *Ptychocaulus*, n.g., of which the type is the well-known *Murchisonia Verneuili*, Barr. (MS.), is distinguished by the peculiarity of a fold on the columella clearly shown by well-drawn sections of the shell. Another interesting feature in the Murchisoniidæ is pointed out by Perner, namely, the fact of the upper part of the spire being partitioned off in several instances.

The Murchisoniidæ range from the Ordovician (D–d5) up to the Middle Devonian (G–g1).

Previous authors such as Koken, Ulrich, and Scofield differ greatly in the genera they include in the family Euomphalidæ, De Kon., and they also give many of them the rank of families. Perner considers it best to regard these latter as sub-families of the Euomphalidæ, and he divides these sub-families into genera. He states that true members of the Euomphalidæ, like the type *E. pentangulatus*, Sow., do not exist in Bohemia, and that the family takes quite a secondary place in the Gasteropod fauna. Only one new genus is described, comprising one species; it resembles *Euomphalopterus*, but has certain distinctive features. The family occurs as early as the Ordovician (D–d17), is most numerous in the Silurian (E–e2), and is only represented by one species in the Devonian (F–f2).

He adopts the family Trocho-Turbinidæ, Koken, for shells bearing a certain external resemblance to *Trochus* or *Turbo*. This group is very extensive in Bohemia, including no less than nineteen new genera and subgenera created by Perner. By far the greater number of species occur in the Silurian (E–e1 and 2), but one, *Trochonema excavatum*, Barr., is found in the Ordovician (D–d4), and others range up to the Devonian (F–f2). For the genus of which *Euomphalus discors*, Sow., is the type he prefers retaining the name *Polytropis* given to it by De Koninck, as it has been so used for twenty years in spite of its preoccupation by Sandberger. In a note to plate 107 he states that he did not see Clarke & Ruedemann's "Guelph Fauna," where they suggest the name *Polemnita*, till this work was in the press.

Several small families follow such as the Delphinulidæ, Fischer, with one new subgenus; the Neritopsidæ, Fischer, containing only two genera, *Naticopsis*, M'Coy, with eight species named by Barrande in manuscript, and referred by him to *Natica*, and *Turbonitella*, De Kon., with five species, all also of Barrande in manuscript, except one which Perner considers identical with *T. Ussheri*, Whidborne.

The suborder *Ctenobranchia*, Schweigg, comprises two sections: (1) Pteroglossa, Troschel, containing the Solariidæ, with two new genera, and the Scalaridæ, Chenu, with eight genera, of which four are new; (2) Tænioglossa, Troschel, in which are grouped the Littorinidæ, Gray, Loxonematidæ, Koken, Turritellidæ, Gray, Chemnitziidæ, Koken, and the Subulitidæ, Lindström. Among these the families Littorinidæ and Chemnitziidæ each contains one new genus, while the Loxonematidæ has two new genera, namely, *Auriptygma* and *Katoptychia*. The former unites some of the characteristics of *Naticopsis*, *Holopea*, and *Macrochilina*. The latter greatly resembles the Triassic *Anoptychia*, Koken; each is represented by two species. *Auriptygma* is confined to the Silurian (E–e2), and *Katoptychia* to the Devonian (F–f2). Only three of the genera into which the family had been previously divided occur in Bohemia. Of these *Loxonema*, Phillips, comprises the greatest number of species, eleven of which Perner refers to *Loxonema*, s.str., and nineteen to a new subgenus which he calls *Stylonema*. None of the species have been previously described, and they range from the Silurian to the Devonian (E, F, and G). He confines *Loxonema*, s.str., to shells of the type of *L. sinuosum*, Sow., characterized by having oblique sutures and lines of growth strongly sinuated or almost subangular near the middle of the whorl. *Stylonema*, on the contrary, has the lines of growth in the main simply curved and seldom sigmoidal, with sutures more nearly horizontal.

Conditions of space render it impossible to notice more than a selection of the new and interesting forms treated. We trust, however, that enough has been written to show what a wide field has been ably traversed by Dr. Perner, and to awaken the desire to study his elaborate work *in extenso*.

JANE LONGSTAFF (DONALD).

V.—EARTHQUAKES: AN INTRODUCTION TO SEISMIC GEOLOGY. By WILLIAM HERBERT HOBBS, Professor of Geology, University of Michigan. New York, 1907.

THE work before us is one deserving of special attention from geologists. It cannot be denied that recent and very important advances made in the study of earthquakes have tended to throw the science of Seismology into the domain of the physicist and mathematician, rather than into that of the naturalist. The construction of delicate recording instruments, the unravelling of the complicated results of different kinds of wave-movement, and the discussion of the conclusions to be drawn from these as to the nature and disposition of the materials entering into the composition of our globe, make seismology (like the study of underground temperatures, terrestrial gravity, or terrestrial magnetism) an important branch of geo-physics. But while this aspect of the subject is not lost sight of, it should ever be remembered that the geologist has at least an equal claim with the physicist to be heard in the discussion of seismological problems. The records of the history of the earth's crust, as studied by the geologist, supply evidence concerning the nature and the effects of seismic action which cannot be neglected if we are to obtain the fullest possible amount of light upon the subject. It is true that the idea, formerly held by geologists, that there is a direct connexion between volcanic and earthquake phenomena, has been steadily losing ground; but, on the other hand, the intimate relations between earthquake movements and the geological phenomena of jointing and faulting—or, as our author prefers to express it, the effects of constant readjustment of blocks of the earth's crust to one another—are coming to be regarded as the essential factor in all great earthquakes. The interpretation of the phenomena of the past, by the study of forces in action at the present time, which is so fully recognised as the true principle of reasoning concerning the external agents operating on the earth's crust, is now felt to be equally applicable to the internal forces acting upon it. 'Seismic geology,' though divorced from Vulcanology, must still be regarded as one of the essential branches of Geological Dynamics.

In the earlier chapters of this work the author, inverting the usual method of treating the subject, deals with the evidences so familiar to the geologist of constant strain and intermittent fracture within the earth's crust, and demonstrates the existence of unstable belts where such conditions attain their maximum. He then shows how the great earthquakes studied in recent years—the Mino-Owari (Japanese) earthquake of 1891, the Assam (Indian) earthquake of 1897, the Owens Valley (Sierra Nevada) earthquake of 1872, the Sonora (Mexican) earthquake of 1887, the Yukutat (Alaska) earthquake of 1899, and the St. Francisco (Californian) earthquake of 1906—were all accompanied by manifest dislocations at the earth's surface along lines of fault.

But in addition to this connexion between great lines of faulting and the occurrence of earthquake shocks—a connexion now generally accepted by geologists as definitely proved—the author, following up and extending the recent work of De Montessus, argues that innumerable lines of minor strain and fracture ('seismotectonic lines') can be detected by means of a study of dislocations on railways, the occurrence of 'craterlets,' and similar evidences of surface disturbance. The manner in which this kind of evidence is employed in seismological investigation has been illustrated in the case of the Charlestown earthquake by a paper published by Professor Hobbs in the Geological Magazine (May, 1907, Dec. V, Vol. IV, p. 197). The results obtained are networks of intersecting lines, which can often be shown to coincide with the existing features ('lineaments') of the district. Examples of 'seismotectonic maps' constructed on this principle are given in chapters vi and vii, including Ischia, Japan, California, the Greater Antilles, Scotland, the eastern United States, the Charleston area, etc., and the existence of such minor lines and their connexion with the surface features of the district is a question well worthy of the consideration of all geologists.

Chapters viii to xii, giving clear but condensed accounts of great earthquakes, especially those of the United States, cannot fail to prove of great service to all students of the subject. The essential and significant details are admirably sifted out from the often confused, trivial, and irrelevant materials of the original descriptions; and many subjects, like the modifications produced in the flow of undergound waters, and the emission of 'sulphurous vapours,' with other minor phenomena, receive judicious treatment. The same praise may be awarded to the chapters dealing with the modes of studying the evidences of disturbance by earthquakes on the land and beneath the sea (chapters xiv and xv).

It is only after the geological aspects of the subject have been fully discussed that the author comes to the study of earthquakes by instrumental means, and proceeds to the discussion of the principles, the construction, and the modes of use of seismoscopes, seismometers, and seismographs. The reader will find in chapter xvi a very intelligible account of all the more recently invented types of apparatus now employed in the study of earthquakes. In his remarks on the relative values and applicability to different conditions of the various instruments, there is one very important point which has been overlooked by the author. As he justly states, all forms of seismograph suffer, and always must suffer, under the disadvantage that pendulums of every kind have a vibration of their own, dependent upon their length, and hence the movement of the earth's surface is complicated with that proper to the pendulum. By the employment in conjunction, and side by side, of pendulums of very different lengths, and by the use of various systems of damping, this disadvantage may be diminished, though it can never be quite overcome. Hence the seismological observatory which has installed in it the most numerous and most varied types of instrument may be expected to obtain the best and most complete records. But there is another and very practical consideration that must also be kept in view. Not only is it desirable that the most delicate observations should be made at a particular spot, but it is equally important that records should be obtained at numerous and widely distributed stations, by means, if possible, of instruments of the same pattern, the records of which can be directly compared. In the selection of an instrument suitable for this work, it becomes absolutely imperative that the original price should not be so great as to make it prohibitive, and that the cost of maintenance (including photographic materials, etc.) should not be excessive. It is these considerations which have necessarily governed the action of the Seismological Committee of the British Association in the work they have carried on for so many years, and by their observance the Secretary of the Committee, Professor John Milne, has been able to establish and to keep maintained some forty seismological stations scattered all over the globe. The only reference to the Milne instrument in this work is a remark on the small amount of magnification of the movement of the earth particle in that instrument, and the author does not appear to be aware that this defect has already been removed by an addition to the instrument made by Professor Milne himself.

The Seismological Committee of the British Association can point with confidence to the important results obtained through the use of this instrument of Professor Milne's during the last twelve years. It has been asserted that an instrument of the Milne type, established at Strasburg, has not given satisfactory results. But how far this may have been due to want of proper adjustment or other causes is somewhat doubtful. The important point to be remembered is that a very large part of our knowledge concerning the distant effects of earthquakes, since the original work of Von Rebeur-Paschwitz, has been obtained by a comparison of the records obtained with the Milne instrument at widely distant stations. The author of this work, in his references to the labours of Professor Milne, is so fair and appreciative that we feel sure any seeming neglect of results obtained during eighteen years in Japan and twelve years subsequently at Shide must be due to misinformation and certainly not to personal prejudice or ill-will. We can very heartily recommend the work as giving a full and very clear account of the recent developments of what the author not inappropriately calls the New Seismology, dealing with the observations of earthquakes at a distance, and the conclusions to be drawn from such observations.

J. W. J.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*January 22nd*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Origin of the Pillow-Lava near Port Isaac in Cornwall." By Clement Reid, F.R.S., F.L.S., F.G.S., and Henry Dewey, F.G.S.[1]

The Upper Devonian strata around Port Isaac consist of marine slates, in which occurs a sheet of pillow-lava over 200 feet in thickness. The pillows measure usually from 2 to 5 feet in diameter, but range up to 8 feet; masses under 1 foot are rare. The individual pillows are quite disconnected, although moulded on one another and adherent where they touch. Where three pillows approached there was an angular vacant space, subsequently filled with calcite, which is often altered into chert. Their mutual relations seem to prove that they were soft when deposited, but not sufficiently soft to squeeze into corners.

Each pillow shows internally a central vacant space or very open sponge, often as much as two feet in length. This is succeeded by a thick shell of exceptionally vesicular lava, which is followed by an outer shell of banded, more or less, vesicular rock. The whole mass is so vesicular that it must have been very light.

If this lava were subaërial, the lightness would not help us to explain the origin of the isolated pillows; but the intimate association with fine grained marine strata shows that it was probably submarine. On calculating the proportion of cavity to rock in two of the pillows, the authors find that the specific gravity of the whole mass must have been very low, not greatly exceeding that of sea-water. The lava seems to have been blown out into thick walled bubbles, kept from touching each other by the escaping steam. The whole mass was for a short time in the spheroidal state, and, although composed of a multitude of large plastic spheres, the sheet could flow like a liquid. This eruption seems to have been analogous to that of Mont Pelé, described by Dr. Tempest Anderson and Dr. Flett, except that it was submarine instead of subaërial.

2. "On the Subdivision of the Chalk at Trimmingham (Norfolk)." By Reginald Marr Brydone, F.G.S.

The object of this communication is to lay before the Society a sketch-map showing the geographical distribution of the sub-divisions, with a brief account of their distinguishing features. Practically the whole of the Chalk exposed on the foreshore comes under the two main divisions—one composed of (*a*) Sponge-beds, very largely yellow, 12 feet, resting on 8 feet of White Chalk; (*b*) White Chalk without *Ostrea lunata*, about 9 feet thick; (*c*) White Chalk containing *O. lunata*, 20 feet; and the other composed of (*a*) Grey Chalk, about

[1] Communicated by permission of the Director of H.M. Geological Survey.

12 feet thick; succeeded by (*b*) White Chalk with *Ostrea lunata*, about 20 feet; (*c*) White Chalk without *O. lunata*, about 8 feet; (*d*) White Chalk with *O. lunata*, about 10 feet; and (*e*) Grey Chalk, about 25 feet. There is no evidence as to the relative positions of these two main divisions. The author seeks to justify his adoption of *Terebratulina gracilis* and *T. Gisei* as the zone fossils of the Trimmingham Chalk, in opposition to the proposal to adopt *Ostrea lunata* as the zone fossil. Other important species are *Pentacrinus Agassizi*, *P. Bronni*, and *Echinoconus Orbignyanus*. The author still adheres to his view that these masses of Chalk can only be *in situ* and must have once formed part of a large continuous mass, and that the bulk of this mass must have lain to seawards of the present coast-line.

II.—*February 5th*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "On Antigorite and the Val Antigorio, with Notes on other Serpentines containing that Mineral." By Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.G.S.

It is by no means certain, as the author ascertained after his joint paper with Miss Raisin, published in 1905, that the first described specimen of antigorite was really found in the Val Antigorio. So last summer he visited that valley, in company with the Rev. E. Hill, and after an examination, of which he gives an account, came to the conclusion that the rock most probably does not occur there *in situ*, though it is found in pebbles, etc., from tributaries.

He next describes other specimens of antigorite serpentine, examined since 1905; some from New Zealand, kindly sent to him by Dr. J. M. Bell, and others obtained in the Saasthal, especially from the Langefluh; giving further particulars about specimens in the National Collection at South Kensington and in the University Collection at Cambridge.

He then discusses the origin of the mineral. Pressure is apparently essential; certainly it can be formed from augite, and, though he has not discovered residual olivine in his own rather numerous specimens, or typical antigorite in Alpine bastite serpentines, he finds indirect evidence of its coming from this mineral, proofs of which are given by F. Becke, M. Preiswerk, and J. M. Bell. If, however, we suppose the former existence of two types of peridotite in the Alps, as at the Lizard and in the Vosges, and pressure sometimes to have preceded, sometimes to have followed serpentinization, we can account for the apparent conflict of evidence.

2. "The St. David's Head 'Rock Series' (Pembrokeshire)." By James Vincent Elsden, B.Sc., F.G.S.

The St. David's Head and Carn Llidi intrusions are of complex composition, ranging from a basic biotite-norite to an acid quartz-enstatite-diorite, and finally to soda-aplite. Throughout all the types, except the last, there is a high magnesia percentage. The extreme types sometimes pass abruptly one into the other, and at other times they are mixed in various proportions. They do not represent a composite intrusion, but simultaneous intrusions of an imperfectly-mixed magma. There is no evidence of differentiation *in situ*, but the facts suggest a common origin from a differentiated magma-basin. The aplite-veins may represent the most acid phase of the differentiated magma.

Petrographically the rocks are of considerable interest, as exhibiting types not very commonly occurring in the British Islands. They also afford unusual facilities for the study of both rhombic and monoclinic pyroxenes, and appear to throw light upon the origin of the sahlite-striation of the latter. Rhombic pyroxene generally crystallized earlier than the monoclinic pyroxene, but sometimes these relations are reversed, and often the two forms are crystallographically intergrown, sometimes as twins. There are two distinct varieties of augite, distinguished by the presence or absence of a basal striation. The relation of these two types lends support to the perthitic theory, that there is an ultra microscopic crystallographic intergrowth of rhombic and monoclinic pyroxene. The probable age of the intrusions is not greater than that of the earth movements which folded the Arenig Shales in this district. The observations recorded in the paper seem to point to the conclusion that acid streaks and cores in basic igneous rocks may not always be due to differentiation *in situ*.

II.—Mineralogical Society.

November 12*th*, 1907.—Professor H. A. Miers, F.R.S., President, in the Chair.

On hopeite and other zinc phosphates and associated minerals from Broken Hill Mines, North-Western Rhodesia; by L. J. Spencer (Geol. Mag., 1907, p. 379). Hopeite is abundant as brilliant water-clear crystals or as larger white crystals reaching 2 cm. across. The crystals are orthorhombic with $a : b : c = 0{\cdot}5786 : 1 : 0{\cdot}4758$. Cleavage flakes parallel to the brachypinacoid show a zonal intergrowth of two substances, distinguished as α-hopeite and β-hopeite: these differ considerably in their optical characters, and slightly in sp. gr. (3·0—3·1) and the temperature at which water is expelled. Associated with the hopeite crystals on the bone-breccia are brown botryoidal masses of vanadinite. The other zinc phosphates occur, not in the bone cave, but with cellular limonite and crystals of descloizite and pyromorphite in connection with the zinc-lead ores (which consist of an intimate mixture of cerussite and hemimorphite with interspersed limonite). The new species *tarbuttite* occurs in great abundance, and is a basic zinc phosphate, $Zn_3 P_2 O_8 . Zn (OH)_2$, with sp. gr. 4·15; the crystals are anorthic with $ac = 55° 50'$, $ab = 84° 34'$, $bc = 76° 31'$, c being a direction of perfect cleavage. Pseudomorphs of tarbuttite after calamine ($Zn C O_3$), descloizite, and hemimorphite are not uncommon. Another new species, named *parahopeite*, has the same chemical composition as hopeite, $Zn_3 P_2 O_8 . 4 H_2 O$, but is anorthic with sp. gr. 3·31. The platy crystals somewhat resemble hemimorphite in appearance; they have one perfect cleavage, approximately perpendicular to the plates, through which emerges one of the optic axes.—The question of a relation between Isomorphous Miscibility and Parallel Growths; by T. V. Barker. A study of the growths on each other of immiscible or slightly miscible pairs of substances has shown that although miscibility and parallel growths are favoured by the same factor—similarity and molecular volume—yet the two properties do not always go hand in hand: for many immiscible or only slightly miscible substances form parallel growths quite readily. Mixed crystals, therefore, should not be regarded as built up of alternating parallel layers.—Notes on zeolites from Cornwall and Devon; by A. Russell. The occurrence of zeolites in various localities was described, e.g. that of heulandite near Okehampton, stilbite at Botallack and St. Ives, chabazite at Luxullian, apophyllite and analcite at Lostwithiel.—Note on the crystallisation of potassium bichromate; by Professor H. A. Miers. Two stages of growth of potassium bichromate crystallising from a drop of solution were described and illustrated by lantern slides.—On various minerals from the Lengenbach quarry and the Ofenhorn, Binnenthal; by R. H. S. Ily. Crystals of binnite, one of them a unique twin, and examples of the regular intergrowth of sartorite and baumhauerite were described, and the occurrence of brookite and molybdenite on the Ofenhorn was for the first time recorded.—Mr. L. J. Spencer exhibited on behalf of Dr. H. J. Johnston-Lavis some minute crystals of hæmatite found in association with chlormanganokalite in blocks ejected from Vesuvius during the eruption of 1906. The crystals have the form of acute scalenohedra β $\{31\bar{3}\} = \{24\bar{6}1\}$. A fine series of zeolites from the neighbourhood of Belfast was shown by Mr. F. N. A. Fleischmann, a new meteoric stone from Simondium, Cape Colony, by Dr. G. T. Prior, specimens of reconstructed ruby and blue spinel, and of the new gem benitoite, by Dr. G. F. Herbert Smith, and a specimen of artificial hæmatite by Mr. C. J. Woodward.

CORRESPONDENCE.

NOTES ON FOSSIL PLANTS FROM SOUTH AFRICA: A CORRECTION.

Sir,—In the description of *Phyllotheca Whaitsi*, sp. nov., on p. 481 of my "Notes" the locality of the specimen found by Mr. Whaits is given as "Prince Albert in shale lying between the Witteberg Series and the Dwyka conglomerate." I am indebted to Miss Wilman, of Kenilworth (Cape Town), for pointing out to me that the locality should be described as Farm Klipfontein, Fraserburg District, a well-known locality of fossil reptiles. The strata form part of the Beaufort Series, and are probably of Permian age. Miss Wilman's correction is confirmed in a letter from Mr. Whaits.

A. C. Seward.

Botany School, Cambridge.

RADIOLARIAN ROCKS OF THE CULM MEASURES, DEVONSHIRE.

SIR,—I wish to call attention to the unfortunate mistake which I have made on pp. 4, 105, 106, 107, 108, and 109 of the Geological Survey Memoir on Plymouth and Liskeard, 1907, in attributing to Mr. Fox alone various statements which I have quoted from the joint papers of Messrs. Hinde and Fox on the Radiolarian rocks of the Culm Measures, in the Quart. Journ. Geol. Soc., vol. li, 1895, and in the Transactions of the Devonshire Association, vol. xxviii, 1896, and in Proc. Geologists' Association, vol. xx, pp. 88, 92, 1907. I desire to express my regret, and to offer my apologies to these authors for the unintentionally deficient references to their joint papers.

W. A. E. USSHER.

28, JERMYN STREET, S.W.
February 12th, 1908.

THE LIQUID AND PNEUMATOLYTIC THEORIES OF GRANITIC MINERALS.

SIR,—I have noticed with much regret that the conclusions arrived at by the Geological Survey[1] as to the crystallisation of the West Country Granites are in hopeless conflict with several communications which the GEOLOGICAL MAGAZINE has honoured me by publishing.

Broadly speaking, the Survey authorities have adopted the high temperature gaseous theory,[2] whereas I have assumed the impregnability of the low-temperature liquid theory. Any attempt at reconciliation is useless, but it may be as well if I submit the list of the authorities on which I have relied. They are in order of date as follows:—

(1) Sorby, "Microscopical Structure of Crystals": Q.J.G.S., 1858.
(2) Sorby & Butler, "Rubies, Sapphires, and Diamonds": Proc. R.S., 1869.
(3) Hartley, "The Identification of Liquid Carbonic Acid in Mineral Cavities": Royal Micro. Soc., March 1st, 1876.
(4) Sorby, "On the Critical Point in the Consolidation of Granitic Rocks": Mineralogical Mag., September 6th, 1876.
(5) Hartley, "On Variations in the Critical Point of Carbon Dioxide in Minerals," etc.: Journ. Chem. Soc., September, 1876.
(6) Hartley, "Observations on Fluid Cavities": Journ. Chem. Soc., March, 1877.
(7) Hartley, "Attraction and Repulsion of Bubbles by Heat": Proc. R.S., 1877.
(8) Hartley, "On the Constant Vibration of Minute Bubbles": Proc. R.S., 1877.
(9) Report on the Conditions under which Liquid Carbonic Acid exists in Rocks and Minerals, by a Committee consisting of Walter Noel Hartley, F.R.S.E., E. J. Mills, D.Sc., F.R.S., and W. Chandler Roberts, F.R.S. Drawn up by W. N. Hartley, F.R.S.E.: Rep. Brit. Assoc., 1877.
(10) A. Daubrée, "E'tudes Synthétiques de Géologie Expérimentale": 1879.
(11) Sorby: Address to the Geological Section of the British Association, 1880.
(12) Fouqué et Lévy, "Synthèse des Minéraux et des Roches": 1883.

I am bound to admit that the first chapter of Daubrée's "Experimental Geology" justifies the views of the Geological Surveyors, and

[1] "Land's End District," pp. 49–60, 1907.

[2] "'Pneumatolysis' refers to the action of gases above critical temperature" ("Falmouth and Camborne," p. 168, 1906).

that Fouqué & Lévy do not directly challenge them. It will, however, be noticed that the papers of Dr. Sorby and Professor Hartley, published as they are in the records of Societies such as the Royal, Chemical, Microscopical, and Mineralogical, and in the Reports of the British Association (and published, moreover, quite independently, and for different objects of research), might very well not have all come under the notice of MM. Daubrée, Fouqué, and Lévy; and that indeed seems to have been the case.

Speaking for myself, I certainly should not have seen most of the above papers had not the authors most generously sent me reprints.

I am certainly in a great difficulty. One of the minerals relied on by the Geological Survey to prove pneumatolytic action at temperatures above the critical temperature of water is topaz. But, in Professor Hartley's paper on Fluid Cavities to the Chemical Society in 1877, one section is entitled "On the Probable Temperature incident to the formation of Topaz," and one conclusion arrived at is that topaz sometimes crystallises under and sometimes over the C.T. of water.

The petrologists dismiss all the evidence relied on by the chemists for ascertaining the temperatures of rock-formation. But there is this fact to be borne in mind, that while the chemists have minutely studied separate minerals, the petrologists have taken a wider view of rocks and magmas.

The following example will serve to show how widely eminent petrologists and chemists differ as to probable temperatures. Professor Hartley, in discussing the formation of negative cavities in quartz, observes:—"The mineral is crystallised at a high temperature, say 150° C." (on Fluid Cavities).[1] The theory adopted by the Geological Surveyors often necessitates a temperature exceeding 365° C.

Since the publication of the Cornish Memoirs I have for the first time understood the irritation that my unfortunate little papers have naturally caused. St. Paul hits the position off exactly: "If I know not the meaning of the voice, I shall be unto him that speaketh a barbarian; and he that speaketh shall be a barbarian unto me."

I can assure my geological friends that for very many reasons I most deeply regret ever having published outside the provinces anything on the subjects of either Petrology or Ripplemark; as both subjects have led to a vast amount of genuine misunderstanding and discomfort, and I may add of mystification; and they are not worth it.

A. R. Hunt.

ORIGIN OF THE SUDBURY NICKEL ORES.

Sir,—In Professor Coleman's interesting restatement of what he regards as "incontrovertible proof" of the igneous origin of the Sudbury nickel ores, he makes the safe assumption that I had not seen the long announced second part of his monograph (Report of the Bureau of Mines, Ontario, vol. xiv, No. 3). It would be inexcusable for anyone to discuss the Sudbury mining field without

[1] Reprint, p. 8.

careful consideration of any work that Professor Coleman had published on it. I am not aware that his second report was available when I prepared my address. Its issue was reported in *Economic Geology* for June, 1906; but as the paper is not included in the Annual List of Literature received by the Geological Society for either 1905 or 1906, I presume *Economic Geology* was supplied with an advanced copy. This view is supported by the fact that Professor Coleman, in a paper in the Journal of Geology for last month, published six months after the manuscript of my address had to be in the hands of the printer, refers to his report as "recently distributed." I notice, moreover, that there is no reference to it in Messrs. Campbell & Knight's paper on the Microstructure of the Nickeliferous Pyrrhotites, which was received in this country after my address had been delivered. As the report was apparently inaccessible to American authors, it is not surprising that it was not available on this side of the Atlantic.[1]

My opinion as to the origin of the Sudbury ores is not so emphatic as Professor Coleman's article would suggest. The opinion which he quotes was introduced by the words "appear to have been," and the next sentence continues the same expression of doubt—"if Dickson's facts be right," etc. Without having been in the field, I should be sorry to express a final opinion on either side. But so far as I am capable of judging from the literature, the igneous origin of the ores is not yet established, and is faced by greater difficulties than the alternative theory. Messrs. Campbell & Knight, in their recent paper in *Economic Geology* (June, 1907), also conclude that "Dickson has a weight of evidence to prove that his specimens are of secondary aqueous origin" (p. 351). They claim that (p. 365) in all the chief mining fields of nickeliferous pyrrhotite the mode of origin of the ores was the same, and that the basic rocks with which the ore bodies are associated were first formed, then fractured, and then "ore-bearing solutions came in and replaced the rock-matter wholly or in part by pyrrhotite. Later on the pyrrhotite, etc., was also strained and broken, and the deposition of pentlandite and chalcopyrite followed." Hence I am not the only one who is not yet convinced that the igneous origin of these ores is "the correct view." J. W. GREGORY.

GEOLOGICAL DEPARTMENT,
UNIVERSITY, GLASGOW.
January 31*st*, 1908.

KITCHEN-MIDDENS IN NORTH CORNWALL.

SIR,—In Mr. B. B. Woodward's interesting paper in the GEOLOGICAL MAGAZINE (January and February, 1908) on "The Drift and Underlying Deposits at Newquay," he mentions kitchen-middens and cooking-sites as occurring towards the upper parts of the deposit of sand (Fig. 1, p. 15, January). It may be interesting to note the similar occurrence in the Trevose district further to the north-east of many such kitchen-middens and cooking-sites. In October, 1901

[1] I am informed (Feb. 17th) that Professor Coleman's report has not even yet been received at the Geological Society's Library.

(in company with Mr. G. Bonsor, Dr. Thelwell, and Mr. Mallett) we found in the blown sand above the cliff near Constantine Island many traces of hearths, at different levels, down to a depth of 8 feet from the highest point of the midden. There were charcoal, burnt bones, and shells of *Patella vulgata*, *Cardium edule*, and *Mytilus edulis* (some showing traces of the action of fire on them). The fact of the differing levels of these hearths seems to show a prolonged occupation of the Trevose peninsula by Neolithic man or his descendants in the Bronze or early Iron ages. There is an extensive circular midden round Constantine Church (ruins), there are others covered with blown sand that can be identified by the shells and bones turned out by rabbits in making their burrows. Also an extensive midden occurred at the Harlyn Bay late Keltic burial-ground. I say occurred, because it has been levelled and planted with trees. From that kitchen-midden were obtained teeth of *Bos taurus*, *Sus scrofa*, and shells of *Mytilus*, *Patella*, *Helcion*, etc., and quantities of broken *Purpura lapillus*, which Mr. Santer Kennard, F.G.S., considered were thus broken to extract colour for dyeing. I cannot verify the reference, as I do not keep the *Illustrated London News*, but, as far as I remember, Mr. George Bonsor, whose discoveries near Carmona have given him a European reputation, found somewhat similar conditions as to kitchen-middens and cooking-sites near St. Mary's in the Scilly Isles, but, so far as I know, his paper on this work has not yet appeared.

R. Ashington Bullen.

Woking.
February 5th, 1908.

OBITUARY.

BERNARD J. HARRINGTON, B.A., Ph.D., LL.D.

Born August 5, 1848. Died November 29, 1907.

We regret to record the death of Dr. B. J. Harrington, who was formerly chemist and mineralogist to the Geological Survey of Canada, and subsequently Professor of Mining and also of Chemistry in McGill University, Montreal. Born in the province of Quebec he was educated at McGill University, and afterwards graduated Ph.D. at Yale. In 1872 he succeeded Dr. T. Sterry Hunt as chemist and mineralogist to the Canadian Geological Survey under Selwyn. To the publications of that Survey he contributed reports and analyses of coals, iron-ores, and sundry minerals. He also prepared a catalogue of the Canadian minerals, rocks, and fossils exhibited in the Paris Exhibition of 1878. He described the new mineral Dawsonite (1874), wrote on the microscopic structure of dykes cutting the Laurentian rocks (1877), and on the minerals of some of the apatite-bearing veins of Ottawa County (1879). In later years he contributed papers on mineralogical subjects to the Transactions of the Royal Society of Canada, the American Journal of Science, and other journals. He had been President of the Chemical and Physical Section of the Royal Society of Canada, and he was appointed a Vice-President of the Chemical Section of the British Association at the meeting held in Toronto.

Dr. Harrington was perhaps most widely known in this country as author of the interesting "Life of Sir William E. Logan," which was published in 1883.

ROBERT LAW, F.G.S.

BORN JUNE 21, 1840. DIED DECEMBER 29, 1907.

THE late Mr. Robert Law, whose death took place at the close of last year, was in many respects a remarkable man. Born at Walsden in Lancashire, on the borders of Yorkshire, he commenced the business of life as a weaver, but was attracted in his leisure hours to the local Working Men's Club and Institute, where his interest was aroused in the Natural History and Archæology of his neighbourhood. Although at the time he was regarded as "a very rough unpolished diamond," yet, after passing through a course of instruction in what may be called elementary subjects, he became passionately devoted to the study of geology, spending what little spare money he had on books and fossils, and his spare time in reading or in tramping the district for miles around. In this way he became so proficient in geological science that he was recognised as its leading exponent in the country round Walsden. He soon widened his sphere of operations, his wanderings taking him to the Mountain Limestone districts of Castleton, Derbyshire, to Clitheroe in Lancashire, and to the Lias of the Yorkshire coast.

About 30 years ago he commenced his first class in geology at Todmorden, under the auspices of the local Science and Art Committee, and in the same year he had a similar class at the Institute at Walsden. By virtue of his position as a teacher, Mr. Law had the privilege of attending several of the Summer training courses in geology and kindred subjects at the Normal College of Science, South Kensington. He had a plain but effective method of teaching, and possessed to a remarkable degree the power of winning the interest and devotion of his students. In a few years he was in very great demand as a teacher, and had classes every evening in the week, as well as on Saturday afternoons. Among the places at which he taught were Bacup, Rochdale, Shaw, Oldham, Hebden Bridge, Halifax, and Lightcliffe.

His friend Mr. Walter Baldwin, of Rochdale, remarks in a letter that "as a lecturer he had a style peculiar to himself and one which took with the working men, as he never lost his Yorkshire accent, which certainly was a strong one. He and the late Mr. James Horsfall, of Rochdale, were the first to draw attention to the minute flint implements from the Lancashire and Yorkshire Moors." They brought a paper on the subject before the British Association at Montreal. The same authors read before the Manchester meeting of the Association in 1887, a paper "On the discovery of Carboniferous Fossils in a Conglomerate at Moughton Fell, near Settle, Yorkshire" (see GEOL. MAG., 1888, p. 30).

If not one of the actual founders, Mr. Law was one of the early, most active, and notable of the leading men connected with the now defunct Todmorden Scientific Association, and regularly took his part in the lectures and debates. He was elected a Fellow of the Geological Society in 1886.[1]

ARTHUR BEAVOR WYNNE.

Born October, 1835. Died December, 1906.

A. B. Wynne, an energetic and enthusiastic geologist, was in 1855 appointed an Assistant Geologist on the Geological Survey of Ireland, under Jukes, and was engaged in surveying chiefly in counties Tipperary, Waterford, and Cork.

Resigning his post in 1862, upon being appointed on the staff of the Indian Geological Survey, he laboured zealously for eleven years in the neighbourhood of Bombay, and in the Punjab, working at the stratigraphy of the Salt Range, and at the problems of mountain-building.

Ill-health compelled him in 1883 to retire from his work in India, but in the same year he temporarily rejoined the Geological Survey in Ireland, to take charge of the Office work. Here he continued to labour until 1890.

He was for many years a supporter and frequent contributor to the pages of the Geological Magazine, taking part in 1867 in the great discussion on Denudation, when he utilized both his Irish and Indian experience. Occasionally he signed a letter in Indian characters, as when writing in 1875, on the inverted strata of the Mendips. To the Memoirs of the Geological Survey of Ireland and India he contributed the results of his field work; while other of his papers were published by the Geological Society, and by the Royal Geological Society of Ireland, of which he was President in 1889.

MARK STIRRUP, F.G.S.

Born 1831. Died June 10, 1907.

A zealous member of the Manchester Geological Society, Mr. Stirrup had communicated to that body the results of observations on the Glacial Geology of Llandudno (1883), and on the effects of Marine Erosion as shown by the Sea-Cliffs and Sea-Caves of the British Isles (1897). He also wrote an account of the early history of that Society (1897).

To the Geological Magazine he communicated in 1885 a translation of Charles Brongniart's important paper on the Fossil Insects of the Primary Rocks. In 1890 he wrote on Wind-Waves and Tidal Currents, drawing attention to Hermann Fol's observations on the movements of water, made, whilst engaged in diving, at depths of more than 100 feet in the Mediterranean. The true Horizon of the

[1] The above remarks are mainly taken from the *Rochdale Observer*, Jan. 4th, 1908.

Mammoth drew some remarks from Mr. Stirrup in 1893–94, and he maintained in opposition to Sir Henry Howorth that the pre-Glacial age of that elephant had not been demonstrated, at any rate so far as the main history of the animal was concerned.

THEODORE H. HUGHES, F.G.S.

Theodore H. Hughes, Assoc. R.S.M., F.G.S., whose death took place in 1907, was for some years an active member of the Geological Survey of India, engaged for the most part in the coalfields of the Damuda and Gondwana Basins. Notices of some of his reports appeared in the Geological Magazine for 1869 and 1872.

PROFESSOR DR. RUDOLF BURCKHARDT.

Born 1866. Died 1908.

We have also to record the death of the eminent naturalist and palæontologist Professor Dr. Rudolf Burckhardt, of the University of Basel, who died at the zoological station Rovigno (Austrian coast of Adriatic) on January 14th, in his 42nd year. He contributed papers to this Magazine on *Æpyornis*, 1893, p. 572; on *Hyperodapedon Gordoni*, 1900, pp. 486 and 529; on Triassic Starfishes, 1901, p. 3.

MISCELLANEOUS.

Mr. Reginald W. Brock, Professor of Geology in Queen's University, Kingston, has been appointed Director of the Geological Survey of Canada, to fill the post temporarily occupied by Professor Robert Bell, who succeeded Dr. George Dawson, as Acting Director.

"The Zones of the White Chalk of the English Coast."—With the appearance of part v on "The Isle of Wight," in the Proceedings of the Geologists' Association for January, 1908, Dr. Arthur W. Rowe, F.G.S., has at length concluded this important work, which has occupied so many years. The numerous maps have been prepared by Mr. C. Davies Sherborn, F.G.S., and the splendid series of photographs by Dr. H. E. Armstrong, F.R.S. "A task of such magnitude," says the author, "should only have been essayed by one with abundant leisure. The brief holidays snatched from an over busy professional life have, during the past twelve years, been given up unreservedly to this quest. Over 30,000 fossils from the White Chalk have been collected, *accuratelg zoned and localised*, so that those who wish to study genera and species *in bulk* can do so unharassed by any uncertainty." We heartily congratulate the author, and are glad to be able to state that Prof. Dr. Charles Barrois, of the University of Lille, France, one of the highest authorities living concerning the Chalk, has kindly written a review of Dr. Rowe's work, which will appear in the April number of the Geological Magazine.

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ASSISTED BY

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APRIL, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. IV.—APRIL, 1908.

ORIGINAL ARTICLES.

I.—On some New Zealand Graptolites.

By Ethel M. R. Shakespear, D.Sc.

THE New Zealand graptolites which are dealt with in this paper were collected by Mr. E. Douglas Isaacson, mining engineer, New Zealand, for the British Museum (Natural History), South Kensington. Dr. A. Smith Woodward, F.R.S., very kindly gave me the opportunity of examining this interesting collection, which was sent to me in the Autumn of 1907. Shortly after its receipt Dr. Woodward forwarded me a copy of the New Zealand Geological Survey publication entitled "The Geology of the Parapara Subdivision, Karamea, Nelson," by James Mackintosh Bell, Director, 1907, which contains brief descriptions and figures of graptolites collected from the same locality as that from which Mr. Isaacson collected his specimens. Since, however, the records of graptolites from New Zealand are very limited in number, and since Mr. Isaacson's collection contains a greater variety of forms than that of any previous observer, it seems advisable to publish the identifications that I have found it possible to make from an examination of his collection.

In addition to the actual specimens, Mr. Isaacson's maps and notes were placed at my disposal, and from these I have obtained the following facts concerning the occurrence of the graptolite-bearing rocks.

The locality from which Mr. Isaacson obtained his specimens is that of Slaty Creek, not far from Aorangi mine, in the Aorere district of the Karamea division. It is about nine miles south of the southern end of the Wanganui Inlet, which is situated at the extreme north-western corner of the Middle Island of New Zealand. The floor of the country consists for the most part of a series of unfossiliferous blue slates (Aorere Series), but interbedded with these is a "highly carbonised band," only a "few inches in thickness." "The auriferous reefs of the locality are only found in intimate association with this graphitic (carbonised) slate. The reef itself has a thin coating of graphite, and between the graphite and the slate is a block pug seam; while the slate itself is generally in a very crushed condition." The graptolites were "obtained almost anywhere on the line of the reef, and both on the footwall and hanging wall of the reef itself in the workings." They are confined to the fine textured slates, the coarser ones being quite unfossiliferous.

According to Mr. Bell (loc. cit., p. 34), the Aorere rocks in this district are as a whole "folded into a great synclinorium," but the "plication of the strata has been enormous, the rocks having been folded into a series of very closely compressed troughs and arches, which have a general trend of about north-north-west, with many variations from regularity." At the locality where the graptolites were obtained the dip of the beds is about 30° to the west.

Mr. Isaacson states that all the graptolites in his collection came from the one band. It is, however, possible to distinguish two main rock types, namely: (*a*) a somewhat coarse shale with an irregular fracture, and (*b*) a fine, smooth, well-laminated shale.

In the first of these (*a*) I have identified the following species :—

Bryograptus Lapworthi, Ruedemann.
Dichograptus octobrachiatus, Hall.
Didymograptus extensus, Hall.
D. gibberulus, Nicholson (*caduceus*, Salter).
D. nitidus, Hall.
Diplograptus sp. (?).
Goniograptus perflexilis, Ruedemann.
Loganograptus Logani, Hall.
Phyllograptus Anna, Hall.
Ph. ilicifolius, Hall.
Tetragraptus Amii, Elles & Wood.

In the second (*b*) I have recognised—

Bryograptus Lapworthi, Ruedemann.
Didymograptus affinis (?), Nicholson.
D. nanus, Lapworth.
D. similis (?), Ruedemann.
Goniograptus geometricus, Ruedemann.
Phyllograptus Anna, Hall.
Phyllograptus typus, Hall.
Strophograptus trichomanes (?), Ruedemann.
Tetragraptus Bigsbyi, Hall (*similis*, Hall).
T. cf. *pendens*, Elles.
T. quadribrachiatus, Hall.

Intermediate in character between these two extreme rock types there are a few slabs of shale, readily distinguishable by the mode of preservation of their contained graptolites, which have yielded *Didymog. nanus*, *Phyllog. angustifolius*, *Phyllog. Anna*, and *Tetrag. Bigsbyi*. These, however, may be grouped with (*b*).

Thus the two types of rock are distinct, not only lithologically, but also palæontologically, and in this one collection there are represented two different graptolitic zones or sub-zones. Either, then, these two graptolitic zones occur within the one carbonaceous band of a few inches in thickness, or there is more than one graptolitiferous band in the neighbourhood of the reef. Without further information it is impossible to decide between these two suggested alternatives, but the evidence brought forward by Mr. Isaacson and Mr. Bell as to the movement that the rocks have undergone, and the occurrence of the graptolites both on the walls of the reef itself and in its neighbourhood, seems to be in favour of the possibility of there being two distinct graptolitiferous bands present.

The fauna of the band (*a*) is characterised by the abundance of the species *Didymog. gibberulus*. It is undoubtedly the same fauna as that described by Mr. Bell; and if we except his identification of *Rastrites* (which may be a fragment of *Goniograptus perflexilis*) the assemblage of graptolites is that which one might expect. The forms which he doubtfully refers to *Climacograptus* and *Diplograptus* may belong to one and the same species; and from an examination of the one or two specimens which occur in the present collection it appears that they belong to a primitive type of *Diplograptus* allied to *Diplograptus inutilis*, Hall. It may be a new species.

The fauna represented in the second band (*b*) seems not to have been detected by Mr. Bell and his assistants, though its previous recognition in New Zealand is evident from the figures of graptolites given by the late Sir James Hector (Handbook of New Zealand, 1886, p. 82). In this band the most characteristic species are *Didymograptus nanus*, and *Tetragraptus Bigsbyi*, while *Didymog. gibberulus* appears to be entirely absent.

Below is a table showing the distribution of these New Zealand graptolites in America and Great Britain; and an examination of this brings out clearly the great similarity between these two New Zealand faunas or sub-faunas and those of corresponding age in the Northern Hemisphere.

	Slaty Creek, New Zealand.		Deep Kill, State of New York.				Wales.			Lake District.	
			Zone of *Tetragraptus*.		Zone of *Didymog. bifidus*.						
	Band (*a*).	Band (*b*).	Bed 1.	Bed 2.	Bed 3.	Bed 5.	Zone of *Didymog. extensus*.	Zone of *Didymog. hirundo*.	Zone of *Didymog. bifidus*.	Upper *Tetragraptus* Beds.	Ellergill Beds.
Bryog. Lapworthi ...	?	r	c	cc	...	...	...	...	...	...	...
Dichog. octobrachiatus ...	fc	...	rr	cc	r	...	...	...	...	1	...
Didymog. extensus ...	c	...	...	cc	...	...	1	...	...	1	...
D. gibberulus	cc	...	...	...	...	?	1	...	...	1	...
D. nitidus	r	...	c	c	...	...	1	1	...	1	...
Diplograptus sp.	r	...	...	...	...	...	...	...	...	...	...
Goniog. perflexilis ...	fc	...	...	cc	r	...	...	...	...	...	...
Loganog. Logani	c	...	...	cc ?	...	...	...	...	...	1	...
Phyllog. Anna	r	fc	...	r	cc	c	...	...	...	1	..
Ph. ilicifolius	r	...	r	cc	...	r	...	...	...	...	...
Tetrag. Amii	r	...	...	c	...	...	1	...	...	1	...
Didymog. affinis ? ...	...	r	...	..	...	...	...	...	...	1	1
D. nanus	...	cc	...	...	...	x	...	r	1	...	1
D. similis ?	...	fc	...	...	r	c	...	...	...	...	...
Goniog. geometricus ...	...	c	...	r	cc	...	...	...	?	...	...
Phyllog. angustifolius ...	...	fc	rr	r	c	...	...	...	...	1	1
Ph. typus	...	r	...	...	c	cc	...	...	...	1?	...
Strophog. trichomanes ?	...	r	...	...	...	...	...	...	...	...	...
Tetrag. Bigsbyi	...	cc	...	cc	c	...	...	...	1	1	1
T. cf. *pendens*	...	fc	...	...	r	...	...	...	...	...	1
T. quadribrachiatus ...	...	rr	...	cc	r	...	1	...	...	...	1

cc = very common; c = common; fc = fairly common; r = rare; rr = very rare.

Especially close is the comparison between the two New Zealand faunas and those of the beds 2 and 3 of Ruedemann in his Deep Kill section (Graptolites of New York, part 1, 1904, pp. 504–507). Some of the new species described by Ruedemann in this great work, which have not hitherto been recognised in other parts of the world, are to be found in Mr. Isaacson's collection. The fauna of the band (*a*) corresponds to that of bed 2, and the fauna of (*b*) to that of bed 3, and this fact gives additional support to the assumption that in the Aorere Series of New Zealand two graptolitiferous zones are represented.

With Great Britain the comparison, though close, is not so striking. This is mainly due to the fact that in Britain the rocks at this horizon are not so rich in species as they are in America. So far, however, as the range of the species which are common to both Great Britain and New Zealand is concerned, it is clear that the fauna (*a*) corresponds to that of the zone of *Didymograptus extensus*, and the fauna of (*b*) to that of the zone of *Didymograptus hirundo*. In Wales the *Didymograptus hirundo* zone is extremely poor in species, and the zone fossil has not yet been recognised from New Zealand. In Britain *Didymograptus nanus* makes its first appearance in this zone, though it is very rare; probably, therefore, the fauna of (*a*) corresponds to that of the highest beds of the *D. hirundo* zone and to that of the base of the overlying zone of *D. bifidus*.

In the Lake District the New Zealand faunas find their representatives in the Middle Skiddaw Slates, and probably also in the lowest beds of the Ellergills.

Mr. Isaacson's present discovery shows indisputably that the association of forms in the part of New Zealand which he has investigated is practically the same as that in the Northern Hemisphere; and it may be anticipated that further work will result in proving that the zonal succession of graptolites so well established in the Northern Hemisphere prevails in New Zealand also.

II.—Marine Beds in the Yorkshire Coal-measures above the Barnsley Coal.

By H. Culpin.

In Green's "Geology of the Yorkshire Coalfield" (Mem. Geol. Surv., 1878, p. 471) reference was made to the occurrence below the Ackworth rock of a band of black shale, which it was said "contains *Aviculopecten* in plenty, and shows that incursions of the sea continued to occur even up to these comparatively late portions of the Coal Measure period."

A recent sinking for coal at Brodsworth, about four miles northwest of Doncaster, gave an opportunity, which the Colliery Management kindly facilitated, for a search for the above and other marine beds above the Barnsley Coal, with the result that four such beds have been noted there, one of which has markedly distinctive lithological and faunal characters.

Taking the beds in descending order, the *first* was found in some 32 feet of 'blue bind,' the base of which was 106½ feet below the

Ackworth rock, 17 feet above the Shafton Coal, and 1,130 feet above the Barnsley Coal. This bed is probably the one mentioned by Green. At Brodsworth its examination yielded numerous fragments of Goniatites, including a curiously preserved *Glyphioceras* sp., showing the suture-lines. The other mollusca were *Lingula mytiloides* (very abundant), *Pterinopecten papyraceus* (abundant), *Posidoniella lævis*, and *Nuculana acuta*. Of fish-remains only *Megalichthys* was determinable. There were occasional traces of plants, including *Calamites* sp. and *Neuropteris heterophylla*, Brongn.

The base of the *second* bed, which was apparently about 15 feet thick, was 219 feet above the Melton Field Coal and 705 feet above the Barnsley Coal. The top of it consisted of blue fucoid-marked shales with a soapy feel. Then came similar shales crowded with *Lingula*, followed by greyish-blue harder shales with abundant *Pterinopecten*, *Goniatites*, etc. The base was a very hard greyish-blue limestone 'cank,' which broke the drills. The lithological characters of the bed were remarkably different, both to the eye and the touch, from the ordinary measures, and should enable the mining expert to readily distinguish and use it as a datum-line in any future boring or sinking. The following is the list of fossils found in it:—

BRACHIOPODA.

Chonetes laguessiana, mut. θ.
Orbiculoidea nitida.
Lingula mytiloides (very abundant).

LAMELLIBRANCHIATA.

Syncyclonema carboniferum, Hind (abundant).
Pterinopecten papyraceus, Sow. (very abundant).
Posidoniella sulcata, Hind.
Myalina compressa, Hind.
Nucula æqualis, Sow.
Nuculana acuta, Sow.
Ctenodonta lævirostris, Portl. (very abundant).

GASTEROPODA.

Euphemus sp. (probably new).

CEPHALOPODA.

Pleuronautilus costatus, Hind.
Glyphioceras micronotum, Phill.
Glyphioceras reticulatum (?), Phill.
Dimorphoceras Gilbertsoni, Phill.
Orthoceras asciculare, Brown.
Orthoceras Steinhaueri, Sow.

PISCES.

Acanthodes.
Elonichthys Egertoni.
Megalichthys Hibberti.
Rhizodopsis sauroides.

PLANTÆ.

Lepidodendron sp.
Neuropteris heterophylla, Brongn.
Neuropteris cf. *rarinervis*, Bunb.

The base of the *third* bed was 100 feet below the Melton Field Coal and 382 feet above the Barnsley Coal. It yielded *Pterinopecten papyraceus* and numerous specimens of *Lingula mytiloides*, which in some parts of the bed were very small, and in other parts exceptionally large. Fish fragments were plentiful, including—

Acanthodes Wardi.
Pleuroplax Rankinei.
Cœlacanthus elegans.
Rhadinichthys monensis.
Rhizodopsis sauroides.

The *fourth* bed, which had a hard 'cank' at its base, was 111 feet above the Barnsley Coal. It yielded only *Lingula mytiloides*, and a fish-scale which was probably *Rhizodopsis sauroides*. In this case, *Spirorbis*, *Carbonicola* var. *aquilina*, and *Naiadites modiolaris* occurred in close proximity to the Lingula material.

Thanks are due to Dr. Walcot Gibson for encouragement and assistance in the work; and to Dr. Wheelton Hind, Dr. A. Smith Woodward, and Mr. R. Kidston for examining and naming the mollusca, the fish, and the plant-remains.

III.—The New Red (Permian) Gravels of the Tiverton District.

By Edgar C. Martin, B.Sc., A.I.C.

Introduction.

AMONGST the Lower New Red deposits of the Tiverton area are loose rubbly aggregations of angular and subangular fragments of grit and sandstone of all sizes in a loose earthy or sandy matrix.[1] These deposits, which seem best described by the term gravel, rest unconformably on the grits and shales of the Culm-measures, from which they appear to have been largely derived. In the deeper areas of deposit, further from the Culm margin, they pass into finer breccias and sand.[2] These gravels were formerly regarded as superficial deposits, and it has been suggested that they may be Boulder-clays.[3] Detailed mapping, however, proved their distinct connection with the Lower New Red Sandstones and breccias, and they have been found in places, as at Washfield and Silverton, underlying the trap, which corresponds to the German Permian Melaphyre (Middle Sötern); hence they are now regarded as deposits of Permian age.

About forty years ago Mr. J. T. Underhill found amongst the fragments in the Exeter Hill gravel-pit, Tiverton, some with an assemblage of Upper Devonian fossils. These were placed in the Exeter Museum, where, some time later, they attracted the attention of the Rev. W. Downes. On the occasion of the construction of the Exe Valley Railway he examined the cuttings between Tiverton and Bolham and noticed fragments of grit with *Spirifer Verneuili*, Murch., *Stropholosia productoides*, Murch., sp., and other Pilton fossils.[4] These fragments were associated with pieces of trap, and having regard to the proximity of the Washfield trap, Downes was led to the conclusion that the Devonian fragments were ejected during the volcanic outbursts.

The present investigation was undertaken at the suggestion of Mr. Underhill with the object of examining the whole area where the gravels occur in order to find how far Devonian fragments could be traced, and in the hope of throwing light on the source from which these fragments have been derived.

In the following account the area has been divided into districts, in order that the places mentioned may be more easily found on the map.

1. District north-west of Tiverton.
2. District north-east of Tiverton.
3. Butterleigh District.
4. Silverton and Bradninch District.
5. Thorverton District.

The first three districts are included in Sheet 310 of the Ordnance Survey (1 inch scale), and the last two districts in Sheet 325 of the Geological Survey.

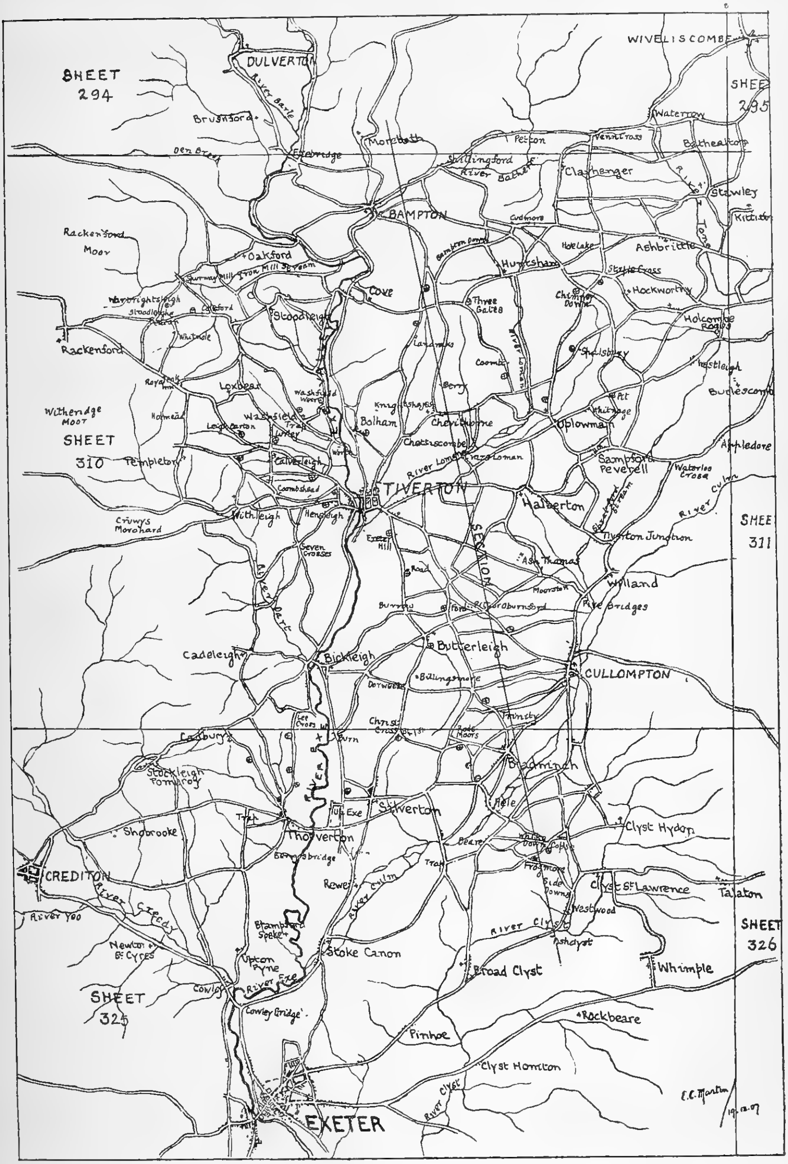
[1] Quart. Journ. Geol. Soc., 1876, pp. 387–389.

[2] Memoirs of the Geol. Survey, Exeter District, 1902, pp. 29, 33.

[3] Geol. Mag., 1872, p. 574: "Boulder-clay in Devonshire."

[4] Rev. W. Downes, B.A., F.G.S., "On the occurrence of Upper Devonian Fossils in the component fragments of the Trias near Tiverton": Transactions of the Devonshire Association, 1881.

MAP OF THE TIVERTON DISTRICT.



Places where Upper Devonian fragments have been found in the New Red Gravels are marked thus ⊕. Scale, 4 miles to an inch.

1. District North-West of Tiverton.

The valley between Washfield and Calverleigh is filled with the gravels as far west as Holmead. Two outlying patches of gravel occur north-west of Stoodleigh.

In a section about a quarter of a mile north-west of Washfield Church, on the Stoodleigh Road, the gravels are seen underlying the trap. Fragments of soft red sandstone containing crinoid joints, *Spirifer Verneuili*, Murch., and *Rhynchonella Partridgiæ*, Whidborne,[1] were found about three feet below the trap. Fossiliferous fragments were also detected in the gravel-pits on Hensleigh Hill and behind the Roman Catholic Chapel, Tiverton, and in the road section at Leigh Barton, near Loxbear.

In a small gravel-pit on the Templeton Road, three-quarters of a mile west of Calverleigh, at an elevation of 800 feet, the following fossils were found in pieces of dark red sandstone and grit:—

Phacops latifrons, Bronn (two heads and one tail).
Spirifer Verneuili, Murch.
Rhynchonella Partridgiæ, Whidb.
Orthis interlineata, Sow.
Tentaculites conicus, F. A. Römer.
Stropholosia productoides, Murch., sp.
Crinoid joints.

The gravels are well exposed at Washfield Weir, by the Exe, and contain fossiliferous fragments. In the pebble bed in the Exe below the weir (the pebbles composing which seem to have been washed out of the cliff or gravel above the weir) fragments of hard grit with the following fossils were found:—

Spirifer Verneuili, Murch.
S. Urii, Fleming.
Productus prælongus, Sow.
Rhynchonella Partridgiæ, Whidb.
Orthis interlineata, Sow.
? *Ctenodonta lirata*, Phil., sp.
? *Sanguinolites mimus*, Whidb.
Adelocrinus hystrix, Phil.

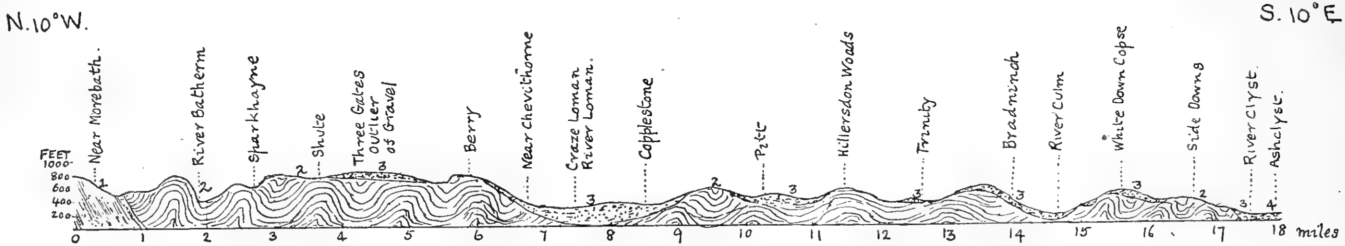
The Stoodleigh Outliers.

Two outliers of the New Red gravels occur in Stoodleigh parish. The first caps the hill north of Stoodleigh village, and can be examined in a large gravel-pit about half a mile north-west of Stoodleigh Church, 936 feet above sea-level. The deposit in this pit is very coarse, and no fossiliferous pieces were detected there. The second outlier covers a much larger area in the north-west part of Stoodleigh parish. It is interesting as being the last as well as the highest patch of the gravels in this direction. It can be examined in a gravel-pit at Stoodleigh Beacon, 980 feet above sea-level. Fragments of yellowish-red grit found in this pit contained *Spirifer Verneuili*, Murch., *Fenestella plebeia*, M'Coy, *Loxonema* (?) sp., and Crinoids.

In the lane east of Stoodleigh Beacon trap occurs, and a fragment containing *Naticopsis Hallii*, Whidb., was found.

[1] Phillips, in his "Palæozoic Fossils of Devon, Cornwall, and West Somerset," refers this very common '*Rhynchonella*' to his Carboniferous species *Rhynchonella pleurodon*. Whidborne ("Devonian Fauna of the South of England," vol. iii) thinks that the Devonian species is specifically distinct, and has named it *Rhynchonella* (*Camarotœchia*) *Partridgiæ*, Whidb.

SECTION FROM MOREBATH, NEAR DULVERTON, TO THE RIVER CLYST.



Permian	{	4. Lower Marls.
		3. Gravels with occasional breccias and sandstones.
Carboniferous		2. Culm Grits and shales.
Devonian		1. Pilton Beds.

In the lane section west of Warbrightsleigh Barton pieces of soft reddish micaceous sandstone were found with *Rhynchonella Partridgiæ*, Whidb., *Fenestella plebeia*, M'Coy, and Crinoids. This section is very close to the outcrop of the Culm-measures, which are quarried in a field to the north. The deposit at Warbrightsleigh is much finer and more consolidated than that occurring at Stoodleigh Beacon.

2. District North-East of Tiverton.

In the gravel-pit at Bolham about 30 feet of a very coarse earthy gravel are exposed. Pieces of dark red 'rotten' sandstone containing *Orthis interlineata*, Sow., and other fossils are common.

At Uplowman the gravels are exposed in a road section north of the Church. A piece of soft red sandstone found here contained *Aviculopecten transversus*, Sow., sp. Another piece was crowded with small Gasteropods and other fossils, including the following species:—

Euomphalus vermis, Whidb.
Bellerophon subglobatus, M'Coy.
? *Macrochilina* sp.
Tentaculites tentaculare, Phil., sp.
Aviculopecten nexilis, Sow., sp.
? *Spiriferina cristata*, var. *octoplicata*, Sow.
Spirifer Urii, Flem.
Crinoid stems.

Similar fragments with the same species were found at Coombe, near Uplowman, and at Pit, north-east of Sampford Peverell.

Three Gates Outlier.

A large outlying patch of gravel caps the hill between Huntsham and Cove. It can be examined in three gravel-pits on the Upper Tiverton–Bampton Road, north of Landrake. In two of these pits fossiliferous fragments were found. In the most northerly pit a piece of crinoidal sandstone measuring $6 \times 2\frac{1}{2} \times 3\frac{1}{4}$ inches was noticed.

Further east the gravels are exposed in a pit by Three Gates Farm. In this pit fossiliferous pieces of grit and sandstone are abundant, and contain the following species:—

Phacops latifrons, Bronn.
Fenestella plebeia, M'Coy.
Penniretipora bipinnata, Phil., sp.
Seminula oblonga, Sow., sp.
Spirifer Verneuili, Murch.
S. Urii, Flem.
Rhynchonella Partridgiæ, Whidb.
Crinoid stems.

Chimney Down Outlier.

This is the last patch of gravel to the north-east, and the fossiliferous fragments are much more plentiful here than elsewhere. This fact is significant, since Chimney Down is only about two miles distant from the outcrop of the Pilton Beds, where the same species of fossils can be found *in situ*.

The gravel-pit on Chimney Down, 878 feet above sea-level, exhibits a very coarse unstratified gravel composed of angular and subangular fragments of grit and sandstone of all sizes up to over two feet in length in a red earthy matrix. The surfaces of the pebbles are very often smooth and somewhat polished. One large fragment of grit ($23 \times 18 \times 15$ inches) contained a fossiliferous layer two inches thick.

Pieces of soft red sandstone, crowded with fossils, are very common. A single piece, about two feet long, yielded the following species:—

Phacops latifrons, Bronn (at least twenty heads, but only one tail).
Bellerophon subglobatus, M'Coy (very common).
Euomphalus vermis, Whidb. (very common).
Pleurotomaria aspera, Sow.
Tentaculites tentaculare, Phil., sp.
? *Macrochilina turbinea*, Whidb.
? *Naticopsis Hallii*, Whidb.
? *Murchisonia* sp.
Spirifer Verneuili, Murch. (very common).
Spirifer Urii, Flem.
Rhynchonella Partridgiæ, Whidb. (very common).
Productus prælongus, Sow. (very common).
Stropholosia productoides, Murch., sp.
Seminula oblonga, Sow., sp.
Athyris (*Cleiothyris*) *Royssii*, Leveillé.
Orthoceras Barumense, Whidb.
Aviculopecten transversus, Sow., sp.
Several undetermined Lamellibranchs.
Crinoid joints.

Another piece of sandstone was crowded with casts of *Cucullæa* similar to those occurring in the Marwood Beds of North Devon.

Spalsbury Outlier.

A small patch of gravel between Chimney Down and Uplowman is exposed in a gravel-pit near Spalsbury. Crinoidal fragments of grit were found here.

3. Butterleigh District.

This includes the district south-east of Tiverton embraced in the Ordnance Survey one-inch map, Sheet 310.

The Exeter Hill gravel-pit, near Tiverton, is mentioned in a letter by H. B. Woodward, F.G.S., to the Geol. Mag. (1872, p. 574), calling attention to the resemblance between the New Red deposit exposed there and the Boulder-clays. Here, as elsewhere, fragments with Upper Devonian fossils occur. One piece of grit contained numerous casts of the small Gasteropod *Bellerophon subglobatus*, M'Coy. Another contained a Lamellibranch similar to *Pleuronectites Piltonensis*, Whidb.

Similar gravel-pits occur at Road Farm and south of Butterleigh, and in both fossiliferous fragments have been detected. They have also been found in the road sections near Ford, and on the Tiverton road 1½ miles north-west of Cullompton. On the common above Trinity a piece of grit with *Stropholosia productoides*, Murch., sp., was found.

Between Tiverton and Butterleigh the fragments of grit are gathered off the fields and used for road-mending. In these fragments the following species have been found:—

Phacops latifrons, Bronn.
Spirifer Verneuili, Murch.
S. Urii, Flem.
Orthis interlineata, Sow.
Rhynchonella Partridgiæ, Whidb.
Stropholosia productoides, Murch., sp.
Fenestella plebeia, M'Coy.
? *Fistulipora* sp.
? *Ctenodonta lirata*, Phil., sp.
Crinoid joints.

4. Silverton and Bradninch District.

A full account of the geology of this district will be found in the Memoirs of the Geological Survey, Exeter district, by W. A. E. Ussher. In the Silverton and Bradninch district the gravels occupy the higher grounds (400 to 850 feet) and are replaced by breccias in the lower grounds. Fossiliferous fragments occur, but are not so common as further north. They have been detected at Christ Cross, near Silverton (847 feet), and in the lane sections north-west of Bradninch. The species found included :—

Spirifer Verneuili, Murch.	*Tentaculites conicus*, F. A. Römer.
Rhynchonella Partridgiæ, Whidb.	Crinoid remains.

A fragment of grit with *Spirifer Verneuili* was found in the section by the Tiverton-Exeter Road, south of Jenny's Portion.

The last patch of gravel mantles the slopes of the large Culm inlier at White Down Copse, in the parish of Broad Clyst; and here, 15 miles in a straight line from the outcrop of the Pilton Beds, fragments of grit with Pilton fossils occur. They were found in the lane section east of Frogmore, and in another section still further to the east. The species found included *Rhynchonella Partridgiæ*, Whidb., *Ctenodonta lirata*, Phil., sp., and Crinoids.

5. Thorverton District.

The following note appears in the Geological Memoir of the Exeter District (p. 7):—"South of Cadbury, between the streamlets near Kidlake (West Bowley on the old series map), amongst numerous fragments of brown grit scattered over the surface one containing casts resembling *Strophomena* was picked up. The stones, although unworn, may be mixed with débris resulting from the denudation of lower New Red rocks."

Fragments with Upper Devonian fossils are fairly common in the road sections and ploughed fields north of Thorverton. They contain the usual fossils, *Spirifer Verneuili*, Murch., and *Rhynchonella Partridgiæ*, Whidb., being the most common. Further west, between Thorverton and Crediton, the gravels are replaced by breccias composed largely of trap. No fossiliferous pieces have been detected in this direction.

Summary and Conclusions.

The New Red gravels of the Tiverton type extend from Warbrightsleigh and Chimney Down on the north to Thorverton and White Down Copse on the south. Further south they are replaced by breccias and sandstones or covered by the higher beds of the New Red series. Throughout the whole of this area of nearly 100 square miles the gravels contain fragments of sandstone and grit with Upper Devonian fossils. These Devonian fragments are most common in the north-east of the district, and are comparatively rare further south. They are found at the entrance of the Crediton valley, but do not appear to be present further west.

All the fossils that have been identified are known to occur in the Pilton and Marwood Beds of North Devon. The only Trilobite found (*Phacops latifrons*, Bronn) is practically the only Trilobite occurring in the Pilton Beds, where it is very common. *Spirifer Verneuili*, Murch., *Spirifer Urii*, Flem., *Rhynchonella* (*Camarotœchia*) *Partridgiæ*, Whidb., and *Productus prælongus*, Sowerby, are the commonest Brachiopods both in the gravels and in the Pilton Beds. The little

Gasteropod *Euomphalus vermis*, Whidb., is also common in the gravels and Pilton Beds. *Bellerophon subglobatus*, M'Coy, is a characteristic fossil in the Marwood Beds of the Barnstaple district; it is also common in the grits that occur further east near Wiveliscombe, and in the grit fragments found in the gravels.

At Chimney Down, in the north-east of the district, fossiliferous fragments of Upper Devonian sandstone and grit are extremely common, whilst trap fragments appear to be absent. This fact, as well as the wide distribution of the fossiliferous fragments, completely disposes of the Rev. W. Downes' theory of volcanic ejection. The facts tend, rather, to prove a drift from the north-east during the period of deposition of the gravels. The grit and sandstone matrices suggest a derivation from the Wiveliscombe end of the Pilton Beds rather than from the more slaty beds found further west. The Devonian fragments in the gravels may even have been derived from a still more easterly extension of the Pilton Beds, now buried under Triassic deposits.

The angular and subangular nature of the fragments composing the gravels, as well as the non-separation of coarse and fine material, gives the impression that the component fragments have not travelled far, and yet at White Down Copse they are found at least 15 miles from the outcrop of the Pilton Beds. The fossiliferous pebbles found at White Down Copse were all subangular. These New Red deposits certainly bear a considerable resemblance to the Boulder-clays, but in the absence of striated pebbles (and none have yet been found) the theory that they are glacial deposits is hardly admissible.

Mr. Ussher regards the gravels as the result of torrential action periodically operating on the margin of an area of depression attended by periodic dessication and wind-drift. This supposition is in accordance with our present views of the climate of England in Permian and Triassic times, and would explain the coarse unstratified nature of the deposits. The derivation from the north-east is natural on this supposition, but difficult to explain on any other theory such as that of marine agency. For the New Red rocks are overlapped on the margin of the Middle Devonian rocks near Williton, and thence to Porlock Triassic rocks alone represent the series. Hence, on the marine derivation theory a drift from the north is highly improbable, and we would have to suppose drift from the east where the extension of Devonian rocks may be expected to occur beneath the New Red rocks. The theory of torrential derivation from the north-east is therefore most probable and is consistent with the appearance of the deposits. These torrents carried the fragments as far as the entrance of the Crediton valley, where they were met by other torrents bringing down fragments of trap from the upper parts of this valley. The fact that the Devonian fragments are apparently absent to the west of Thorverton and that the gravels are replaced by a breccia composed largely of trap is thus explained.

The author's best thanks are due to Mr. J. T. Underhill for proposing the investigation and to Mr. W. A. E. Ussher for some of the above suggestions.

IV.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

(PLATE VI.)

(*Concluded from the February Number, page* 74.)

Genus CANINIA.

1840. *Caninia*, Michelin.
1850. *Cyathopsis*, d'Orbigny.
1906. *Amplexi-Zaphrentis*, Vaughan.

(For full synonymy of the type species see below.)

Corallum simple, turbinate and conical, often slender and cylindrical for a great part of its length.

Major septa well developed and meeting in the centre in the lower, conical part of the coral, but in the cylindrical portions usually becoming amplexoid in character.

Minor septa of various lengths in different species.

Cardinal fossula variable in extent, characteristically limited by tabulæ only, at the inner end, and with the flanking septa loose or disconnected.

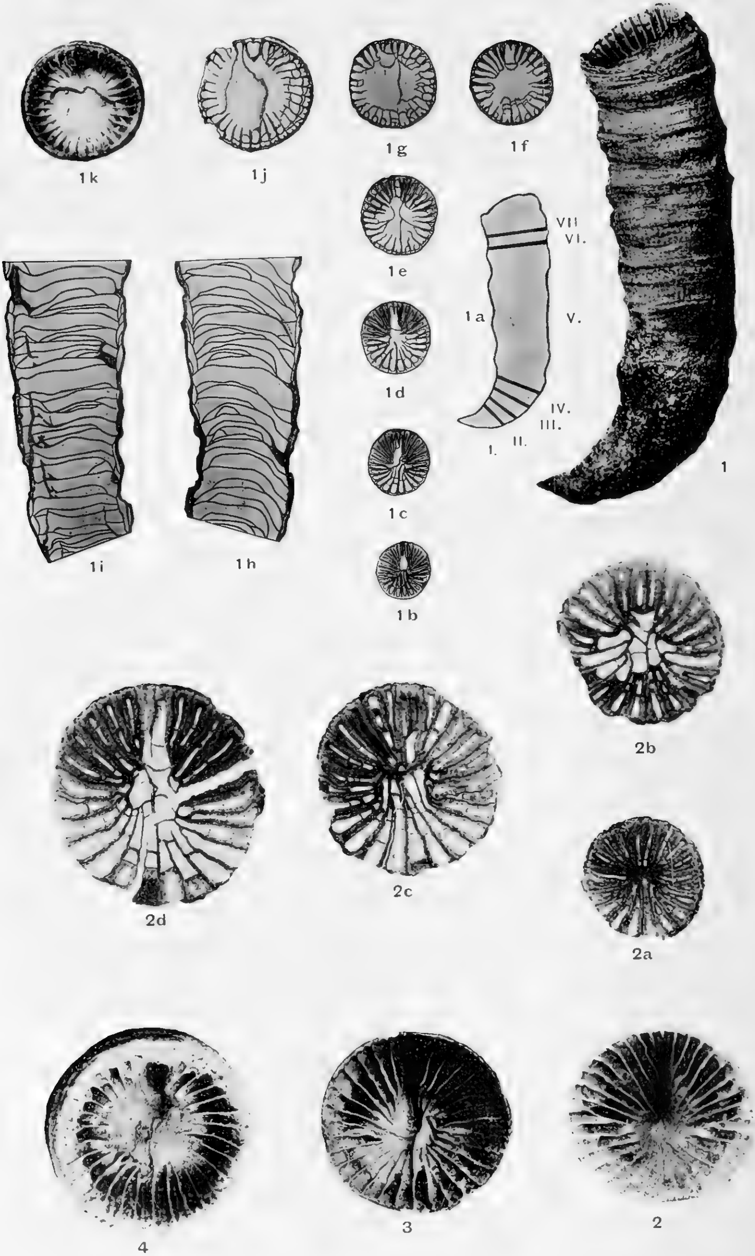
Tabulæ well developed, but variable in regularity; they may be highly arched and vesicular. A marginal ring of more or less vertical *dissepiments*, usually thin and delicate, intervenes in the mature stages of growth between the tabulæ and the wall.

The foregoing re-definition of the genus *Caninia* is founded on an examination of *C. cornucopiæ*, and of allied forms found in the English Visean, most of which are at present undescribed. Reasons for regarding this species as the genotype will be adduced in the sequel, when discussing that coral. Previous authors seem to have regarded the genus as typified by *Caninia gigantea*, Mich. (equivalent, according to McCoy, to *Siphonophyllia cylindrica*, Scouler). The mistake is easily explained, and it is somewhat surprising that it appears to have been overlooked for so long a time.

The genus was at first defined by Michelin without mention of species, while the first species given (*C. cornucopiæ*, q.v.) was referred to by name only, without any diagnosis; it was not until Michelin published his important "Iconographie Zoophytologique" that any description of illustrative species appeared. But Michelin, in this publication, adopted a geographical and not a zoological arrangement for his data, describing the coral faunas of various districts without any regular zoological order; the work also appeared in parts, whose publication was spread over several years (1840 to 1847).

The genus *Caninia* is first mentioned in the "Iconographie" (p. 81) without diagnosis, and a new species, *C. gigantea*, figured and described. Before any further parts containing a reference to the genus were

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.



Bemrose, Collo., Derby

Caninia Cornucopiæ, Mich.

CARBONIFEROUS LIMESTONE, TOURNAI.

issued, Lonsdale[1] adopted Michelin's genus, taking as his example the only form, *C. gigantea*, yet described; it was not till several years later, when dealing with the fauna of Tournai, that a description of *C. cornucopiæ* appeared.

Lonsdale's example was followed by McCoy and other later writers, and amongst these Stuckenberg should be mentioned.[2] Some observations on *Caninia* were made in 1897 by Angelis d'Ossat,[3] but the question of the genotype is not discussed. This author describes two species, but Stuckenberg and the older writers are followed, i.e. the forms referred to *Caninia* belong to the group of *C. gigantea*, and closely resemble the *Cyathophylla*. Whether *C. gigantea* can properly be retained in *Caninia*, as here re-defined, must depend on a thorough re-examination of that species, but the genus itself, as exemplified by *C. cornucopiæ*, possesses such distinctive characters that, although, in the absence of the present evidence, it was discarded by Milne-Edwards & Haime, de Koninck, Nicholson, and others, it may now fairly be restored.

The nearest genus to *Caninia*, as above emended, seems to be *Campophyllum*, M.-Ed. & H. (type *C. flexuosum*). In this, however, the dissepiments are smaller, more closely set, and form a somewhat broader marginal zone. It is possible that *Campophyllum* must be included in the comprehensive genus *Cyathophyllum*, and a re-examination of the genotype is necessary. In the typical *Cyathophylla* the dissepimental zone is much broader than in *Caninia*.

'*Endophyllum*,' M.-Ed. & H., is characterised by the partial or complete discontinuity of the major septa through the dissepimental zone; this feature rarely occurs in *Caninia*.

Stuckenberg's genera *Zaphrentoides* (loc. cit. (1), p. 191 of German text) and *Pseudozaphrentoides* (loc. cit. (2), p. 90 of German text) differ in the rudimentary condition of the primary septa, all of which lie in conspicuous fossulæ (in certain of the species, however, some of the septa considered as primary are probably the youngest of the series).

D'Orbigny selected *Caninia cornu-bovis*, Mich., as the type of his genus *Cyathopsis*; as reasons will presently be given for regarding that species as a fully grown form of *Caninia cornucopiæ*, and as the salient features of both are represented in Dr. Vaughan's subgenus *Amplexi-Zaphrentis*, these groups are consequently here considered as synonymous with the older genus *Caninia*.

Caninia cornucopiæ, Mich. (Plate VI, Figs. 1–4.)

1840.	*Caninia cornucopiæ*, Mich.: Congrès de Turin.
—	,, ,, Michelin in Gervais: Dict. d. Sc. Nat., Suppl., i, p. 485.
1842.	*Cyathophyllum mitratum*, de Koninck: Descr. Anim. Foss. Terr. Carb. Belg., p. 22, pl. C, figs. 5a–5d.
1842.	,, *plicatum*, ibid., p. 22, pl. C, figs. 4c–4e.
1845.	*Caninia cornu-bovis*, Mich.: Icon. Zooph., p. 185, pl. 47, fig. 8a.
1846.	,, *cornucopiæ*, ibid., p. 256, pl. 59, fig. 5.
1848.	,, ,, Bronn: Index pal., pp. 213 & 368.

[1] In Murch., de Vern., & Keyserl.: "Russia and the Ural Mountains," vol. i, p. 615 (1845).

[2] A. Stuckenberg: (1) Korallen u. Bryoz. d. Steinkohlen. d. Ural. u. Timan.: Mem. Com. Geol., vol. x, liv. 3, St. Petersburg, 1895. (2) Anthoz. u. Bryoz. d. Unter Kohlenkalk v. Central Russlands: ibid., N.S., liv. 14, 1904.

[3] Angelis d'Ossat, Corall. e. Brioz. d. Carbonifero [Carnian Alps]: Atti d. R. Acc. d. Lincei, ser. v, mem. ii, p. 256 (1897).

1850. *Amplexus cornu-bovis*, M.-Ed. & H.: Pol. Foss. Terr. Pal., pl. ii, figs. 1–1*b* and 1*e*.
— *Lophophyllum Dumonti*, ibid., p. 350, pl. iii, figs. 3, 3*a*.
— *Cyathopsis cornu-bovis*, A. d'Orb.: Prod. Pal. Univ., t. i, p. 105.
1852. *Amplexus* ,, M.-Ed. & H.: Brit. Foss. Cor., p. 174.
1854. ,, ,, J. Morris: Cat. Brit. Foss., p. 46.
1857. ,, ,, Pictet: Traité d. pal., t. iv, p. 452, pl. 107, figs. 17*a*–17*c*.
— *Lobophyllum Dumonti*, ibid., t. iv, p. 453, pl. 108, fig. 18.
1860. *Lophophyllum* ,, M.-Ed.: Hist. Nat. d. Cor., t. iii, p. 353.
— *Amplexus cornu-bovis*, ibid., p. 349.
1861. *Lophophyllum Dumonti*, de Fromentel: Int. à l'ét pol. foss., p. 290.
1872. *Amplexus ibicinus*, de Kon.: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. l. Belg., p. 67, pl. vi, figs. 2, 2*a*.
— ,, *cornu-arietis*, ibid., p. 72, pl. vi, figs. 4, 4*a*.
— *Zaphrentis cornucopiæ*, ibid., p. 100, pl. x, figs. 5–5*b*, and pl. xv, fig. 2.
— ,, *vermicularis*, ibid., p. 95, pl. x, figs. 1–1*d*.
— ,, *Nystiana*, ibid., p. 103, pl. x, figs. 8–8*a*.
— ,, *Edwardsiana*, ibid., p. 83, pl. vii, figs. 4–4*b*.
— *Lophophyllum* (?) *Dumonti*, ibid., p. 55, pl. iv, figs. 4, 4*a*.

External Characters.

Corallum very variable in shape. When growth is regular (Pl. VI, Fig. 1) the base is strongly curved and conical, the coral becoming more cylindrical as growth proceeds. Most of the examples from Tournai only show the commencement of the cylindrical stage, fully

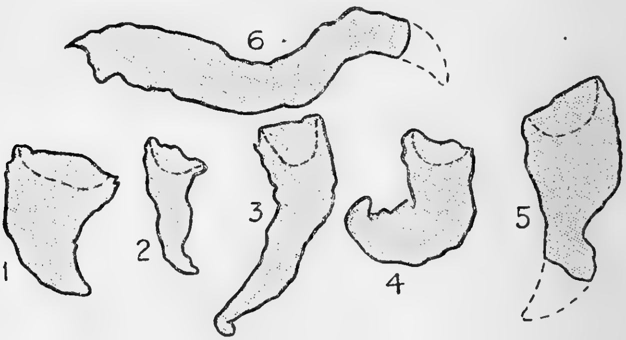


Diagram E.—Outlines of *Caninia cornucopiæ*, Mich., showing unusual habits of growth. All half natural size. Tournai. Geol. Survey Coll. Figs. 1–6. R.C. 341–346 respectively.

grown specimens being comparatively rare. Exceptions to such regular growth are frequent; the coral may either expand continuously to its maximum diameter (about 3 cm.) or remain narrow for a considerable length, abruptly expanding and contracting as growth proceeds. Such specimens are often contorted in a remarkable manner; some curious examples are given in outline in Diagram E.

The *epitheca* is of medium thickness, smooth, with numerous fine annular striations; constrictions of growth are frequent, not uncommonly amounting to an interruption in the continuity of the epitheca. Longitudinal ribbing is practically absent, although faint indications may be occasionally observed.

The *calyx* is deep in young specimens, becoming on the whole shallower with increasing age. The nature and arrangement of the major septa are greatly dependent upon the habit of growth, and age, of the corallum, and since they vary within somewhat broad limits, many names founded on the aspect of the calyx, have been applied to the one species. When growth is perfectly uniform, gradual and successive changes in the development of the septa take place as the coral grows older and more cylindrical. Before considering modifying factors, the history of the calyx, in such regular specimens, may first be detailed.

Commencing with young examples ('*Zaphrentis vermicularis*,' de Kon.), the uniformly thin major septa usually reach the centre of the calyx (often anastomosing in an irregular manner), though some may fall short and join their neighbours; the long counter septum is frequently so connected, and often remains a prominent object until the cylindrical stage is reached, or even throughout growth. In these young examples, the (cardinal) *fossula* is very marked and deep, extending with parallel walls to the centre of the calyx. Minor septa are not yet apparent. From the species founded on such young examples, this may be termed the *vermicularis* phase.

As growth proceeds, the major septa may continue to reach the centre of the calyx for some time, their arrangement becoming very regular ('*Lophophyllum Dumonti*,' M.-Ed. & H., and *Zaphrentis cornucopiæ*, de Koninck, Nouvelles Recherches, pl. x, fig. 5*a*); the counter septum continues prominent and the rudimentary minor septa make their first appearance. This period may be called the *dumonti* phase. Beyond this the septa begin to fall short and leave a smooth bare tabular area (about 2 mm. in diameter) in the centre of the calyx floor, which forms the inner end of the cardinal fossula (see Pl. VI, Fig. 2). The expansion of the coral now becomes less rapid, the calyx shallows, while the septa retreat further from the centre and the cardinal fossula becomes shorter and rather broader ('*Zaphrentis nystiana*,' de Kon.); this may be called the *nystiana* phase.

A thin ring of dissepiments next appears around the internal margin of the calyx, thinning away near the rim,[1] while the central tabular area now amounts to one-third the diameter of the calyx ('*Zaphrentis edwardsiana*,' de Kon., see Pl. VI, Fig. 4). With further growth the coral becomes cylindrical, and only a slight change is manifested in the calyx. The septa, however, may become still shorter, so that the bare tabular area increases up to one-half the diameter of the coral. The cardinal fossula may also shorten and form a marginal, but still distinct, depression of the calyx floor (see Pl. VI, Fig. 1*k*). The dissepiments do not increase in number or

[1] This feature, though not directly referred to by de Koninck, is seen in the type-specimen of his *Zaphrentis edwardsiana*. As the epitheca of that species is of medium thickness, the recognition of the dissepimental margin may be included in the words "épithèque très épaisse," given in his diagnosis.

thickness, and as they rarely reach the rim of the calyx they may at first sight seem to be absent. This may be termed the *cornu-bovis* phase (ex. *Caninia* '*cornu-bovis*,' Mich.), and with it the development of the corallum is completed.

As above noted, the *minor septa* usually arise at the conclusion of the *dumonti* phase, but their appearance may be delayed to a very late stage, and they are sometimes hardly visible. They are best developed in broad, widely expanded specimens (e.g. Diagram E, Fig. 1), but even here they remain rudimentary.

The (cardinal) *fossula*, whose varying characters are referred to in the foregoing paragraphs, typically lies on the convex side of the corallum, but is often laterally disposed.

But, save for the appearance of the dissepimental ring (a feature confined to the mature part of the corallum), none of the phases above described are truly ontogenetic, for, as will now be explained, they are intimately connected with the habits of growth of the corallum.

From an examination of many broken specimens which are devoid of an infilling of foreign matter, and clearly show the internal structures, two factors controlling septal development are found.

First, it is seen that as the coral becomes cylindrical, the septa die away beneath each tabula and are rebuilt upon its upper surface (see Diagram F, Fig. 1, A); i.e. they become amplexoid in character. But the cylindrical habit may be acquired at any period of growth (e.g. Diagram E, Fig. 3), and consequently amplexoid septa, characteristic of the *nystiana* and succeeding phases, may occur at any time. It often happens that examples showing the long septa of the *dumonti* phase are found to have amplexoid septa in their lower portions.

There is, however, a second factor influencing septal development. It will be noticed from the vertical sections (Pl. VI, Figs. 1*h* and 1*i*, and Diagram F, Figs. 2 and 3) that the tabulæ are by no means equidistant, and from this fact one may infer that the growth of the coral varied somewhat in rapidity from time to time. Hence, although septal information was slower in the cylindrical part of the coral as opposed to the conical part, the development of the septa seen in the calyx, and the depth of the latter, are also dependent on the rapidity of growth between the formation of the last tabula and the death of the animal (Diagram F, Fig. 1, B).

The vertical sections (Pl. VI, Fig. 1*h*, and Diag. F, Figs. 2 and 3) also show that the depression of the tabulæ in the cardinal fossula, though usually considerable, is by no means constant in amount. On the whole the depression lessens as the cylindrical habit is assumed, but the sections show that the size of the fossula in the calyx must be by no means a constant feature.

Conversely to the connection of amplexoid septa with a cylindrical habit, it may be expected that specimens showing continuous expansion of the coral should also show the long septa of the *dumonti* phase, even at a relatively late period of growth; this is indeed the case, and is well exemplified in the broad form of the coral (Diag. E,

Fig. 1) where such septa may be found even when the dissepimental zone, marking a mature stage of growth, is well established.

The foregoing paragraphs are intended to demonstrate that the development of the septa in the calyx is not of specific value in this species, but is largely dependent on two factors, whose relative importance must be expected to vary in different specimens. There remain, however, other data amply sufficient for a recognition of the species, and these will be noticed after describing the internal characters.

Average dimensions.

Height of fully grown adult, at least 6 cm. (a considerably greater length is sometimes attained; see Diag. E, Fig. 6). Diameter of rim of adult calyx, 1·5 to 2 cm. Number of major septa to above diameters, 32 to 33 respectively. (Diameters of 2·5 to 2·8 cm., with 37 septa, are occasionally reached.)

Internal Characters.

(a) *Horizontal sections.*

1. *Nature of the septa.*—The *major septa* are very thin; their inner ends taper to a fine point and are often curiously twisted; there is, however, occasionally a slight thickening at the inner end of the long counter septum. The cardinal septum dwindles in length at an early stage, and soon becomes very short.

2. *Grouping of the septa.*—There is usually a slight, but distinct, curvature, concave to the cardinal fossula. In the lower, conical part of the corallum, the septa are much thickened by a deposit of stereoplasma, which at first affects them all, but as growth proceeds this becomes restricted to those septa in the two cardinal quadrants, and finally dies away altogether. The deposit characterises the *vermicularis* and *dumonti* phases (i.e. in which septa continuously reach the centre of the coral) and transverse sections of such parts compare well with each other (Pl. VI, Figs. 1*b* to 1*d* and Figs. 2*a* to 2*d*). But when the septa become amplexoid, it will be seen from Diag. F, Fig. 1, that the length of the septa in transverse sections largely depends on the relation of the section to the nearest tabula, for a section may show either very short or very long septa, according as it is cut immediately underneath, or immediately above, one of the tabulæ.

It will be apparent also that a section cut between well-separated tabulæ will usually show longer septa than one cut between closely set tabulæ (Diag. F, Fig. 1, B).

Since amplexoid septa may appear at any stage, transverse sections of this coral should be judged relatively, the appearance of a section being independent of the diameter. Thus, in a broad, rapidly expanding form of the coral (Diag. E, Fig. 1) sections illustrating the *dumonti* phase may be twice the original size of the enlarged figures on Pl. VI, Figs. 2*a* to 2*d*, and contain many more septa; conversely, with forms acquiring the cylindrical habit at an early stage, sections in the *dumonti* phase may appear when but few septa are developed.

3. The (cardinal) *fossula* has no continuous wall (as in *Zaphrentis konincki*, q.v.). The bounding septa are often unconnected, and the inner end is not closed by septa, but by the intersection of a tabula in the plane of section. In sections across the amplexoid part of the coral the size of the fossula varies considerably, according as the section is cut across the top or bottom of the tabular depression.

4. The rudimentary *minor septa*, appearing in the more mature part of the coral, never transgress the delicate dissepimental ring there found. Where they seem to do so, it will be found that the supposed 'inner wall' of dissepiments is in reality the epitheca repeated by rejuvenescence. One, or two, rings of dissepiments are seen in average specimens; in unusually broad examples, however, three or even four rings may be present, but such cases are rare.

(b) *Vertical Sections.*

Pl. VI, Figs. 1*h* and 1*i*, and Diag. F, Figs. 2 and 3.

These show that the tabulæ are arranged in a fairly regular manner, varying from ·5 to 2 mm., but on the whole about 1 mm. apart. They are dome-shaped in the lower or conical part of the coral, but become flattened in the cylindrical portions. Their depression into the cardinal fossula is at first very marked,[1] but lessens somewhat in the cylindrical portions (Pl. VI, Fig. 1*h*, and Diag. F, Figs. 2 and 3). The tabulæ do not extend through the thin marginal zone of dissepiments developed in the adult stages of growth. These dissepiments have an elongated outline, and are directed upwards and outwards at a very steep angle. They are usually thin and delicate, there being rarely more than two rows of them. They appear to be additional structures, and in no way caused by a "splitting of the wall."

Summary.

There are several constants of value in the determination of this species. They are:—(1) The epithecal characters; (2) the spacing of the major septa (i.e. their number in a given diameter); (3) the thickening of stereoplasma in the lower and conical part; (4) the characters of the *dumonti* phase (Pl. VI, Figs. 1*b*–1*d* and 2*a*–2*d*); (5) the nature of the dissepiments, and their restriction to the mature growth stages; (6) the nature of the tabulæ. Of these, (2), (4), and (6) are of particular importance.

Localities (both from Dr. Vaughan).

Tournaisian (subzone γ): Burrington Coombe (Mendips); Frome (lowest exposure in the Vallis Vale sequence of quarries).

[1] In many vertical sections cut down the cardinal fossula, some of the tabulæ, while strongly depressed, are seen to bend upwards before reaching the wall. This is due to the fact that the fossular depression, instead of lying wholly in the plane of section, enters it obliquely at those points, and at some distance from the wall. Such an appearance will always be noticed if the coral be twisted so that a straight plane of section cannot always pass down the centre of the fossula.

Remarks.

The synonymy given is a long one, but it should be remembered that the species concerned were founded in days when modern methods of investigation were lacking, and when calicinal characters, so strikingly variable in this species, had to be largely depended upon.

The conclusions above set forth were not reached without a detailed investigation of the abundant material at hand. Several hundred specimens of this species, procured from the type locality, Tournai, and mostly in a fine state of preservation, have been examined, besides numerous examples from the Bristol area, kindly communicated by Dr. Vaughan.

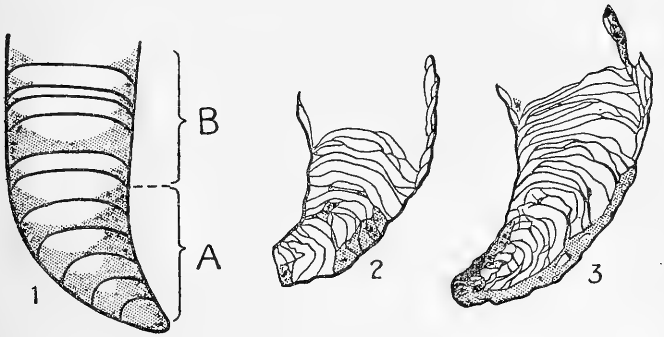


Diagram F.

Fig. 1.—Ideal section illustrating factors governing the appearance of the septa in calices and in transverse sections of *Caninia cornucopiæ*, Mich. Septa shaded. A shows progressive rapidity in retreat of the septa from the tabular surfaces as the coral becomes more cylindrical. B shows development of septa influenced by distance between tabulæ (i.e. by variable rate of growth).

Figs. 2 and 3.—Vertical sections cut down the middle of the cardinal fossula (right-hand side of figures), showing depression of tabulæ into the fossula and appearance of marginal dissepiments in mature growth stages. Epitheca repeated by rejuvenescence at top of Fig. 3. Tournai.
Fig. 2.—Brit. Mus. Nat. Hist. R. 11,689. Fig. 3.—Geol. Surv. R.C. 349. Both natural size.

The synonymy, lengthy as it is, might, with some justification, have been further extended. It is, however, very desirable, not only for zonal purposes, but on general palæontological grounds, that the limits of specific determination should be defined as clearly as possible. A common standard in such matters is not perhaps attainable, but it is believed that a re-examination of the material will confirm the assignation of such apparently diverse forms to the one species.

A suite of specimens, in various stages of growth, and in an exceptionally fine state of preservation, is preserved at the British Museum, while a more complete assemblage is in the possession of the Geological Survey. Both collections were derived from Tournai.

Although this is the only species originally associated with the genus *Caninia*, no figure or description accompanies the first appearance of the name.[1] The paragraph concerned (for which I am indebted to Mr. W. D. Lang) runs as follows:—

"Le genre *Caninia* de M. Michelin, Congrès de Turin, 1840, est du groupe des caryophyllies unistellées ou isolées. Ses caractères sont: polypier pierreux, libre ou fixe, subturbiné, simple, cylindrique, formé de cellules superposées (chaque cellule garnie marginalement de lamelles, quelquefois très courtes et sinueuses" [quelquefois], "atteignant le centre, mais remarquable en ce qu'il est décomposable en petits conoides, représentant sans doute la succession des principales phases vitales du polype, et s'emboitant les uns dans les autres en dehors et en avant de l'axe central; l'extérieur est strié

"*C. cornu-copiæ*, Mich. Espèce type de ce genre dédié au prince Ch. Bonaparte; elle n'a encore été rencontrée que dans des terrains de formation secondaire, à Sablé (Sarthe), en Belgique, etc. Il en a été donné une figure dans notre Atlas,[2] ses caractères la rapprochent des *Amplexus*, Sowerby."

One of the localities (Sablé) seems to be wrongly given, since it does not accompany the fuller description of the species given later on by Michelin.

I have inserted the word 'quelquefois' in the above description, since it appears to be required to make the paragraph intelligible.

Two years later, de Koninck (Description des Animaux Fossiles, etc., p. 22) described the coral under the name *Cyathophyllum mitratum* (Schlot.), remarking that the exterior is very smooth compared with that of the majority of other species; by an extraordinary mistake, afterwards rectified by him, he at that time included *Cyathaxonia cornu* as a young form of the species. The accompanying figures are poor, though one of them (pl. C, fig. 5*c*) gives a good idea of the tabulæ seen in a broken specimen.

Michelin's first description of his type species appeared in 1846 (Iconographie, p. 256). His diagnosis is generalized, but he noticed that the fossula is deep and prolonged to the centre, and that the coral, on being broken open, shows an almost complete succession of "fissures infundibuliformes s'emboitant les unes dans les autres" (this is very commonly found in examples from his locality, Tournai). At the same time (loc. cit., p. 185) he described another species, *C. cornu-bovis*, and refers to a figure of this new species having been prepared for, but not published in, the Supplement to the Dictionnaire des Sciences Naturelles for 1840. References to p. 485 of the Supplement are given under the descriptions of both *Caninia cornucopiæ* and *C. cornu-bovis* (although in reality the first mention of the latter appears in the Iconographie). In the latter case, the words "pour le genre" are added: this may mean either that one should look to the Supplement for a description of the genus (which is not given in the Iconographie), or that the generic description in the Supplement should be regarded as a specific description of *C. cornu-bovis*. But these are only matters for surmise, and since *Caninia cornu-bovis* is only the adult form of *C. cornucopiæ*, and as *C. cornucopiæ* was the

[1] Michelin in P. Gervais: article on *Astræa*, Dict. Sci. Nat., Suppl., I, p. 485 (1840).

[2] No figure is given in the Atlas, however; this point will be referred to immediately when discussing Michelin's diagnosis of *C. cornu-bovis*.

only species originally associated with the genus *Caninia*, and was then definitely given as the type (a statement never withdrawn by Michelin), in my opinion it must continue to be so regarded, and the name *cornu-bovis* abandoned.

While the description and figures in the Iconographie leave much to be desired (the best figure is that of *C. cornu-bovis*, pl. 47, fig. 8*a*, where the dissepiments are clearly indicated), Michelin made two observations of great value to later workers in recognising his species; he noted that specimens were in de Koninck's collection as well as in those of Vanderdecke, de Verneuil, and himself, while he also quotes certain of de Koninck's figures[1] of *Cyathophyllum mitratum* as examples of *Caninia cornucopiæ*, and further the only locality given is Tournai, where he remarked that the species were very abundant. Accordingly, when de Koninck redescribed the species many years later, he was able to give a much fuller diagnosis than might have been expected.

As de Koninck's final description was taken from specimens quoted by Michelin himself, it may be accepted with some confidence, and the present diagnosis of the species is primarily compiled from corals compared with de Koninck's figured specimens, and also from the latter's final description ("Nouvelles Recherches," p. 100) given below:—

"Polypier de taille médiocre, en forme de cône allongé assez fortement recourbé, finement pédicellé, à bourrelets d'accroissement peu marqués et à épithèque mince. Calice circulaire à bords amincis et assez profond; trente à trente-deux cloisons principales bien développées, assez fortes, surtout vers leur partie supérieure, mais ne s'étendant pas jusqu'au centre où se trouve un petit plancher lisse d'environ 2 millimètres de diamètre. La plupart des cloisons sont droites, il n'y a que celles qui sont le plus rapprochées de la fossette septale qui s'infléchissent un peu avant de se rejoindre; elles alternent avec le même nombre de cloisons rudimentaires peu apparentes. La fossette septale, qui est assez grande et profonde, s'étend du centre du calice jusqu'à la muraille: elle est située du côté de la grande courbure. Hauteur, 4 à 5 centimètres, diamètre et profondeur du calice, 1, 5 à 2 centimètres."

While this diagnosis in reality only refers to one phase of the coral's growth, this phase is by far the commonest at Tournai, and there can be no reasonable doubt as to its coincidence with Michelin's own conception of the species, described by him as being so abundant at this locality. The sections and calyx figured on Pl. VI, Figs. 2–2*d*, are from this common phase of the coral.

Of the rich assemblage of corals found at Tournai, this species is, as its author noted, remarkable for the ease with which it can be broken open to show the tabulæ within, and their deep depression into the cardinal fossula. While this character cannot now be given the importance assigned to it by Michelin, it has a certain value in recognising his species, since amongst the common corals of Tournai only *Amplexus coralloides* and *Caninia gigantea* have this property, and it is easy to see from Michelin's text and figures that neither of these are referred to under *Caninia cornucopiæ*.

De Koninck ("Nouvelles Recherches," p. 67) regarded *C. cornu-bovis* as a synonym of *Caninia ibicina* (Fisch. d. Wald.). Enquiries kindly instituted by Professor Yakowlew of St. Petersburg and Professor

[1] Descr. Anim. Foss., pl. C, figs. 5*a* and 5*c*.

Pavlow of Moscow (to whom I wish to return my sincere thanks for the trouble they have taken in the matter) have failed to bring to light the specimen figured by Fischer de Waldheim in his "Oryctographie du Gouvernement de Moscou" (Pl. xxx, fig. 5), but as far as one can see from the figure and description there given, the external area of the original specimen is entirely destroyed, and if this is so it would be impossible to specifically (or probably even generically) identify it; in these circumstances, therefore, while calling attention to de Koninck's opinion, one is compelled to retain Michelin's name for the coral.

De Koninck further included d'Eichwald's *Lophophyllum breviceps* (Lethæa rossica, t. i, p. 527, pl. xxix, fig. 6) as a synonym of *L. dumonti*, M.-Ed. & H. (which, in my opinion, is clearly a young form of *Caninia cornucopiæ*); d'Eichwald's species, however, has not been included here in the synonymy, since his figure and description, while certainly leaving the impression that de Koninck was correct in his views, are not sufficiently clear to settle the point without a personal examination of the original specimen, and this for the present I have been unable to carry out. For a similar reason, McCoy's *Cyathopsis cornucopiæ* and *Cyathopsis cornu-bovis* are also excluded from the synonymy, although there can be little doubt from McCoy's description ("Palæozoic Fossils," p. 90), that he was dealing with forms at any rate congeneric with *Caninia cornucopiæ*. One of McCoy's localities for *Cyathopsis cornucopiæ* is given as "Carboniferous shale near Glasgow." This must have been from an Upper Visean horizon, and it is therefore not probable that a specimen from so high a level was quite identical with the Tournaisian species.[1]

Affinities.

Compared with other Tournaisian corals *Caninia cornucopiæ* is a very distinct species, and amongst such I have not yet noticed any bearing a real resemblance to it. It is true that de Koninck claimed for the species a great similarity with *Zaphrentis delanouei*, but while that may be so for the calices he examined (though the septa are always thinner in *C. cornucopiæ*), the two are completely different in transverse sections (see Plates V and VI) as well as in epithecal characters; the only real similarity occurs in transverse sections across the comparatively rare amplexoid growth stage of *Zaphrentis delanouei*, and in such cases a further section across the lower conical portions will immediately solve the difficulty.

Amplexus spinosus, de Kon., differs in epithecal characters, in the possession of an extremely shallow and ill-marked cardinal fossula, and in the absence of a *dumonti* phase.

Caninia gigantea, Mich., is far larger, has more closely set septa, and the marginal zone of dissepiments is thick, and is developed at an early stage of growth.

[1] McCoy noted in his description of *Cyathopsis cornucopiæ* that "the absence of the vesicular zone of the true *Caninia* is not a little remarkable." This, of course, was because he erroneously took the true *Caninia* to be *C. gigantea*, and was unaware that *Caninia cornucopiæ* developed a dissepimental margin in its final growth stages.

Amplexus coralloides, Sow., differs in the possession of a very inconspicuous cardinal fossula, no dissepimental margin, and an absence of a *dumonti* phase.

Amplexus cornuformis, Ludw., may present resemblances in transverse section, but the tabulæ (if de Koninck is correct in assigning to *Amplexus cornuformis* the tabular sections given on pl. ii, figs. 1*c* and 1*d*, of Milne-Edwards & Haime's "Polypes Fossiles") are more irregular and vesicular than in *Caninia cornucopiæ*.

Corals, as yet undescribed, of a very similar nature to *Caninia cornucopiæ*, are found in the Visean, and many of these are certainly congeneric. Through the kindness of Mr. Sibly, I have been able to examine several of these from the shales overlying the Derbyshire Limestone. But none of them seem quite identical with Michelin's species, and the majority show well-developed minor septa, and, as far as one can judge from transverse sections, they appear to have highly vesicular tabulæ. Other closely related forms are also present in the Visean of the South-West Province, and concerning these Dr. Vaughan has kindly drawn up the following notes, where the differences from typical examples of *C. cornucopiæ* are clearly set forth.

"*Caninia* aff. *cornucopiæ*, mut. D_{2-3}, agrees very closely with the Tournaisian species.

"The following differences are, however, constant in the specimens which I have specially studied, i.e., of the Tournaisian species from N. Mendips and Stackpole Quarry (Pembroke) and of the Visean mutation from Oystermouth (Gower) and the Hodder :—

"The Tournaisian species is curved almost throughout its length, whereas the Visean mutation adopts a cylindrical habit at an early stage. Apparently connected with this habit of growth is the persistence of the thin vesicular jacket throughout the cylindrical stage of the D_{2-3} mutation and its very brief development in the Z–C species.

"The most striking differences seen in a comparison of a set of serial slices are (1) the deep siphuncular depression of the tabulæ in the case of the Tournaisian form, and the broad, relatively shallow depression in the case of the Visean mutation; the lower form may therefore be stated to have a Caninoid and the upper a Campophyllid type of fossula. (2) The greater abundance of tabular intersections between the septa in a horizontal section of the upper form, pointing to the closer approximation of the tabulæ, a fact which is confirmed directly by comparing vertical sections."

Another mutational form is locally extremely abundant in Scotland, on the horizon of the Middle Skateraw Limestone, especially in the shales overlying that limestone in the East Barns Quarry near Dunbar.

This form differs from the Tournaisian species in having more widely spaced septa, and, like the mutation described above by Dr. Vaughan, a comparatively slight depression of the tabulæ into the cardinal fossula, but in other respects the resemblance is extremely close. It is interesting to note that the remarkable variation in habits of growth, seen in the Tournaisian species, also occurs here. The simple conical form is by far the commonest, as it is with the original species at Tournai and in the Bristol area.

The occurrence is, however, strictly local, and I am not yet aware of such corals in other parts of Scotland, though McCoy, as previously noted, records an apparently similar form from "Carboniferous shale near Glasgow."

Distribution.

Little can yet be said concerning the distribution of the species in Britain. The only undoubted examples that have so far come under my notice, have been found by Dr. Vaughan in the South-Western Province. He writes:—

"This species is confined in the South-Western Province to the top of Z and C, that is, it immediately precedes and accompanies the introduction of *Caninia cylindrica*; its maximum lies immediately below the first occurrence of the latter species. In the Gower the species was noted in the Upper Z and γ of the cliff section between Rhossili and the Worm."

One or two fragments, possibly belonging to this species, have been found by Dr. Matley in the Rush Slates of co. Dublin (locality R 6*b*), but they are not specifically determinable.

Although the chief object of this paper has been a revision of the species concerned, some aspects of the question of the zonal value of such fossils, may be briefly noticed in conclusion.

The usual habitat of these corals seems to have been a calcareous mud. They commonly swarm in limey shales, but are comparatively rare in, if not absent from, massive limestones. But no rule to this effect can be given, and in Scotland, certainly, small rugose corals of this type are noticeably local in their distribution. In a bed whose position is accurately known over a wide area, they appear and disappear in a remarkable manner, as if they were very sensitive to conditions of deposit and food supply.

That they may be of the highest stratigraphical value over an area where such conditions seem to have been constant, is not for a moment to be disputed; Dr. Vaughan's admirable work in the South-Western Province supplies an excellent instance. But, as a rule, in correlating over areas exhibiting lithological variation, the relative abundance or scarcity of such corals is of no great value. More trustworthy results should be attained if some of these forms can be clearly proved to have undergone some definite evolutionary change with the passage of time, but until this can be done it would be safer to regard them as untrustworthy for zonal purposes.

The particular corals dealt with in the foregoing articles are of a somewhat simple type, and their structure can hardly be expected to admit of considerable modification. Nevertheless, there is some evidence that an evolutionary change did take place, and that it is, in a general way, helpful to the stratigrapher. It is also always possible that aberrant types may be found of narrow vertical range, though in view of the local occurrence of these corals, evidence apparently pointing to such a fact should be received with caution.

Now that zonal work in the Lower Carboniferous rocks is being actively prosecuted in many areas in Britain, it may be expected that in a few years much light will be thrown on these problems, of such interest to geologists in general.

I wish to thank Dr. Kitchin and Dr. Thomas for valuable help during the preparation of this article, and also Mr. J. W. Tutcher for the care he has given to those of his photographs appearing in the plates.

EXPLANATION OF PLATE VI.

CANINIA CORNUCOPIÆ, Mich.

FIG. 1.—Fully grown adult of regular form (*C. 'cornu-bovis'*). Tournai. Geol. Surv. R.C. 331.

FIG. 1*a*.—Key diagram to segments cut from above.

FIGS. 1*b* and 1*c*, 1*d* and 1*e*, 1*f* and 1*g*.—Lower and upper surfaces of segments ii, iii, and iv respectively.

FIG. 1*h*.—Longitudinal section of segment v, cut down the cardinal fossula (right-hand side of figure). Dissepiments partly obscured by intersections of septa (shaded) in the plane of section.

FIG. 1*i*.—Counterpart of 1*h*. Tabulæ outside fossular depression.

FIG. 1*j*.—Lower surface of segment vi, showing ring of dissepiments, and, to right of fossula, a fragment of epitheca repeated by rejuvenescence. (Micro. section.)

FIG. 1*k*.—Calyx (segment vii).

Except the diagram, Fig. 1*a*, all the above are very slightly enlarged ($\times \frac{13}{12}$). 1*b*–1*j* are from camera lucida drawings.[1]

FIG. 2.—Adolescent calyx. The common form at Tournai, representing the original conception of the species (conclusion of *dumonti* phase). Shape of corallum as in lower part of Fig. 1. Tournai. Brit. Mus. Nat. Hist. R. 11,680. $\times \frac{3}{2}$.

FIGS. 2*a*–*d*.—Serial sections below same, showing characters of the *dumonti* phase.[2] $\times$ 3.

FIG. 3.—Adolescent calyx (near '*Lophophyllum dumonti*'). Tournai. Brit. Mus. Nat. Hist. R. 11,672. $\times \frac{3}{2}$.

FIG. 4.—Adult calyx ('*Zaphrentis edwardsiana*,' de Kon.). Rim broken down, showing dissepiments round base of calyx. Brit. Mus. Nat. Hist. R. 11,688. $\times \frac{3}{2}$.

Errata.

p. 26 (January Number), line 20 from top of page, for '4*a*' read '4*b*.'
p. 71 (February Number), line 19 from top of page, for 'inner' read 'minor.'

REVIEWS.

I.—ZONES OF THE WHITE CHALK OF THE ENGLISH COAST. By Dr. A. W. ROWE. Proc. Geol. Assoc., 1900–1908.

A GEOLOGIST, more confident of his hammer than his pen, friend and rival of Lyell in the establishment of the theory of actual causes, associate of Ami Boué in the foundation of the Geological Society of France, profoundly and permanently influenced the direction

[1] The segments are, of course, opaque, and the septa consequently appear white on a dark ground; in the drawings, however, this colouring is reversed, to secure uniformity with the transparent microscopic sections 2*a*–2*d* and 1*j*.

[2] Strictly speaking, only Figs. 2*d* and 1*d* are in the *dumonti* phase, Figs. 2*b*, 2*c*, and 1*b*, 1*c*, being in the *vermicularis* phase.

of French geology. Towards the close of his life, in 1849, Constant Prévost let it be known that he had brought to light from his notebooks a work which had lain dormant since 1821 on the geological structure of the cliffs of Normandy.[1] A desire to make it less imperfect, the hope of embracing in its scope the whole coast of France, had allowed him to defer its publication. Before putting the final touches to it he wished to make an appeal to young geologists who had a long future before them, as well as to those who from their position and residence by the coast would be able to make prolonged local researches. But when he died in 1856 his collaborators had not yet appeared, and his descriptions of the Normandy cliffs remained for ever in his notebooks, whilst his geological theories forged ahead and the Geological Society of France, founded by him, developed and flourished. And it is only in our days, after eighty-seven years, that the dream of one of our masters is at last realized in the work that bears the title "The Zones of the White Chalk of the English Coast," a work which has for author A. W. Rowe and for collaborator C. D. Sherborn.

The fact is it is very difficult to study a cliff thoroughly. A cliff shows too much, all at once. It shows so much that it always appears as if one had missed something, and one is always condemned to a sense of incompleteness, whatever care may be taken to rivet the attention, to brace up soft muscles for the climb, or whatever dexterity one may show with the chisel and the pencil.

The English Chalk has, without doubt, been the object of work of high value on the part of members of the Geological Survey, as seen in the works of Whitaker and Strahan and the admirable memoir by Jukes-Browne on the Cretaceous rocks; but the best-made maps, the most careful geological surveys, are always at the mercy of a trench, or of a new quarry bringing to light contacts previously invisible. The observer who describes a cliff is protected from these risks; if he allows any fact to pass unnoticed he has only himself to blame; he has not been competent to take the necessary trouble.

For my own part I never stand before a cliff that I have previously studied without making some new observation or noticing something which had formerly escaped me. But to-day the harvesters have passed over the English coast in Rowe and Sherborn, and the work for the gleaner who follows their footsteps will be but small.

Let us rapidly examine the characters of the Chalk cliffs in the different counties studied.

Kent.

Twelve years of observation are condensed into the fine sections of the Kentish cliffs; anyone with the descriptions and sections in his hand can follow the coast and recognize without hesitation the succession of the eight zones of the Chalk and their limitations at any point. The author has brought precision and exactness where

[1] Constant Prévost, "Description géologique du littoral de la France": C.R. Acad. Sci. Paris, vol. xxix, November 26th, 1849, pp. 615–622. The work of C. Prévost, "Sur les falaises de la Manche," had been seen by Cuvier and Brongniart, who reported upon it to the Academy.

formerly had been approximation. He has not confined himself to re-describing the zones with uncertain limits, but with fine analysis he distinguishes a succession of beds which furnish fixed datum-lines —such as the "Bedwell line" in the zone of *Uintacrinus*, the "*Ammonites leptophyllus* bed" (where he mentions 105 examples), the "Sponge bed" forming the base of the *Uintacrinus* zone, the "*Echinocorys pyramidatus* bed," the "*Echinoconus* bed" formed of a carpet of this species, the "Whitaker 3-inch flint-tabular" band towards the top of the *Micraster cor-anguinum* zone, etc. Thus he takes under consideration at the same time the lithological and the palæontological characters; the former, though more easy to recognize at first sight and having the advantage of furnishing at each point geometric limits, but failing from want of permanency from place to place. The author has rendered lasting service in fixing the distances which separate the absolute datum-lines, the limits assigned to his life-zones. Whether the name-fossils chosen for these zones are suitable is open to discussion, as it is well known that the range of few name-fossils are confined to one zone. No one has ever relied upon one fossil for obtaining a zonal determination, and though the name-fossil attains its maximum development in the zone to which its name is applied, we rely more upon a group of associated forms peculiar in certain characteristics or in themselves as our zonal guides. It is this association of life-forms and their variations, as we trace them zone by zone, which gives to zonal geology its value.

Sussex.

The collection of fossils, easy and amusing though it be at certain points of the Chalk cliffs, becomes, unfortunately, exacting at other points where one proposes to base an analysis of the section on their distribution. Thus, in the Beachy Head section the author was forced to rely entirely on the genus *Micraster* for limiting the zones, mapping out the chalk foot by foot, and taking the specimens obtained from each foot of chalk to the water's edge and there cleaning and determining them before proceeding to the next foot. It becomes very difficult to collect this genus of fossils when they are rare or when they are shorn off by the battering action of the shingle at the foot of the cliff, or in those dangerous places where one has to pass hurriedly whilst fragments of cliff are falling from above, or the sea threatens to cut off one's retreat below. The description of Beachy Head gives a fair example of the perseverance of the author in search of his junctions, for there he uses wreckage to increase his reach up the cliff; or that of Seaford Head, where he descends roped at the point where he has noticed the fossils he is in search of by the calcite fracture of their tests, afterwards carefully extracted by the knife from the face of the battered cliff. Hence those geologists who have described the Seaford cliffs before him must not be astonished when comparing their work with his to find it considerably perfected.

Dorset.

The whole of this coast bristles with difficulties, but in spite of altered and consequently barren rocks the author has been able to fix with varying degrees of accuracy the limits of every zone. The scenery of this boldly sculptured coast is controlled by the influence of the great Isle of Purbeck fault. Inland the beds are horizontal (Wool), and the chalk is so soft that it may be crushed between the finger and thumb; on the coast the beds are folded, broken along the Purbeck fault, and the chalk itself so compacted that it needs to be cut with the chisel. All large fossils are broken, the fragments of the belemnites are often considerably displaced, and the flints shattered into pieces and often drawn out into long dusty lines. Finally, the thickness of the beds themselves is modified, the *cuvieri-* and *Terebratulina*-zones, normally about 134 feet thick where horizontal inland, are reduced to 70 feet on the coast (Durdle).

One of the most remarkable features of this coast is seen at Durdle Cove among slide-planes, where the beds have been pushed northward over one another, ground up into a paste at the junction and re-cemented, thus exposing the *Terebratulina*-zone above and the *planus*-zone below, and the *planus*-zone above and the *Micraster cor-testudinarium*-zone below by the cutting back of the cliff by the sea. Notwithstanding the complexity of such inverted succession, the determination of the exposed masses by means of *Micraster* was so definite—the determination being impossible to obtain in any other way—that it speaks highly for the author's method.

Much new information has been given about these complicated sections and poor faunas of Dorset, especially as regards the higher zones. The *Marsupites*-zone yields a fairly rich fauna, and, what is more important, a fauna which closely agrees with that from the same zone on the coast of Kent and Sussex. As regards the belemnites of the higher beds, we note that *Actinocamax quadratus* is limited to a narrow band about the middle of the zone, and *A. granulatus* to the extreme base of the same zone, whilst *Belemnitella mucronata* and *B. lanceolata* are found in profusion from base to top of their zone.

Devon.

If the chalk exposures of Dorset afford views of greater variety and physical features more complicated and remarkable, those of Devon are of special interest on account of the accessibility of the cliffs and the unaltered state of the Chalk. No section on the English coast gives so much detail or tells the story of zonal succession in so convincing or so graphic a manner. It affords a scope for the study of the Echinoidea which would alone render it famous.

Giving a limited exposure from the *cuvieri-* to the *M. cor-testudinarium*-zone, it differs from all other sections by the varying zonal measurements. The *Terebratulina*-zone, for instance, varies from 70 to 156 feet in a comparatively short distance, and the *cuvieri*-zone from 0 to 80 feet. Many facts point to littoral conditions, showing that in Devon we get nearer to the western shore of the Cretaceous sea, as we do in the western part of the Paris Basin. Throughout the whole coast there are few lithological characters on which we can rely for more than a quarter of a mile, and this uncertainty applies with equal truth to measurements and to the distribution and variety of the fauna.

There is evidence of erosion along the whole coast as seen in the chalky beds with glauconitic grains, in which is a mingled fauna from Cenomanian deposits and the lower bed of the White Chalk. At Martin Rock the disappearance of the *cuvieri*-zone, etc., on the cliff face affords an example of contemporaneous erosion, the beds having been apparently deposited against a Greensand bank. The *Terebratulina*-sea must have extended further westwards than the previous seas, and that of *Marsupites* still further, for it has left its traces among the flints of the Haldon Hills.

Along this western margin of the Cretaceous sea, in its more littoral conditions, we meet with the lowest occurrences of several White Chalk fossils. Among the most interesting are the Micrasters, as *M. cor-bovis* and *M. leskei* both occur in the *cuvieri*-zone of Devon, that is, lower in the series than in any other exposure in England. *M. cor-testudinarium* appears to have originated in eastern waters, as this group-form is almost entirely absent in the *planus*- and *cor-testudinarium*-zones of the west.

Yorkshire.

The coast of Yorkshire is severe. It is distinguished from all other English sections by the nature of the rock, the peculiar lithology of the beds, the paucity and condition of the fossils, and its physical conformation. There is no counterpart in the south to the grand screes of Speeton, nor are the southern cliffs, however lofty, comparable to the mighty tide-bound ramparts of Bempton.

None but very keen observers would have been able to define around Flamborough Head the limits of the zones, and to fix their boundaries within one or two feet, and the keenness of the authors is clearly shown by the fixing of the zone of *M. cor-testudinarium* below Breil Head, where no man is known to have landed, and where the rocks are so numerous that, even with the smallest sea on, their boat would have been staved in.

Nowhere do we see the workings of local variation in geographical distribution of fossils more strongly brought out than in this county, and yet we are still able to trace the continuity of life-forms, though in a markedly attenuated degree. The zones of *Rhynchonella cuvieri* and *Terebratulina* are quite in a line with those of southern sections, poor though the fauna is, and it is only when we reach the horizon where *Micraster* usually helps us that the difficulty begins. *M. leskei*, *M. cor-bovis*, *M. cor-testudinarium* were not found, but such Micrasters or fragments of Micraster as were found agreed in all essential features of the test with those in the zones of the more prolific south. The same is seen in the zone of *A. quadratus*, for while the name-fossil is absent, possibly by reason of the thinness of the beds, *Cardiaster pillula*, though notably rare, is found, as usual, at this horizon. The zone of *Marsupites*, though lacking many of its characteristic guide-fossils, exhibits the customary division into *Marsupites*- and *Uintacrinus*-bands.

Further, the vertical range of certain fossils, usually restricted in their distribution, is so vast that their very persistence is bewildering. As instances we quote a range of 800 feet for *Act. granulatus*, and

650 feet for *Act. verus*; while *Cardiaster ananchytis* has been traced for 640 feet and *Infulaster rostratus* for nearly 700 feet outside the limit of their ordinary zones. In point of fact this extension of known ranges for fossils is one of the most conspicuous results of the work in this area.

Isle of Wight.

Whoever visits the Isle of Wight loves to return, but he who has studied its geology cannot leave it. The memoir by Dr. Rowe is fresh proof of this, since after having studied the cliffs of the island he was moved to examine the interior. We owe to this circumstance, and to his association with C. D. Sherborn, a geological map of six inches to the mile, unique of its kind, on which eight zones are defined with precision in a mass of Chalk apparently uniform. These zones show from one extremity to the other of the island variations in thickness, contemporaneity of deposit, and varied faunas, which have furnished information as to the migration of species. The zone of *B. mucronata* shows considerable differences in its thickness, indicative of important pre-Tertiary subaerial denudation.

In this island the Chalk is seen in its greatest thickness and most uniform sedimentation. The principal modification observed is in relation to the mechanical forces which tilted the beds; the Chalk is there hardened, and the flints are crushed as one passes from north to south in proportion to the inclination of the strata.

This memoir is in advance of those of previous writers by reason of the exactness of the stratigraphical observations; it is in advance of the previous memoirs of its author in the revision of the list of fossils, which gives detailed information on zoological groups like sponges, corals, bryozoa, and annelids, which have up to now been neglected.

The mass of the White Chalk, 1,500 feet in thickness, of uniform, slow, placid, and uninterrupted sedimentation, taking place over vast periods of time and over a large extent of country, allows us to follow every stage in unbroken continuity in the evolution of a genus and the equally interesting zonal variations in a species. Studies such as these afford the surest contribution to our knowledge of the evolution of fossil forms. They differ widely from the ordinary systematic papers where so many new species are established on isolated or unsatisfactory specimens, providing so much difficulty and uncertainty in future identification. The author of these memoirs, instead of making new species, has followed the variations of the different typical Micrasters throughout the successive horizons and established series of individual forms, besides distinguishing the mutations in the successive beds from one variety to another of the same specific type.

He has shown that not only is the zonal theory correct, in that at certain levels of the Chalk there exist fossils which are either rigidly restricted to one particular zone (e.g. *Inoceramus labiatus*), or that certain groups of guide-fossils, though not so restricted, are by their association equally characteristic of horizon; but he has also shown that certain fossils vary so markedly in shape or other essential features, as they range from a lower to a higher level, that we can assign these very shape variations with unerring certainty each to its particular zone.

Another point of interest is the attempt to trace the almost equally instructive variations in horizontal distribution as dependent on the nature of the deposit, the depth, current, and temperature of the Cretaceous sea from Yorkshire to Devon, thereby educing the fact that a fossil which occurs but sporadically in one area may have developed abundantly in another. Regarding other forms like *Kingena lima*, previously recorded only from the lower and upper beds of the White Chalk, Dr. Rowe has filled in the gaps and found that at those levels where it is rarest in the southern counties it is commonest in Lincolnshire. He has shown the same with regard to *Infulaster rostratus*, which appears earlier in Yorkshire than in the south, with *Cidaris pleracantha*, and with many others.

The work as a whole is stated to be frankly zonal, and therefore zoological; it is, however, of a very high geological standard, enhanced by the accompanying maps and sections drawn on so large a scale by C. D. Sherborn, which show at a glance the position of every zone, every point of interest, every fold of the beds on the coast. The fifty-six fine photographs taken by Dr. H. E. Armstrong, which must have necessitated so many visits and the expenditure of much time and care, succeed in bringing to the eye in a wonderful manner all the critical zonal junctions of importance in the White Chalk of the English coast.

The magnificent White Chalk cliffs of England have at last found interpretation worthy of their grandeur and of their teachings. The work of Dr. Rowe and his associates, C. D. Sherborn and H. E. Armstrong, stands as a model for the future, and as a lasting monument of descriptive geology. CHAS. BARROIS.

II.—GEOLOGY OF INDIA.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR 1906, by T. H. HOLLAND, F.R S., F.G.S., Director. The Mineral Production of India during 1905, by T. D. LATOUCHE, B.A., F.G.S. Numerous papers on Indian Geology by Officers of the Geological Survey of India.—All the above extracted from the " Records."

(*Concluded from the March Number, page* 126.)

PETROLOGY.

For some time past the attention of the officers of the Indian Survey, including the present Director, has been drawn to a remarkable series of rocks found in the Visagapatam district, and forming a portion of the Eastern Ghauts. By all accounts this region must be a petrologist's paradise: without going too closely into particulars, either petrological or topographical, it may be stated that in this region a great igneous massif with borders of extremely basic rock underlies a development of sillimanite[1] schists, which appear to be

[1] Sillimanite: composition $Al_2O_3SiO_2$, as for andalusite = silica 36·9, alumina 63·1 = 100.

invariably associated with the underlying complex. The massif thus referred to extends as an ellipse 250 miles long and 60 miles wide in a direction parallel to the adjacent coast of the Bay of Bengal. Together with its covering of metamorphosed sediments it forms a denuded plateau, 3,000 to 4,000 feet in altitude, which is completely carved into hills and valleys. Messrs. Walker & Collins, writing from Canada, and working on rock-specimens obtained by Mr. Middlemiss a few years ago, describe the petrology of this interesting district.

They commence by stating that the suite of specimens appears to represent a metamorphic rock series resulting from various stages of mingling of ultra-basic igneous and of argillaceous sedimentary materials. From a mineralogical point of view their observations are especially interesting, but we may confine our own remarks on the present occasion to the composition and development of the mineral Sapphirine as it occurs in these Visagapatam rocks. Sapphirine, as a mineral species, seems to have been originally recognized by Steenstrup from Fiskernäs in Greenland, and it has been found to occur abundantly in the area now under description. The authors tell us that the true birthplace of this mineral, as evinced by the Indian rock-specimens, is the metamorphic zone of the contact between the 'khondalites' and spinel-bearing magmatic segregations. This Sapphirine-bearing zone is the result of the intermixture of these highly argillaceous schists with segregated spinel rock: the product is rich in alumina, magnesia, and the oxides of iron, but poor in silica; lime is practically absent. Steenstrup's examination of the Sapphirine rocks at Fiskernäs led to the same conclusions.

A comparison of the respective composition of spinel, Sapphirine, and sillimanite indicates the intermediate position that Sapphirine bears to the other two minerals in all its constituents. This is thought to substantiate the view that it is really a product of their interaction. Thus from the pure aluminate of iron and magnesia, viz. spinel, which may be regarded as the utmost limit of a basic species, we arrive at Sapphirine with its 15 per cent. of silica, largely replacing the iron-oxides of spinel, and thence to sillimanite, which is simply a sub-silicate of alumina with a small amount of iron-oxide. It is noteworthy that the amount of alumina is nearly the same in all three minerals, ranging from 65 to a little under 60 per cent. In addition to their notice of Sapphirine the authors describe certain rock-types, containing cordierite, which appear to be new to petrography, whilst a form of pyroxene has been detected having the pleochroism of hypersthene, but with inclined extinction; for this variety the name clino-hypersthene is suggested.

It will be remembered that Mr. Holland in 1901 described the Sivamalai series of Elæolite (nepheline) Syenites and Corundum Syenites of Southern India. On the present occasion we have a note by Mr. Walker on the Nepheline Syenites from the hill-tracts of the Visagapatam district, based on specimens also collected by Mr. Middlemiss. The field relationships of these rocks appear to be those of igneous intrusions, occurring along with other gneissoid igneous types, which form a part of the great boss extending from the Godavari to the Mahanadi, and, as we have already seen, constitute for 250 miles the northern portion of the Eastern Ghauts. To use the author's words, "this giant eruptive is overlaid in part by metamorphosed sediments, principally khondalite, and to a less extent by laterite."

In describing the typical light-coloured nepheline rock, greenish-brown hornblende, brown biotite and magnetite grains, more or less idiomorphic, occupy only a very small portion of the rock-mass. Anhedra of nepheline and large irregularly rounded grains of felspar constitute the major portion, the amount of nepheline being estimated at 37 per cent. The most interesting constituent, as seen under the microscope, is the felspar, which is really a complex of the ordinary perlitic type; a small quantity, equal to about one per cent., of original calcite also occurs. The bulk analysis of the rock shows 52 per cent. of silica, 26 per cent. of alumina, 3 per cent. of iron-oxides and magnesia, nearly 2 per cent. of lime, and 14 per cent. of soda and potash in equal amounts. An analysis of miaskite from the Urals is given for comparison. The Director remarks that, judging by the previously known associations of this class of rock in South India, Ontario, and Montana, we should be justified in searching for corundum deposits.

There is a further report on the manganese-bearing rocks. The typical rock of this series (intrusive) is composed of potash-felspar, manganese-garnet, and apatite. Its common form when fresh has a texture resembling a medium-grained granite. Mr. Fermor proposes to distinguish this kind of rock as *kodurite*, after the Kodur manganese mine, where it is well exposed. It is further suggested that, as the manganese-garnet is intermediate in composition between spessartite (manganese alumina-garnet) and andradite (lime iron-garnet), the term spessart-andradite might be used, and shortened for convenience into *spandite*. Thus we have a newly-named rock with a newly-named mineral to match.

Economic Geology.

The following remarks are based partly on Mr. Latouche's statement for 1905, and partly on Mr. Holland's Report for 1906.

In the Geological Magazine for July, 1907, we noticed some facts in connection with the "Mines and Minerals of the Indian Empire," based to a certain extent on Mr. Holland's Report for 1903. It can scarcely be expected that any great change has taken place in two years, i.e. from 1903 to 1905. Yet there is an increase in the total value from £4,988,527 in 1903 to £5,707,956 in 1905, and the increase has been steady ever since the beginning of the present century. Gold still heads the list, being nearly double the value of the coal. The greatest leap, however, has been made in petroleum, which has risen from £354,365 in 1903 to £604,203 in 1905—doubtless due to exploitation in Burma; whilst the yield of rubies in that country has fallen from £98,575 to £88,340 within the period. Amongst the various mineral products dealt with the following may be selected for brief notice.

Bauxite.—The more aluminous laterites of India yield in abundance samples which contain nearly 60 per cent. of alumina, with less than 3 per cent. of silica. As much as 13·76 per cent. of titanium oxides has been found in some samples of bauxite, and as little as 2·70 per cent. of ferric oxide. It is contended that the samples come within the limits of bauxite marketable as a source of aluminium, and in this respect compare favourably with the material now being mined so largely in the South of France. Respecting the development of these Indian bauxites for use as a source of aluminium, the Director appears to favour the notion of the manufacture of pure alumina locally by extraction with alkali, and the export of the pure oxide to aluminium works abroad. He considers that the exploitation of the Indian deposits offers a promising field for private enterprise.

Coal.—There is a considerable yield of coal from beds of Tertiary age in Assam, and mention is made of two fields in connection with the Bengal-Assam Railway, belonging to the same series as those well-known in the Makum field. These coals are said to possess a high average value as fuel, but contain much sulphur and moisture. On the other hand, some of the mines in the Makum field itself are known to have yielded very satisfactory results. As an instance, however, of the minor position held by Tertiary coal in India, it appears that, whilst in 1905 about eight million tons were raised from the Gondwana coalfields, not quite half a million tons were raised from Tertiary beds, and of these latter more than 50 per cent. is produced in Eastern Bengal and Assam. Mr. Latouche states that no coal was extracted in Burma, "the mines in the Shwebo district having been closed, but prospecting for coal is being carried on in the Chindwin district. The result of the examination of the Tertiary coalfields of the Northern Shan States has been disappointing, as the quality of the coal was found to be very poor."

Petroleum.—The production of petroleum remains about the same as before in Assam, where the amount is very small, but has largely increased in Burma, which is now beginning to yield important results. In 1905 the output was again the highest recorded, amounting to over 142 million gallons. The question between the old shallow hand-dug 'twinza' wells and the scientific borings of the several oil companies is naturally a serious one, and Mr. Holland thinks that the native oil industry must soon begin to wane unless the Burmans succeed in finding some means of reaching a greater depth than 400 feet, which at present is their limit. There are several oil-fields, the geological features of some having already been described in the Records. In one case it is shown that the oil-bearing-sands, instead of being continuous over the whole dome, are very limited sandbanks in which the oil is stored. The great variation in thickness, horizontal extent, and levels of each of them points to this, as also does the abundant current-bedding so typical of the strata immediately above. "Perhaps one of the most interesting and puzzling features of this area is the occurrence of the largest quantities of gas, *not* in the centre, where the anticlinal crest reaches a maximum elevation, but at a considerable distance further south; in fact, the field appears to terminate southwards as a gasfield." In another oil-field the effect of a Miocene anticline, lately observed, is brought under discussion.

Gold.—Mysore heads the list in 1905, as heretofore, with a value of £2,363,457. The other contributions are scarcely worth noticing, except that in 1905 the river dredgings in Burma yielded a value of £2,712, which may be the firstfruits of a paying industry. In consequence of frequent applications for licences to work the alluvial deposits in Upper Burma Mr. J. M. Maclaren was deputed, during the field season of 1905–6, to report on the work in progress on the concessions already granted, and generally on the conditions for alluvial gold-dredging in the rivers of Upper Burma. Mr. Latouche's report on the gold of the Loi-Twang area is not very encouraging. Excluding a small nugget, the value per cube yard in the richest gravel met with was not much more than two grains. The financial aspect of Mr. Maclaren's report is confidential, but we owe to his journey an interesting note and map on "The course of the Upper Irawadi" (*Geographical Journal*, November, 1907) when examining the auriferous alluvial deposits of that and other rivers.

Iron-ores.—The production of iron from its ores in India is still very limited, and according to the statistics supplied by Mr. Latouche the value is even less in 1905 than in 1903, or at least seems to be. Anyhow, the value in 1905 is returned as only £13,827. And yet Mr. Holland announces the discovery of something very like an iron-mountain, whose ores were intended to be used in some future works on the Bengal-Nagpur Railway. The ordinary quartz iron-ore schists of the Dhārwars occur in this locality; but the same schists appear to have been altered locally by intrusive igneous rocks, with the segregation of large bodies of almost pure hæmatite.

Manganese-ore and Mica.—These in point of production more than hold their own. As regards the amount of manganese-ore, this rose from 150,297 tons in 1904 to 253,896 in 1905. The value of this ore Mr. Latouche (p. 57) puts at £82,979, whereas in the table (p. 47) the export value appears to be £248,309. This difference in valuation is so great as to call for some explanation.

W. H. H.

III.—A Summary of the Geology of India. By Ernest W. Vredenburg, A.R.S.M., A.R.C.S., of the Geological Survey of India. Small 8vo; pp. 67, with table of formations. (Calcutta: Thacker, Spink, & Co., 1907.)

THIS is an extremely useful little book, and should be of great service to travellers in India desirous of obtaining a succinct account of the geology of that country in its tripartite division. According to this author the geological formations of India may be classified as follows:—

Recent formations.
Pleistocene.
Siwalik System (Pliocene and Upper Miocene).
Pegu or Mekran System (Lower Miocene and Oligocene).
Eocene.
Mesozoic or Secondary.
Permian and Upper Carboniferous.

Lower Carboniferous and Devonian.
Silurian, Cambrian, and Pre-Cambrian.
Oldest Sediments.
Fundamental Gneiss or Archæan.

In consequence of splitting the Miocene and Carboniferous formations under the above arrangement a word of explanation is necessary. For instance, he observes that there may be no difficulty in deciding whether a particular bed is newer or older than the Middle Miocene, or than the Middle Carboniferous, yet great uncertainty remains, in the first instance, as to whether certain strata in the Siwaliks are to be referred to the Upper Miocene or the Pliocene, and in the second case whether portions of the Lower Gondwana should be referred to the Upper Carboniferous or the Permian. Hence the use of local terms to include a geological group is held to be justified.

The several systems enumerated in the above list are then dealt with in reversed order, commencing with the Archæan so largely developed in peninsular India. He considers the Central Gneiss of the Himálaya to be in part at least of Archæan age. Much has been done of late years in the petrology of this group of rocks. Amongst other matters the author refers to certain enstatite-bearing rocks in the south-east of the peninsula, the types of which most nearly resemble a granite in composition, as having been called 'charnockites' by Holland because the tombstone of Job Charnock, the alleged founder of Calcutta, consists of a slab of that rock.

We could scarcely venture on the present occasion to follow Mr. Vredenburg in his brief but lucid descriptions of the several sedimentary series, whether fossiliferous or the contrary. There is a great amount of useful information conveyed within the scope of a very few pages. A glance at the geological history of India during the period usually known as Permo-Carboniferous (i.e. Upper Carboniferous) must suffice, for this deals with a subject to which special importance is attached.

The author commences by referring to the extensive orogenic upheaval in many parts of the globe at a period which he places towards the end of the Middle Carboniferous. Thus the junction with the Upper Carboniferous is usually indicated by an unconformity-conglomerate, which often exhibits peculiar characters that have been regarded as glacial. After indulging in a certain amount of speculation in connection with this well-marked phenomenon in the history of our planet, he proceeds to deal with (*a*) the Gondwana facies, and (*b*) the Marine facies. We need not in this case follow the author into details of the Gondwana system, but it is interesting to note that in the Himálayan region typical Gondwanas are said to be found in the neighbourhood of Darjeeling and in Bhotán.

There is, however, on p. 40 a statement in connection with the peninsular Gondwanas to which some exception might be taken. "It will be seen," says the author, "that the age of the Coal-measures of India differs considerably from that of the Coal-measures of Great Britain and the *Franco-Belgian* basin, *all of which are Lower or Middle Carboniferous in age*" (the italics are ours). We wonder whence he derives his authority for this statement, since almost any textbook would tell him that the English Coal-measures, including the Millstone Grit at their base, are of Upper Carboniferous age, nor is there any reason to doubt that the Franco-Belgian coals are practically of the same age. There may be some coals of Lower Carboniferous age in the Scotch measures, but even this is not universally conceded. Moreover, it is not usual to recognize Middle Carboniferous in the European classification. The point does not, of course, affect Indian geology.

The marine facies (*b*) of this group, as it occurs in the Salt Range, Himálayas, etc., is next dealt with, and the author mentions the discovery of *Gangamopteris* in the Zewan Beds of Kashmir, to which allusion has already been made in the preceding review. Then follows an account of the Indian equivalents of the Triassic, Jurassic, and Lower Cretaceous; this is also in duplicate, viz., (*a*) Gondwana, (*b*) Marine. Next in succession comes the Upper Cretaceous, the Eocene, the Pegu or Mekran (Flysch) system (Oligocene and Lower Miocene), the Sivalik system, and lastly the Pleistocene (Quaternary Era). A table of geological formations in the Indian Empire completes the work. W. H. H.

IV.—Geology of the Transvaal.

Transvaal Mines Department. Report of the Geological Survey for 1905. pp. 1–114, 26 plates, and 5 maps. Pretoria, 1906. Price 7*s.* 6*d.*—Report of the Geological Survey for 1906. pp. 1–140, 30 plates, and 7 maps. Pretoria, 1907. Price 7*s.* 6*d.*

MEMORY chronicles success, but is happily not so mindful of failure. If it were not so ordained few past workers in African stratigraphy, after a perusal of these Reports of the Transvaal Geological Survey, would be able to retain that strong conviction of infallibility so dear to the possessor.

It is scarcely twenty years ago since even the bare outline of the geology of the Transvaal was to all intents unknown. Nowadays our knowledge of the stratigraphy of the country assumes a stable form, and the geological formations stand revealed in something like order. But in the interim between the work of the early pioneers and these, the latest achievements of an organised survey, what a kaleidoscopic view has been presented to the student.

Transvaal stratigraphy, we have read, was of the simplest. It was complex. The Witwatersrand Beds were older than the Pretoria Granites; they were newer: the junction between the two was a faulted one; it was a natural one: the Witwatersrand Beds were Devonian, were Silurian, were Cambrian, were Archæan. Out of chaos came order. If mists still obscure the dawn of the Transvaal rock-succession it is not for the want of effort on the part of the staff of the Transvaal Geological Survey, whose enthusiastic labours have resulted in the discovery of ineradicable landmarks situated toward the region in which the dawn will assuredly break.

The Reports for 1906–7 determine the following rock-succession for the Transvaal, commencing with the newest formation :—

KARROO SYSTEM.

Volcanic Series { Lebombo rhyolites.
Bushveld amygdaloids.
Bushveld Sandstone Series.
Coal-measure Series.
Glacial Conglomerate and Shales.

(Unconformity.)

WATERBERG SYSTEM.

Waterberg Sandstones and Conglomerates.
Felsitic lavas, agglomerates, and shales.

(Unconformity.)

TRANSVAAL SYSTEM.

Pretoria Series.
Dolomite.
Black Reef Series.

(Unconformity.)

VENTERSDORP SYSTEM.

Boulder Beds, Klipriversberg and Vaal River Amygdaloids.
Elsburg Series.

(Unconformity.)

WITWATERSRAND SYSTEM.

Upper Witwatersrand Series.
Lower Witwatersrand Series.

(Unconformity.)

Moodies Series.
Crystalline Series.

Between the ancient crystalline series and the Karroo System there are therefore interposed four unconformable, wholly unfossiliferous systems, consisting of limestones, shales, sandstones, and volcanic rocks.

Limitation of space prevents even a mention of the outlines of the many interesting geological features of the districts in which this complicated succession has been so carefully worked out and so clearly described by Mr. Herbert Kynaston (the Director) and by Messrs. Mellor, Hall, Humphrey, and Steart. The readers interested in economic questions rightly receive due attention; while those with a predilection towards physiographical studies are provided with photographs, diagrams, and descriptions of the interesting drainage systems of the Mathlapitsi, Olifants, and Letaba Rivers.

Both Reports, indeed, are albums of excellent photographs of rock scenery, rock-sections, and minerals. The accompanying colour-printed maps are likewise excellent, though it is unfortunate that the colour adopted for the Karroo System should be wholly distinct from that of the published maps of the Cape Geological Commission.

In a new country it is a good sign that the educational value of a geological collection is not lost sight of, and that the museum at Pretoria, under the curatorship of Mr. Tweddill and his assistant, Mr. Gardthausen, continues to receive valuable additions. W. G.

V.—Cape of Good Hope, Department of Agriculture.

The Tenth Annual Report of the Geological Commission. 8vo; pp. 296. Cape Town, 1906.

The Eleventh Annual Report of the Geological Commission. 8vo; pp. 176. Cape Town, 1907.

Colour-printed Geological Maps on the scale of 3·8 miles to 1 inch (1 : 238,000):—Sheet 2, Swellendam–Riversdale, 1907; Sheet 4, Malmesbury–Ceres, 1906; Sheet 45, Postmasburg (Griqualand West), 1907; Sheet 46, Barkly West, 1907. Published by the Geological Commission, Cape Town. Price 2*s.* 6*d.* each.

THE Reports embody the results obtained by a vast amount of arduous field-work, often carried on in districts where food and water are scarce, rivers are broad, choked with sand, and fordable only at wide intervals, and where travelling is limited to a short season. Under these hampering conditions it is surprising to find how much solid work has been accomplished. Of the actual extent of the area described we find no precise statement in the Reports, but incidentally we read of the survey of 6,000 square miles by one geologist in one season. To the field-work must be added the preparation of the reports and maps, and the task of seeing them through the press—work apparently accomplished by Mr. A. W. Rogers (the Director) and Mr. A. L. du Toit without clerical assistance. The Survey indeed may be characterised as one yielding a maximum result at a minimum cost.

The Report for 1905 contains an account of the Geology of parts of the divisions of Uitenhage and Alexandria by Mr. Rogers, with a map and 6 diagrams; of the coastal plateau in the divisions of George, Knysna, Uniondale, and Humansdorp, by Mr. E. H. L. Schwarz, with a map and 15 illustrations; of Glen Grey and parts of Queenstown and Wodehouse, including the Indwe area, by Mr. du Toit, with a map and 7 diagrams; of parts of Hay and Prieska, with some notes on Herbert and Barkly West, by Mr. Rogers, with a map and 5 diagrams; of portions of the divisions of Vryburg and Mafeking, by Mr. du Toit, with a map and 4 diagrams; of the Divisions of Tulbagh, Ceres, and Worcester, by Mr. Schwarz, with 16 illustrations (on field-work mainly done in 1896); and a short account of a raised beach deposit near Klein Brak River, by Mr. Rogers, with a plan.

The Report for 1906 contains an account of the Geology of parts of Bechuanaland and Griqualand West, by Mr. Rogers, with 12 figures; of the eastern portion of Griqualand West, by Mr. du Toit, with 13 figures.

Among some of the many and interesting results obtained attention may be directed to the discovery by Mr. Rogers of undoubted glacial conglomerates among rocks so ancient as the Griquatown Series; to the occurrence of the Blink Klip Breccia in Hay; and to the account of the diamond pipes of the Kimberley area by Mr. du Toit.

The two Reports deal with almost every formation known in Cape Colony, from the oldest up to the newest. Much work was carried on among the unfossiliferous rocks, older than the Table Mountain Sandstone. The reader is therefore mercifully spared long lists of fossils and of finding old friends under changed names.

Questions of economic interest, such as water supply, minerals of the Knysna District, salt deposits, occurrences of asbestos, etc., are not lost sight of. The Report for 1905 includes a detailed description by Mr. du Toit of the Indwe Coalfield, and is accompanied by a map on a scale of one inch to 1½ miles, showing the outcrops of the Guba and Indwe seams and the position of shafts and boreholes.

On the separately issued colour-printed maps, which maintain the clearness of the earlier issues, the horizontal section at the foot of sheet 45 is a welcome innovation.

Where so much is given it were indeed ungracious to ask for more. In many respects the Reports are books of reference; the reader, therefore, would welcome the free use of headlines and the insertion of page references to the tables of contents which accompany the descriptions of each separately surveyed area. Reference figures and lettering on the diagrams and illustrations would be better if double, and in some cases treble the size, for they are sometimes so minute as to be scarcely legible, even under a hand-lens. Dip-arrows and figures on the black and white maps are also much too small and may easily escape notice. W. G.

VI.—The Pre-Glacial Flora of Britain.

In the Geological Magazine for 1888, p. 567, we reprinted a list of the plants then recorded by Mr. Clement Reid (Ann. of Botany, August, 1888) from the Pre-glacial, Inter-glacial, and Post-glacial deposits of Britain. The Pre-glacial plants were obtained from the Cromer Forest-bed, and the number then enumerated was 58. By his indefatigable labours, especially with regard to plant-seeds, he was enabled to increase the number of species to 78 in 1899, when he published his instructive work on "The Origin of the British Flora." With the aid, meanwhile, of an enthusiastic lady-geologist, his wife, Mr. Reid has almost doubled the number of plant-remains from the Pre-glacial deposits of the Norfolk and Suffolk coasts. No less than 147 are now recorded in a paper "On the Pre-Glacial Flora of Britain," read before the Linnean Society in June, 1907 (Journ. Linn. Soc. Botany, vol. xxxviii, 1908, p. 206). This paper is particularly valuable, not only on account of critical remarks on the species, and on the methods of preserving and identifying the seeds and fruits, but for the series of five photographic plates containing 181 figures of the species. In their concluding remarks Mr. and Mrs. Reid state that the plants "suggest climatic conditions almost identical with those now existing, though slightly warmer."

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 19*th*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Two Earth-Movements of Colonsay." By William Bourke Wright, B.A., F.G.S.[1]

[1] Communicated by permission of the Director of H.M. Geological Survey.

The supposed Torridonian rocks of Colonsay exhibit in their folding and cleavage the effects of two movements analogous in their results to those proved by Mr. Clough in the Cowal district of Argyll. Not only the planes of the first or slaty cleavage, but also the quartz veins formed along them have been folded by the second movement, and may be observed to be crossed at considerable angles by the cleavage produced during this second movement. An extensive series of lamprophyre dykes, obviously later than the first cleavage, are found to be folded and cleaved by the second movement. Moreover, some of these dykes traverse and are chilled against a mass of syenite, which can also be proved to be later than the first cleavage. The distinctness of these two movements is, therefore, considered to be completely established. The second cleavage being of the nature of strain slip, its development along the axial planes of the folds is of interest and is briefly discussed.

2. "Notes on the River Wey." By Henry Bury, M.A., F.L.S., F.G.S.

The part of the River Wey within the Wealden area is divided into six sections: (1) The consequent river cutting the Chalk at Guildford; (2) the subsequent stream coming in from the east at Shalford; (3) the western subsequent stream parallel to the Hog's Back; (4) the continuation of the last westward (the Tilford River), rising at Selborne and receiving many tributaries, including the Headley River, from between Blackdown and Hindhead; (5) the short obsequent section from Farnham to Tilford (the Waverley River); and (6) the portion above Farnham coming from Alton and beyond (the Farnham River). Part 1 deals with the relation of sections 6, 5, and 4 to the Blackwater. It is assumed that there was a consequent river coming down from Hindhead, flowing northwards along the "Waverley River," and joined by the Farnham, Tilford, and Seale rivers. This seems to have been the original head of the Blackwater. But subsequently capture took place by section 3 of the Wey, with the result that the Tilford River passed into the Wey basin, and section 5 was thus beheaded. The development of an obsequent stream near the course of the last eventually tapped the Farnham River, but not the Seale.

Part 2 deals with the Palæolithic Gravels of Farnham. Their height and distribution is discussed, with a view of determining the river which originated the gravels. The ridges constituted by the gravel drop to a lower platform along the Waverley River: this is regarded as the left bank of the consequent valley before that was beheaded. If this were the case, the gravel would have been formed by the Farnham River while still tributary to the Blackwater. At this time, too, probably the Headley tributary drained into the Farnham, and not the Tilford River, giving rise to the south-western portion of Alice Holt.

Part 3 deals with the Farnham branch of the Wey and the Alton district, which is remarkable in that there is a complicated series of Chalk valleys, which spread over some 50 square miles of country and discharge their waters into the Wealden area. One possible explanation is that this portion originally drained into the Whitewater over the present col of Golden Pot. In discussing this explanation, it appears that the Tisted tributary has the characters of a consequent stream; but there is no very good evidence, except alignment, of the former connexion of the two basins. On the other hand, the Farnham River rather appears to have originated in a Chalk surface than in Wealden beds; and thus it and its tributaries may have been developed on the Chalk portion of the peneplain of the Weald. Thus the Farnham stream appears to present a case of the conversion of a Chalk valley into a Wealden one in its lower part, while in the Caker stream the reverse is the case, and it is the upper part of the stream that has entered Wealden beds.

On April 1st, 1908, at 7·45 p.m., a Special General Meeting will be held, to consider the following resolution, signed by ten Fellows of the Society:—

"That the Council be requested to take the necessary steps, at an early date, in order to allow of the admission of women to full Fellowship of the Geological Society of London."

The following amendments to the foregoing resolution will be proposed and seconded:—

"That it is desirable that women should be admitted as Fellows of the Society, assuming that this can be done under the present charter."

"That a ballot of all the Fellows of the Society resident in the United Kingdom be taken to ascertain whether a majority is in favour of admitting women to the Society, and, if so, whether as Fellows or as Associates."

CORRESPONDENCE.

GLACIATED ERRATICS IN SCILLY.

Sir,—During September, 1907, Professor A. G. Nathorst and I made a flying visit to Scilly in order to see the very interesting deposit with striated erratics discovered by Mr. George Barrow. On St. Martin's Head, the highest point in the Isles, we obtained some additional evidence. When I formerly visited this spot in company with Mr. Barrow we did not succeed in tracing the striated erratics to a greater height than 100 feet above the sea, though we noticed unstriated fragments of a similar buff sandstone at higher levels. During this later visit Professor Nathorst and I worked slowly up the slope leading to the Beacon, turning over the boulders of sandstone half imbedded in the soil. We thus found that though at the higher elevations the exposed surfaces of this rock had all lost their striæ through the action of the weather, yet in every case the surfaces protected by soil were beautifully glaciated. We traced these erratics up and up, till we found an imbedded block at a level less than 20 feet below the highest point, which is marked 160 feet above Ordnance datum.

On returning to London I showed these striated masses of reddish or buff fine-grained sandstone to several of my colleagues, for I could not recognize them as belonging to any Cornish rock. Neither could my colleagues from South Wales identify them; but Mr. Lamplugh at once recognized them as exactly resembling the Upper Old Red Sandstone of the South of Ireland. This was an unexpected find; but as we know that during the Glacial Epoch glaciers in the South of Ireland descended to the sea-level and thrust long tongues into the Atlantic, there is nothing surprising that the icebergs calving off should drift over to Scilly and there be stranded. CLEMENT REID.

HAMPSTEAD.
February 26th, 1908.

OBITUARY.

EDMUND V. MOJSISOVICS, Sc.D.

BORN OCTOBER 18, 1839. DIED OCTOBER 2, 1907.

JOHANN AUGUST GEORG EDMUND MOJSISOVICS EDLER VON MOJSVÁR was born on October 18th, 1839, at Vienna. Matriculating at the University of Vienna in 1858, he there studied jurisprudence, and in 1864 graduated as a Doctor of Laws. While at the University he pursued also geological and geographical studies. An enthusiastic mountaineer, he was, when only 23 years of age, one of the founders of the Austrian Alpine Club, which was formed in 1862. From 1862 to 1865 E. v. Mojsisovics was Secretary of the Club, and in that capacity edited the first volume of their *Mitteilungen*, that appeared in 1863, and the first volume of their *Jahrbuch*, which was issued some two years later. Up to this time E. v. Mojsisovics was an ardent mountaineer, and contributed to the publications of the newly-formed club a number of articles on his mountaineering expeditions.

In 1865 E. v. Mojsisovics joined the Austrian Geological Survey as a volunteer, and during the summer months of that year was occupied in an investigation of the Ortler Alps. But his great physical exertions during these months brought on an affection of the muscles of the legs that not only confined him to his bed during the following winter, but prevented him from again attempting any particularly arduous climbing. Nevertheless, his health was so far restored during the summer of 1866 that in the months of August and September he was able, together with Professor Eduard Suess, to carry out geological investigations in the Salzkammergut. In 1867 Mojsisovics became officially attached to the Survey, being promoted in 1873 to the rank of Chief Geologist, and in 1893 to the position of Vice-Director, a position which he occupied until the year 1900.

In 1871 he married Charlotte Voelcker, the daughter of Georg Voelcker, a London banker.

During his thirty-five years' connection with the Austrian Geological Survey his work was almost exclusively confined to the Alps, at first in the Vorarlberg and the North Tyrol, later in the South Tyrol and the neighbouring parts of Venetia, but more especially in the Salzkammergut and the surrounding districts of Upper Austria, Salzburg, and Upper Steiermark. Only in the year

1879 did he for a time leave his work in the Alps in order to carry out some geological investigations in Bosnia and Croatia.

He retired from the Geological Survey in 1900, and went to reside near Mallnitz, in Carinthia, a village picturesquely situated at a height of about 3,800 feet on the Mallnitzer Tauern, one of the southern extensions of the Hohe Tauern. But his retirement amidst the mountains which he loved so well was not for long, for on the morning of the 2nd of October he succumbed to a most painful affection of the tongue and throat from which he had suffered for some time past.

Notwithstanding the amount of the field-work which Dr. E. v. Mojsisovics had accomplished, he was also a most prolific writer, being the author of some one hundred and fifty works, some, especially his palæontological memoirs, being of considerable size. His first important work seems to have been one "Über die alten Gletscher der Südalpen," that appeared in 1863 in the publications of the Austrian Alpine Club, in which he proposed to substitute for the threefold division of Alps a twofold subdivision into the Western and Eastern Alps as being the more natural one, a view which is now generally adopted. Perhaps one of his most important geological works was that entitled "Die Dolomitriffe von Südtirol und Venetien," which appeared during the year 1878; his researches here showed that these enormous masses of dolomite, the remains of Triassic coral reefs, included the faunas of several distinct Triassic horizons.

Another large work, a geological monograph of the Salzkammergut, unfortunately remains unfinished. Only a short stretch of the geological relationships of this district was contributed by E. v. Mojsisovics to Dr. Diener's work entitled "Bau und Bild der Ostalpen," which appeared in 1903. Of the monograph itself, which was to have appeared under the title "Das Gebirge um Hallstatt," only the palæontological part, bearing the title of "Die Cephalopoden der Hallstätter Kalke," has been published. This, however, is an enormous work; it forms Band vi of the "Abhandlungen der k.k. geologischen Reichsanstalt." The first part, with the sub-title "Die Mollusken-Faunen der Zlambach- und Hallstätter Schichten," but dealing only with the Cephalopoda, was issued in three sections, of which the first (pp. 82; 32 plates) appeared in 1873, the second (pp. 92; 38 plates) in 1875, and the third, forming a supplement (pp. 182; 23 plates), so late as 1902, the whole making a volume of some 356 pages and 93 plates. The second part of "Die Cephalopoden der Hallstätter Kalke" appeared in 1893; it is in two volumes consisting of 835 pages of text and 130 plates, and contains descriptions of more than 700 species. In the meantime, however, E. v. Mojsisovics issued several important works. Thus, in 1882 he published his work on "Die Cephalopoden der Mediterranen Triasprovinz" (Abhandlungen der k.k. geologischen Reichsanstalt, Bd. x), a large volume comprising 322 pages of text and 94 lithographic plates. But E. v. Mojsisovics did not confine his attention to the Triassic fauna of the Alps; in 1886 his memoir on the "Arktische Triasfaunen" (pp. 157; 20 plates) was issued by the Imperial Academy of Sciences of St. Petersburg, the same Academy publishing some two years later his memoir "Über einige arktische Trias-Ammoniten des nördlichen Sibirien" (pp. 22; 3 plates). In the same year appeared his work "Über einige japanische Trias-Fossilien" (Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients, Bd. vii, pp. 163–178; 4 plates). Having published some preliminary remarks on the Cephalopod faunas of the Himalayan Trias in 1892, his "Beiträge zur Kenntnis der obertriadischen Cephalopoden-Faunen des Himalaya" was published by the Vienna Academy in 1896 (Denkschr. d. kais. Akad. d. Wissensch., math.-naturw. Kl., Bd. lxiii, pp. 575–702; 22 plates), an English translation of the work appearing in 1899 in the *Palæontologia Indica* (series xv, Himalayan Fossils, vol. iii, part 1).

Probably there is no one to whom we are more indebted for our knowledge of the Triassic rocks and of their Cephalopod faunas than to Dr. E. v. Mojsisovics, the zoning of the Triassic rocks being in a very great measure, in fact almost entirely, due to his researches.

He was the recipient of many honours and distinctions, the University of Cambridge conferring upon him in 1884 the degree of Doctor of Science (*honoris causa*). He was also a member of many learned societies, including the Geological Society of London, of which he was elected a Foreign Member in 1893.

GENERAL SIR RICHARD STRACHEY, R.E., G.C.S.I., LL.D., F.R.S.

Born July 24, 1817. Died February 12, 1908.

This distinguished officer, who was born at Sutton Court, Somerset, was engaged in important military and engineering works in India from 1836 until 1871. The construction of irrigation works, canals, and railways was varied by active military service, Strachey having taken part in the first Sikh war; but while his energies were concentrated mainly on the practical applications of science, he was greatly interested in botany, meteorology, geology, and physical geography. Thus he utilized his opportunities, when engaged in topographical surveys, of making observations on the glaciers of the borders of Tibet and on the geology of the Himalayas; and the results were communicated to the Geological Society and published in vols. vii and x of the Quarterly Journal. He was a member of the Council of the Society during the years 1853–5, and again in 1866–7; and President of the Royal Geographical Society from 1887 to 1889. During the later years of his life General Strachey served at times on the Council of the India Office.

REV. THOMAS WILKINSON NORWOOD, M.A., F.G.S.

Born 1829. Died January 26, 1908.

The Rev. T. W. Norwood, formerly of Cheltenham, and for some years a member of the Cotteswold Naturalists' Club, was appointed Vicar of Wrenbury in Cheshire in 1878. There he remained for twenty-nine years, when he retired to Snaith in Yorkshire, and died January 26th, 1908, at the age of 79. During his residence in

Gloucestershire he formed a large collection of Liassic and Oolitic fossils, among which were many remarkably fine examples of *Hippopodium ponderosum*, *Terebratula simplex*, and *T. plicata.*

We regret to record the death of Dr. H. C. Sorby, F.R.S., Past President of the Geological Society, which occurred at his residence, 6, Beech Hill Road, Sheffield, on Monday, the 9th March, in his 82nd year. We shall write more fully of Mr. Sorby's work in our May Number.

MISCELLANEOUS.

Natural Caverns in Chalk.

In a paper on the Chalk published in the *Rochester Naturalist* (see vol. iii, 1907, pp. 466, etc.) Mr. S. Sills draws attention to the natural chambers or caverns that have occasionally been encountered in well-sinkings or borings in the Chalk. Thus Prestwich mentioned a cavern that was proved in the Chalk at a depth of 270 feet below the surface at Knockholt, near Sevenoaks. It was 30 feet long by 12 feet wide and 18 feet high, with a stream of water running through it.

Beneath the city waterworks at Strood, near Rochester, a natural chamber was discovered in 1879. The cavern was found to be roughly Z-shaped on plan, the stem of the letter lying in the line of a fault from north to south. The upper arm was 28 feet long and 10 feet wide, with a height of from 12 to 17½ feet; it appeared to terminate in a tunnel-shaped fissure. The stem measured 16 feet in length, with a width of 9 to 12½ feet. The lower arm was 18 feet long and from 3 to 10 feet in width, ending in a large fissure which extended from floor to roof.

Later excavations proved the fissure of the upper arm to be much more extensive, and in 1903 it was explored to a distance of 130 feet from the cavern, and was found to be 4 or 5 feet wide and 5 to 6 feet high. The floor was paved with a layer of tabular flint; and the sides were scored, and in many places deeply undercut, by the action of flowing water. The [illegible] would appear to have found its way primarily along the flint [illegible]d, being intercepted by the fault, was diverted to the big fissure where it found exit to the river. The level of the flint layer is about one foot above low-water mark of ordinary tides in the Medway, and the rise of the waters to 17 or 18 feet above this level would pen up the stream until the ebb released the waters. Fine sand and clay washed down, from strata overlying the Chalk, through pipes and fissures, gradually silted up the stream bed. The force of the stream being insufficient to remove this silt, a fresh passage was carved out above it in chalk already softened by the water's action. This process was repeated until the present result was obtained.

It was observed that at various points, where deviations in direction took place, there were enlargements of the passage-like chambers; and that the excavation was both horizontal and vertical, while the roof was drilled deeply, as if by a tool, in many places.

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., Dr. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

MAY, 1908.

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Yours very truly
H. C. Sorby

THE

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No. V.—MAY, 1908.

ORIGINAL ARTICLES.

I.—Henry Clifton Sorby, and the Birth of Microscopical Petrology.

(WITH A PORTRAIT, PLATE VIII.)

JUST half a century ago, the Geological Society was engaged in passing through the press a very remarkable memoir—a memoir that was destined to revolutionize one of the branches of the science which the Society had been founded to promote. Yet on its appearance this memoir, "On the Microscopical Structure of Crystals," was met with ridicule on the part of some, with scepticism by others, and by a neglect that was almost universal. Nevertheless, its author, Mr. Sorby, lived to find Microscopical Petrography recognised all the world over as one of the most important branches of geological science, to see appearing year by year an enormous mass of literature devoted to this branch of science, and to be himself hailed by the geologists of all lands as the pioneer in this new and fruitful field of scientific research.

It is an interesting task to trace the movements of the master mind in the various stages of the evolution of this new scientific method; and this task has become a duty inasmuch as very misleading statements on the subject have obtained a somewhat wide currency. It is a fortunate circumstance that Sorby has himself left us a number of autobiographical reminiscences[1] which enable us to trace the gradual development of new methods and fruitful ideas, and at the same time to remove prevalent misconceptions on the subject.

The family of Sorby (or Sowerby) is one having many offshoots in Yorkshire, and the particular branch to which the geologist belonged is said to have been established in Sheffield ever since the time of Henry VIII. Sorby's father was a partner in a firm of edged-tool manufacturers and a colliery proprietor, who resided at Woodbourne, then an outlying country house, but now enclosed in the busy district

[1] "Unencumbered Research: A Personal Experience," by H. C. Sorby; one of a volume of "Essays on the Endowment of Research," published in 1876 (pp. 149–175). "Fifty Years of Scientific Research": an address delivered before the Members of the Sheffield Literary and Philosophical Society, at Firth College, on Tuesday, February 2nd, 1897.

of Attercliffe. At this house Sorby, who, I believe, was an only child, was born on May 10th, 1826.

When about seven years of age the boy was sent to a dames' school at Harrogate, and here I may notice a curious coincidence not without interest to geologists. Young Sorby became the playfellow of another child residing in the same town, whose father was part-proprietor with the Sorbys of the Orgreave colliery a few miles away from Sheffield. The children parted in 1834, not to meet again for forty-four years, when Sorby had become President of the Geological Society, and the other lad, Mr. W. H. Hudleston, one of the leading workers in the geological world. The two playfellows both grew up to be Presidents of the Geological Society and recipients of the Wollaston Medal.[1]

After leaving Harrogate, Sorby went to the Collegiate School (now the Grammar School) of Sheffield, where he tells us that he received a prize entitled "Readings in Science," which had a large share in directing his mind into the channel of scientific research. A still more important influence was exercised, however, by the instructions of a mathematical tutor under whom he was placed on leaving school. This tutor, the Rev. Walter Mitchell, who is known as the author of a treatise on Crystallography published in Orr's "Circle of the Sciences," and some original papers on the same subject, had been a medical student, and was able to instruct Sorby both in Chemistry and Anatomy. At a very early age Sorby seems to have made up his mind to devote his life to scientific research, and to this end he tells us that, besides studying various branches of science, he laboured to make himself proficient in drawing and the representation of objects in colour. From the very first, Sorby appears to have set his face against any attempt to obtain academic distinction or the passing of examinations. To have a well-trained and untrammelled mind in a healthy body was always the one object of his ambition.

Sorby constantly maintained that the true atmosphere for a life of scientific research could only be obtained by leisure and mental quiet, and a complete absence of those pressing cares incident to a business or profession. His own circumstances were particularly fortunate ones, for he succeeded to a moderate but easy competence. In 1876 he writes: "Original research can be carried on in a satisfactory manner only when an investigator has abundance of time for work, and freedom from those cares that interfere with reflection. I am thankful to say that complete immunity from such routine employment" (a business or profession) "has been my own happy lot. My entire life has been spent either in scientific research or in preparation for it." ("Unencumbered Research," pp. 149–150.)

An additional advantage enjoyed by Sorby was that of being, like Darwin, free from the important, though often harassing, duties connected with scientific societies and similar organisations. The

[1] I am indebted to my friend Mr. Hudleston for information upon which the above statements are based, and he also tells me that the Orgreave property is in the district rendered famous in Scott's "Ivanhoe."

cause of this was not, as in Darwin's case, ill-health, but a perhaps over-scrupulous devotion to a widowed mother who begrudged the time that might have been lost by frequent visits to London. During his mother's life Sorby was accompanied by her on all his summer expeditions, and, indeed, he seldom, if ever, left Sheffield without her.

When only 20 years of age Sorby commenced his scientific publications by a paper on Agricultural Chemistry, which was read at the Chemical Society in December, 1846.[1] This paper was based on 132 determinations of sulphur and phosphorus, made by himself, in different crops. Very soon, however, his attention was directed to a subject which all through his life had a great fascination for him, namely, the mode of deposition of sedimentary deposits, and the conclusions that may be derived from their study. The gardens of the house at Woodbourne ran down to the River Don, and here he carried on various experiments on the flow of water and the deposition of sediment. He tells us, too, that one day, while walking out to Orgreave, he was caught in a shower of rain, and whilst sheltering in a quarry near Handsworth his attention was directed to the current-structures exhibited in the sandstone rocks. For these structures he proposed a new classification, and he also prepared a map of the Rother and Don to illustrate the changes in the courses of these rivers.[2] (See "Fifty Years of Scientific Research," p. 4.)

Sorby has told us in very explicit terms how his mind was first drawn to the study of rocks—by means of thin sections for examination under the microscope—at a date long anterior to the publication of the epoch-making paper we have alluded to at the commencement of this article. After stating that at a very early date he was attracted to the study of the shells in the Bridlington Crag, and that he employed the microscope in their study, he says that he had made the acquaintance of William Crawford Williamson, while they were both very young and were journeying together from Scarborough to York. Williamson was an adept in the preparation of sections of hard substances for microscopical study. His maternal grandfather and uncle (the Crawfords) were skilful lapidaries, and young Williamson in his youth learned the use of diamond- and emery-wheels and the general art of the lapidary. (See "Reminiscences of a Yorkshire Naturalist," 1896, pp. 5–6.) Sorby says that he was led to visit Williamson at Manchester some time between 1842 and 1849, and "found him making sections of fossil wood, teeth, scales, and bones. He showed me how to prepare them, and on my return home I made similar sections. It occurred to me, as early as 1849, that a great deal might be learned by applying a similar method to the study of the structure of rocks, and I show

[1] Chem. Soc., Mem. iii (1845–8), pp. 281–284; Phil. Mag., xxx (1847), pp. 330–334.

[2] Sorby's papers on these subjects will be found in Sheffield Lit. and Phil. Soc. Rep., 1847, Aug. 6, Dec. 3; 1848, March 3; 1850, p. 13. Proc. W. Yorks. Geol. Soc., iii (1851), pp. 220–224; (1852), pp. 232–240; ibid., vii (1854), pp. 372 et seq. Proc. Yorks. Phil. Soc., i (1855), pp. 372–378. Brit. Assoc. Rep. (1855), pt. 2, pp. 97–98; (1856), p. 77. Sheffield Lit. and Phil. Soc. Rep. (1858), p. 9. Brit. Assoc. Rep. (1858), pt. 2, p. 108. *Geologist*, vol. ii (1859), pp. 137–147, etc.

a slide prepared from what is probably the first transparent microscopic section of a rock ever prepared, and also exhibit another slide from the first drawing of the structure made in 1849."[1] He goes on to relate: "My first published paper in connection with the structure of rocks was in relation to an interesting deposit called the Calcareous Grit, below the Castle Rock at Scarborough. I wrote a paper, sent it to the Geological Society, and it was published by the Society in 1850. That paper was the first of its type, and it is interesting to refer to it because at that early date I had developed almost all the methods that are employed even up to the present day in studying the microscopic structure of rocks." ("Fifty Years of Scientific Research," p. 5.)

This early paper seems never to have attracted the attention it deserved. That Sorby's estimate of its importance is not by any means exaggerated will at once appear upon a perusal of it. Sorby separated the constituents of the rock both by mechanical and chemical methods; he determined the proportions of these constituents to one another, measuring their particles down to the $\frac{1}{20000}$ of an inch; he prepared sections of the rock, little more than $\frac{1}{1000}$ of an inch thick, finding it necessary to make some of these sections of large size; and not only did he employ very high powers of the microscope, but he used polarized light, both parallel and convergent, and showed their use in distinguishing between calcite, quartz, and chalcedony.

This little memoir, which was read before the Geological Society on November 6th, 1850, gave, in fact, a remarkable forecast of the methods and modes of reasoning which have brought microscopical petrography to its present position as a branch of geological research. The paper, as published in the Quarterly Journal of the Geological Society (vol. vii, pp. 1–6), was without illustrations, but a plate with some of Sorby's own drawings was published in the Proc. W. Yorks. Geol. Soc., iii (1851), pp. 197–206.

Sorby continued all through his life this work on the structure of limestones and other sedimentary rocks, being led especially to note the part played by calcite and aragonite, and the wonderful pseudomorphic changes going on in calcareous deposits. To this subject he devoted his two addresses to the Geological Society in 1879 and 1880, and his latest memoir, completed on his deathbed, was a further exposition of the problem.

But Sorby's studies were not by any means confined to the calcareous rocks. He informs us that Daniel Sharpe's writings directed him in 1851 to the study of slaty cleavage, and of his work in this direction he writes as follows:—"For some time I had been occupied with the study of the microscopical character of rocks possessing slaty cleavage, a problem which had previously attracted much attention, but was still involved in so much obscurity that several theories, all equally unsatisfactory, had been propounded. The more I studied the microscopical structure of these cleaved rocks, the more was I puzzled with the observed facts. One day when quietly walking in my garden and

[1] We understand that these early sections and drawings are to be preserved in the City Museum at Sheffield.

reflecting on things in general the simplest possible explanation of the whole flashed across my mind. I immediately went to my work-room, mixed some small pieces of coloured paper with wet pipeclay, and on compressing them in the manner that slate rocks are proved to have been compressed, I found that I obtained a very good representation of the characteristic structure on which their cleavage depends. From that moment forwards the whole theory of cleavage took a new shape in my mind, and after studying by experiment, with the microscope and in the field, those facts which this new hypothesis indicated as important, in a few years I had the satisfaction of finding that it was universally accepted as a satisfactory explanation of one of the great phenomena of geology." (Essay on "Unencumbered Research.")

When Sorby brought forward his theory of slaty cleavage it was met, as he informs us,[1] with great opposition on the part of those in authority, and in consequence of this opposition he withdrew the paper which he had sent to the Geological Society, and forwarded it to the Edinburgh Philosophical Journal.[2]

The study of the microscopical structure of slates naturally led to the examination, in the same way, of the schists, and after some years of work upon them Sorby published his papers on mica-schist, in which he enunciated his theory of stratification- and cleavage-foliation.[3] It is worthy of note that in these papers he shows that he was already alive to the great importance of studying the nature of the cavities contained in the crystals of rocks, and the substances which they contain. In his paper on mica-schist he proved that some cavities contain water, and in a paper published about the same time on the Magnesian Limestone[4] he indicated that the cavities contain aqueous solutions. It was at a later date (1869) that he proved carbon dioxide in a liquid state to be present in some of these cavities.

It will be seen from the above account that Sorby's work in microscopic petrography commenced in 1849, was carried on by him continuously down to 1856, and, therefore, that the statements which have been made that in the year 1856 he first learned how to cut sections from rocks from Alexander Bryson, who had in turn been taught by William Nicol,[5] have no foundation in fact.

Everyone will acknowledge the valuable work done by the ingenious William Nicol in preparing the sections of fossil wood for Witham's work on the subject. I am not aware, however, that Nicol anywhere claims to have invented the method. Alexander Bryson, indeed, in

[1] "Fifty Years of Scientific Research," pp. 5–6.

[2] Edinb. New Phil. Journ., lv (1853), pp. 137–150; Proc. W. Yorks. Geol. Soc., iii (1853), pp. 300–311; Phil. Mag., xii (1856), pp. 127–129. In 1876 I induced Sorby to exhibit some of the artificial products and specimens on which he based his conclusions concerning slates and schists to the Loan Exhibition of Scientific Objects, and these are still to be seen in the Science division (Geological Section) of the Victoria and Albert Museum, South Kensington.

[3] Brit. Assoc. Rep. (1856), pt. 2, p. 78; Edinb. New. Phil. Journ., 2nd ed., iv, p. 339.

[4] Brit. Assoc. Rep. (1856), pt. 2, p. 77.

[5] "The Founders of Geology," 1st ed. (1897), pp. 276–280, and 2nd ed. (1905), pp. 462, etc. "The History of the Geological Society of London" (1907), pp. 170–172.

a paper written in 1856, states, "The method of preparing fossil woods and other inorganic substances for examination under the microscope had its origin in this city" (Edinburgh). "But as the claims of two or three eminent individuals (all deserving praise) are mingled in this improvement, I refrain from considering them." [1] As a matter of fact, Brewster employed thin sections of minerals before 1816, and many anatomists made transparent sections of bones and teeth at a very early period. Sorby, as we have seen, tells us that Williamson,[2] who had learnt the lapidary's art as a boy, and was a pupil of Sharpey in London, taught him, in 1849, how to make sections of hard substances, and that he himself perceived the importance of applying the method to the study of rocks. Bryson informs us that he showed his own and Nicol's collections of sections to Sorby in 1856; but after the latter had published his important paper in 1858 Bryson wrote to dispute his conclusions in a paper on the "Aqueous Origin of Granite." [3]

The manner in which Sorby was led from the study of limestones, slates, and schists to that of the igneous rocks has been well described by himself. After stating that the physical conditions under which certain kinds of rocks are formed at a great distance below the surface of the earth had constantly engaged his attention, he says: "Their microscopical structure had been most puzzling. The evidence of igneous fusion and of the presence of liquid water were about equally strong, and for some time it seemed difficult to adopt any theory which assumed either igneous or aqueous origin of such minerals and rocks. All at once the correct explanation flashed upon me. Both igneous and aqueous action must have occurred more or less simultaneously, and the facts which I published have, as I believe, had no small share in causing such a theory to be almost universally accepted by geologists." ("Unencumbered Research," pp. 158–159.)

Sorby's epoch-making memoir was read at the Geological Society on December 16th, 1857, under the title "On some Peculiarities in the Microscopical Structure of Crystals, applicable to the determination of the Aqueous and Igneous Origin of Minerals and Rocks." [4] His account of what took place on that occasion is very interesting. He says: "My late good friend Leonard Horner was the chairman, . . . after I had read this paper he said he had been a member of the Geological Society ever since its foundation, and during the whole of

[1] Edinb. New Phil. Journ., iii (1856), pp. 297–308.

[2] William Crawford Williamson had almost as versatile a genius as Sorby himself. At a very early age he originated, by his study of the Yorkshire cliff-sections, the zonal classification of strata by the aid of their fossils. At a subsequent date he led the way in this country to the study of the Foraminifera and the microscopical characters of their shells. All the later years of his life were devoted to the study of coal-balls, and to the important results of fossil botany that this study originated. Yorkshire may well be proud of having produced in a single generation two such men as Williamson and Sorby!

[3] Edinb. New Phil. Journ., xv (1862), pp. 52–53.

[4] The paper, which was published in November, 1858, and was illustrated with three plates of interesting drawings made by Sorby himself, appeared under the title "On the Microscopical Structure of Crystals, indicating the Origin of Minerals and Rocks": Quart. Journ. Geol. Soc., vol. xiv, pp. 453–500.

that time he did not remember any paper having been read which drew so largely on their credulity. But very fortunately I had taken some microscopes and objects with me and had shown them to my friend Professor Phillips, of York. He got up and said the chairman might speak as he had done, but he had nothing to do but look through the microscopes and see that such things existed, and they might depend on it, in a few years, the facts that Mr. Sorby had described would be universally acknowledged to be correct, which has turned out to be true." ("Fifty Years of Scientific Research," p. 9.)

In spite of John Phillips' characteristically generous intervention, Sorby's paper did not for a long time gain the attention which it deserved. Sorby says himself: "In those early days people laughed at me. They quoted Saussure, who had said that it was not a proper thing to examine mountains with microscopes, and ridiculed my action in every way. Most luckily I took no notice of them." ("Fifty Years of Scientific Research," p. 5.)

It was in Germany and on the part of Dr. Ferdinand Zirkel that Sorby's work was destined to find full and complete recognition. The story has been so well told by Fouqué, the account being endorsed by Zirkel himself, that we cannot do better than to quote it.

"En 1862 il [Sorby] avait entrepris avec sa mère un voyage d'agrément sur les bords du Rhin. Arrivé à Bonn, il fit connaissance d'un élève du corps des mines de Prusse, nommé Zirkel, par lequel il fut accompagné et dirigé dans quelques excursions. Ils visitèrent ensemble l'Eifel, le Siebengebirge, et les environs du lac de Laach. Chaque jour, chemin faisant, une conversation intéressante et animée s'engageait entre le touriste et son guide sur la nature des roches volcaniques, sur les minéraux qui les composent, et sur les merveilleux détails de structure que le microscope y révéle. Sorby exposait avec clarté et chaleur les magnifiques résultats de ses études. Le soir, après l'excursion de la journée, l'entretien se prolongeait encore. Enfin, de retour à Bonn, le maître emprovisé mit sous les yeux de son jeune auditeur quelques préparations microscopiques qu'il avait apportées, et lui fit apprécier par lui-même la netteté et l'importance des faits qui avaient été l'objet de leurs longues causeries. Quelques jours plus tard, en quittant Zirkel, il laissait en lui un disciple enthousiaste, qui, désormais sa consacrant entièrement aux études de géologie micrographique, allait bientôt dans cette voie marcher de découvertes en découvertes, grouper autour de lui un essaim de travailleurs, et devenir l'un des savans les plus célèbres de l'Allemagne."[1]

So much in earnest was Zirkel that he at once proceeded to the laboratory of the Reichsanstalt at Vienna, and as the result of his work during the winter prepared a memoir only second in importance to Sorby's own paper. This paper, containing descriptions of the microscopical characters of thirty-nine very typical rocks, was read before the Vienna Academy[2] on March 12th, 1863. With splendid

[1] *Revue des deux mondes*, July 15th, 1879, p. 409.

[2] "Mikroskopische Gesteinstudie": Sitzungsb. d. k. Akad. d. W. math. naturw. Cl., Bd. xlvii, Abth. 1 (1863), pp. 228–290.

energy Zirkel continued his labours in the new field of research, and published in succession a number of valuable papers in which minerals like leucite, nepheline, apatite, sphene, etc., were recognised as rock-constituents; and he found a worthy coadjutor, as enthusiastic as himself, in his brother-in-law, Hermann Vogelsang, whose "Philosophie der Geologie und Mikroskopische Gesteinstudien," published in 1867, and illustrated by descriptions and beautiful drawings of rock-sections, did much towards making the new method of research widely known. Investigators like Heinrich Fischer, Tschermak, Doelter, Von Lasaulx, and many others took up the work, and numerous papers on the subject were published. In 1873 microscopical petrography may be said to have become established as a recognised department of geological science by the publication of two very important works. Zirkel, himself, gave to the world his "Mikroskopische Beschaffenheit der Mineralien und Gesteine," full of very detailed descriptions of the minute characters of minerals and rocks, while Heinrich Rosenbusch, in his "Mikroskopische Physiographie der petrographische wichtigen Mineralien," developed the optical principles on which mineral determinations must be made by the aid of the microscope. The publication in 1877 of Rosenbusch's "Mikroskopische Physiographie der massiger Gesteine," and in 1879 of Fouqué & Michel-Lévy's "Minéralogie micrographique des roches éruptives françaises," with its magnificent atlas of plates, followed by the numerous memoirs of these two authors, and by Lacroix, showed how abundant was the harvest which had sprung from the seed sown by Sorby in 1850.

It has often been remarked as strange that Sorby did not himself do more in cultivating the field of research which he had so happily discovered. It is true that he never lost his interest in the subject, as was shown by numerous papers on the structure of the sedimentary rocks, on new applications of the microscope, on the determination of the refractive index of minerals, and of the position of the axes of double refraction, and the study of meteorites, slags, and artificially fused rocks. But it was the characteristic of Sorby's mind always to seek for new veins of research rather than to bury himself in mines in which he had already broken ground.

In 1898, when receiving a portrait presented by his fellow-townsmen, he said: "The first thing is to find out some new subject or other, and open out some new line of investigation which is enough to occupy one all one's life. The difficulty is to avoid discovering new things and at the same time to work up old. I suppose that will go on to the end of the chapter, and I do not know that in doing so I am doing wrong, because possibly it is better to invent new things than to work up old ones thoroughly." These words exactly express the dominant sentiment in Sorby's mind during his whole life.

I fear that it must be confessed that, in the land of its birth, the new science of microscopical petrography made its way to the front much more slowly than in Germany. Sorby, it is true, almost from the first, found a trusty henchman and doughty champion in David Forbes, who at the Geological Society and elsewhere was always ready to take up the cudgels in Sorby's defence when, as was frequently the case, the new method was assailed or ridiculed. But Forbes wrote little on the subject except his paper on the Igneous Rocks of South Staffordshire in 1866,[1] and some articles in popular journals, describing the method and its application. He made an extensive collection of some thousands of rock-sections, however, which is now preserved in the Manchester University.

In 1864 I went to Sheffield to take charge of a Chemical Laboratory in that town, and had the great privilege and pleasure of making the acquaintance of Sorby. He had then just been led by the study of meteorites to devote his attention to the microscopical character of irons and steels—a research as pregnant with results of technological value as his earlier work has been prolific in scientific developments. I was able to supply him with analysed specimens for his work, and he in return taught me to make and use microscopical sections of rocks. It is interesting to recall the simple methods he employed in those days. A chip broken from the rock to be studied was roughly reduced to a flat-sided fragment, by the aid of a grindstone of coarse sandstone. The subsequent work was done by cementing on a little square of plate glass, and then rubbing on laps with emery and afterwards on hone-stones. Sorby had an amusing faith in the virtue of the skin of his thumb for putting a final polish on the sections!

After joining the Geological Survey in 1867, I sought to utilize the methods taught me by Sorby, and prepared a paper on the "Origin of the Northampton Sand," which was read at the Geological Society on March 16th, 1869; it was there very kindly received and ordered to be printed. But the permission to publish was afterwards withdrawn by the authorities, and the paper did not appear till six years afterwards, when it was printed, but without illustrations, in the Survey Memoir I wrote on the Geology of Rutland (1875). Two others of my colleagues at that time, James Clifton Ward and Frank Rutley, also devoted themselves to microscopic work, but with little more encouragement than myself.

In 1869 Samuel Allport commenced his valuable series of papers on Microscopical Petrography, and in the following year John Arthur Phillips followed suit. Allport led Professor Bonney to take up the subject, and I need only refer to the great work accomplished by himself and his numerous pupils, as establishing the use of the method in this country.

It may be interesting, in concluding this sketch of the history of the origin of Microscopic Petrography, to state that, 58 years after the publication of Sorby's first paper on the subject, the geologists of all lands, who had assembled to celebrate the Centenary of the Geological Society, determined to send their greetings to the veteran investigator to whom they owed so much, and who then lay on his deathbed. Professors Iddings, of Chicago, and Loewinson-Lessing, of St. Petersburg, requested Professor Zirkel and myself, as Sorby's oldest friends, to draw up an address to him, and this was signed by the President of the Society and those who had specially devoted themselves to Microscopical Petrography. The following is a copy of the address:—

[1] Geological Magazine, Vol. III (1866), pp. 23–27.

"To the Father of Microscopical Petrography.

"We the undersigned, assembled to celebrate the Centenary of the Geological Society of London, desire to unite in expressing our profound conviction of the important service rendered to the branch of science which they cultivate by Dr. Henry Clifton Sorby. They deplore the circumstances which prevent him from joining them on this occasion, but beg to be allowed to assure him of their great admiration of his life's work, of their filial regard, and deep affection. They rejoice to know that he still finds consolation and happiness in his labours of love in connection with the promotion of scientific research and education.

"Arch. Geikie, P.G.S.

F. Zirkel, Leipzic.	J. W. Judd, Kew.
W. J. Sollas, Oxford.	J. P. Iddings, Chicago.
W. L. Brögger, Kristiania.	T. G. Bonney, Cambridge.
Whitman Cross, Washington, D.C.	F. Loewinson-Lessing, St. Petersburg.
Frank D. Adams, Montreal.	A. Harker, Cambridge.
F. W. Rudler, London.	T. McK. Hughes, Cambridge.
H. Arnold Bemrose, Derby.	J. W. Evans, London and Bolivia.
A. Wichmann, Utrecht.	Grenville A. J. Cole, Dublin.
A. Lacroix, Paris.	F. H. Hatch, Johannesburg.
H. A. Miers, Oxford.	J. W. Gregory, Glasgow.
J. S. Flett, London.	G. T. Prior, London.
J. J. H. Teall, London.	Hans Reusch, Kristiania.
C. Barrois, Lille.	C. Vélain, Paris.
G. F. Becker, Washington, D.C.	W. W. Watts, London."

From the dinner given to the assembled geologists by the Geological Society Club at its Centenary Meeting a telegram of recognition and condolence was also sent to their veteran associate, confined to a sick-room, and these marks of esteem and affection afforded him intense pleasure.

Many other problems of geological science were attacked by Sorby, during his long and busy life, with more or less success. Among these we may notice the pseudomorphous origin of the Magnesian Limestone and Cleveland Ironstone, the nature of the Coccoliths in the Chalk, the origin of Cone-in-cone structure, the mode of formation of impressed pebbles, many questions connected with denudation and the deposition of rocks, the formation of river terraces, and practical enquiries with respect to water supply and the contamination of rivers by sewage. Even in those cases where his solution of difficulties may not produce conviction in the minds of the readers of his papers, they cannot but be impressed by the ingenuity of the methods of inquiry which he devised.

But Sorby's work was by no means confined to geology. Scarcely any branch of knowledge or question of scientific interest escaped his attention. The use of the spectroscope in connection with the microscope; the nature of the colouring matters in blood, hair, foliage, flowers, bird's eggs, and minerals; meteorological problems of all kinds; improvements in blowpipe analysis and in the methods of detecting poisons, were among the subjects treated of in papers written by him between 1860 and 1879. In this latter year, after the death of his mother, Sorby, who had removed from Woodbourne to Broomfield in Sheffield in 1853, bought a yacht, and from that time forward spent nearly half the year on the water. His yacht, the "Glimpse," was, however, nothing but a floating study and laboratory, which enabled him to widen the sphere of his researches and find new fields of investigation. Archæological studies among the churches of East Anglia; the evolution of mythical forms of animals in ancient church architecture; Roman, Saxon, and Norman structures, and the bricks employed in each of them, were among the subjects which engaged his attention; while enquiries among old manuscripts in the British Museum, the collection of ancient books and maps, and the study of Egyptian hieroglyphics were among his amusements. His short cruises around the coast were devoted to the collection of marine plants and animals, the preparation of catalogues showing the distribution of the marine flora and fauna, and the devising of methods for preserving plants and animals with their natural colours and exhibiting them as transparent objects; and in this he attained a remarkable success.

Those who had the pleasure of knowing Sorby in his home at Sheffield or on board his yacht can never forget the simple and lovable character of the man, and the devotion shown to him by his servants and sailors. The almost hermit-like seclusion of his earlier years had fostered many little amiable eccentricities in his habits, but his enthusiasm for science, his capacity for work, and his generous recognition of the labours of others were always conspicuous. Although, as we have seen, his great work in originating Microscopic Petrography received little notice for nearly twenty years, yet afterwards his labours were fully recognised. The Wollaston Medal of the Geological Society in 1869, the Boerhaave Medal in 1872, a Royal Medal in 1874, and the presidency, in succession, of the Microscopical, Mineralogical, and Geological Societies, with a doctor's degree given him by Cambridge, were among the honours which he received, while many foreign societies were proud to enrol him among their members.

Sorby was ever loyal to his native town of Sheffield, and was a warm supporter of its scientific and educational institutions. And Sheffield was justly proud of Sorby. It has been well said that what Priestley was to Birmingham, and Dalton and Joule to Manchester, Sorby was to Sheffield. From his youth up, he was a leading spirit at the local Chemical Society, the Sheffield Literary and Philosophical Society, and the West Yorkshire Geological Society. To the founding of Firth College in 1883 and its development into a University College, and finally into the University of Sheffield, he contributed unstinted labour as well as liberal support. By his will he not only enriches the City and University Museums with his valuable collections but also founds a Chair of Geology in the Sheffield University.

The long and active life of research, during which nearly 250 papers[1] issued from his pen, found a fitting conclusion. In the Autumn of 1903, after returning from his Summer's cruise, he had a fall which produced partial paralysis. For many months he was unable to move himself in bed, but, bright and cheerful as ever, he enlisted the aid of his nurses, and continued his labours and the calculations based on five years observations, writing with pencil while lying on his back. For a time he recovered so far as to be able

[1] An almost complete list of these papers has been published in the *Naturalist* for 1906; it was revised by Sorby himself.

to be wheeled about his room, and even to be carried into his garden and to be taken for carriage drives, but in January, 1906, he broke his leg, and was again entirely confined to his bed. The numerous pencilled letters that I received at this time showed unabated cheerfulness and delight in his work. On July 17th, 1905, he wrote: "What troubles me most is that I have such a vast lot of half worked-up scientific material, which takes me longer time than I could have expected to get into shape, and I fear I may never be able to finish it," and many subsequent letters expressed the same anxiety. He was able, however, to complete the paper "On the Application of Quantitative Methods to the Study of the Structure and History of Rocks," which is now being published by the Geological Society, to send a note to *Nature* on the colouring matter of flowers, and also to make some short communications to local journals. He was greatly cheered when he heard of the reception of his paper, and by the kind message from British and foreign geologists, to which he replied by sending copies of his portrait to those who had signed it.

Early in March Sorby's illness assumed a more alarming form, but he was cheerful and busily engaged in discussing scientific problems till within a few hours of his death, which took place on March 9th.

His best epitaph would be that written by himself: "My entire life has been spent either in scientific research or in preparation for it." John W. Judd.

II.—Note on *Dinodocus Mackesoni*, a Cetiosaurian from the Lower Greensand of Kent.

By Arthur Smith Woodward, LL.D., F.R.S.

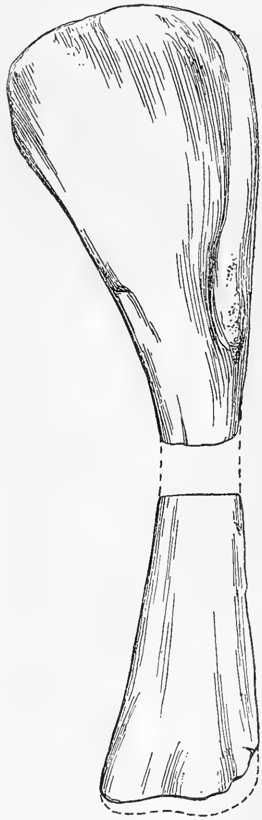
In 1840 Mr. H. B. Mackeson discovered a group of bones of a large reptile in the Lower Greensand near Hythe, Kent; and in the following year the specimen was briefly noticed by Professor (Sir Richard) Owen, who provisionally referred it to the genus *Polyptychodon*.[1] The fossil was presented by Mr. Mackeson to the British Museum, and ten years later the bones were described in detail by Owen,[2] who recognised that they agreed most closely with those of the Jurassic *Cetiosaurus*, but still thought they might belong to the 'crocodile' whose teeth were known as *Polyptychodon*. Subsequent discoveries proved that *Polyptychodon* was a Pliosaurian, with limb-bones quite different from those of the Hythe fossil reptile,[3] and Owen eventually realised that the specimen represented a species of Dinosaur, to which he gave the undefined name *Dinodocus Mackesoni*.[4] Without adding to our knowledge of *Dinodocus* Lydekker[5] placed it in the family Cetiosauridæ, while Marsh[6]

[1] Proc. Geol. Soc., vol. iii (1841–2), pp. 325, 451; also Rep. Brit. Assoc., 1841 (1842), p. 157.
[2] "Rept. Cret. Form." (Mon. Palæont. Soc., 1851), p. 47, pls. xii, xiii, and woodcuts.
[3] H. G. Seeley, Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 436.
[4] "Hist. Brit. Foss. Rept." (1884), index to vol. ii, p. ix.
[5] "Catal. Foss. Rept. Brit. Mus.," pt. i (1888), p. 136.
[6] Geol. Mag., Dec. III, Vol. VI (1889), p. 206.

agreed that it was truly a Sauropodous Dinosaur, though of uncertain affinity.

The remains of *Dinodocus* are very fragmentary, and Owen records that owing to the difficulty of extricating them from the matrix they were "less characteristic" when they reached the British Museum "than when [he] took the description and sketches of them on the spot where they were found." The published description, in fact, gives no clear idea of the nature of the bones, and they can only be interpreted by discoveries which have been made since it was written.

The task of determining all the bone-fragments would be more laborious than profitable, but a careful study of the collection has proved that some of them can be united into two important elements, the humerus and the ulna, which are specially worthy of notice. These are now mounted for exhibition in the British Museum, and the humerus is represented in the accompanying text-figure.



Anterior aspect of left humerus of *Dinodocus Mackesoni*, Owen, from the Lower Greensand, near Hythe, Kent; $\frac{1}{13}$ nat. size. [Brit. Mus. No. 14695.]

The upper half of the left humerus is shown in Owen's pl. xii, fig. 6, and described as a "fractured portion of the ilium." The bone itself is in small pieces, but there is a perfect mould of its anterior face in the hard Greensand matrix, so that at least this aspect can be completed in plaster. The lower half of a humerus is described and figured by Owen (loc. cit., p. 48, pl. xii, fig. 1) as "lower end of shaft of femur"; but its surface is so much fractured and the distal end is so incomplete that it is not easy to determine whether the specimen belongs to the right or to the left side. On the whole, I am inclined to refer the bone to the right side, and have reversed the drawing of it in the accompanying figure. The two halves do not quite meet in the middle, the lower fractured end having been ground to display the nature of its cross-section. As remarked by Owen, the bone is solid, but the cancellous interior is of so open a texture that it might readily disappear in a fossil. The extreme length of the humerus must have been originally about 1·25 m., the width of its upper end 40 cm., and the width of its lower end not less than 30 cm. Its upper end is deeply concave on its anterior face, the deltoid crest being specially prominent. The shaft is slender, and the lower end, which lacks a few centimetres in the fossil, shows the usual prominence on the anterior face above the outer condyle.

A fragment of the upper end of the right humerus fits on the impression of its anterior face, which is correctly identified by Owen (loc. cit., pl. xiii, fig. 2, H).

Impressions of the right ulna and radius are preserved on the slab of Greensand described by Owen as exhibiting the shaft of a tibia and the lower end of a fibula (loc. cit., p. 49, pl. xiii, fig. 1). The ulna, which seems to lack only a short piece at its upper end, is a relatively stout bone about 60 cm. in length. Its upper portion is trihedral, with each of the three faces a little indented in the middle and measuring respectively 13, 15, and 17 cm. across. One view of it is drawn, upside down, in Owen's pl. xii, fig. 2, as a "lower end of shaft of humerus." A fragment of this region, showing the posterior indented face and two angles, is also represented in cross-section by Owen in his text-fig. 2, p. 50, as if it were complete, while the extent of the central loose tissue is hypothetically and erroneously shaded. Further down the cross-section is nearly as shown in Owen's text-fig. 1, p. 50. The distal end, which is complete and exhibits the usual pitted surface for a cap of cartilage, is represented by Owen in his text-fig. 6, p. 51, while the cross-section 15 cm. higher up is given in text-fig. 7, p. 51. The bone is less expanded at the upper end than in *Cetiosaurus* and *Morosaurus*. The radius itself is not preserved, and only the upper half of it is seen in impression. It evidently conforms to the Cetiosaurian pattern.

Of the other fragments of *Dinodocus*, it suffices to remark that none of them are metatarsals or other foot-bones. The specimen shown in Owen's text-figs. 10 and 11, p. 52 (also in pl. xiii, fig. 5), suggests the distal end of a fibula.

It is thus evident that *Dinodocus* is a large Sauropodous Dinosaur, with a remarkably slender fore-limb. In its slenderness the humerus differs from that of *Cetiosaurus* and *Morosaurus*, while agreeing exactly with the Wealden humerus named *Pelorosaurus* by Mantell.[1] There is, in fact, no justification at present for regarding *Pelorosaurus* and *Dinodocus* as distinct genera. As already remarked by Seeley,[2] the Pelorosaurian humerus probably belongs to the same reptile as the Wealden vertebræ named *Ornithopsis*. The latest large Sauropodous Dinosaur seems, therefore, to have been more slightly built and more active on land than the *Cetiosaurus* of earlier date.

III.—On Changes of Level and the Production of Raised Beaches.

By T. F. Jamieson, LL.D., F.G.S.

I HAVE occasionally drawn attention to the effect produced on the relative level of sea and land by variations of pressure on the surface, such as would be occasioned, for example, by the increase or diminution of the loads of ice which existed during the Glacial period. I argued that the position of the surface must be always tending to an exact equilibrium between the upward and the downward pressure, and that any variation in the superincumbent load must result in some

[1] Phil. Trans., 1850, p. 379.

[2] Quart. Journ. Geol. Soc., vol. xxxviii (1882), p. 371; also Geol. Mag., Dec. III, Vol. IV (1887), p. 479.

change, however small, in order to rectify the balance. For if the balance was not perfect, motion must necessarily ensue, either up or down as the case might require.

The earth is such a large solid mass that we are apt to look upon it as perfectly immovable and rigid, and for all practical purposes no doubt it may be so considered. But in the great operations of nature with which geology has to deal such is not the case, and changes of pressure so small as to produce no visible effect to ordinary observation will, when continued for thousands of years, occasion changes that are manifest to all. In the following remarks we wish to draw attention to some results that have not, apparently, attracted the notice they deserve.

In a recent paper [1] I mentioned that one of the most obvious effects continually in progress is the denudation of the land by rain, rivers, and glaciers. These are always at work, wearing away the surface and transporting material down to the sea. Here, therefore, we have a process constantly going on which tends to lessen the weight of the land so that it will no longer balance the upward pressure; consequently the land will be forced up, and this rise of the land will help to compensate for the denudation which would otherwise in course of time tend to level down the continents altogether.

From the amount of sediment supposed to be annually carried into the sea by the Mississippi, Croll calculated that on an average about one foot in depth over the entire surface of a continent would be worn away in the course of 6,000 years.[2] Of course, this is only a very doubtful approximation, for the annual quantity of sediment carried into the sea by a large river is a matter very difficult to ascertain with any approach to accuracy; but it will serve to show the direction in which things are moving. The denuding action will evidently go on most energetically where there is a heavy rainfall and a rapid slope on the surface. The earth's action [3] may be compared to that of a spring of enormous strength, on which the surface load exerts a downward pressure. When we lessen the pressure on this spring the result must inevitably be a rise, which will show itself in a change of the relative level of sea and land; and here comes in the point to which we desire to draw attention. The raised beaches observed on so many coasts may probably find their explanation in this action; but I am not aware that such a connection has ever been mooted.[4] Upheavals by volcanic action and obscure subterranean forces have been invoked, but no relation has been drawn between the existence or the varying level of these beaches and the denudation of the adjoining lands, whereas an interesting connection of this nature, I think, may be pointed out.

Taking the case of Scotland, we have raised beaches all round it, and I have elsewhere [5] endeavoured to show that on the east side, as

[1] Ibid., p. 486. [2] Geol. Mag., November, 1905, p. 485.
[3] Lyell, "Student's Elements of Geology," 2nd ed., p. 91.
[4] [See papers by Dr. C. Ricketts, "Subsidence Effect of Accumulation": Geol. Mag., 1872, p. 119; 1873, p. 141; 1883, p. 93; 1883, pp. 302, 348, etc. J. S. Gardner, op. cit., 1881, p. 241 and Plate, p. 289.—Edit. Geol. Mag.]
[5] Journ. Geol. Soc., vol. xxi (1865), p. 190; Geol. Mag., January, 1906, p. 23.

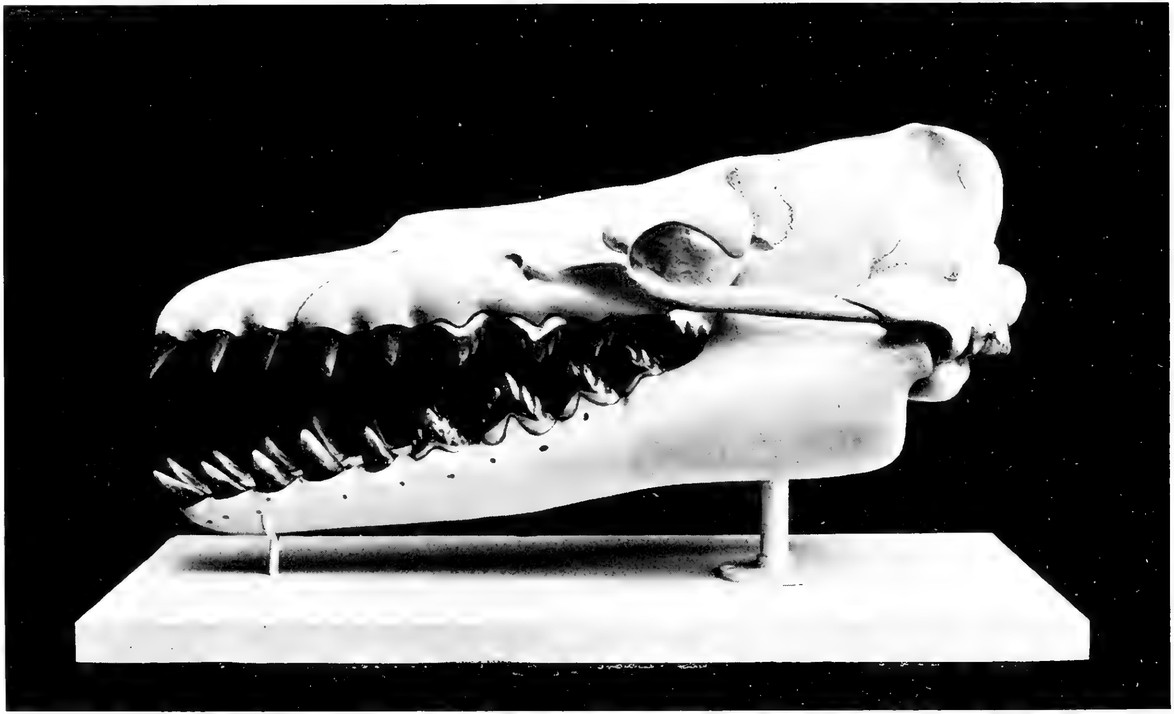
we trace the beach northward, the elevation gradually lessens from about 30 feet along the Firth of Forth to about 17 feet at Montrose and 8 feet or so at Aberdeen; a result which harmonizes with the smaller denudation that we might expect from the lesser rainfall along the valleys as we go north. In tracing the beach inland along the Forth we find its elevation increasing somewhat as we go up, and here again the result harmonizes with the theory. Again, on the West of Scotland we have higher beaches corresponding to the heavier rain along that side of the country. In the Shetland Islands, on the other hand, Messrs. Peach and Horne[1] particularly remarked the entire absence of any raised beaches. Now this is just the very thing we should expect on the theory here advanced, for the denudation caused by the rainfall there must be too slight to cause any noticeable rise. Islands, however, close to a mainland or continent would probably move up or down with the adjoining land, for unless they were some distance off they probably would not move independently. But the absence of these beaches in Orkney, and more particularly in Shetland, is an interesting and important fact which harmonizes so well with the explanation now offered that I am inclined to think this theory may prove to be the true one. Indeed, when one considers the frequent occurrence of raised beaches along the coasts of the world it seems difficult to account for them so well in any other way; for I fail to see how such widespread elevations of small amount could be effected all along the margins of our continents by the causes commonly assigned, whereas the denudation everywhere going on by rain and rivers is just such a universally present action as we require. Without the slow continuous rise of land thus brought about, the permanence of continents is not so easily explained.

The constant denudation by rain and rivers must inevitably lessen the downward pressure which the land exerts on the upward force that balances it, so that a rise must ensue, otherwise the equilibrium between the two antagonistic forces could not be maintained. Moreover, some lateral movement or pressure from beneath the sea-bottom towards the land would seem to be another necessary consequence, in order to replace the mass of matter removed by denudation and to make good the density lessened by the rise of land.

Raised beaches seem to occur all round Ireland, and Professor Hull tells us (in his Physical Geology of that country, 2nd ed., p. 143) that on following them from Antrim southward towards Dublin their elevation is found to decrease from the north to the centre of Ireland. This also is what might be expected, seeing that the rainfall decreases in the same direction. It would be desirable, however, to test the matter by observation on small islands, like the Azores and St. Helena, far off from any coast. In such cases there should be little evidence of recent raised beaches, although elevations of course might happen from causes entirely different from those we have been considering.

The continual accumulation of sediment brought down into the ocean by rivers must augment the load upon the sea-bottom and cause it to sink. This increase in the downward pressure, as already stated,

[1] Journ. Geol. Soc., November, 1879, p. 810.



Restored model of the Skull and Mandible of *Prozeuglodon atrox*, Andrews. About $\frac{1}{6}$ nat. size.
Middle Eocene: Fayûm, Egypt.

would tend to generate a lateral subterranean movement, or squeeze towards the land; for resistance in that direction would always be diminishing owing to the lessened pressure exerted by the rising land, which would lower the density immediately beneath it. Some evidence of such movements in former times ought to be found in the strata of the earth, for actions of this sort must have taken place ever since rain and rivers began their work upon the globe.

IV.—Note on a Model of the Skull and Mandible of *Prozeuglodon atrox*, Andrews.

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

(PLATE IX.)

During the last few years several papers have been published which throw much light on the early history of the whales, a matter about which there have been great doubt and difference of opinion. Two important points appear to have been settled: first, that the Zeuglodonts (*Archæoceti*) are descended from the primitive group of land-carnivores, usually known as the Creodonta, and, second, that the Toothed-whales (*Odontoceti*) are really derived from the Zeuglodonts. On this second point there may still be room for doubt, although in the opinion of the present writer the evidence brought forward by Professor Abel[1] in several papers, is at least sufficient to demonstrate the extreme probability that the Archæoceti are really ancestors of the Odontoceti. The origin of the Baleen-whales (*Mystacoceti*) is still obscure, but the fact that numerous true teeth are found in the unborn young, points to the probability that these animals also may have originated from the same, or a closely related stock as that from which the Odontoceti have descended.

The series of forms linking the Zeuglodonts to the terrestrial Creodonts has been discovered quite recently in the Middle Eocene deposits of Egypt. The earliest type is from near the bottom of the Lower Mokattam series (Middle Eocene) of Cairo: this animal, which has been described by Professor E. Fraas[2] under the name *Protocetus atavus*, is known from a nearly complete skull and some cervical vertebræ. The skull, which is about 60 cm. in length, much resembles in its general structure that of *Prozeuglodon* (see Plate IX) or *Zeuglodon*, but has a rather more slender snout, with the nostrils situated relatively farther forward than in the later forms. The full Eutherian dentition (i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{3}{3}$) is present. The secant premolars and molars show no trace of the serration of their edges so characteristic of the later Archæoceti, but are much like those of a Creodont of the Hyænodont group; the third and fourth premolars have large inner (third) roots, while the same seems to be

[1] "Eine Stammtypus der Delphiniden aus dem Miocän der Halbinsel Taman": Jahrb. der k.k. geol. Reichsanstalt, vol. lv, pt. 2 (Vienna, 1905), p. 375.
"Die phylogenetische Entwicklung des Cetaceengebisses und die systematische Stellung der Physeteriden": Verhandl. d. deutsch. Zool. Gesellschaft, 1905, p. 84.

[2] "Neue Zeuglodonten aus dem unterem Mitteleocän vom Mokattam bei Cairo": Palaeont. Abhandl., N.S., vol. vi (1904), p. 199.

the case with at least the first and second molars. The molars are crowded together at the back of the jaw and seem already to be undergoing the degeneration which in later forms leads to the loss of at least some of them. The axis vertebra is very similar to that of a carnivore, and the centra of the other cervicals are not shortened up as in the later Zeuglodonts. Altogether *Protocetus* may be regarded as a Creodont that has become adapted to an aquatic life.

From beds of rather later age in the Fayûm Mr. Beadnell collected remains of another Zeuglodon, which has been described under the name *Prozeuglodon atrox.* Plate IX is a photograph of a model of the restored skull and mandible of this species, and gives a very good idea of its chief peculiarities. The model has been skilfully constructed by Mr. F. O. Barlow, mainly from a cast of the skull and mandible which are the types of the species, but some details were added from a less complete but comparatively undistorted specimen. The skull on the whole is quite Zeuglodon-like, but the snout is a little shorter than in *Protocetus,* and the nostrils a little farther back, though not so far as in *Zeuglodon.* There is a strong high sagittal crest, the tympanic bullæ are well developed, and the zygomatic arch is somewhat stouter than in later forms. The dentition appears to be exactly intermediate between that of *Protocetus* from the beds below and that of *Zeuglodon osiris* from those above. The dental formula seems to have been i. $\frac{3}{3}$, c. $\frac{1}{1}$, pm. $\frac{4}{4}$, m. $\frac{2}{3}$ (?). The incisors are conical, sharply pointed teeth, separated from one another by moderate intervals. The canine is larger than the incisors in front and the premolar behind, probably a relic of the Creodont condition. The first premolar is a single-rooted tooth, and in one specimen it can be seen that it must have been preceded by a milk-tooth. The other premolars have the compressed serrated crowns characteristic of the group. The second upper premolar has two roots, while the third and fourth have a large third (inner) root as in *Protocetus* and the Creodonts. The molars were probably two in number: it is not clear whether their posterior root was single or imperfectly divided into two. Another Creodont character in the upper jaw is seen in the presence of deep fossæ on the inner side of the premolars for the reception of the points of the lower teeth. None of the lower teeth have more than two roots.

In beds of about the same age as those in which *Prozeuglodon* occurs there are found two or three very large Zeuglodonts, one, *Eocetus Schweinfurthi*, E. Fraas, being likewise in many respects intermediate between *Protocetus* and *Zeuglodon*, while another, *Zeuglodon isis*, is, so far as known, close to the true Zeuglodonts. The occurrence of these large forms so early shows that specialisation in this particular direction was very rapid. In the upper beds of the Middle Eocene (Qasr-el-Sagha series) of the Fayum only true Zeuglodonts are found, differing in no important respect from the various species which at that time had already spread over most of the seas, remains having been found in Europe, America, and New Zealand.

The great rapidity with which both the primitive whales and the Sirenia seem to have become completely adapted to an aquatic life is very suggestive. In both cases these groups appear to have arisen from terrestrial mammals during the Lower Eocene period, and long before the close of the Middle Eocene had become almost as completely adapted to an aquatic life as their descendants at the present day. It may be of interest to consider the reasons for this rapid change. In the first place it is pretty certain that at the close of the Mesozoic period all the groups of great marine reptiles had, for some unknown reason, become extinct, so that, excepting the fishes and a Rhynchocephalian, no vertebrates inhabited the early Eocene seas. The consequence of this would be that if any terrestrial forms should adopt an aquatic life, the freedom from competition and, to some extent, from powerful enemies, would offer exceedingly favourable conditions for their rapid spread and multiplication in the seas, while the great development and differentiation of the land mammals at the same period would render the conditions of terrestrial life more and more exacting. Consequently, when the primitive swamp-loving Proboscidean ancestor of the Sirenia and the early Creodont from which the Zeuglodonts arose took to living in the water, everything was in their favour. The rapidity with which these animals became adapted to their new conditions of life is probably the direct result of the complete change in the mechanical conditions of life. For one thing, the limbs cease to support the weight of the body, which is now borne by the water in which it floats. On the other hand, the limbs are still used for propulsion, and consequently there is a forward thrust at their proximal ends. The consequence of this thrust in changing the structure of the pectoral and pelvic girdles has already been discussed in the case of the Plesiosaurs. The manner in which movement through the water is affected of course differs widely in different groups of aquatic animals. Thus, in the whales it is by the fore-limb and a transverse tail-fin, the hind-limb being lost; in the Ichthyosaurs by both the fore and hind paddles, the former being the more important, and a vertical tail-fin; in the sea-crocodiles (*Metriorhynchus*, etc.) by the hind-limb and tail; and in the Plesiosaurs by the oar-like fore and hind paddles. Whatever means, however, is employed to propel the body through the water, during motion it is subjected to a pressure on its anterior end, more or less in the direction of the long axis, and during very rapid movement this pressure must be considerable. Most of the peculiarities of the skull of the whales seem to result from this new condition. In the first place, to facilitate passage through the water a more or less slender rostrum is as a rule developed, though in the later and larger forms of some of the groups it may be lost or masked by other structures. In the next place, the pressure seems to have brought about the spreading back of the posterior ends of some of the facial bones, so that the premaxillæ and especially maxillæ overlapped the bones behind to a great degree. The same force also may have had much to do with the shifting back of the external nares. The peculiarities in the structure of the cranial portion of the skull are also capable of explanation in the same way. The primitive whales seem to have had brains of considerable size, and the brain-case would be liable to distortion from continual frontal pressure. This pressure seems, for instance in *Phocæna*, to have resulted in the squeezing out of the parietals from the middle line, and the extension back of the frontals to the supraoccipital and interparietal, which are greatly enlarged to resist the backward thrust. The shortening up of the Cetacean brain seems to be in part due to this compression of the skull and in part to the complete reduction of the olfactory region. The shortening and, in some forms, the fusion of the cervical vertebræ seem also to be a consequence of the same cause. The great size of many of the Cetacea is no doubt rendered possible partly by abundance of food and partly on account of the support of their weight by the water. It is very notable that some of the earliest members of the group, already in Middle Eocene times, attained very large dimensions, but in this case, as usual, it does not appear that these giants gave rise to any of the later stocks, which are derived from the smaller and more plastic members of the group.

No doubt the various changes above noticed may be regarded as entirely the result of selection acting on variations in the necessary direction, but the rapidity with which these changes took place and the apparent uselessness of some of them, at least, suggest, that in spite of generally accepted doctrine that acquired characters are not inherited, in some cases complete change of the conditions acting throughout the life of each individual for generations does actually give rise to and direct the modifications undergone.

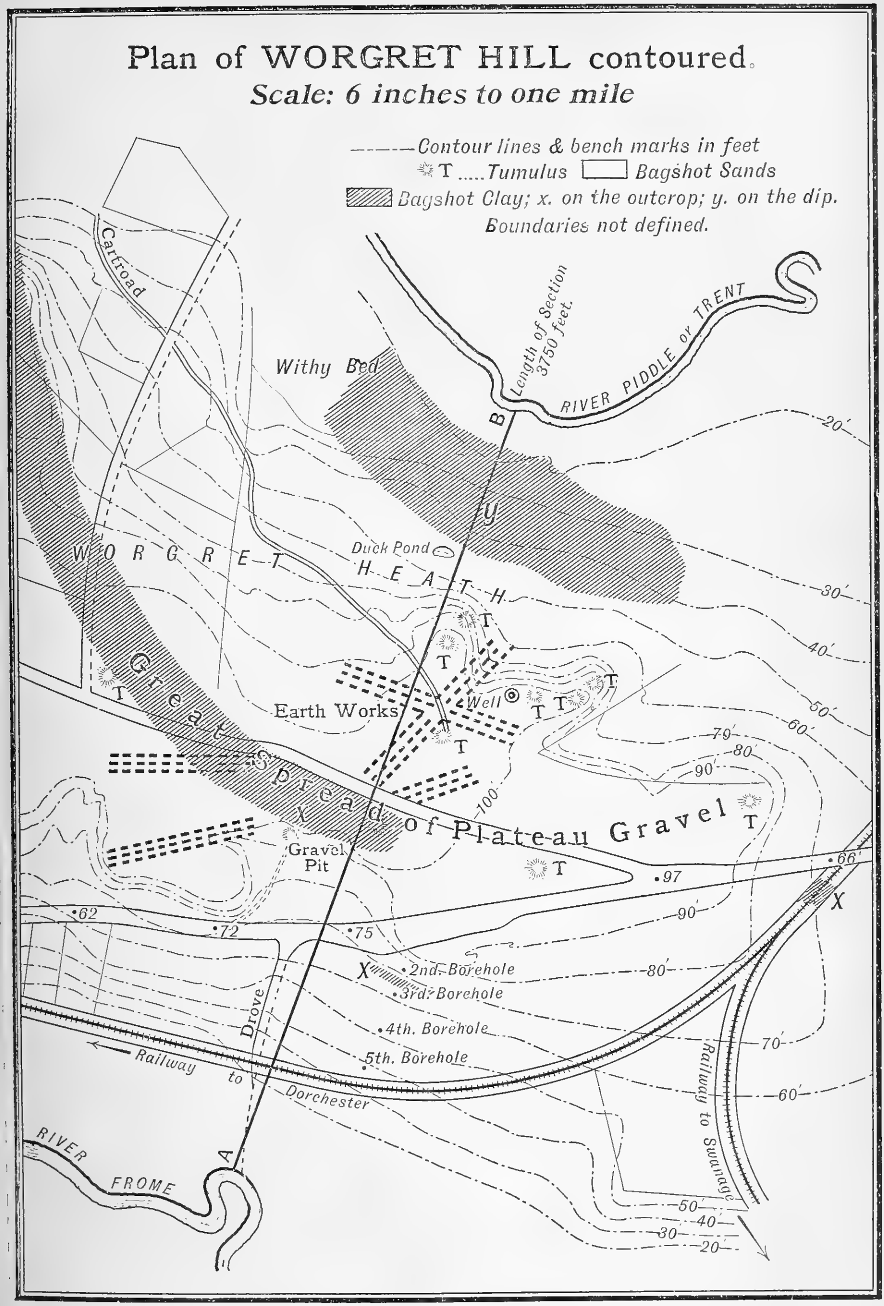
V.—On some recent Wells in Dorset.

(Part I.)

By W. H. Hudleston, M.A., F.R.S., F.G.S.

THE requirements of towns, and even of camps, in the matter of water supply are so great nowadays that surface waters are avoided as likely to be contaminated, and there is consequently a great desire to rely on deeper sources. Quite an official literature has sprung up of late years, and important memoirs have been issued by the Geological Survey on the "underground sources" of several counties. So far as I am aware there has been no official memoir relating to the county of Dorset, and this probably arises from the circumstance that the artesian principle has not been made use of to any great extent until recently, although the Dorset syncline would seem to be eminently suitable for artesian wells.

Nevertheless, some important sinkings and borings have been executed in Dorset of late years, and these works, altogether irrespective of their economic importance, as yielding abundant supplies of good water, are of further interest to the geologist in that they afford evidence of the character and development of some of the Tertiary strata, which cannot otherwise be obtained. The Bagshot Beds of this county, for instance, have always presented difficulties to the stratigraphist, since few reliable outcrops can be obtained in the interior of the country on account of the yielding nature of the sands and clays of this formation. It is for these reasons that I venture to offer in the pages of the Geological Magazine an abstract of two papers which have already appeared in the Proceedings of the Dorset Field Club, the one relating chiefly to a deep but not artesian well, sunk for the supply of the town of Wareham, and the other a paper



Plan of WORGRET HILL contoured.
Scale: 6 inches to one mile
Contour lines & bench marks in feet
T .....Tumulus
Bagshot Sands
Bagshot Clay; x. on the outcrop; y. on the dip.
Boundaries not defined.
Cartroad
Withy Bed
Length of Section 3750 feet.
RIVER PIDDLE or TRENT
B
y
Duck Pond
WORGRET HEATH
Earth Works
Well
Great Spread of Plateau Gravel
Gravel Pit
2nd. Borehole
3rd. Borehole
4th. Borehole
5th. Borehole
Drove
Railway to Dorchester
Railway to Swanage
RIVER FROME
A
20′
30′
40′
50′
60′
70′
80′
90′
100′
•62
•72
•75
•97
•66′

Fig. 1.

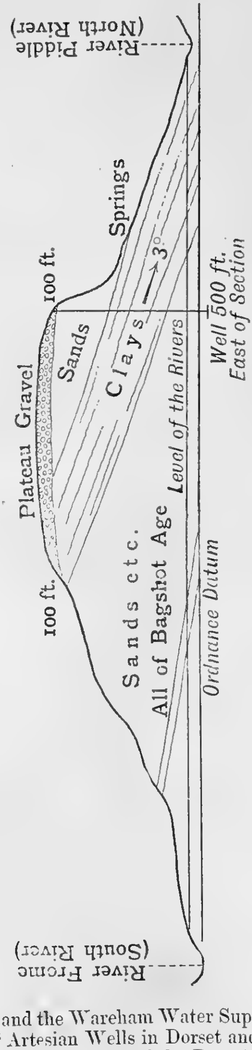
dealing with artesian wells generally, but more especially with one bored at Bovington Camp in the Autumn of 1906.[1]

I. The Worgret Hill Well and Borehole.

Worgret Hill (see Plan, Fig. 1,[2] and Section, Fig. 2) is situated about one mile to the west of the town of Wareham, and is crossed by

Fig. 2.

Worgret Hill.—Section along the line A–B of the Plan (Fig. 1).



Length of Section, 3,750 feet. Scale, 6 inches to 1 mile. Vertical scale greatly exaggerated.
N.B.—The second water was tapped at 108 feet below the surface in the first borehole.
Superficial beds (excepting Plateau-gravel) not shown in this section.
The exaggeration of the vertical scale increases, in appearance, the angle of the dip. This angle is believed to diminish in the direction of the Frome Valley.

[1] (1) "Worgret Hill and the Wareham Water Supply": Proc. Dorset Field Club, vol. xxvii (1906). (2) "Artesian Wells in Dorset and elsewhere": ibid., vol. xxviii (1907). By permission of the Council of the Dorset Field Club.

[2] The Ordnance 6 in. map is contoured at 50 and 100 feet. The intermediate contours on the Plan were fixed approximately by myself and Mr. Bloomfield during the Winter of 1905–6.

the high road from that town to Dorchester. To anyone coming from Wareham it presents the first sharp rise from the low platform on which Wareham is built,[1] and the contour map shows us that it consists of an elevated platform with steep sides, sloping to the south and north rivers respectively.

As regards its geological features, Worgret Hill may be said to occupy a central position in the great trough or syncline of Wareham,[2] being about equidistant from the outcrops on either side. Except for Plateau-gravel on the summit platform it consists wholly of clays and sands of the Bagshot series, and it is the alternation of these which constitute its water-bearing capacities (see Section, Fig. 2). These Bagshot Beds extend for an unknown depth downwards, and quite possibly hereabouts attain their maximum thickness so far as this part of Dorset is concerned.

In the year 1898 a trial borehole was made at Worgret by Messrs. Pike Bros., and in 1899 the sinking of the well commenced. After getting through the Higher Bagshot Clay Series an abundant supply of water was found in a coarse silicious sand with much 'lydite,' struck at about 108 feet from the surface, and this water rose to a level of 91 feet from the surface in the well. Borings were subsequently continued about this period to a depth of 121 feet from the surface.

In November, 1900, there was a fortnight's test-pumping, when the flow was found to be 94 gallons per minute. In August, 1901, the permanent pumps were fixed, and in November of that year a further test-pumping yielded 56,000 gallons of water in ten hours. There seems to have been some suspicion as to the turbidity of the water, and Mr. Chatterton, the engineer, then felt satisfied that if some turbidity still existed it could be got rid of by deepening the well.

On February 4th, 1903, an enquiry instituted by the Local Government Board was held at Wareham, in the matter of the application of the Town Council to borrow a certain amount for the purposes of a water supply. This was sanctioned in September, 1904, and the tender of Messrs. Docwra & Sons to carry out the works was accepted. These works consisted chiefly in making a reservoir on the top of Worgret Hill, and in laying the mains to and throughout the town of Wareham. During the operations Messrs. Docwra used a considerable quantity of water from the well, and it was found to be still turbid with much fine sand.

There was still some dissatisfaction at the turbidity of the water, and in June, 1905, cavities in the sides of the well had to be filled with gravel. It was also decided to start a borehole from the bottom of the well in the hopes of finding a more satisfactory supply of water. On October 7th Mr. Chatterton, the engineer, wrote to the effect that the test-pumping showed that the boring yielded practically no further supply of water. At that time the borehole had passed through the

[1] The cross roads in the centre of Wareham mark 21·1 feet above O.D.

[2] For a diagrammatic sketch of the Trough of Wareham see Proc. Dorset Field Club, vol. xxiii, p. 148.

second great Sand-series, and was already encountering some grey and mottled clays, which he conceived might indicate the presence of the Reading Beds, and that possibly the Chalk was not far off; after going through this Clay-series for 30 or 40 feet further, he began to have his doubts as to the position, since there was no change in the nature of the ground, the boring being still in the grey clay. It was pointed out that the samples brought up tallied with the regular pipeclay series of the Bagshots, and that the Chalk was still far distant. The boring was carried through these clays to a depth of 215 feet from the surface, and on October 30th operations were finally discontinued.

Worgret Well and Borehole.

Details of beds from 101 feet *above* Ordnance Datum to 114 feet *below* Ordnance Datum:—

			Thickness. ft.	in.	Depth. ft.	in.
		Pleistocene.				
x.		Plateau-gravel	9	0	9	0
		Bagshot Beds.				
		A. Higher Bagshot Sand Series.				
		B. Higher Bagshot Clay Series.				
		C. Second Bagshot Sand Series.				
		D. Pipeclay Series.				
A (40 ft.).	*a.*	Fine dry sand, gradually getting coarser ...	28	6		
	b.	Sandy loam	6	0		
	c.	Fine dry sandy loam, white in colour	5	0		
	d.	Fine sand, waterlogged	6	0	49	0
		The Top Water.				
B ($54\frac{1}{2}$ ft.).		Loamy clay, gradually becoming more sandy towards the base. No divisions were made in this series	54	6	103	6
		Stems, leaves, and fruits were found in pale-coloured pipeclay below 82 feet.				
C (166 ft.).	*a.*	Streaky beds of sand and loam from one to three inches thick	4	6		
		The Second or Main Water. At 108 feet the water came in and rose to 91 feet.				
	b.	Coarse dark sand	4	0		
	c.	Coarse sand, getting finer below	9	0	121	0
		(Termination of the original boring.)				
	d.	Pyrites, sand, and wood	1	0		
	e.	Alternations of grey sands and clay	8	0		
	f.	Thick grey sand	12	6		
	g.	Alternations of grey sand with some grey clay ...	20	0		
	h.	Very coarse dark grey sand	3	6	166	0
D (49 ft. proved).	*a.*	Grey pipeclay, said to contain leaves in places	10	6		
	b.	Stiff yellowish clay, compact, and rather heavy, also mixed	9	6		
	c.	Mixed bluish grey and yellow clays, rather gritty	4	0		
	d.	Reddish ochry clay, staining the fingers like ruddle	1	0		
	e.	Additional boring not detailed. Terminates in grey pipeclay	24	0	215	0

In explanation of the above table, it may be stated there is no longer any idea of making use of the top water, and that all the calculations as to supply refer to the second or main water. This is considered to be sufficient in amount for all the requirements of Wareham, but unfortunately it takes so long to clear from fine sand as to be detrimental to the pumps. It is worthy of note that the normal water-level in the well stands at a height of 91 feet from the surface. Pumping may lower the water-level in the well to 97 feet below the surface, but no amount of pumping can reduce the water-level below this point. Hence Mr. Drew infers that there is a leakage in the upper six feet of water, but that below this horizon there is no lateral escape. In connection with this subject it may be useful to remember that the whole of the 62 ft. 6 in. of the Second Sand-series (C of the column) is saturated, and these saturated beds rest on the second Clay or Pipeclay series of the Bagshots (D of the column) at 166 feet below the surface.[1] The second water was first tapped in a waterlogged sand at a depth of 108 feet from the surface, and there is this anomaly in the situation, viz., that this water is much closer to the Clay-series (B), which holds down the water, than it is to the Clay-series (D), which holds it up. It may be that the proximity of a roof of clayey beds to the stratum from which the water is actually drawn has a tendency to increase the amount of fine sediment which hitherto has proved to be so prejudicial to this water.

The Plateau-gravel (*x*).—This is generally regarded as a Pleistocene formation, but is certainly one of high antiquity, since it apparently antedates the formation of both the valleys, viz., those of the Frome and Pydel, which flank the block of Bagshots on which it rests.[2] It is of some importance economically, since the best road-metal of the district is obtained from these beds.

A very interesting and instructive section of these beds was disclosed in January, 1905, during the excavation for the reservoir on the summit of Worgret Hill. The excavation was more or less a true square, and I selected the eastern side as a type of the whole (see Fig. 3, based on a photograph taken by Mr. Churchill). The face of gravel here is remarkably vertical, and the gravel holds together so well as to cause surprise to some of the workmen. The peculiar interest of the section at the reservoir arises from the discharged colour noticeable in the upper part of the Plateau-gravel owing to the action of peaty acids having dissolved out or reduced the colouring matter, chiefly iron and manganese oxides. This no doubt may be seen to a certain extent in most gravel-pits; but here a further feature has been produced, viz., the irregular piping of the yellow unreduced gravels by percolation from above.

Particulars of the Bagshot Beds.

The Higher Sand-series (A).—The general character of these beds on the surface is that of the ordinary pale-yellow Bagshot Sands of

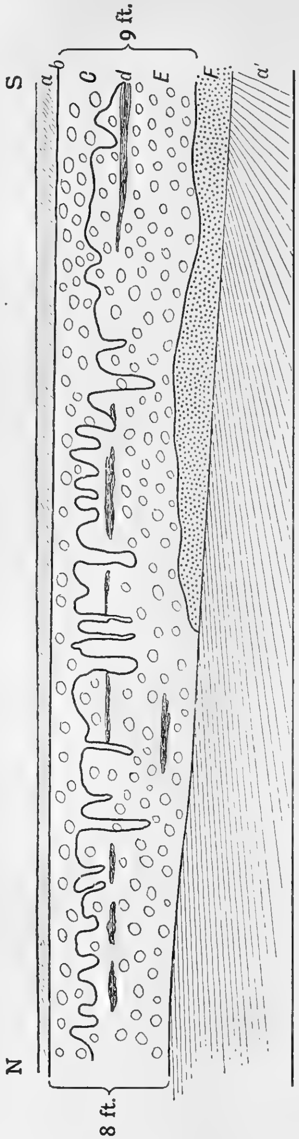
[1] The late Mr. L. W. Pike informed Mr. Drew that throughout the area of Furzebrook and Grange, where his operations for clay were carried on, he invariably encountered at the same level a body of water which he believed to be identical with that found in the well at Worgret.

[2] See Proc. Dorset Field Club, vol. xxiii, pp. 149, 150, article "Creechbarrow."

the district. The waterlogged sands at the base (A, *d* of the column), described as fine in the section, are certainly coarse, where they are seen to come out on the dip slope, and contain much water (the top water).

Fig. 3.

Eastern Face of the Excavation in the Plateau-Gravel for the Reservoir at Worgret, January, 1905.



Explanation of signs.

a. Surface of the plateau.

b. Summit-line of the excavation.

C. Plateau-gravel, bleached by the action of peaty acids, *grey* in colour.

d. Lines of exceptional accumulation of black oxide of manganese.

E. Lower portion of the Plateau-gravel, retaining for the most part its original *yellow* colour, but irregularly stained with black oxide of manganese, and piped by the action which has altered the colour of the gravel above.

F. Bagshot sand *in situ*, on which the Plateau-gravel rests.

d'. Floor of the reservoir.

The Higher Clay-series (B).—The fruits and plant remains are approximately on the same horizon as those from Norden and Bournemouth.

The Second Sand-series (C).—The most interesting bed in this series is the one indicated in the table as C, *b*, which contains such a large quantity of water. This is composed of angular grains of a highly crystalline quartz; the larger fragments are dull or fatty, and range up to ⅛ inch. There is also a considerable amount of dark-coloured silicious fragments, such as go under the general term of 'lydite.'

The Pipeclay Series (D).—As this group is only known from boring, the arrangement of the details is somewhat arbitrary since the several clays were much mixed. There can, however, be little doubt that series D represents the Pipeclay Beds of the northern and southern outcrops, though inferior to the clays of the southern outcrop in quality. Much the same varieties of clay as we find in the Creech district came up from the borehole, and there was no difficulty in recognising the greyish-white pipeclays alternating with the inferior or variegated varieties known in the workings as 'two-ball' clay.

"When we come to speculate on what lies below the termination of the borehole (215 feet from the surface), it is almost impossible to predict what may be the thickness of the remainder of the Bagshot Beds. Below the pipeclay series it is almost certain that another sandy series would be encountered as constituting the base of the formation, and there may be bands of iron grit such as occur on this horizon at many places in the Isle of Purbeck. None of the Government geologists, so far as I know, give us any assistance in estimating the thickness of the Bagshot Beds at their full development in Dorset.

"*The Lower Tertiaries.*—We may naturally conclude that both the London Clay and the Reading Beds will have to be encountered ere the Chalk can be reached. Very little is known about these beds, which are best studied, perhaps, on their outcrop in the Wool district. In a borehole section it may not be very easy to distinguish between Bagshots and London Clay, as the latter formation in this country consists largely of sand. Probably the most distinguishing feature of the London Clay is the amount of black flint pebbles which it contains, and which are sometimes cemented by iron-oxide into a most intractable conglomerate. The Reading Beds are also mainly sandy, but side by side with these sands are developments of mottled clays largely used for brick-making. A total thickness of 100 feet for the London Clay and Reading Beds is, perhaps, fairly approximate.[1] It is quite possible that some of these Lower Tertiaries may contain good water-bearing beds."

The main interest, from a geological point of view, consists in the estimated thickness of the unproved Tertiary beds down to the Chalk. As regards the Bagshot portion of this unknown quantity, I may refer to two short memoirs by the Government Surveyor, Mr. Clement Reid, F.R.S., "Geology of the Country round Bournemouth" (1898) and "Geology of the Country round Dorchester" (1899), and although in the question of the total thickness of the Bagshot system in the

[1] This estimate was subsequently increased to 125 feet.

Wareham district we have no direct information from Mr. Reid, yet the following passage (p. 25 of Dorchester Memoir) may possibly throw some light on the as yet unproved strata below the termination of the Worgret borehole: "Close to Organ Ford, and for nearly a mile to the westward, white pipeclay mixed with carbonaceous clay can be seen in the road south of the stream. This bed is apparently equivalent to the stratum that is worked at its southern outcrop round Creech, though at its northern outcrop it does not appear to be more than 50 feet above the London Clay." The statement is important as showing that in the neighbourhood of Organ Ford, rather more than three miles due north of Wareham, the Pipeclay series, towards its northern outcrop, is quite low down in the Bagshot system. Now, when we come to consider the bearing of these facts on the hypothetical estimate of 85 feet for the "Remainder of the Bagshot Beds unproved," as given for series E in a tabular column attached to the Report,[1] it seems to encourage the belief that, when the boring rod reached 215 feet from the surface of the Worgret Hill plateau, 85 to 100 feet would be a fairly liberal estimate of the thickness of the remainder of the Bagshots. The chief element of uncertainty lies in the fact that the Pipeclay series was not gone through, but we may assume almost with certainty that a *third* Bagshot Sand-series, with a development of 60 or 70 feet, would still have to be encountered ere the Lower Tertiaries were reached.

(*To be concluded in our next Number.*)

VI.—On a Method of Splitting Ironstone Nodules by means of an Artificial Freezing Mixture.

By L. Moysey, B.A., M.B., B.C., F.G.S.

Most geologists who have had anything to do with the ironstone nodules in the Coal-measures have been struck by their perverse and refractory behaviour under the hammer. How one nodule will refuse to break under the most well-directed blows, and another, though breaking easily, will exhibit to the disappointed collector a clean bright surface of clay-ironstone, without a trace of that organism that he hoped, and almost had a right to expect, was there. It seems therefore necessary to find some other and perhaps less violent method of breaking them.

The nodules used for the following experiments were taken from a now disused brickfield situated near Ilkeston, in Derbyshire, on the Shipley Hall estate, owned by E. M. Mundy, Esq., the horizon being just below the *Top Hard Coal.* The clays of this pit, unlike most of the South Derbyshire Coal-measure clays, teem with nodules for the

[1] This refers to the Report made by Mr. Hudleston to the Town Council of Wareham as to the advisability of continuing the boring. In this Report the particulars of the work already executed are given in a tabular form together with an approximate estimate of the probable thickness of the remaining Tertiaries ere the Chalk was reached. The total thickness of the beds above the Chalk on Worgret Hill was finally estimated at 425 feet.

most part symmetrical, with smooth surfaces ranging in size from a small orange to a large dinner plate, and in shape oval, round, or flattened. Almost every nodule which was found naturally cracked contained some organism or another in a good or bad state of preservation; it is therefore justifiable to assume that those nodules which are still intact also contain organisms. Many of these stones have been broken by mere brute force, always with the disappointing result of obtaining a clean fracture without any sign of fossil; or perhaps the surface showed that a fossil was there, but that it was completely ruined by being broken across in a plane a little above or a little below its actual position in the nodule. Heating them to red heat and plunging them in water was then tried; but this apparently was a too violent method, as the stone when it did break did so into small fragments quite independent of the position of the fossil. The method also is not unaccompanied with danger, as the stones are apt to explode with great force, either in the fire or when plunged into water.

During this Winter, however, several nodules, most of which had been subjected to severe hammering to no purpose, were brought home and frozen, with, as it seems to me, fairly good results.

Nothing of novelty, however, can be claimed for this method, as it is probable that many geologists have made use of a freezing mixture in this connection; though there is scanty, if any, literature on the subject, the late Professor Constantin Baron von Ettingshausen of Graz in Austria practised it successfully on Tertiary shales containing fossil plant-remains.

The method now adopted was to keep the nodules soaking in water, then to place them in a tin cannister, and surround the tin with an ice and salt mixture in a pail. After leaving them in the cold atmosphere thus generated for forty-eight hours, it was found that most of them showed a crack running right round them. On thawing, some were found to be cracked right through, and a light tap with a hammer split them and revealed, in many instances, a very perfect fossil. Others, however, though appearing to be cracked, simply shelled off an outer husk of disintegrated stone, leaving a hard solid core as refractory as ever, which, on again freezing and thawing, sometimes split and sometimes cast off another shell.

From these failures it was thought that perhaps the water did not penetrate into the heart of the nodules in every instance, so several nodules were heated gently to drive off the imprisoned air by expansion, and were then plunged, while hot, into water. After this treatment, in many instances, otherwise refractory nodules were successfully split.

A curious secondary result of these experiments has been the discovery of a greater proportion of rare fossils in the nodules thus artificially split than in those found naturally broken in the clay-pit. Out of some ninety nodules cracked by freezing, there have been found three specimens of *Belinurus*, one *Palæoxyris*, two specimens of a new shrimp-like animal, and one possibly new animal which may turn out to be a complete but diminutive example akin to the *Arthropleura armata* of Jordan from Saarbrucken.

The pit has yielded many rare fossils; for instance, two specimens of *Fayolia*, ten of *Palæoxyris*, ten of *Eurypterus*, eight or nine of a new shrimp-like animal, fourteen of *Belinurus* and *Prestwichia*, and one of a true insect. But these have been collected (except in the case of the shrimp-like animal, which has been found mostly during the last year) during a space of time extending over the last five years, and in the proportion of one rare animal to several thousand stones examined.

From the ninety nodules split by freezing were obtained—

18–20 nondescript plant-remains,	6 ferns,
1 root-filament,	1 *Unio*,
17 *Annularia* and *Calamocladus*,	3 *Belinurus*
1 *Sphenophyllum*,	1 *Palæoxyris*,
3 *Lepidophyllum*,	1 ? *Arthropleura*,
1 Calamite,	2 shrimp-like animals,

the remainder splitting badly or containing unidentifiable remains. Of the naturally split stones found in the clay-pit, the commonest organisms would certainly be the ferns; second would come the nondescript plant-remains, that is, a jumble of stems, fern-leaves, etc.; third, *Calamocladus*, etc.; and fourth, *Calamites*.

Of course, the extraordinary proportion of rare fossils may be due to chance, or, more possibly, to that factor combined with an instinctive collection of such nodules as are likely to contain good specimens. To this instinctive selection may be attributed, to a great extent, the undue preponderance of *Calamocladus*, etc.; as these plants are usually, in this pit at any rate, contained in small symmetrical oval nodules, which would be more likely to be brought home than rough irregular ones. But it is conceivable that those fossils, like fern fronds or stems, which have a fairly broad surface and a layer of coaly material more pervious to water than the stony matrix, would be easily cracked by the recurrent frosts of Winter; and that those of an animal nature which have a chitinous covering more durable than the stone, or at any rate have no coaly film to let the water into the plane of the fossil, and those plant-remains that do not show a large flat surface inside the stone, would be the ones that would resist longest the natural disintegrating agencies. Hence it is possible that those nodules which resist the longest may be just those which it would be most worth while to persevere in cracking; and in this way the poverty of the faunal record in most coalfields may prove to be more apparent than real.

REVIEWS.

I.—Physiography. By Rollin D. Salisbury, Professor of Geology and Head of the Department of Geography in the University of Chicago. 8vo; pp. v + 770, with 24 plates and 707 text-figures. London: J. Murray, 1907. Price 21*s*. net.

PHYSIOGRAPHY owes much to the enthusiasm and industry of its exponents in North America, of which the big volume before us is one more token. The science has ill-defined borders which can be to some extent rearranged at will to suit the scope of its demonstrator. But although so eminent a geologist, Professor Salisbury exerts restraint and skill in the subordination of his geological knowledge to the strict requirements of his subject, which, in his introduction, he defines thus: "Physiography has to do primarily with the surface of the lithosphere, and with the relations of air and water to it. Its field is the zone of contact of air and water with land, and of air with water" (p. 4). And in discussing the relation of the science to geology, he adds: "Geology has to do with the history of the earth; while physiography has to do with a late chapter only of that history,—the history of the present surface."

As thus defined, physiography is a sufficiently vast subject, dealing always with phenomena and processes that embrace the whole earth in their scope. Its far-reaching conceptions rise clear above the tangle of minute detail so repellent to the impatient imagination; and if in these days of specialized education there should ever be attempted a course of scientific instruction for budding poets and other aspirants in imaginative literature, assuredly physiography, equally with astronomy, should be one of the subjects to be taught. And really, when one thinks of it, the want of such a course is serious; for, more than ever, we need the stimulus of an inspiriting utterance of our new ideas in perfect form, while the poets, mostly helpless from imperfect education, can still only harp upon obsolete instruments, or set our teeth on edge when they venture to touch the new strings. Nor, if the imaginative person can keep pace with the strenuous American student, need his grounding in physiography take long, for, in the preface to this comprehensive book, we read that the work outlined in it "is essentially the work covered in the University of Chicago in a twelve weeks' course, taken most largely by students who have but recently entered college."

Lest the somewhat massive proportions of the book should daunt the beginner, let us note, however, that of its 770 pages the half are occupied by the text-figures which illustrate every feature that is described. By their numbers and excellence these figures afford admirable aid to the letterpress.

Notwithstanding the size of the volume, Professor Salisbury's treatment of his subject is designedly simple and elementary. The new-fangled terms of the American school of physiography, when introduced, are clearly explained and illustrated, and there is no attempt to bring forward the whole battery of them. Thus, while 'consequent' and 'antecedent' streams are discussed, there is no mention of such further refinements as 'obsequents' and 'subsequents.' Every new science must require the introduction of new technicalities, and the word in which an idea first conveniently crystallizes out is likely to survive, even though it be no better than, say, 'peneplain.' Still, our innate conservatism forbids too hearty a welcome to the strangers, and it is perhaps pardonable in a British reader who chanced to light upon the picture of a butte (p. 171) to which is appended as an explanatory note "The butte is really a monadnock," that the phrase should bring with it a reminiscence of Lewis Carroll's quaint line "For the Snark was a Bojum, you see." But let that pass; 'butte' is good, and 'monadnock' also has its uses!

And now for a rapid glance at the contents of the work. It is divided into four parts of unequal length. Part i, the longest, of 480 pages, deals with the Lithosphere, in ten chapters, entitled: "Relief Features," "The Work of the Atmosphere," "The Work of Ground-water," "The Work of Running Water," "The Work of Snow and Ice," "Lakes and Shores," "Vulcanism," "Crustal Movements: Diastrophism," "Origin and History of Physiographic Features," and "Terrestrial Magnetism." Part ii, on Earth Relations, containing only one chapter, of 24 pages, discusses the astronomical aspect of our globe. Part iii, on the Atmosphere, has 200 pages, divided into eight chapters, headed: "General Conception of the Atmosphere," "Constitution of the Atmosphere," "Temperature of the Air," "The Moisture of the Air," "Atmospheric Pressure," "General Circulation of the Atmosphere," "Weather Maps," and "Climate." This part is bountifully illustrated with meteorological maps of all kinds, both general and local, the local examples being here, as throughout the book, almost wholly American. Part iv treats of the Ocean, somewhat disproportionately as it seems to an islander—a prejudice of environment perhaps—in no more than 50 pages, divided into seven short chapters: "General Conceptions," "Composition of Sea-water," "The Temperature of the Sea," "The Movements of Sea-water," "The Life of the Sea" (brief and poor), "Materials of the Sea-bottom" (the same), and "Relation of the Sea to the Rest of the Earth" (only a little over a page of elementary generalizations by way of summary).

With a book of this kind it is of course impossible in our limited space to do more than thus roughly to indicate its range. The outlook throughout is centred on the United States of North America, for whose students it was primarily written; but to the British reader it is stimulating from the freshness of its illustrations and examples, which bring vividly before him the magnificent diversity of conditions that obtains within the limits of the great republic.

A special feature of the book are the contour-maps which constitute the twenty-six plates, and are arranged to exemplify the various topographical forms described in the text and pictorially represented in the figures. These are intended to familiarize the beginner with the reading of such maps, and to lead him on to the systematic study of the larger official maps mentioned in lists given at the end of most of the chapters, where also the advanced student will find references to the technical literature of each subject. These map-plates are rendered pleasing in appearance by being printed in the three conventional colours, black, blue (water), and brown (contours). Among many advantages, this method of printing has some disadvantages, for one needs sharp eyes to read the contour-heights, so very sparsely bestowed on most of the maps; and there is also a too frequent recurrence of faulty registration, by which streams are displaced from their valleys, and contours are made to cross surfaces of standing water (e.g. pls. xviii and xx).

Some minor points that seem open to criticism (e.g. the too limiting definition of 'ravine' on p. 119; and the apparent hair-splitting in the sentence on p. 338—"The cones are often called volcanoes, though they are really the results of volcanic activity") must pass without discussion. Of misprints we have noticed only two; one in the letterpress of fig. 701, where 'new moon' should read 'full moon'; and the other on p. 140, where, by the dropping of a letter, we get the strange-looking 'hills de gullies.' G. W. L.

II.—Problems of the Artesian Water Supply of Australia, with special reference to Professor Gregory's Theory; being the Clarke Memorial Lecture delivered before the Royal Society of New South Wales, October 31st, 1907; by E. F. Pittman, Government Geologist of New South Wales. Proc. Roy. Soc. N.S.W., vol. xli.

In the September number of the Geological Magazine for 1907 there was a notice of Australian geology, and incidentally the subject of the Flowing Wells was dealt with, including a short account of Gregory's views thereon. In the following number of the Geological Magazine there appeared a letter from Dr. Malcolm Maclaren, in which he strongly protested against these views on the source of Australian artesian waters. Whilst concluding his letter, Dr. Maclaren indicated that some of his former colleagues in Australia would discuss the subject more fully.

This has now been done by one at least of the writer's colleagues in the Clarke Memorial Lecture to which attention is directed. After explaining the general principles of artesian flow, more especially according to American authorities, Mr. Pittman expresses his opinion that the view adopted by most American geologists has much to recommend it, viz., that all underground waters have their origin in rainfall. The material point, then, to be argued is, "Whether the artesian water supply of the Australian basin has been derived from rainfall, and has been stored in the porous sandstones under hydrostatic or hydraulic pressure, or whether, as contended by Professor Gregory, it has been evolved from underground masses of igneous rocks, and is forced above the surface in bores by the influence of temperature and rock-pressure."

Surely Mr. Pittman is here somewhat overstating his case, since it is doubtful if Professor Gregory maintains that the artesian supply of Australia is wholly due to the above-mentioned causes. He appears to admit the effect of ordinary artesian pressure in a number of instances, and indeed has entered into most elaborate calculations respecting the underground hydrostatic curve. The question between Gregory and Pittman really is, as to whether the alternative causes suggested by the former have any foundation in fact.

After his preliminary remarks the lecturer proceeds to consider the question under two heads: (1) the objections of Professor Gregory to the hydrostatic pressure theory, which are discussed and answered; (2) his suggestions as to the cause of the ascent of the water in the flowing wells.

(1) The objections. These are considered *seriatim*, and it will be sufficient to mention some of them, viz.: loss of head through friction;

rate of flow of underground waters; anomalies in temperature; anomalies in pressure; salinity of artesian waters and the presence of alkaline carbonates; zinc in Toowoomba water (?); tidal wells; outlet for artesian basin, etc., etc.

As regards the loss of head through friction, Mr. Pittman sees no such great difficulty, quoting well-known instances from the Dakota and Paris basins as disproving this notion of the loss of head through friction to anything like the extent claimed by Professor Gregory, whose own book, "The Dead Heart of Australia," may be quoted to show the incorrectness of these views.

The anomalies in temperature are no doubt very puzzling, as many of the flowing wells in Australia show the rate of increase to be 1° F. for every 22 feet, which is greatly in excess of the average of 1° F. for every 53 feet.

To explain this difficulty Mr. Pittman compiles a table showing an increase of 1° F. ranging from 130 feet to 17½ feet in depth, drawn from localities in Europe and America. Gregory rejects the explanation of "different ratios of conductivity" in the rocks themselves, and the lecturer admits that some of the high temperatures may be due to the bores having been put down to centres of expiring volcanic activity. "It is only reasonable to suppose that the porous Triassic sandstones which form the base of the artesian basin have also been intersected by many dolerite dykes which do not appear at the present surface." But are these anomalous temperatures any proof of the *plutonic* origin of the water? It is more or less an assumption, we believe, that there is any such thing as plutonic water. This is probably nothing more or less than Daubrée's *quarry-water*,[1] though possibly the Professor may consider the views of the eminent chemical geologist as somewhat out of date.

As regards anomalies in pressure, the consideration of this subject would lead us into a study of isopotentials, which can scarcely be followed without special topographical knowledge, but the subject of saline contents may occupy our attention for a moment. The following are the particulars of Gregory's objections under this head:—(1) that the water does not increase in salinity with sufficient regularity as it flows from east to west; (2) that the dissolved constituents vary irregularly in nature as well as in amount in the wells of the central basin; (3) that the presence of alkaline carbonates in the majority of the well-waters and of zinc in "the well of Toowoomba" are evidence in favour of the plutonic origin of the water. To the first two objections Pittman says there is nothing remarkable that in a distance of 600 miles there should be variation in the accidental constituents of the artesian water, as such variations occur in shallow wells in close proximity; moreover, he contends that the average salinity of the South Australian wells is distinctly higher than that of the wells in the eastern States. But the most extraordinary thing is the idea that the presence of alkaline carbonates should be quoted as evidence of plutonic origin. The artesian waters

[1] For an explanation of this term *vide* Review of Daubrée's "Experimenta Geology," GEOL. MAG., 1879, p. 427.

of Iowa and Texas are shown to contain carbonates (chiefly of soda), and the artesian waters of the Cretaceous basin of Alabama also contain considerable quantities of alkaline carbonates. In any case it is unnecessary to go to any plutonic depths to discover the source of the alkaline carbonates in the Australian basin, and he points out the probable presence of felspars in the porous sandstones from which much of the water is derived. We might quote an instance much nearer home, viz. that of the artesian wells in the Chalk under London, where the soda salts (including carbonates) are said to increase with the depth of the bore. It appears that the presence of zinc in the well at Toowoomba was due to artificial contamination—not that the small amount discovered, even if the result of natural causes, could have been accepted as evidence of the plutonic origin of the water.

(2) The cause of the ascent of the water in the flowing wells. This, according to Professor Gregory, is due to the *internal heat of the earth* and *rock pressure.* The discussion on this latter subject raises some points of interest. He remarks that attention was first called to the importance of rock pressure in reference to flowing wells by Mr. Robert Hay. Mr. Pittman points out that it is an old theory, and was thought to have been disposed of by Arago early in the nineteenth century. But we may observe that there always has been a recrudescence of heterodoxy in all branches of human thought, so that it is not surprising to learn of others in Australia, like Mr. F. B. Gipps, advocating this view. On the whole, the weight of authority, especially in America, is against the rock-pressure theory, and an important official in that country, *apropos* of the Kansas flowing wells, writes to Mr. Pittman as follows:—"Rock pressure as a cause of artesian flows has been advocated by several geologists besides Mr. Robert Hay, but has never been supported by any real evidence, and has never received official sanction, nor has it been generally accepted by careful private investigators. In fact, it should be regarded simply as a suggestion advanced to explain flows for which no other cause was known at the time."

Both Mr. Pittman and Professor Gregory agree in deploring the waste of artesian waters throughout Australia. It seems probable that even under the hydrostatic theory those portions of the basin furthest from the intake must be, to a certain extent, dependent on previous accumulations. If this is the case the Australian borer, though not living entirely on his capital like the coal-miner, is using up resources which cannot immediately be replaced.

In a postscript Mr. Pittman points out that the rocks termed Triassic in this paper include the lower water-bearing sandstone (of fresh-water origin) of the great Australian artesian basin. In Queensland they are known as the Trias-Jura, and are there overlain in places by the Blythesdale Braystone, a porous marine sandstone, which forms the basal bed of the Lower Cretaceous system. This formation is not known to occur in New South Wales, where the artesian water occurs in the older Triassic (or Trias-Jura) sandstones.

W. H. H.

III.—Traité de Géologie. I : Les Phénomènes Géologiques. By Émile Haug, Professor of Geology at the Faculty of Sciences in the University of Paris. 8vo ; pp. 546, with 71 photographic plates and 195 text-illustrations. Paris : Armand Colin, 1907.

THIS is a veritable picture-book of geology, with descriptions of phenomena and features relating to atmosphere, hydrosphere, lithosphere, pyrosphere, and barysphere. It embodies the latest results of observation and research, which are placed before the reader in a manner attractive as well as instructive, and withal characterized by terse and lucid explanation and sound judgment. We are, however, in this as in many other modern scientific books, brought face to face with an exuberance of technical terms, the use of which may be necessary as we specialize more and more, although their multiplication tends to vexation. Those who read steadily through this book may gather the meaning of terms as they progress, but to those who take it up for reference the absence of an index is a serious drawback that time will not wholly remedy. A volume such as this, even if it be the first part of a general treatise, requires an index. Moreover, the subject is likely to appeal to a number of readers and students who might not need the second or subsequent parts. A very useful feature of the work is the series of bibliographies appended to each chapter, in which from about ten to more than sixty references are included.

In a brief introduction the author explains the aims and objects of geological inquiry, and points out that Geodynamics, including Geomorphogeny, are the topics discussed in his present volume. Examples of geological phenomena are followed by explanations of Lithogenesis, Orogenesis, and Glyptogenesis, the formation of rocks, their upheaval, and sculpture; subjects dealt with in detail further on. The author then considers the general morphology of the earth, the distribution of life on land and in water, and especially the various conditions under which marine forms exist. Deutogenous or detrital sediments, as well as those of organic and chemical origin, are considered; and the subject leads on to that of Diagenesis, wherein the transformation of sediments, the effects of dissolution, decomposition, and recrystallization are dealt with. Concretions and dolomitization, peat, lignite, and coal are successively discussed.

The facies of formations is next explained as the sum of their lithological and palæontological characters in a certain area. Where the same facies prevails the formation is Isopic, where a different but still synchronous facies occurs it is Heteropic.

This subject, which is properly discussed from a natural history point of view, is a fascinating one for stratigraphical geologists, who have to deal not only with the occurrence of certain species forming palæontological zones or horizons irrespective of sedimentary conditions, but also with the occurrence of genera and species whose range is limited by depth of water and character of sea-bottom. The use of the term homotaxis is regarded as appropriate for strata with identical palæontological and lithological characters which occur at different chronological horizons in areas apart.

Various accumulations, such as oolite, bone-beds, and phosphates, are dealt with. Under continental conditions there are deposits subaerial, alluvial, and laguno-lacustrine; so under marine conditions there are deposits neritic, bathyal, and abyssal. In the French language, as remarked by the author, there is no single word to express the adjective 'shallow': *peu profond* seems to be the usual term. He employs the word 'neritic' to indicate the truly littoral formations, remarking that the higher marginal deposits of ancient seas have nearly always been destroyed by subsequent erosion, so that the actual extent of strata preserved seldom corresponds to the limits of the ancient sea.

We turn now to the consideration of Geanticlinals and Geosynclinals; to areas of synclinal depression and deposition, and their relation to continental areas. The Pacific is described as a depression having a convex form, suggesting that it was an ancient continental site.

Metamorphism and the crystalline schists or crystallophyllian formations, plications and dislocations, fan-structure, erosion-thrusts, and torsion come in for due treatment. Here, as elsewhere, the examiner will find a mine of helpful terms. "What is meant by a Dissymmetric Brachyanticlinal?" would, for instance, be a capital question. The diagrams and views of folds and thrusts are very good, but some of the views might with advantage have been accompanied by explanatory diagrams in the text.

Volcanic phenomena and earthquakes are very fully treated both in text and illustration; and the views of the eruption of Vesuvius in 1906 and of the destruction caused by the Japanese earthquake of 1891 are striking and effective.

It is remarked that there is nothing to indicate with certainty that the volcanoes of Auvergne are extinct. Vesuvius in ancient times was not regarded as a volcano, until it awoke in A.D. 79. While generous acknowledgment is given to the work of others, we miss (on p. 260) a reference to the Report on the Eruptions of the Soufrière in St. Vincent, by Dr. Tempest Anderson and Dr. J. S. Flett (1902), although the "Volcanic Studies" of the former are noted in the bibliographic list.

Fumaroles, geysers, metalliferous veins, the origin of petroleum, and other subjects of practical interest are dealt with; including the depth to which water can penetrate in the rocky crust, the *nappe phréatique*, which may be interpreted as the plane of saturation or water-table, springs, and the action of subterranean water. Glyptogenesis, or the sculpturing of the earth's surface, is naturally attractive, whether in the form of corrasion or corrosion, chemical or mechanical water-action. There are good figures of honeycomb (alveolar or cellular) weathering, of decomposed basalts, of sand erosion, and of the remarkable wall of Tanaron in the Basse-Alpes, which recalls to mind the structural features of the ridge of tilestones near Llandeilo. The view of sand-dunes in the Sahara is excellent.

The action of running water (ablation), the meanders of rivers, the base-level of erosion, and other matters relating to potamology receive illustration and explanation. There are fine views of river gorges and also of glaciers, and the brief remarks on the excavation by glacial action of certain valleys and of fjords, afterwards occupied by sea, are treated with due indication of divergent opinions.

The final chapter deals with marine erosion, with beach lines, and the questions of oscillation of land and sea.

IV.—Bulletin of the Pennsylvania State College (June, 1907). Fasciculus of the School of Mines and Metallurgy. Small 8vo; pp. 155.

THERE are no less than seven Schools in this College, the subjects ranging from Languages to Engineering, but we only propose to notice the seventh, which is under the charge of Professor Wadsworth, M.A., Ph.D., who has been a Fellow of the Geological Society of London since the year 1889. His wide experience in the rich mining districts of Michigan pre-eminently fit him to take charge of a School of Mines.

The fasciculus consists largely of the details of the work which the students have to carry on from the first to the fourth year. There is a general notice of the scope and object of the school. "The instruction must comprise all things requisite to find and obtain the earth's mineral wealth and prepare it for the market. This requires that the students should be trained to prospect or to conduct exploitations in the forest and field; to distinguish the useful minerals and rocks; to understand the geological principles that govern the formation and association of useful mineral products, etc., etc." Thus it will be at once perceived that this school is animated by a thoroughly practical spirit, and there is no room for the amateur geologist here.

On p. 56 the work of the School of Mines and Metallurgy is arranged in groups in the following order:—

1. Geology.
2. Geological Laboratory.
3. Metallurgy.
4. Metallurgical Laboratory.
5. Mineralogy.
6. Mineralogical Laboratory.
7. Mining.
8. Mining Laboratory.
9. Mining Geology.
10. Mining Geological Laboratory.
11. Mining Law.
12. Ore Dressing and Coal Washing.
13. Ore Dressing Laboratory.
14. Palæontology.
15. Palæontological Laboratory.
16. Petrography.
17. Petrographical Laboratory.

In describing the methods adopted with reference to these courses a certain amount of repetition is inevitable. The subjects more directly relating to geological science include Geology, Mineralogy, Mining Geology, Palæontology, Petrography, and their respective 'laboratories.' Professor Wadsworth again points out how important it is for the student to endeavour "to understand the connection and structural relations that rock masses bear to one another, and to the valuable deposits that they contain." Amongst the textbooks used in this particular course (Geology) we are glad to notice some well-known British authors, such as the two Geikies, Bonney, Judd, and Milne. As regards structural geology more especially, we note the names of Green, Prestwich, Fisher, and other British authors. The 'Geological Laboratory' work includes a course of mapping, but it mainly resolves itself into a series of field-excursions, where the student can be taught at the 'bedside.'

A very brief allusion to the remainder of the five selected subjects must suffice. Mineralogy is intimately associated with Crystallography and Macroscopical Petrography. Under this heading Dana, Wadsworth, Story-Maskelyne, and Lewis are the leading textbook authorities. The 'Laboratory' plays a most important part in this section, where the practical work of examining, testing, and identifying specimens of minerals and rocks is carried on. "In this way each student is required to determine in his course from one thousand to three thousand different mineral specimens belonging to the selected species." In Mining Geology particular attention is given to the occurrence and use of stone, clay, lime, cement, coal, iron-ore, and other economic products worked in the State. The object of the courses in Palæontology "is to familiarize the student in the field and laboratory [? museum] with the more common fossils, particularly those that characterize the Palæozoic formations. The student will be practised in the determination of the varying types which he is expected to draw and describe." Petrography is considered under two heads, viz., Optical and Microscopical Mineralogy and Microscopical Petrography. In this course the alterations of minerals are especially studied. Amongst the textbooks quoted are Iddings, Van Hise, Hatch, and Harker.

Throughout this fasciculus Professor Wadsworth never fails to impress upon his readers how much benefit men engaged in prospecting have derived, or are likely to derive, from such studies, and more especially from Mineralogy and Mining Geology (p. 116). He seems to be conscious that four years is rather a short period for the absorption of such a mass of information as is afforded by the State College of Pennsylvania. We feel sure, however, that the finished article, after passing through all these courses and laboratories, ought indeed to be *factus ad unguem.*

V.—The Glaciation of East Lothian.

In this country there are no geological papers more sumptuously printed and illustrated than those which in quarto form issue from the Royal Society of Edinburgh. One of these, just received by us, is entitled "The Glaciation of East Lothian, south of the Garleton Hills" (Trans. R. Soc. Edin., vol. xlvi), by Professor P. F. Kendall & Mr. E. B. Bailey. In it the authors deal with the operations which took place during the retreat of the ice-sheet which invaded the region and overrode the Lammermuir Hills during the period of maximum glaciation. The general direction of the ice-movement was from W.S.W. to E.N.E., eventually turning east and a few degrees south of east, from the Garleton Hills towards St. Abbs Head.

The district is described as presenting "the special characteristics of an ice-dressed surface," the topography being that of a drumlin country. Long low mounds or ridges run parallel with one another, separated by shallow broad-bottomed grooves or valleys. Instead of being formed of Boulder-clay, as in the case of true drumlins, these mounds have been fashioned in solid rock and are merely coated over with Boulder-clay. Examples of 'crag and tail' are noted where ice met an isolated resistant mass of rock, and the excavation of a shallow tarn is pointed out where a change of slope occurred along one of the grooves. Attention is also called to the presence of large transported masses of Carboniferous Limestone, in one case one-third of a mile long and a quarter broad.

Turning to the phenomena attending the retreat with occasional re-advances of the ice-sheet, the authors remark, "Thus step by step the enveloping ice shrank back to leave the Lammermuirs standing like a stone in the midst of melting snows; and stage by stage the memorials of this retreat were furnished by the obstructed drainage of the hill country, joined by the waters issuing from the glacier itself."

The phenomena in question did not affect the higher portions of the Lammermuir Hills; they indicate the action of water impounded in front of the retreating ice-sheet, and serve to explain the anomalous drainage system, which could not have been produced under any existing circumstances. The peculiarities of the surface features were observed more than forty years ago by Professor John Young and Sir Archibald Geikie, and the latter suggested that they might be due to the modifying influence of direct glacial erosion. Thus instances were given of narrow glens or ravines, quite dry, and open at each extremity, along which, with the present configuration, no stream could ever have flowed. The present authors point out that many of the typical examples of these deserted ravines have been excavated entirely in drift deposits, and cannot therefore be vestiges of a pre-glacial drainage system. They are, in fact, overflow channels which have been cut by glacially diverted waters, and have failed in later times to retain streams.

There are, however, numerous glacial drainage-channels still occupied as watercourses, and to these special attention is drawn. They exhibit a marked tendency to the formation of 'corroms' and the consequent establishment of short cuts. The term corrom (cothrom), as remarked by the authors, is a Gaelic word used in place-names in the Ardgour district of Argyllshire to denote a delta-watershed. Its literal meaning is a 'balance,' and it is intended to illustrate that a stream issuing upon such a cone has the chance of flowing either the one way or the other. In the present district it has been found that there are many cases where a tributary stream has thrown out a cone or delta into a deserted glacial drainage-channel and established a watershed within it.

The authors deal with these highly interesting features, and describe the later erosion that has been produced by streams that have been left in occupancy of glacial drainage-channels. This erosion is seen in the winding gorges that have been carved on the floors of some of the ancient valleys.

It should be mentioned that the authors use the term corrom in reference to function and not to origin; remarking that "many a great beheaded valley must have found itself in just such plight, and accepted a corrom as the watershed of its lower reaches."

The memoir, which is issued to the public at 4*s.* 6*d.*, is illustrated by four beautiful photographic plates, a colour-printed map, and six text-illustrations.

VI.—Geological Survey, Western Australia. Bulletin No. 27: Palæontological Contributions to the Geology of Western Australia. By Robert Etheridge, F. Chapman, and W. Howchin. 8vo; pp. 71. Perth, W.A.

This Bulletin contains five papers, all of them of considerable interest from the geological standpoint as well as from that of the palæontological. The first is a brief statement made by Mr. R. Etheridge on "Plant Remains from the Collie Coalfield," in which the writer, after citing the views as to the age of the beds entertained by Mr. H. P. Woodward (1891, 1894) and by Mr. Robert Etheridge, F.R.S. (1894), forms the opinion on the evidence of *Glossopteris* remains that the beds are of Permo-Carboniferous age, in this confirming his father's views, which, as will be shown in the sequel, were well founded. In the next paper, "Notes on Fossils from the Collie Coalfield, West Australia, in the Collection of the National Museum, Melbourne," Mr. F. Chapman refers to the conclusive settlement of the age of this coal-bearing stratum by Sir Frederick McCoy in 1898. The specimens upon which this important determination was based are described in detail and figured by Mr. Chapman from the new and valuable material secured for the Museum by Sir John Forrest. The species identified are *Glossopteris Browniana*, var. *Australasica*, Brongniart (sp. and var.); *G. Indica*, Schimper; *G. angustifolia*, Brongniart; *G. Gangamopteris*, Feistmantel; together with specimens of the rhizoma of *Glossopteris* (= *Vertebraria*), and some plant-fragments of uncertain affinities.

In addition to the plant-remains a small series of Foraminifera was obtained in the whitish sandstone accompanying the coal-seams. They proved from their exceptional minuteness very difficult to determine, but the presence among them of a characteristic Carboniferous species, *Valvulina plicata*, d'Orb., is an additional testimony, if such were required, to the correctness of the age assigned to the rocks from which they are derived. Their presence in strata associated with the Collie coal-beds is also interesting, as showing that these deposits are due to drifted material of marine or estuarine origin. The forms enumerated consist of the species above mentioned, together with *Truncatulina Haidingeri*, d'Orb., *Endothyra* sp., *Bulimina* sp., *Pulvinulina* cf. *exigua*, Brady.

The third paper is by Mr. R. Etheridge, and contains descriptions and figures of fossils from the Irwin River, W.A., collected by Mr. E. S. Simpson and Mr. C. F. V. Jackson. The fossils consist of casts and impressions, mostly badly preserved, and therefore difficult of determination. The following are the species: *Dielasma nobilis*, sp. nov., *Spirifera*, sp. ind., *Cyrtina carbonaria*, var. *Australasica*, Eth. fil., *Cliothyris Macleayana*, Eth. fil., *Productus subquadratus*, Morris, *Chonetes*, sp. ind., *Deltopecten subquinquelineatus*, McCoy, *Modiola* (?), sp. ind., *Myalina* (?) *Mingenewensis*, sp. nov.

The fourth paper is also contributed by Mr. R. Etheridge, and in this the Carboniferous fossils of the Irwin River are carefully described and figured. The facies of these fossils is stated to be that of the Carboniferous as distinguished from the higher Permo-Carboniferous.

One of the fossils, a Goniatite of the genus *Gastrioceras*, is of special interest, being of an unusual size. The following are the species identified: Foraminifera—*Nubecularia Stephensi*, Howchin. Actinozoa—*Pleurophyllum Australe*, Hinde. Polyzoa—*Fenestella fossula*, Lonsdale. Brachiopoda—*Dielasma* sp., *Seminula subtilita*, Hall (?), *Spirifera* sp., *Reticularia lineata*, Martin, *Productus semi-reticulatus*, Martin, *P. tenuistriatus*, var. *Foordi*, Eth. fil., *P. undatus*, Defrance, *P. subquadratus*, Morris (?), *Chonetes Pratti*, Davidson. Pelecypoda—*Aviculopecten Sprenti*, Johnston, *Aviculopecten* sp., *Conocardium* sp., *Stutchburia* sp. Gasteropoda—*Bellerophon costatus*, J. de C. Sowerby, var. Cephalopoda—*Gastrioceras Jacksoni*, sp. nov.

In the fifth and last paper Mr. W. Howchin describes a small collection of Foraminifera from a calcareous marlstone at Gingin, which are regarded by Mr. R. Etheridge as probably of Upper Tertiary age, though the evidence is insufficient to establish the exact horizon.

A. H. F.

VII.—Geological Survey, Western Australia. Bulletin No. 28: The Geology and Mineral Resources of Lawlers, Sir Samuel, and Darlot (East Murchison Goldfield), Mount Ida (North Coolgardie Goldfield), and a Portion of the Mount Margaret Goldfield. By Chas. G. Gibson, Assistant Geologist. 8vo; pp. 73, with 3 maps and 5 mining plans. Perth, W.A.

In this report some of the most important of the mining centres of the State are dealt with. The area surveyed is described in the title above. As stated in previous reports, the rocks of the district consist of a complex of crystalline rocks, the age of which, as far as the evidence indicates, is Pre-Cambrian or Archæan. There is an acidic and a basic series, that is, there are 'granites' and 'greenstones,' the granites occupying the larger area, but not being the oldest rocks, as they are often intrusive in the greenstones. Both are traversed by numerous granitic and felspathic dykes, as well as by dolerite dykes traversing the granite of the Lawlers district. Quartz veins occur, apparently of later origin than the granite, generally at the junction of the latter with the basic rocks, indicating a possible genetic connection between the granite and some of the quartz veins.

Mr. Maitland, in his prefatory note, lays stress upon the fact that the quartz reefs are of later date than the granite intrusion, because this indicates that the reefs are not likely to be cut off, which might have happened had their formation preceded the intrusion. The question has obviously an important bearing upon the results of gold-mining in the area under review.

The report is well illustrated with photographic reproductions showing the physical features of the country, and with maps, plans, and sections of the mines in operation.

A. H. F.

VIII.—Catalogue of Students' Collection in Sedgwick Museum. By Henry Woods, M.A., F.G.S.

THE third edition has been issued (price 6*d.*) of a "Catalogue of the Fossils in the Students' Stratigraphical Series," Sedgwick Museum, Cambridge, by Henry Woods, M.A. It will undoubtedly be welcome to many teachers as well as students, to those who write textbooks as well as to those who conduct classes, and we hope also to those who act as examiners. It will probably not be welcome to the majority of expert palæontologists or specialists. Nevertheless, as a *via media* it is an important sign of the times. Those who have to deal with students and amateurs who require only a general knowledge of geology and palæontology, know full well that to attempt to teach a knowledge of fossils combined with modern palæontological nomenclature is an almost hopeless task. Those who seek to become specialists in one or more branches of palæontology (for no one can be expert in all) must learn the older and more comprehensive names of fossils, as well as those applied to the present subdivisions both of genera and species. For them to neglect the history of the subject would be fatal. To the amateur, to the student who wishes to apply geological knowledge to engineering or mining questions, and to the more advanced geologist who cares not to grapple with the genealogical side of palæontology, a simpler system of nomenclature, such as that given in the present list, should be ample. Therefore, we rejoice to see in this Catalogue the familiar names of *Goniatites sphericus*, *Aviculopecten papyraceus*, *Avicula contorta*, *Waldheimia numismalis*, *Ammonites serpentinus*, *Rhynchonella spinosa*, *Ostrea gregaria*, *Cyprina Islandica*, and *Rhinoceros tichorhinus*.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

Annual General Meeting.

February 21*st*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The Reports of the Council and of the Library and Museum Committee for the year 1907, proofs of which had been previously distributed to the Fellows, were read. It was stated that the flourishing condition of the Society had been marked, in the year under review, by a further increase in the number of Fellows, the number elected being 74 (20 more than in 1906). Of these, 58 paid their admission fees before the end of the year, making, with 16 previously elected Fellows, a total accession of 74 in the course of 1907. During the same period, the losses by death, resignation, and removal amounted to 47 (9 more than in 1906), the actual increase in the number of Fellows being, therefore, 27 (as compared with an increase of 12 in 1906). The total number of Fellows on December 31st, 1907, was 1278.

The balance-sheet for that year showed receipts to the amount of £3,100 17*s.* 10*d.* (excluding a balance of £216 1*s.* 7*d.* brought forward from 1906), and an expenditure of £3,148 2*s.*

Reference was made to the issue of the "History of the Geological Society" prepared and edited by Mr. H. B. Woodward. It was intimated that the Council had decided to publish, in a style uniform with that of the Quarterly Journal, a Centenary Record, which would include, besides a general account of the proceedings at the centenary celebration, the centennial address delivered by the President and the addresses of congratulation received from all parts of the world.

The list of Awards of the various Medals and Proceeds of Donation Funds in the gift of the Council was read.

The President handed the Wollaston Medal, awarded to Professor Paul von Groth, F.M.G.S., to Mr. F. W. Rudler, I.S.O., for transmission to the recipient, addressing him as follows:—

Mr. Rudler,—The Council of the Geological Society has this year assigned its highest distinction, the Wollaston Medal, to Professor Paul von Groth in recognition of the value of his lifelong services in the investigation of "the mineral structure of the Earth." His original researches have placed him among the leaders of mineralogy and crystallography in our day; and his right to that eminent position has been greatly enhanced by the genius which he has shown in the teaching of his subject, by the organization of his laboratory for advanced training, by the admirable arrangement and execution of his text-books, and by the zeal and success with which for thirty years he has edited and published his now indispensable "Zeitschrift für Krystallographie und Mineralogie." His laboratory has become the Mecca of modern mineralogy, to which pilgrims repair from all parts of the world to learn the methods of the great master at Munich. His remarkable personal charm has endeared him to all who have come into close contact with him, and who discover that he is at once one of the most retiring and yet most popular of scientific men.

It is to myself a peculiar pleasure that I should be privileged on the present occasion to transmit the award of the Council to so old a personal friend of my own. He will, I am sure, regard the Medal with special interest, since it bears the name and the effigy of one of the foremost of English mineralogists, whose reflecting goniometer was doubtless a familiar instrument in Professor von Groth's hands from his student-days onwards. In asking you to receive it for him, I would wish you to convey with it an expression of the cordial wishes of the Society for his prolonged health and activity. We earnestly trust that he will not only be able to complete the gigantic task of his "Chemische Krystallographie," but continue for many years thereafter to reap the fruits of his labour by witnessing the quickened advance of the science to which he has so unremittingly devoted his strenuous life.

Mr. Rudler, in reply, read the following message received from the recipient:—

Mr. President,—I regret that official duties at Munich prevent me from coming to London to receive the Wollaston Medal, and from thanking in person the Council of the Geological Society for the great honour conferred upon me.

As my researches in Physical and Chemical Crystallography have not been very closely related to Geology, while my Mineralo-geological work on the mineral deposits of the Alps, the rocks of the Vosges, etc., has been of itself too unimportant to have afforded a reason for the gift to me of the highest distinction that the Geological Society of London has to bestow, I am compelled to regard the award of the Medal as intended to be a recognition of my work, during many years, as a teacher of Mineralogy and Crystallography to pupils who were, many of them, Geological students.

I rejoice to be able to say that from no country have better pupils come to my laboratory and lectures than from England itself, and that it has been a great happiness to continue with such pupils the work which Professor Miller founded at Cambridge with his introduction of Rational Indices, and which my highly-esteemed friend Professor Maskelyne did so much to encourage at Oxford by his lectures on Crystalline Symmetry.

In this sense, as a fellow-worker in the scientific training of the junior mineralogists of England, I have pleasure in accepting, with the most hearty thanks, the distinction conferred upon me, and hope to be permitted to give like help to other pupils from the same country in the more immediate future.

The President then presented the Murchison Medal to Professor Albert Charles Seward, F.R.S., addressing him in the following words :—

Professor Seward,—The Murchison Medal is awarded by the Council to you as a mark of appreciation of the services you have rendered to geological science by the skill, zeal, and success with which you have for many years pursued the study of fossil plants. Your researches have embraced a wide botanical range and an extended series of geological formations, while the materials on which you have worked have come to you from many different and distant regions of the globe. Your studies of the Wealden flora have enabled you to present an ampler and more vivid picture of the vegetation of later Mesozoic time than was before obtainable. Your discussions of the *Glossopteris*-flora and of the European and Eastern Mesozoic floras have been full of suggestion to geologists. It is only by trained and persistent students, who, like yourself, have an intimate knowledge of living forms, that the structure and genetic relations of the plants and animals of past time can be satisfactorily elucidated. We wish you many long years of active life, and we confidently expect that, from the Chair of Botany in Cambridge, you will continue to advance the study of Palæobotany, and will in this way sustain and extend the reputation of the great Cambridge geological school.

Professor Seward replied as follows :—

Mr. President,—I desire to express my sincere thanks to the Council of the Society for selecting me as the recipient of the Murchison Medal: the news of the award came to me as one of the pleasantest surprises that I have ever had. A student is not supposed to look forward to material rewards for what little he is able to contribute towards the advancement of Natural Knowledge; but, when a reward comes, it awakens feelings no less pleasurable than those of a schoolboy receiving his first prize. I little thought, sir, when I first became acquainted with your name nearly thirty years ago, that I should ever have the pleasure and privilege of receiving a Medal from your hands. As I have been for some years, officially at least, a botanist, the high compliment paid to me by the Society is the more appreciated. This is, perhaps, one of the very few occasions when it is pardonable to speak of oneself. The first stimulus I received which made me respond to the attraction of Geology, was supplied by some University Extension Lectures delivered by my oldest geological friend, Dr. Marr. A few years later I began to read Botany at the suggestion of Professor McKenny Hughes, a suggestion for which I have every reason to be grateful; but it was the fascination of geology which caused me to diverge from the path originally marked out for me, and to give my allegiance to Natural Science.

On looking through the list of Murchison Medallists I was reminded that last year the award was made to Mr. Harker; though I have often regretted that Palæontology did not secure his affection, I am proud to appear next him in so honourable a list. In my undergraduate days Harker was one of my best friends, whose generous help I am not likely to forget. I rejoice also to find myself in the company of Professor Goeppert and Professor Roemer in the list of Medallists. It was once my privilege to spend some weeks in examining the classic collections of Goeppert in the University of Breslau, where the hospitality of the late Ferdinand Roemer taught me that differences in age and nationality count for little among those whose lives are devoted to the common cause of Science. Professor Geinitz, another Murchison Medallist, received me in Dresden twenty years ago with a friendliness which made a lasting impression. The name of Professor Newberry reminds me of another friendly senior.

To follow such men as I have named is not merely an honour, but a strong incentive to do my utmost to render myself less unworthy of being permanently associated with them in the records of the Society.

In handing the Lyell Medal, awarded to Mr. Richard Dixon Oldham, to Mr. G. W. Lamplugh, F.R.S., for transmission to the recipient, the President addressed him as follows :—

Mr. Lamplugh,—In asking you to transmit to Mr. Oldham the Lyell Medal, which has been awarded to him, I would wish you to express to him the appreciation of the Council of the value of the work which he has done in the advancement of Geology. During his long connection with the Geological Survey of India, he was able to add much to our knowledge of the geological structure of that great dependency. At the same time he was always alive to the bearing of his observations on the wider problems of our science. Besides his ordinary official duties, he from time to time has undertaken special subjects of enquiry. Of these, probably the most important was his careful investigation of the effects of the great Indian Earthquake of June 12th, 1897. Since he retired from his Indian appointment he has continued to take part in the discussion of seismic phenomena, and he has written some noteworthy papers dealing more particularly with the relations of the subject to the internal constitution of the globe. I greatly regret his absence to-day from illness.

It would have been to me no small satisfaction that it should have fallen to me to present this Medal, for one of the pleasant memories of my life is that I counted his father among my friends. As the worthy son of a distinguished sire, he has carried on the family tradition. Will you tell him that the Society trusts that, as he is now once more resident in this country, we may often see him at our meetings, and that for many years to come we may be favoured with communications from him on the geological questions in which we are all interested.

Mr. Lamplugh, in reply, said:—

Mr. President,—In the unavoidable absence of Mr. Oldham, I will ask your permission to read the following letter, explaining the circumstances, which I received from him this morning:—

"If you are not, like me, laid up with a mild attack of the universal influenza, I should be very much obliged if you would represent me to-morrow, accept the Medal, and express on my behalf my gratitude for the favour which the Council has accorded me. The grant is the more gratifying as, since I have been free to follow my own inclinations, these have led me to a branch of our science which had almost ceased to be regarded as Geology, but finds its proper place in the 'Principles' of the founder of the Medal which I ask you to accept on my behalf."

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Herbert Henry Thomas, M.A., the President addressed him in the following words:—

Mr. Thomas,—The Balance of the Proceeds of the Wollaston Donation Fund has been by the Council awarded to you, in recognition of the value of your investigations into the composition of sedimentary rocks and also of the work done by you in the Palæozoic series of South Wales. The Society hopes that you may be encouraged to continue your interesting enquiries into the derivation of the finer sediment in ancient stratified formations—a subject which has hitherto been comparatively little studied, but from the pursuit of which much light may be expected to be thrown on the geographical conditions of former geological periods.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Miss Ethel Gertrude Skeat, D.Sc., addressing her as follows:—

Miss Skeat,—The Council has this year awarded to you the Balance of the Proceeds of the Murchison Geological Fund as a mark of appreciation of your geological work, especially among the Glacial deposits of Denmark and the Lower Palæozoic rocks of Wales. It is with much gratification that we hail in you another woman who is worthily placed on the roll of those who have gained our awards. We trust that you may be able to devote many active and happy years to the further prosecution of the studies in which you have shown such conspicuous success.

In presenting a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Harold J. Osborne White, F.G.S., the President addressed him in the following words:—

Mr. Osborne White,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund has been awarded to you by the Council, in acknowledgment of the service which you have rendered to Geology by your researches among the Cretaceous and Pleistocene deposits of Berkshire and Oxfordshire. Your detailed investigation of the zones of the Upper Chalk has brought to light some interesting indications of flexures and of a considerable erosion of the Chalk before the deposition of the Reading Beds; while your papers on the Plateau- and Valley-Gravels in the western part of the London Basin have important bearings on the history of the rivers of that region and on the origin of the present configuration of the ground. We hope that you may be encouraged to continue and extend these observations.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Thomas Franklin Sibly, B.Sc., to Professor E. J. Garwood, M.A., for transmission to the recipient, addressing him as follows:—

Professor Garwood,—A second moiety of the Balance of the Proceeds of the Lyell Geological Fund has been assigned to Mr. Sibly, on whose behalf I would ask you to receive it, as a mark of the Council's appreciation of the zeal and ability with which he has applied the method of zonal classification to the Carboniferous Limestone of various districts in England. There still remain many tracts of the British Isles in which that portion of the Palæozoic series has never yet been worked out in detail. We shall be glad if he will be encouraged to enter some of them, and thus to continue the work which he has already so successfully pursued.

The President then proceeded to read his Anniversary Address, giving first of all Obituary Notices of several Fellows deceased since the last Annual Meeting, including Prof. Marcel Bertrand (elected For. Memb. in 1899); Dr. E. Mojsisovics von Mojsvár (elected For. Memb. in 1893); Prof. Carl Klein (elected For. Corresp. in 1903); Sir Richard Strachey (elected a Fellow in 1851); Sir James Hector (el. 1861); C. L. Griesbach (el. 1874); the Rev. R. Baron (el. 1889); Prof. B. J. Harrington (el. 1883); Dr. E. J. Routh (el. 1864); Mark Stirrup (el. 1876); Lord Allendale (el. 1851); A. B. Wynne (el. 1860); J. F. Walker (el. 1867); Robert Law (el. 1886); Edward Power (el. 1892); P. L. Addison (el. 1888); and T. W. H. Hughes (el. 1865).

He then dealt with the published work of the Geological Society of London during the first century of the Society's existence, describing in the first place the traces of the Neptunist and Vulcanist controversy, as preserved in the early papers published by the Society. The contributions to Geology which had appeared in the "Transactions," "Proceedings," and "Quarterly Journal," were discussed under five heads: (1) British Geology; (2) Foreign Geology; (3) Petrography; (4) Palæontology; and (5) Physiography. In each of these divisions a rapid review was offered of the general character of the contributions presented to the Society, with a more particular reference to some of the outstanding papers, especially to those which inaugurated a new departure in geological research. In the last portion of the Address reference was made to certain contrasts which such a review as had been given presented between the past and the present character of the papers published by the Society. Some of the conclusions to be drawn from the contrast were urged on the attention of the Fellows. The heritage of distinction which had been handed down from the founders of the Society and their successors was a precious possession of which every Fellow might well be proud, and which ought to be continually borne in mind as a stimulus to sustain and extend the Society's prestige.

The Council elected for the ensuing year is as follows:—

Officers:—President: Professor W. J. Sollas, Sc.D., LL.D., F.R.S. *Vice-Presidents:* Frederick W. Rudler, I.S.O.; Aubrey Strahan, Sc.D., F.R.S.; J. J. H. Teall, M.A., D.Sc., F.R.S.; and A. Smith Woodward, LL.D., F.R.S. *Secretaries:* Professor E. J. Garwood, M.A.; and Professor W. W. Watts, M.A., M.Sc., F.R.S. *Foreign Secretary:* Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., LL.D., Sec.R.S. *Treasurer:* Horace W. Monckton, Treas.L.S.

Ordinary Members of Council: Professor S. H. Cox, F.C.S.; Alfred Harker, M.A., F.R.S.; W. H. Hudleston, M.A., F.R.S.; F. L. Kitchin, M.A., Ph.D.; George W. Lamplugh, F.R.S.; Richard Lydekker, B.A., F.R.S.; Professor Henry A. Miers, M.A., F.R.S.; Richard Dixon Oldham; Professor Sidney Hugh Reynolds, M.A.; Leonard J. Spencer, M.A.; Charles Fox Strangways; Richard H. Tiddeman, M.A.; Henry Woods, M.A.; and George William Young.

II.—Palæontographical Society.—The sixty-first annual meeting of the Palæontographical Society was held on March 20th, in the Geological Society's rooms, Burlington House, W., Dr. Henry Woodward, F.R.S., President, in the chair. The annual report alluded to the unusually varied contents of the volume for 1907. It provides indexes and title-pages for several monographs completed or discontinued. The Council favoured the plan of publishing smaller works; the current volume included a complete Monograph of British Conularia, by Miss Ida L. Slater, with five plates drawn by the authoress. Losses in membership by death had scarcely been repaired during recent years, and the Council welcomed a contribution from the Carnegie Trust for the Universities of Scotland, which provided five plates of Scottish Carboniferous Fishes, described by Dr. Traquair. Mrs. G. B. Longstaff, Mr. H. A. Allen, Dr. F. A. Bather, and Mr. William Hill were elected new members of Council, and Dr. Henry Woodward, F.R.S., President, Dr. G. J. Hinde, F.R.S., Treasurer, and Dr. A. Smith Woodward, F.R.S., Secretary.

III.—Zoological Society of London.—*April 7th*, 1908. Dr. Henry Woodward, F.R.S., Vice-President, in the Chair.

On behalf of Mr. Thomas Codrington, Dr. A. Smith Woodward, F.R.S., F.Z.S., exhibited a collection of 168 stones, weighing altogether 7 lbs. 13 oz., taken from the stomach of an elephant shot by Mr. H. Thornicroft in Northern Rhodesia. The animal was a large male, with tusks weighing 45 lbs. each. The stones showed no signs of attrition.[1]

Dr. C. W. Andrews, F.R.S., F.Z.S., exhibited a restored model of the skull and mandible of *Prozeuglodon atrox*, And.[2] This animal is one of the links uniting the true Zeuglodonts with the land Creodonts. It is found in the Middle Eocene of Egypt, where also the earlier type, *Protocetus*, was discovered by Fraas at a somewhat lower horizon. The model was constructed by Mr. F. O. Barlow for the British Museum of Natural History.

[1] The habit of swallowing stones to assist the gizzard in digestion is common to all birds; crocodiles also are found to follow the same practice. Stones have likewise been found within the ribs of several fossil marine reptiles. Although stones had more than once been found in the stomachs of elephants, these mammals do not require such artificial aids to digestion; it therefore seems to imply a depraved taste on the part of the individual and not a normal healthy practice.

[2] See *ante*, pp. 209–212 and Plate IX.

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., Dr. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

JUNE, 1908.

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Fig. 1.

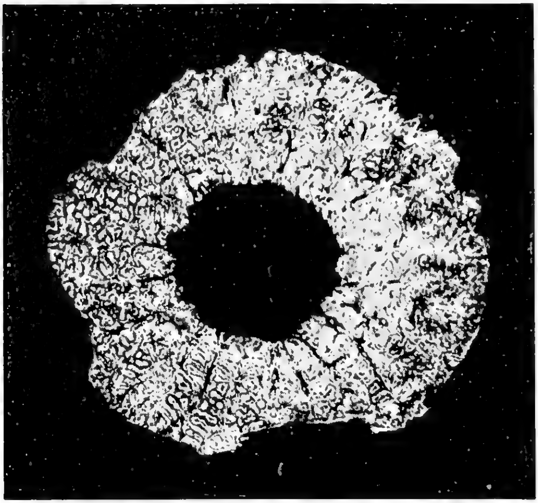

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Fig. 2.

Transverse sections of a tooth of a Labyrinthodont reptile from the Upper Karroo Beds of Cape Colony.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. VI.—JUNE, 1908.

ORIGINAL ARTICLES.

I.—A LARGE LABYRINTHODONT TOOTH FROM THE UPPER KARROO BEDS OF WONDERBOOM, NEAR BURGHERSDORP.

By Professor H. G. SEELEY, F.R.S., F.L.S., F.G.S., King's College, London.

(PLATE X.)

THIS vomerine tooth was found by Dr. D. R. Kannemeyer when resident at Burghersdorp. It is the only evidence of the dentition of the animal known, and is interesting as being of much larger size than any Labyrinthodont teeth hitherto found in South Africa, though smaller than the large teeth of *Mastodonsaurus giganteus* from the Keuper of Würtemburg. Its presumed position on the palate is based upon the anchylosis of the tooth with a bone which shows a flat oblique suture at the base of the crown. This sutural surface is usual on vomerine teeth, and indicates that the tooth was directed downward, outward, and a little backward.

The base of the crown is closed and convex, and appears to be formed of dense tooth substance in which a labyrinthic structure is visible. On one side of the base there is a smooth surface, convex from above downward, concave from side to side, which is imperfectly preserved. This surface extends on to the palate, and is an indication of a vacuity, situated probably beneath an anterior nasal aperture. The bone about the base of the tooth projects all round it as a slight collar.

The tooth is broken transversely, 1½ inch of the length of the crown is preserved in front, and little more than one inch on the hinder border. The total length to the base is about 2 inches. This may indicate, by approximation of the lateral curvatures, an original length of 2¾ inches. The base is transversely ovate, rather wider in front than behind, and rather more convex on the outer than on the inner side. But this irregular sub-triangular ovoid form is soon lost, and at the superior fracture the tooth is circular, with a diameter of more than half an inch.

The external surface is marked with close-set fine linear ribs, which are flattened and have a tendency to be gathered into bundles, by the grooves from time to time becoming deeper, especially in the lower part of the crown, where the number of ribs is greater. They do not often show dichotomous division; but the ribs which rise from the base irregularly die away in the grooves. They have an appearance of being finer and more numerous in the lower part of the crown than at the transverse fracture, where they number about eighty. There is practically no enamel on the crown, which shows only a faint surface gloss. On receiving the tooth I had a cast made, and a transverse section was prepared so as to show the labyrinthic structure of the crown. The cut surface now has the appearance of being bordered at the circumference by close-set tubes which correspond to the external vertical ribs. Under the microscope these sections of the reed-like sheath of the tooth are mostly sub-quadrate, and hollow; separated from each other by a narrow band which passes inward and folds into the labyrinthic substance of the tooth. The centre of the crown of the tooth is occupied by the pulp cavity, nearly circular, slightly longer than wide; with a number of fine films at irregular intervals, radiating outward from it as vertical plates dividing the folded tooth substance.

The folding of the dentine is more complicated than in any genus yet examined. Counting from the inner border there are about twenty-five folded labyrinthic plates of dentine, which radiate to the circumference, without greatly varying in width. Each of these plates is made up of twelve or more alternate folds to right and left of the tooth substance, with each fold often plicated, and including spaces more or less small, frequently ovate, sometimes more elongated. The dentine is composed of tubes which show a radiating arrangement in harmony with the curvature of the folds. Each layer bears a thin film upon its external infolded surface which appears to correspond in position to enamel. This layer passes outward between the folds of dentine, and appears to extend over the external surface of the tooth, though most of the enamel is manifestly lost. Between the folded plates are a series of supplementary wedge-shaped folds, about half as numerous, which are continuous with the dentine of the plates on each side, sometimes by its being folded over on the one side, and connected by anastomosis on the other side.

The most distinctive features of the tooth are: (1) the external layer of vertical tubes of dentine; (2) the denseness of the folding of the dentine; (3) the connection of the folds with each other in ways different to those known in *Mastodonsaurus*; and (4) the number of small vacuities included in the folds of the dentine.

The only clue to the form of the skull is given by the small palatal vacuity, presumably palato-nasal, which descends upon the base of the tooth, and may be evidence that the skull was broad, depressed convex in front, with the nares in a forward position. The only genus with the skull of this type hitherto indicated is the imperfectly known *Batrachiosuchus* of Dr. R. Broom; but that type is far too small to have carried teeth of this size, which may indicate a skull twice as large, or about 18 inches long. The teeth in *Batrachiosuchus* are undescribed. I do not anticipate that it will prove referable to *Ptychosphenodon* (Geol. Mag., 1907, Dec. V, Vol. IV, p. 433), but it is from an animal equally large.

There are no grounds for generic definition at present, but the genus is probably undescribed. And in the absence of evidence of other generic characters than the dense folding of the tooth substance it may be sufficient to record the species as *Syphonodon thecomastodon*.

The photographs were made for me by A. Campion, Esq., in the Metallurgical Laboratory, Coopers Hill. The transverse section is enlarged four diameters and the segment is enlarged twelve diameters.

EXPLANATION OF PLATE X.

FIG. 1.—Transverse section of the summit of the crown of the tooth of the Labyrinthodont reptile *Syphonodon*, rather more than four times the natural size; broken on the margin in polishing.

FIG. 2.—A segment of a transverse section of the same tooth, about twelve times natural size, showing a few of the radiating plates of folded tubes of dentine. Externally a few of the close-set quadrate tubes are seen which form the sheath to the tooth and suggest the trivial name *thecomastodon*.

II.—ON SOME RECENT WELLS IN DORSET.

(PART II.)

By W. H. HUDLESTON, M.A., F.R.S., F.G.S.

(*Concluded from the May Number, p.* 220.)

II. THE BOVINGTON BOREHOLE.

FOR some years past the troops encamped at Bovington had to be content with such water as was supplied by a well a few hundred yards to the S.S.E. of the recently excavated borehole. The following particulars have been gathered respecting this well, but I cannot guarantee that in all respects they are strictly accurate. It was sunk in the Bagshot Beds about 1899, and is said to be 87 feet deep; the water-level stands at 82 feet from the surface, and the yield is 360 gallons per hour. The same Bagshot water-level was struck in the borehole. On comparing these two water-levels it is found that the one in the borehole stands at 85 feet above Ordnance Datum, whilst that in the well stands at 73 feet above O.D. This difference of 12 feet in a horizontal distance of 450 feet amounts to 1 in 37·5, showing a dip in the Bagshot Beds of $1\frac{1}{2}°$ to the S.S.E. This may not exactly represent the direction of maximum dip, but there are good reasons for believing that the line of maximum dip of the Bagshots hereabouts is not far from S.S.E.

Since the War Office was not satisfied with the amount of water yielded by the well they bethought themselves of obtaining an artesian supply, and accordingly entered into a contract for the execution of a borehole, which was to be prosecuted to a depth of 600 feet, unless a good supply of water was reached at a less depth.[1] Ultimately the boring was continued to a depth of 726 feet, and the following is a record of the beds encountered:—

[1] The engineers employed were Messrs. Le Grand & Sutcliff. The operations lasted from July to November, 1906.

	Thickness. ft. in.	Depth. ft. in.
SUPERFICIAL (14 feet).		
Soil	1 0	
1. *Marly Clay*[1]	2 0	
2. *Gravel.* Plateau-gravel with yellow flints	11 0	14 0
BAGSHOTS (151 feet).		
3. *Sand with loam bands.* Coarse, yellowish sand of uniform sized grain invested with ferric oxide. The '*loam bands*' consist of fine white powdery loam	20 0	34 0
4. *Coloured clay and sand.* Fine sediments, mostly discoloured and clayey	10 0	44 0
5. *Brown sand.* Loose sugary sand	4 0	48 0
6. *Light grey sand*	3 0	51 0
7. *Loose grey sand.* Sharp quartzose, clean	7 0	58 0
8. *Coloured sandy clay.* Whitish clay, slightly stained with iron; sets hard	4 0	62 0
9. *Coarse sand.* Loose, yellowish, coarse quartzose sand with small fragments of soft white silica, and one or two largish pebbles of lignite (see No. 17)	[water-level 85] 29 0	91 0
10. *Coloured clay and sand.* 'Two-ball' pipeclay	6 0	97 0
11. *Live sand.* Loose yellowish sand, rather coarse and with specks of soft white silica	24 0	121 0
12. *Blue clay.* A fine, unctuous, grey clay, like some of the grey pipeclays	12 0	133 0
13. *Coloured clay and sand*	4 0	137 0
14. *Live, coarse sand.* A very clean, angular quartzose grit, said to be full of water. Would make good building sand ...	18 0	155 0
15. *Brown coarse sand* (*live*). Similar to the above, but dirty ...	10 0	165 0
LOWER TERTIARIES (115 feet).		
16. *Sand and pebbles.* Coarse, dirty greyish sand with black flint pebbles (of the Blackheath type), and some small buff pebbles of another material	1 0	166 0
17. *Sand and wood.* Fragments of lignite	0 6	166 6
18. *Clay, sand, and pebbles*	4 6	171 0
19. *Dark sandy clay, hard*	9 0	180 0
20. *Coloured clay and pebbles*, reddish	5 0	185 0
21. *Dark sand and clay.* Dries pale grey and sets rather stiff ...	42 0	227 0
22. *Dark clay and stones.* The stones are of irregular shape, (?) corroded flints	1 0	228 0
23. *Live sand.* Fine, pulverulent, grey sand, not very loose ...	19 0	247 0
24. *Coarse sand and pebbles*, live (i.e. water)	5 0	252 0
25. *Mottled clay.* Light brown in colour...	5 6	257 6
26. *Hard dark clay and sand*	4 6	262 0
27. *Hard grey sand with some clay*, sets like a sandstone ...	13 0	275 0
28. *Green sandy clay and flints at bottom.* An earthy greensand, ranging from pale green to darker green; the flints are green-coated, mostly unworn and somewhat corroded ...	5 0	280 0
CHALK (proved to depth of)...	446 0	726 0

It is a decided gain to have obtained the exact particulars of the Tertiaries, both as to character and thickness, in any one spot in the county, and these the Bovington Borehole supplies. Without doubt the Bagshot Beds are much thicker towards the centre of the basin, at Worgret for instance, than they are here, so near to their outcrop, nor can we say for certain whether this difference is wholly due to removal

[1] The italics represent the descriptions of the foreman of the works.

of the upper beds by denudation or to less deposition within the area. As might be expected, the Bagshots maintain their reputation as a sandy series, but there is a certain amount of the usual clays, some iron-stained, or mottled red, and some approaching the character of pipeclay. Nos. 10 and 12 may to a certain extent represent the famous Pipeclay horizon of the Creech district, and their position in the series is not inconsistent with this supposition. There is a marked change in the character of the sediments below No. 15, which may fairly be taken as the base of the Bagshots. In No. 16 we first encounter the black flint pebbles so characteristic of a London Clay horizon, but the Lower Tertiaries throughout the county are so extremely uninteresting, both from an economic and a geological point of view, that there is no need to dwell upon details beyond pointing out that No. 25 probably represents the plastic clays in the lower part of the Reading Beds which are much used for brickmaking in Dorset.

Owing to the method of boring it was not possible to ascertain whether the Chalk is fossiliferous here, so that no question as to horizon can be entertained. Assuming that the usual thickness of the Chalk in Dorset is about 900 feet, the bottom of the borehole is just half-way through that formation. There was no supply of water in the topmost Chalk until a depth of 70 feet was reached, but the first great supply was obtained a little below 400 feet, when the water-level rose to within 96 feet of the surface. The artesian pressure, therefore, was equal to raising a column of water nearly 200 feet into the Tertiaries in addition to 70 feet of waterless Chalk. The War Office not being satisfied with the Upper Water Supply, boring was continued, when a lower and increased water supply was obtained, bringing up the total to 60,000 gallons per day, and the water-level was raised to 93 ft. 6 in. below the surface. It should be noted here that hydrostatic pressure may, to a certain extent, be reduced by springs on the south side of the syncline, such as those outside Wool, which are about 75 feet above O.D. Moreover, in that direction the protective cap of Lower Tertiaries soon fails (see Fig. 4). The main water occurred between 675 feet and 685 feet.

The borehole is situated about half a mile above Bovington Farm-house on the west side of the road which divides Bovington Heath from Wool Heath. There is a patch of Plateau-gravel on the hillside, and it is on this platform that the mouth of the borehole is situated 170 feet above O.D. The crest of the hill due north of this position is about 1¼ miles distant, and there the Plateau-gravel attains an elevation of 283 feet at the high end of Wool Heath. The nearest outcrop of the Lower Tertiaries (London Clay and Reading Beds) is in the Moreton plantations, 1½ miles N.N.W., and the nearest outcrop of the Chalk is about 2½ miles distant in the same direction (not in the line of section). Along the line of section, north and south, the distance of the two outcrops of Chalk, across the syncline, is a little under 4½ miles, and this gives the width of the Tertiary basin through Bovington. The fact is that, previous to its final disappearance, about two miles east of Dorchester, the Tertiary basin is very much narrowed in the vicinity of Wool and Bovington owing to the northerly advance of the Chalk on the south side of the synclinal. A line drawn

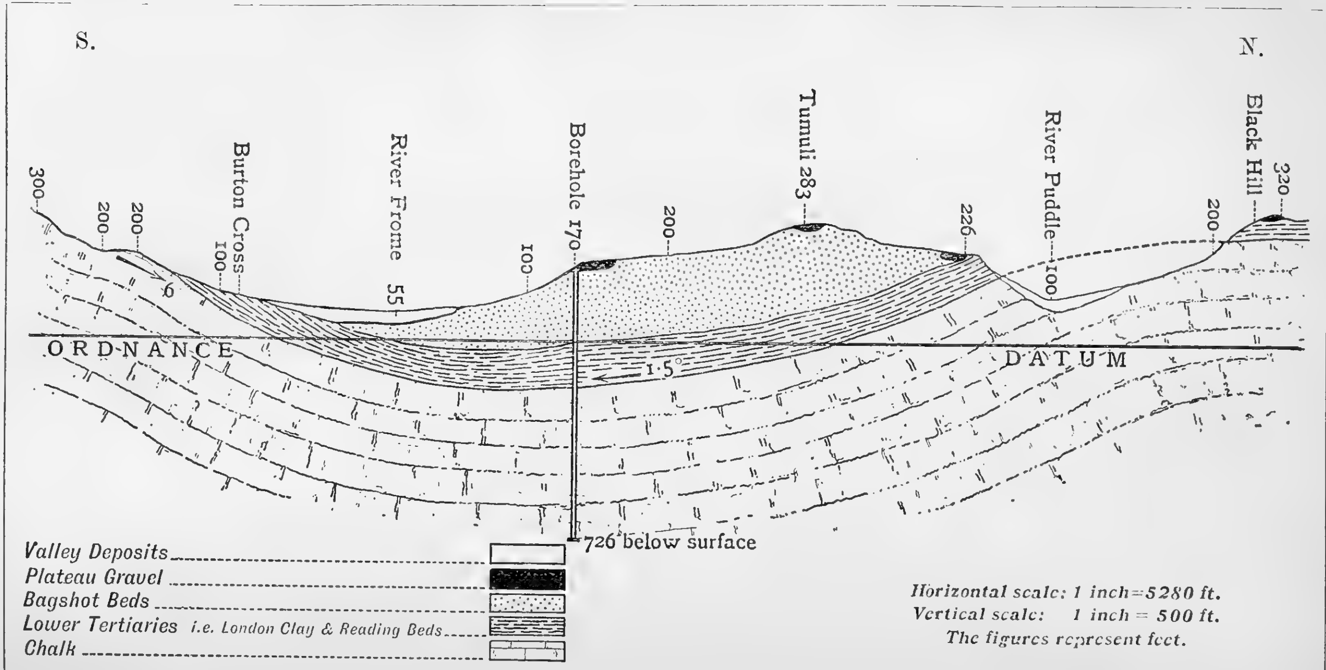


FIG. 4.—TRANSVERSE SECTION THROUGH THE DORSET SYNCLINE, SHOWING THE GEOLOGICAL POSITION OF THE BOVINGTON BOREHOLE.

across the basin through Holme instead of through Wool, shows a width of nearly nine miles, as against the 4½ miles through Wool or Bovington.

When we come to study the geological position of the Bovington Borehole, the measurements of the Borehole section, in conjunction with the surface plotting based upon the ascertained contours, enable us to obtain a fairly accurate conception of the prevailing conditions. The true axis of the tectonic syncline (see Fig. 4) can only be fixed approximately, but in this case it probably almost coincides with the axis of the Frome valley, which here runs very nearly in the trough of the syncline. On the meridian of Worgret near Wareham, on the other hand, the bed of the Frome lies a long way south of the synclinal axis. Generally speaking, the southern limb of the Dorset syncline is shorter, and therefore steeper than the northern limb. In this case a northerly dip of 6° is assigned to the south limb above Burton Cross, on the strength of dips observed in the Chalk near Wool. According to statements previously made in this paper, there is reason to believe that the northern limb in the neighbourhood of the borehole has a dip from 1·5° to 2° southwards, taking a sort of average, although there may be subsidiary folds within the general syncline. This is in conformity with the general rule that the dip of the northern limb is at a lower angle than that of the southern one.

From the Bovington Borehole to the margin of the Chalk escarpment near Bulbarrow is a distance of about twelve miles in a northerly direction, and if we deduct three miles for areas covered by Tertiaries along this line, there remains nine miles of Chalk outcrop on which the rain may fall directly to feed its underground waters. It is well known that a large percentage of the water which falls on this absorbent formation sinks into it instead of flowing over the surface as is the case with clays. Moreover, the rainfall on the North Dorset downs is much heavier than in the Frome valley, and still more so in comparison with Weymouth. Hence there is an abundant supply in the region lying to the north of the borehole, and assuming the preponderance of a southerly dip, which may be taken for granted, this water in its underground passage is bound to find its way south until its progress is arrested by the pressure of water from the opposite limb of the syncline. Meanwhile it is kept down by Tertiary beds, etc., having a thickness of 280 feet. Taking the average elevation of the base of the Chalk between the Dorsetshire Gap and Bulbarrow at 650 feet *above* O.D., this may be accepted as the elevation at the outcrop in the escarpment of the North Dorset Downs. On the supposition that the Chalk is 900 feet thick beneath Bovington, this would bring the base of the Chalk to 1,010 feet *below* O.D. at the borehole. Adding these two sums together, we obtain 1,660 feet as the difference in height of the base of the Chalk between the one point and the other. This sum of 1,660 feet vertical has to be distributed over a horizontal distance of twelve miles, and this shows an incline of 1 in 38 = about 1·5°. Thus from the results of an independent calculation, we obtain precisely the same amount of dip for the northern limb of the syncline as had previously been deduced in another way. (See p. 245.)

Other Artesian Wells and Borings in Dorset.

Messrs. Eldridge, Pope, & Co.'s well at Dorchester.[1] The operations were conducted in 1880–1. The mouth of the well is on the north side of the London and South-Western Railway Station, and probably about 250 feet above O.D. The total depth bored in this case was 597 feet, wholly in the Chalk. A well was dug for 70 feet and the rest completed with 6 inch tubes. The water-level at the time work was finished stood at 45 ft. 8 in. below the surface—hence this well is 'sub-artesian' like the one at Bovington. The yield obtained was 3,000 gallons per hour. The first indications of having struck a supply of water appear to have occurred after the boring rod had passed 467 feet. Hence, in this case nearly 500 feet of Chalk was pierced ere an adequate supply of water could be obtained. According to Mr. Pope it is concluded that the base of the boring is 220 feet above the Upper Greensand, which would give 817 feet for the thickness of the Chalk at Dorchester.

The history of artesian water supply at Wimborne (Fig. 5) is an interesting one, for there the hydrostatic pressure, before the supplies had been tapped so freely as in later years, was sufficient to raise the water from the Chalk to the surface and far above it. Forty years ago (in 1867) a three-inch borehole was made at Ellis's brewery, where the Chalk is said to have been reached at a depth of 97 feet. There was such an uprise that the yard was flooded by a column of water of considerable height. It is interesting to note that in this case the water seems to have been obtained without sinking into the Chalk to any depth. This brewery is situated in the Allen Valley flat and about 60 feet above O.D.

By far the most important of the artesian wells at Wimborne are the Wimborne Waterworks and the Bournemouth Waterworks. These are situated at the north end of the town in the valley flat of the Allen, close to each other and to Warford Bridge, at an elevation of about 66 feet above O.D. As regards the Wimborne Waterworks, Mr. Fletcher[2] says that this boring was executed under his superintendence about twenty years ago. It is a 7½ inch bore, and until the Bournemouth Well was sunk within 200 or 300 yards of it the water rose in the tube-well 6 feet above the surface of the soil. This well is situated on the south-east side of Warford Bridge, and the following is the vertical section:—

		Thickness. ft.	in.	Depth. ft.	in.
Superficial	Peaty matter	6	0		
	Sub-calcareous silt...	8	0	15	0
	Valley gravel and sand-rock	1	0		
Reading Beds	Plastic and variegated clay	45	0		
	Clays and sands sometimes impregnated with pyritous salts	26	0	75	0
	Flints of junction bed	4	0		
Chalk	Chalk and flints	40	0	130	0

[1] For the particulars subjoined I am indebted to Mr. Alfred Pope and to Messrs. Le Grand & Sutcliff.

[2] I have to thank Mr. Walter J. Fletcher, the County Surveyor, for much valuable information in connection with the Wimborne wells.

This is, of course, only a very generalised section, but the chief point to note is that in the Wimborne Waterworks the boring was carried down only 40 feet into the Chalk.

We now come to the consideration of the Bournemouth Waterworks, by far the most important work of the kind hitherto attempted in Dorset. In this case the vertical section shows 96 ft. 9 in. of superficial and Tertiary beds down to the Chalk—an amount of Tertiaries slightly in excess of the adjacent boring. It must not be forgotten that although these are called the "Bournemouth" Waterworks, the water is derived from the Dorset Chalk, and subsequently conveyed into the adjoining county.

The following is the vertical section:—

	Thickness. ft.	in.	Depth. ft.	in.
Superficial Beds...	7	6	7	6
Lower Tertiaries	89	6	97	0
Soft Chalk (Upper Heading)	61	6	158	6
Hard Chalk	23	0	181	6
Band of flint	0	6	182	0
Chalk to bottom of well (Lower Heading) ...	28	0	210	0
Trial boring in Chalk	45	0	255	0

Thus the "Bournemouth" Well is 210 feet, whilst the Wimborne Well is 130 feet deep.

Some of the particulars of the "Bournemouth" Waterworks may be gathered from a study of Fig. 5.[1] A 21 inch trial borehole was commenced in 1894 and finished in 1895; boring was continued to a depth of 223 feet, and it was noticed that the greatest increase in the yield of water took place shortly before arriving at that depth, the Chalk removed appearing to be much softer. The well was started in 1896, and in February, 1899, on its attaining a depth of 210 feet, a 6 inch trial boring was sunk to a further depth of 45 feet, i.e. to 255 feet from the surface. The Chalk, however, was found to be very compact at this depth, and, as there was no sign of more water at the lower level, the sinking of the well was stopped at 210 feet from the surface and the bottom concreted. The bottom of the well, therefore, is about 145 feet below O.D.

The horizontal section also serves to show the character of the Headings. The Lower Heading was first commenced in 1899 at a depth of 195 feet from the surface, and excavated on opposite sides of the main shaft. In the course of a few months a total length of about 800 feet was attained, and the flow of water was considered equal to about 1¼ million gallons per day. In July, 1899, fresh Headings (the Upper Heading) were started at a level of 155 feet from the surface in softer Chalk, much fissured; the result by November was a flow of water somewhat exceeding 1½ million gallons per day. At present I have no precise information as to the level produced by natural hydrostatic pressure in the well, but the pumping arrangements are so complete that this level is soon lowered, not only

[1] The horizontal section of the Bournemouth Waterworks at Wimborne is reproduced, by the kind permission of the Editor of *Water* and of Mr. Cripps, the engineer of the works. (See paper by Mr. Cripps in *Water*, September, 1906.)

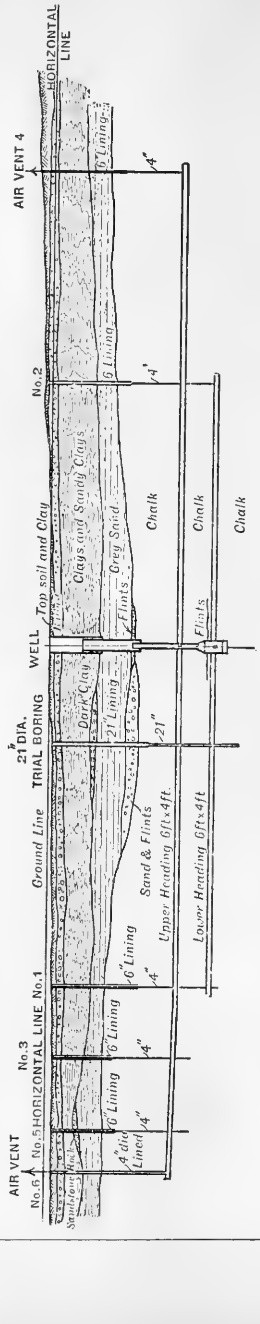


FIG. 5.—SECTION SHOWING WELL, HEADINGS, AND BORINGS, BOURNEMOUTH WATERWORKS. Enlarged from an illustration in *Water*.

in the "Bournemouth" Well, but in all other wells, and the exhaustion is certainly felt as far as Kingston Lacy, two miles distant. The total yield of water is anticipated at 3 million gallons per day.

Attention should be drawn to the difference between the Bovington and Wimborne waters as regards their mineral contents; and, considering that they both proceed from the Chalk, this is all the more remarkable. The amount of solids obtained by evaporation in the case of the Bovington water, according to an analysis made at Devonport, is returned at 16·8 grains per gallon. Of this amount carbonate of lime contributes but little, whilst the chlorides are comparatively abundant. Hence the water must be soft. The analysis of the water of the Wimborne waterworks shows 22·19 grains per gallon, of which 14·8 grains may be expressed as carbonate of lime. Thus the Wimborne water is fairly hard, and much pains are taken to soften by artificial means the supply intended for Bournemouth.

It is evident that position with regard to existing contours is an important factor in an artesian well, and the valley of the Allen at Wimborne seems to fulfil the requirements of the case in a remarkable degree. But there is also another element in the problem, viz., the character of the Chalk encountered during operations. It has been said that permeability in the Chalk depends not so much on the nature of the Chalk itself as on the fissures by which it is traversed. This is well illustrated by the experience of the headings in the Bournemouth Waterworks at Wimborne. At the same time it is not incorrect, in a general sense, to regard the Chalk formation, with very limited exceptions, as a sponge, owing to the facility with which the water-level moves up and down, according to the amount of rainfall in those areas, such as the Hampshire and Wiltshire plateau, where the Chalk itself forms the surface. That the surface contours, and consequently the surface-flow, has some influence on the underground flow may be conceded, yet the controlling factors of the latter are in the main "the difference of pressure along the lines of flow, the varying texture of the strata traversed, and the disposition of contiguous impermeable strata."[1] In regard also to the degree of artesian pressure existing at any given spot, this may sometimes be modified by the action of springs, which, like excessive pumping, tend to bleed the underground arteries, and thus lower the general water-level for considerable distances.

III.—On some Fossil Reptilian Bones from the State of Rio Grande do Sul, Brazil.[2]

By Arthur Smith Woodward, LL.D., F.R.S.

A FEW fossil reptilian bones discovered by Dr. Jango Fischer in 1902 at Santa Maria da Bocca do Monte (Serrito) in the Rio Grande do Sul, which have been submitted to me by Dr. H. von

[1] Baldwin-Wiseman, on the "Motion of Sub-surface Water": Quart. Journ. Geol. Soc., vol. lxiii, p. 98. A sketch-map of sub-surface water-levels in the Chalk of Dorset, Wiltshire, and Hampshire is appended to this paper.

[2] Reprinted from Revista do Museu Paulista, vol. vii (1907), pp. 46–57. See also abstract in Rep. Brit. Assoc., 1903 (1904), p. 663.

Ihering (San Paulo Museum), are of much interest. They not only appear to determine the geological age of the formation from which they were obtained, but also foreshadow the discovery of an early Mesozoic South American land fauna, which has long been expected.

They comprise three nearly complete vertebral centra and a fragment of a fourth centrum, with one digit of four phalanges and a separate ungual phalange. The bones were found together under such circumstances that they probably all belong to one individual.

The vertebral centra are remarkable for (i) their very short antero-posterior extent, (ii) the deeply ovoid shape of their articular ends, and (iii) the considerable constriction of their sides.

The best-preserved specimen (Figs. 1, 1A) is evidently not much crushed, and shows that both the articular ends are slightly concave.

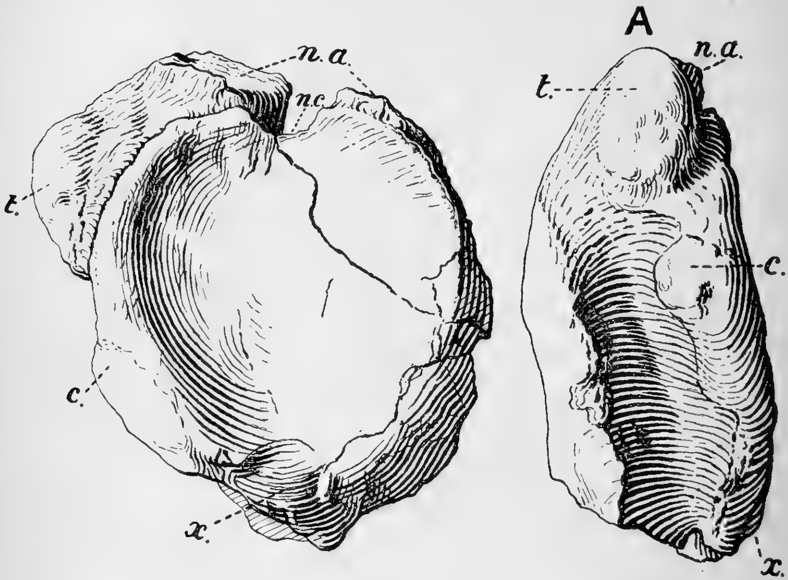


Fig. 1.—Cervical vertebra, anterior and right lateral (A) views. *c.* articulation for capitulum of rib; *n.a.* base of neural arch; *n.c.* neural canal; *t.* articulation for capitulum of rib; *x.* facette for intercentrum. $\frac{2}{3}$ nat. size.

It also exhibits the characteristic constriction of the sides, with the prominent anterior rim, which bears a deeply ovoid, rounded boss (*c.*) for the articulation of the capitulum of a double-headed rib. The lower part of the same rim is bevelled in such a way (*x.*) as to suggest that an intervertebral wedge-bone may originally have been present. The neural canal (*n.c.*) produces a shallow groove in the centrum. The base of the neural arch (*n.a.*) still remains, and proves that it is firmly fused with the centrum, not merely articulated by suture. This arch extends from end to end of the centrum, but leaves a slight rim of the latter projecting in front. Its lateral portion is produced somewhat downwards and ends in a deeply ovoid, rounded boss (*t.*), for the articulation of the tuberculum of the rib already mentioned. It is thus evident that the rib must have been stout, deep, and antero-posteriorly compressed at its double-headed upper end.

One of the most imperfect vertebral centra is essentially identical with that just described, showing a similar rib-articulation and a space for a wedge-bone. The other good specimen (Figs. 2, 2A), however, is somewhat smaller, with no clear indication of a facette on the centrum either for a rib or for a wedge-bone. Its articular ends are slightly concave. The base of its neural arch seems to show that it agrees with that of the other vertebra in being fused with the centrum, while the neural canal similarly forms a shallow groove.

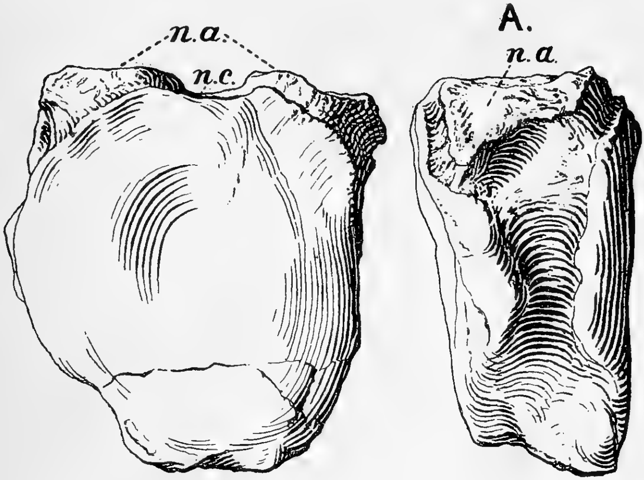


Fig. 2.—Dorsal vertebra, anterior and right lateral (A) aspects. ⅔ nat. size.

The first type of vertebra (Fig. 1) obviously belongs to the cervical, while the second (Fig. 2) must be referred to the dorsal region. If, therefore, these specimens represent one and the same individual, the neck must have been comparatively large and stout, doubtless for the support of a heavy head.

The digit of four phalanges (Figs. 3, 3A) is interesting on account of the shape of the claw. The ungual phalange is laterally compressed and unsymmetrical, the left or less deep side being flattened or almost hollowed, while the other side is slightly convex. The bone is not marked by any lateral groove, but its lower face is considerably excavated and has a sharp rim. The two phalanges following the ungual are short and broad, and much constricted round the middle. The next bone, which perhaps admits of more than one interpretation, is more elongated than those just mentioned, but not so long as the ungual. It seems to be displaced in the fossil, being, in fact, accidentally turned on its long axis to an extent of 45°, so that its imperfect right side only is seen in Fig. 3, its left side in Fig. 3A. If this interpretation be correct the bone is another phalange, with the saddle-shaped proximal articular face somewhat deeper than wide.

The detached ungual phalange (Figs. 4, 4A, 4B) resembles the corresponding bone of the digit just described in the concavity of its lower face (Fig. 4A) and in its lack of bilateral symmetry; but it is relatively large and expanded. Its articular face (Fig. 4B) is oblique and much deeper than broad; its slightly convex side (Fig. 4) is excessively large, owing to the expansion of the thin, rounded, distal border; while its flattened left side (Fig. 4A) is a comparatively small triangular area.

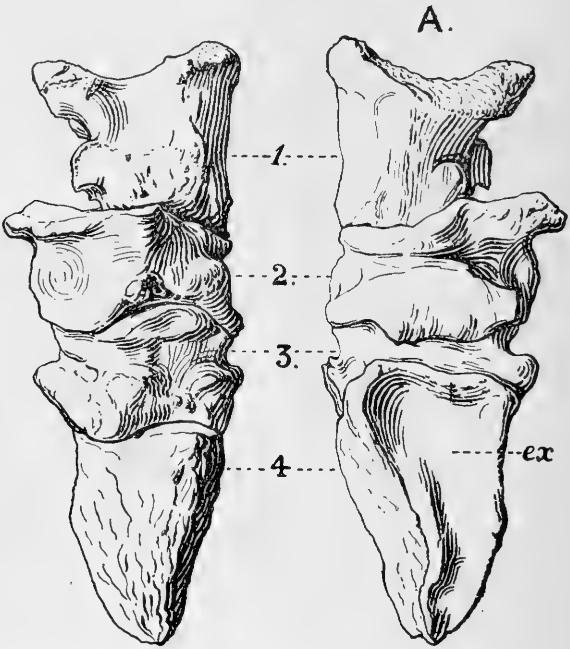


FIG. 3.—Digit with four phalanges (1–4), upper and lower (A) views. *ex.* excavation of lower face of ungual phalange. $\frac{2}{3}$ nat. size.

The two ungual phalanges evidently belong to one and the same foot, which must have had obliquely-curved digits. If constructed as in the Sauropodous Dinosaurs this foot would be of the left side, the large claw belonging to digit I, while the series of four phalanges would probably represent digit III.

It is difficult to determine the affinities of a reptile known only by remains as fragmentary as those now described. It is evident, however, that the bones are those of a land-reptile; and the characters of the vertebræ suggest that they belong either to an Anomodont or to a primitive Dinosaur. The fact that the dorsal vertebral centrum shows no clear mark of an articular facette for the rib seems to prevent its reference to an Anomodont; while the shape and characters of the cervical vertebra are so closely similar to those of a corresponding vertebra from the Karoo Formation of South

Africa ascribed to the Dinosaurian *Euskelesaurus* by Seeley[1] that the new Brazilian reptile is probably allied to the latter. The striking inequality in the size of the obliquely-curved toes is also less suggestive of an Anomodont than of a Dinosaur; and although it is possible that some of the larger Anomodonts had a digital formula like that of lizards and crocodiles, this was not the normal condition, and a digit with four phalanges is more likely to have belonged to a Dinosaur than to a member of the more primitive order.

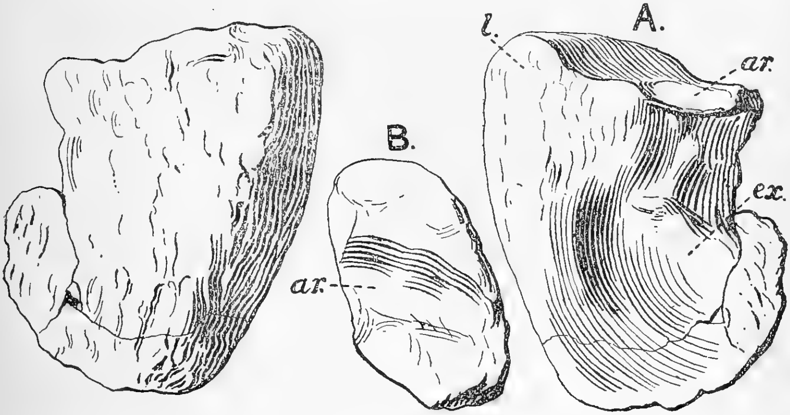


FIG. 4.—Ungual phalange, upper, lower (A), and articular (B) views. *ar.* hollowed articular face; *l.* flattened inner face; *ex.* excavation of lower face. $\frac{2}{3}$ nat. size.

I therefore refer the new Brazilian fossils to a short-necked Dinosaur allied to *Euskelesaurus*, and I propose to name this reptile *Scaphonyx* in allusion to the unique inferior excavation of the ungual phalanges. The species may be known as *Scaphonyx Fischeri.*

If this determination be correct, the rocks in which the bones were found may be regarded as of Triassic age. *Scaphonyx* is also to be considered as the first fossil land-reptile discovered in South America which clearly belongs to the fauna of 'Gondwana Land.'

Postscript, April, 1908.—The preceding paper was written in 1904, when Professor Seeley's determination of the cervical vertebra of *Euskelesaurus* had not been questioned. Since that time Baron F. von Huene (Palæont. Abhandl., N.S., vol. viii, 1906, p. 123) has expressed the opinion that the vertebra in question does not belong to a Dinosaur, but to an Anomodont; while Dr. R. Broom has described similar vertebræ from the Upper Beaufort Beds of the Karoo Formation under the new generic name of *Erythrosuchus* (Ann. S. African Mus., vol. v, 1906, p. 193). According to Dr. Broom's description this reptile is not a Dinosaur, but exhibits many resemblances both to Belodonts and to Anomodonts. From new specimens submitted to me by Dr. I. C. White, I am now of opinion that *Scaphonyx* is an Anomodont.—A. S. W.

[1] H. G. Seeley, "On *Euskelesaurus Brownii* (Huxley)": Ann. Mag. Nat. Hist. (6), vol. xiv (1894), p. 339, fig. 7. Original vertebra now in the British Museum.

IV.—Sedgwick Museum Notes.

Notes on some Fossils from Nepal.

By F. R. Cowper Reed, M.A., F.G.S.

AMONGST the foreign Jurassic fossils in the Sedgwick Museum, acquired or presented many years ago and but rarely referred to, some specimens labelled "Himalayan Lias" recently came under my notice. They were marked as having been presented by Mr. J. Leckenby in 1872, and had been carefully kept together with the old label, giving the locality and history. Some of them had at some subsequent date been mounted and identified with well-known European Liassic species.

The old label accompanying them bore the following inscription:— "Ammonites from the Salagrammi River near Mooktinath, 18,000 ft. above the level of the sea. Presented to me by Dr. Wallich. April, 1822. [Signed] T. F. C." The whole label is in the same handwriting as the initials T. F. C., and Mr. Daydon Jackson, General Secretary of the Linnean Society, to whose kind assistance I owe much information about Dr. Wallich, considers it almost certain that the person thus signing himself was Major-General Thomas Frederick Colby, R.E., F.R.S., F.G.S. (1784–1852), Director of the Ordnance Survey, after whom Portlock[1] named the well-known trilobite *Remopleurides Colbii*, and who was actively interested in geology in his time. The present Director of the Geological Survey of India has also made to me the same suggestion as to the identity of T. F. C.

Dr. Wallich (1786–1854), whose full name was Nathan Wolff Wallich, though during his scientific career he called himself simply Nathaniel Wallich, was born in Copenhagen in 1786, went out to India in the Danish service in 1807, and entered the service of the N.E.I. Company in 1813, becoming Superintendent of the Calcutta Botanical Garden in 1815, and retaining that post till his retirement in 1846. He travelled extensively in India and Nepal, and contributed various papers to the Transactions of the Asiatic Society of Bengal, dealing with the plants he discovered. His name first appears in the list of members of that Society in the year 1820, and on several occasions he presented fossils to the Society's collection, but none apparently from Nepal, though many plants were collected and described by him from that country. The type-set of his great Indian collections is in the possession of the Linnean Society, but the geographical indications of the localities are stated to be of the scantiest. It is therefore of especial interest that the precise locality where these fossils were found was recorded at the time on the label accompanying them.

Mooktinath or Muktinath is situated on the upper part of the river Kali or Buria Gandak, on the north side of the main Himalayan range and south of Lob Mantang; it is also known as Ihochumigarsa, and has the altitude 13,100 feet against it, according to a recent (1891) official map of India, published in Calcutta. The apparent discrepancy

[1] Portlock: Geol. Rep. Londond., p. 256.

in the name of the river is explained in an old paper on the Ancient Geography of India by Lieut.-Col. F. Wilford (Trans. Asiatic Soc. Bengal, vol. xiv, 1822, p. 415), who states that the alternative name for the Gandaca (= Gandak) is the Sallagramma, and he adds the valuable and illuminating remark that the river is so called because of the stone of that name found in its bed. This is of importance because the ammonite-bearing concretions of precisely similar character to those in this Wallich collection are known throughout India as Salagrams, and are used as charms. Thus Everest[1] figured an ammonite of this type from the Himalayas in 1833 with the note that such are the Salagrams of the Hindoo temples; and Mr. H. J. Colebrooke[2] presented to the Geological Society in 1818 "argillaceous nodules containing Ammonites and called Salagrams, worshipped by the Hindoos." Mr. G. H. Tipper, of the Indian Geological Survey, on seeing Wallich's ammonites in the Sedgwick Museum at once recognised them as being typical Salagrams. Dr. T. H. Holland, however, informs me that some so-called Salagrams are only small rounded boulders of quartzite. In Blanford's[3] figures and descriptions of the Cephalopods from Nepal in General Hardwicke's collection no precise localities are given, but the word 'Sulgranees' appears on plate C in J. E. Gray's work,[4] where some of these fossils are figured, and Blanford[5] has recently suggested that it is probably a corruption of the word 'Saligram.' The latter has also expressed the view that "it is very doubtful if any of the Ammonites represented in the 'Illustrations' came originally from Nepal at all; it is more probable that they came from further west, from the region whence Ammonites have been supplied to India in all probability for ages. It is certain that there has long been an importation of small Ammonites into India from the Tibetan side of the Himalayas, chiefly from the Spiti district, N.N.E. of Simla, or from the neighbourhood of the Niti pass, north of Kumaun." It was previously stated in Blanford & Oldham's Geology of India (2nd ed., 1893, p. 229), that Jurassic rocks were known to occur north of Nepal, characteristic fossils having been brought by traders, but no locality in Nepal itself is given, so that it appears doubtful if any recorded occurrence in Nepal with the precise locality has previously been published. It must not, however, be overlooked that Oppel[6] refers to a specimen of *Ammonites sabineanus*, Oppel, in a black nodule from the river 'Gundock' (? = Gandak), which had been kept in the collection of the Jardin des Plantes in Paris since 1825; this fossil may possibly have been obtained from the same spot as Wallich's specimens, particularly as the mode of occurrence suggests a Salagram, and as the same species is most probably represented

[1] Everest, Himalayan Fossils, Asiatic Researches: Trans. Asiat. Soc. Bengal, vol. xviii (1833), pl. i, fig. 3.

[2] Trans. Geol. Soc. London, vol. v (1821), p. 643.

[3] Blanford: Journ. Asiat. Soc. Bengal, vol. xxxii (1863), p. 124.

[4] J. E. Gray: Illustrations of Indian Zoology; chiefly selected from the collection of Major-General Hardwicke (published 1830–2), plate C (no description).

[5] Blanford: Proc. Malac. Soc., vol. v, No. 6 (October, 1903), p. 345. Crick: Geol. Mag., Dec. V, Vol. I (1904), p. 62.

[6] Oppel: Paläontologische Mittheilungen, vol. iv (1863), p. 302.

amongst ours from Muktinath; moreover, it is one of those described by Oppel as associated in other parts of the Himalayas with species (*A. frequens*, etc.) allied to or identical with ours. One of the Ammonites from Nepal, described by Gray in his above-mentioned work, was dedicated to Dr. Wallich (*A. Wallichi*, pl. C, fig. 3); the specimen[1] is in the British Museum collection, and the same species has been recognised by Mr. Crick amongst our fossils from Muktinath. To Mr. Crick I am much indebted for valuable help in the identifications.

In the Sedgwick Museum Collection from Muktinath there are in all sixty-three specimens, the majority of which are ammonites and belemnites; and from a preliminary examination of this material it seemed evident to me that they were wrongly referred to the Lias. Having Salter & Blanford's work on the "Palæontology of Niti" (Calcutta, 1865) at hand, a comparison with the illustrations of Jurassic fossils in that book naturally suggested itself, and then with Oppel's figures of Himalayan Cephalopods in his "Paläontologische Mittheilungen" (vol. iv, 1863). Finally Uhlig's uncompleted memoir in the *Palæontologia Indica* on the fauna of the Spiti Shales was consulted. From these investigations it became obvious that many of the Cephalopods were closely similar to, if not identical with, previously described Upper Jurassic forms from the Himalayas. Mr. G. H. Tipper (of the Geological Survey of India), on seeing the specimens, at once recognised their mode of preservation and lithological characters to be unquestionably identical with that of fossils from the Spiti Shales. At the British Museum I was subsequently enabled with Mr. Crick's kind assistance to make a direct comparison of them with Blanford's type-specimens from Niti, and my views as to the stratigraphical horizon and affinities of the fossils were confirmed by Mr. Crick, who is also of the opinion that many of the species are identical and others closely allied.

Until Professor Uhlig has completed his researches on the fauna of the Spiti Shales it would be undesirable to attempt a detailed description of this interesting material, but so far as the works of the above quoted authors take us the following genera and species can be recognised:—

Belemnites cf. *sulcatus*, Miller.

The large stout form figured by Blanford under this name (Palæont. Niti, p. 76, pl. x, figs. 1–7) and the large phragmocones precisely correspond with some of our specimens, but there is also the more slender form named *B. Gerardi* by Oppel, which Blanford considered a synonym of the present species (Crick, Geol. Mag., Dec. V, Vol. I, 1904, p. 64). Boehm's work on the allied species of *Belemnites* from the Moluccas suggests that more than one species is included under this name. The figures given by Everest[2] of a belemnite from the

[1] Crick: op. cit., pp. 62, 63; and Proc. Malac. Soc., vol. v, No. 4 (April, 1903), p. 286.

[2] Everest, Himalayan Fossils, Asiatic Researches: Trans. Asiat. Soc. Bengal, vol. xviii (1833), p. 108, pl. i, figs. 16, 17.

Himalayas represents a form similar to Blanford's *B. sulcatus*. In Somaliland a closely allied form has been found (Crick, Geol. Mag., Dec. IV, Vol. III, 1896, p. 296).

Hoplites Wallichii, Gray.

One specimen in our collection may be without doubt identified with this species,[1] and especially resembles one of the specimens figured by Blanford (op. cit., pl. xv, figs. 1*a–c*).

Perisphinctes cf. *biplex*, Sowerby.

The species from Niti which Blanford (op. cit., p. 79, pl. xi, figs. 1*a–c*; pl. xii, figs. 1*a–c*) referred to Sowerby's *A. biplex*, is the most abundant ammonite in the Muktinath collection, but mostly occurs only as external casts, similar to that figured by Everest,[2] and mentioned by him as being the Salagrams of Hindoo temples. The true specific reference of this form must for the present be left uncertain.

Perisphinctes cf. *torquatus*, Sowerby.

Mr. Crick pointed out to me that several of our specimens are indistinguishable from the form described by Blanford (op. cit., p. 80) as *Am. torquatus*, Sowerby, of which the specimens are in the British Museum.

Perisphinctes aff. *frequens*, Oppel.

A large, nearly perfect ammonite, measuring between 15 and 16 c.c. in diameter, appears to be closely allied, if not identical, with Oppel's species, *A. frequens*, from the Himalayas.[3] A smaller specimen may perhaps belong to the same species, or be a variety. The larger one appears to be in rather a different state of preservation and not to have come out of a nodule.

Perisphinctes cf. *sabineanus*, Oppel.

One small specimen, measuring about 40 mm. in diameter, may be compared with Oppel's *A. sabineanus* from the Himalayas.[4] It is not in quite the same state of preservation as the other ammonites, more resembling in this respect the large example of *P.* aff. *frequens*.

Oppelia (*Streblites*) cf. *Griesbachi*, Uhlig.

The external impression of one side of an *Oppelia* may be compared with Uhlig's *O. Griesbachi*[5] from the Spiti Shales; the serrated keel and ornamentation of the whorls, as well as the general shape and characters of the shell, are apparently identical.

[1] Crick, op. cit., p. 118.
[2] Everest, op. cit., pl. i, fig. 3.
[3] Oppel, op. cit., p. 295, t. 87; Siemeradzki, Mon. Amm. *Perisphinctes*, Palaeontographica, Bd. xlv, Lief. 3 (1898), p. 237.
[4] Oppel, op. cit., p. 288, t. 82, figs. 1*a–c*, 2*a*, *b*; Siemeradzki, op. cit., p. 110, pl. xx, fig. 2.
[5] Uhlig, Fauna of the Spiti Shales, Palæont. Indica, ser. xv, vol. iv (1903), p. 47, pl. v, figs. 2*a–c*, 3*a–c*, 4*a*, *b*; pl. vi, figs. 1*a–c*, 2*a–d*, 4*a–d*, 5*a*, *e*.

Parallelodon egertonianus (Stoliczka).

The internal cast of a large lamellibranch possesses the shape and characters of hinge and teeth of the well-known *P. egertonianus* of the Spiti Shales.[1] This species has also been found in Somaliland.[2]

Nucula sp.

One imperfect internal cast of a species of *Nucula* occurs in the collection adhering to the outside of a nodule containing an example of *Peri. biplex*. The hinge-line with its minute transverse teeth is visible, but the specimen is too imperfect for further description.

Rhynchonella cf. *variabilis*, Schlotheim.

Only the pedicle valve of one example of a *Rhynchonella* is present, and it is likewise attached to the exterior of a geode. The form from Niti referred by Blanford[3] to *Rhynch. variabilis*, Schlotheim, is apparently identical.

Fossils from Nepal are so rare and difficult to obtain that the above mentioned are of special interest, and stratigraphically fill up a gap in our knowledge as to the eastward extension of the Spiti Shale fauna.

The extension of the Spiti Shales eastwards from Nepal has been proved by their discovery[4] in Central Tibet, near the Kongra La and Kampa dzong, in about 28° N. lat. and 88° E. long., during the last expedition into Tibet. But Boehm's[5] researches in the Sulu Islands have carried the distribution of the distinctive fauna of these beds still further to the east, for on the south coast of the islands of Taliabu and Mangoli, between 1° and 2° S. lat. and 124° and 126° E. long., some of the typical species (*Hoplites Wallichi*, Gray, and *Phylloceras strigile*, Blanf.), with others closely allied to Himalayan forms (e.g. *Belemnites alfuricus*, Boehm, aff. *B. Gerardi*, Oppel), have been found; and even in Dutch New Guinea, at 2° 22′ S. lat. and 139° 50′ E. long., Boehm (op. cit., 1907, footnote on p. 118) states that representative ammonites of the same fauna occur, and probably also on the Strickland River in 142° E. long., in British territory.[6] Rothpletz[7] had previously described and figured *Belemnites Gerardi* from the island of Rotti in about 11° S. lat. and 123° E. long. Several stratigraphical subdivisions of the Spiti Shales were recognised by Diener[8] in the Himalayas, and Boehm likewise maintains that in the Moluccas also they include horizons from the Oxford Clay upwards to the passage beds between the Jurassic and the Cretaceous.

[1] Stoliczka: Mem. Geol. Surv. India, vol. v (1866), pt. 1, p. 89, pl. viii, fig. 7.

[2] R. B. Newton: Geol. Mag., Dec. IV, Vol. III (1896), p. 294.

[3] Blanford & Salter: Palæont. Niti, p. 101, pl. xxi, figs. 7*a–c*.

[4] Hayden: Geol. of Provinces of Tsang and Ü in Central Tibet, pp. 31–34 (Mem. Geol. Surv. India, vol. xxxvi, pt. 2, 1907).

[5] Boehm: Beitr. z. Geol. Niederland. Indien, i, pp. 1–46, pls. i–vii (Palaeontographica, Suppl. iv, Lief. 1, 1904); pp. 59–120, pls. ix–xxxi (Palaeontographica, Suppl. iv, Lief. 2, 1907).

[6] Boehm: Neues Jahrb. f. Miner., Beil. Bd. xxii (1906), pp. 393–396, and references.

[7] Rothpletz: Die Perm-, Trias-, und Jura-Formation auf Timor und Rotti, p. 104, t. xiii, figs. 6–8, 10, 12 (Palaeontographica, Bd. xxxix, Lief. 2, 1892).

[8] Diener: Denkschr. Kais. Akad. Wiss. Wien, Math. Natur. Kl., Bd. lxii (1895), pp. 582–588.

Two other specimens in Wallich's collection certainly come from a different horizon, and their mode of preservation is not the same. One is the imperfect valve of a species of *Halobia* comparable with *H. charlyana*, Mojs., which has been recorded from the Trias of Rotti and Sumatra;[1] it occurs in a black shaly limestone. The other is the internal cast of an ammonoid almost wholly replaced by crystalline calcite, but showing in one part the suture-line, the characters of which, so far as they are visible, suggest that it may be referred to the genus *Ptychites*, and the shape of the shell much resembles that of *Pt. rugifer*, Oppel. It is evident, therefore, that the Trias also occurs near Muktinath.

V.—Preliminary Note on some Unrecorded Exposures of the Quartz-Felsite in North-West Carnarvonshire.

By A. B. Badger, M.A., B.Sc.

During an investigation of the rocks of North-West Carnarvonshire older than the Llanberis Slates, the detailed results of which I hope soon to publish, I have discovered certain exposures of quartz-felsite which are not marked as such on the maps of the Geological Ordnance Survey, nor have been described, as far as I know, by other observers.

Reference to maps 75 N.W., 78 S.W., and 78 S.E. of the 1 inch Geological Survey, or to Sheet 7 of the Geological Index Map, will show that in the area stretching from Bangor and Bethesda on the north-east to the Vale of Nantle on the south-west two bands of quartz-felsite are marked, the one extending from Bangor to Carnarvon, the other from the Penrhyn Slate Quarry through Llanberis to the village of Llanllyfni. As is well known, these rocks have been variously regarded as of Pre-Cambrian, early Cambrian, and Post-Cambrian age.

The exposures which I desire to record lie to the west of the eastern band of felsite, and proceeding generally from north-east to south-west occur at the localities named below.

Locality.	1 Inch Geological Map.	6 Inch Ordnance Map.
(1) Farm of Ty'n y caeau	78 S.E.	Carnarvonshire, XII, N.W.
(2) Gwirfai River, near Bontnewydd...	78 S.W.	,, XV, S.E.
(3) Near Gadlys Farm	,,	,, ,,
(4) Near Llanwnda Railway Station ...	,,	,, ,,
(5) Glynllifon Park	75 N.W.	,, XX, N.E.
(6) Brynmawr Farm	,,	,, XX, S.E.
(7) East of Llanllyfni	,,	,, XX, S.E. and XXI, S.W.

(1) *Ty'n y caeau Farm.*—This locality lies about $2\frac{1}{2}$ miles to the north-west of Penrhyn Quarry, the most northerly point at which the eastern band of quartz-felsite has been found hitherto. The outcrop is about 330 yards in length and 50 yards in breadth at its widest. It strikes 60° east of north and forms a low ridge. On the north-west

[1] Volz: Zeitschr. deut. geol. Gesell., vol. li (1899), p. 35, t. i, figs. 12, 13.

it is covered by conglomerates and grits, while to the south-east there is low-lying swampy ground, the boundary on this side probably being a fault. The rock is grey in colour, and at the south-western end of the exposure near the farm buildings flow-structure is well displayed on the weathered surfaces; elsewhere, however, this is not so apparent. The microscopical characters are generally those of the Cwmyglo rock, but specimens from the eastern side do not show flow-structure, and are much decomposed and brecciated.

There do not appear to be any other exposures of the quartz-felsite between this point and those so well known near the north-west end of Llyn Padarn, some five miles away.

(2) *Gwirfai River, near Bontnewydd.*—The small village of Bontnewydd is about two miles south of Carnarvon. A quarter of a mile to the east the ground rises into the hilly slopes which lie in front of Mynydd Mawr and Moel Eilio. Debouching from a somewhat narrow channel, cut through this higher ground, the Gwirfai River flows eastward from Lake Cwellyn through Bontnewydd to Carnarvon Bay. The Geological Survey Map shows the river as traversing the quartz-felsite from Bettws Garmon to within a mile and a half of Bontnewydd, and for the next mile and a quarter as traversing Cambrian grits and conglomerates. Stratified rocks, however, do not occur for all this distance; they crop out about two-thirds of a mile west of the quartz-felsite, and from this point extend for 300 yards to the west. Again, just at the opening of the gorge grits and conglomerates are found, but for some 600 yards east of that opening the sides of the gorge are formed of quartz-felsite. The latter rock shows numerous phenocrysts of quartz and felspar, the first-named mineral being much cracked.

It may be remarked in passing that the stratified rocks which are found at the mouth of the gorge lie directly on the felsite and comprise grits of quartz and pink felspar, and very coarse conglomerates which have a remarkable resemblance to those so well known at Llanddeiniolen.

(3) *Gadlys Farm.*—In a lane leading from the main road a little north of Llanwnda Railway Station there is a small opening in which pink quartz-felsite is exposed.

(4) *Llanwnda Station.*—Half a mile to the south-west of the last exposure, quartz-felsite is again exposed in a few patches on the eastern bank of the railway cutting some 100 yards south of the station.

(5) *Glynllifon.*—The next series of exposures occurs in Glynllifon Park, the residence of the Hon. Frederick Wynn, owing to whose kindness it is that I have been able to examine this locality. The Geological Ordnance Map marks the eastern half of Glynllifon as "altered Cambrian Sandstone," probably because the surveyors mistook the quartz-felsite noted below as exposed in Coed Penbrynmawr for a metamorphic rock. The other exposures, however, to which I refer, occur in parts of Glynllifon marked on the map as unaltered Cambrian Grits and Conglomerates.

Most of the exposures of the igneous rock are found in or near the narrow valley of the little stream called the Afon Llifon, which here extends from the so-called 'East' Lodge on the north for a distance of about half a mile to near Glynllifon House on the south-west. The width of the outcrop so exposed is only some 150 yards, but I am informed that the rock was found in excavations for cellars at the back of the house, which shows that it extends at least 300 yards further westwards. At one exposure it is seen that grits coarse and fine lie directly on the felsite; these rocks are apparently continuous for a mile or more to the west.

At the quarry called Gallt-y-Prif a narrow band of the quartz-felsite is found among the grits, brought in apparently by faults.

The greater part of Glynllifon is covered with drift, and there are no other exposures of the felsite or of the so-called Cambrian Grits, either to the east or south of those just described, except in the locality first mentioned. This is near the southern boundary wall, in the wood named on the 6 inch map, Coed Penbrynmawr. Here in several openings the quartz-felsite is again exposed. The quartz-felsite of Glynllifon varies from cream-coloured to grey and reddish-grey in colour, and contains many quartz phenocrysts much corroded and broken; in places it is much cleaved, in others it is massive.

(6) *Brynmawr Farm.*—A few yards south of the southern boundary wall of Glynllifon, continuing the line of the exposures in Coed Penbrynmawr, there is a small opening where the quartz-felsite is again to be found, and further on for half a mile to the south-west there are other exposures in the somewhat steeply sloping ground on which stands the farm called Brynmawr. Judging from the Survey Maps these rocks were considered to be metamorphosed Cambrian Sandstones.

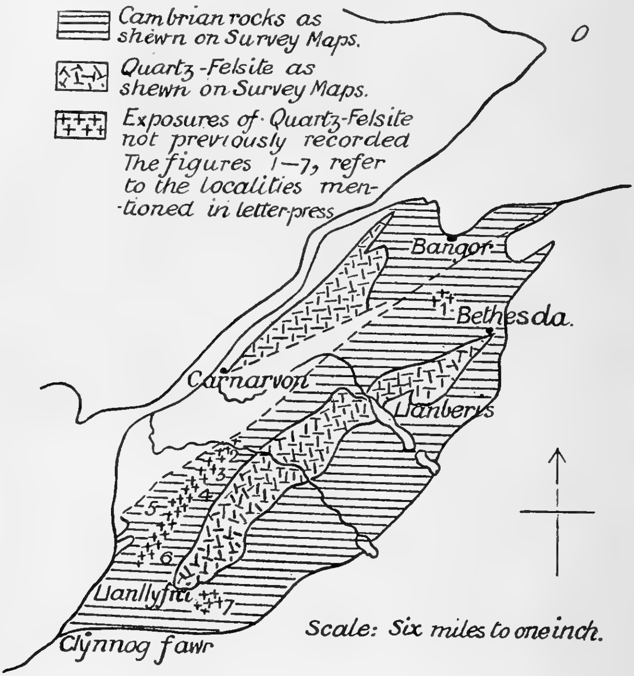
(7) *Llanllyfni.*—On Sheet 75 N.W. of the 1 inch Geological Ordnance Map, the boundary between the quartz-felsite and the adjoining rocks, the so-called Cambrian Slates and Grits, is drawn as passing from Nantle Railway Station south-westwards to a point just north of the village of Llanllyfni. The stratified rocks are marked as forming a continuous band, a mile or more wide, wrapping round the felsite. As a matter of fact much of this area is formed of the felsite faulted against the slates and grits. It is exhibited at the following places, so-named on the 6 inch ordnance map or so known locally: Penglog,[1] Tyddyn Agnes, Gwynfaes, Taldrwst isaf, Taldrwst ganol, Taldrwst ucha, Singrig Quarry, and Tanyrallt Quarry. The area over which the rock is exposed is rather more than half a mile from south-west to north-east and about one-third of a mile from north-west to south-east. Probably the felsite is present over a still larger area, but deep drift obscures the outcrops.

In this locality the felsite is extremely schistose, the felspars having been in most cases completely broken down. In some places the quartz grains are very numerous, while elsewhere they are few and small.

The surface of the ground between the exposures numbered (2) to (6) inclusive is largely formed by Drift, so that one cannot actually trace the course of the quartz-felsite from exposure to exposure by means of the surface features. There cannot, however, be any reasonable doubt

[1] This is probably the locality just referred to by J. H. Blake, Q.J.G.S., xlix, p. 463.

but that a continuous band of that rock does extend for a distance of four and a half miles along a line running from Bontnewydd on the north-north-east to Brynmawr Farm on the south-south-west, and that such an outcrop should be marked on the Survey geological maps instead of the rocks at present represented on them. Whether this middle band of felsite is continuous with the eastern band, or not, or whether the Survey maps are correct in showing the so-called Cambrian Grits as extending continuously from the Gwirfai River to the south-west, it appears at present impossible to determine, for the relationships of these older rocks are completely obscured by the thick covering of glacial deposits.



Sketch-map of some unrecorded exposures of Quartz-Felsite in North-West Carnarvonshire.

VI.—Note on the Geology of the Falkland Islands.

By J. Halle, Geologist to the Swedish Magellanic Expedition.

(Communicated by Dr. Carl Skottsberg, Director of the Expedition.)

The Swedish Magellanic Expedition spent some time in the Falkland Islands before proceeding to Tierra del Fuego, where important work is being carried on. The writer utilised his stay in the Falklands to study the geology and collect fossils. The following is a brief note of the work there.

The Devonian formation, which constitutes the larger part of the islands, was carefully surveyed, and fossils discovered in several new localities. The stratigraphical and tectonic conditions, on the West Island especially, proved to be of much interest. My most important task, however, was to solve the question of the supposed occurrence of Permo-Carboniferous layers of the Gondwana type. Some fragmentary plant fossils, collected in 1902 during the Swedish Antarctic expedition, were described by Professor Nathorst in Stockholm under the name of *Phyllotheca* sp., and compared with a species from the *Glossopteris* flora, but owing to the fragmentary condition of the specimens their determination remained doubtful. I have now been able to settle the question. Fossils, principally leaves of *Glossopteris*, occur in many places, and it is evident that the whole southern part of East Falkland south of Wickham Heights belongs to the Gondwana system. At the base of the *Glossopteris* series I discovered a Boulder-clay formation containing blocks of stone apparently of Glacial origin, which undoubtedly corresponds to the well-known moraines from other parts of Gondwanaland.

Of more recent formations, an interesting Forest-bed, discovered on West Point Island by Mr. A. S. Felton, was made an object of special investigation. The bed, which contains great quantities of large trunks, is covered by old 'flowing soil,' and is probably of Pre-glacial age. After having been worked out, my collections will give important information as to the phyto-geographical and climatological conditions of these islands during the early Quaternary period. I have also paid attention to the other Pleistocene deposits, as well as to the question of changes of level, supposed to have occurred in the latest period. The result of these researches cannot be communicated until the observations and collections have been thoroughly studied.

VII.—An Analysis of London Clay.

By J. H. B. Jenkins, F.C.S.

The sample analysed was derived from a well-boring made at East Ham by Messrs. C. Isler & Co., who gave the following table of the strata passed through:—

		Thickness. ft.	in.	Depth. ft.	in.
Soil ...	Mould ...	3	0	3	0
River Gravel	Ballast ...	14	0	17	0
London Clay	London Clay ...	59	0	76	0
	Sand, Shells, and Pebbles ...	10	0	86	0
Woolwich Beds and Thanet Sand.	Blue Clay and Shells ...	10	0	96	0
	Mottled Sand ...	6	0	102	0
	Sandstone ...	5	0	107	0
	Gray Sand ...	16	0	123	0
	Live Gray Sand...	30	0	153	0
	Dead Gray Sand Loam ...	26	6	179	6
	Green Coated Flints ...	0	6	180	0
	Chalk and Flints ...	120	0	300	0

The sample was taken from the stratum of clay between 17 and 76 feet below the surface.

It was a wet, stiff clay, of dark-gray colour. On heating to 120° C. it lost 20·1 per cent., and there was a further loss of 6·3 per cent. on ignition.

The residue was of brick-red colour, and on analysis gave the following results:—

Silica	67·9
Alumina	18·3
Ferric Oxide	8·7
Lime	1·3
Magnesia	1·2
Potash...	1·6
Soda	1·4
	100·4

VIII.—Mottled Foraminiferous Limestone in West and North Lancashire.

By J. Wilfrid Jackson (Manchester Museum).

EARLY in 1904, whilst spending a holiday at Silverdale, near Carnforth, I noticed at the roadside near the Silverdale Hotel several heaps of a peculiar mottled limestone which was being broken up for road-metal. The resemblance to specimens I had seen from Derbyshire struck me at once, and I was not long in locating the quarry from which the material had been derived. The exposure of the rock is situated near the turn of an old cart track leading from Silverdale Green to Burton Well. When I visited the place there was a section visible of about 12 to 14 feet long and 2 to 3 feet deep. On the top was a thin layer of surface soil with vegetation on it. The floor of the quarry was also of the same mottled limestone. The strata here and in the immediate neighbourhood are rolling with a general dip of 10° E.

Whilst traversing the district again in 1905 I came across another small exposure of this mottled limestone in a small roadside quarry near Woodwell, about three-quarters of a mile south-west of that at Burton Well. Here about the same depth was exposed, the strata dipping slightly to the S.E. I cannot say definitely, as yet, whether these two sections are exposures of the same bed, but it is highly probable.

Quite recently I came across a small slab of mottled limestone at the Chadwick Museum, Bolton, which the curator, Mr. T. Midgley, informed me had been obtained from Grange-over-Sands by a Mr. H. Wright. It is part of a large slab found under some feet of Boulder-clay on the Eden Park Estate, and both pieces are beautifully glaciated. The direction of the scratches as the block lay undisturbed was noticed to be from north to south. I also possess a specimen and slides of mottled limestone from the Boulder-clay near Burscough Bridge, South Lancashire, collected by a friend of mine, which is highly foraminiferous, and agrees closely with the Silverdale specimens.

The Silverdale specimens partake of exactly the same character as those described by Messrs. Barnes and Holroyd from Derbyshire.[1]

[1] "On the Mottled Carboniferous Limestone of Derbyshire": Trans. Manch. Geol. Soc., vol. xxvi, p. 561.

The matrix is light-coloured and fine-grained, with irregularly shaped patches (? nodules) of a fine-grained dark-coloured limestone. The patches have no definite shape, being mostly very uneven in size, some of them being long cylindrical bodies with irregular contours. The patches are in no case confluent, and, like the Derbyshire examples, there is a tendency for them to break along the line of contact with the lighter portion. When exposed to the weather for any length of time, and along the numerous cracks and fissures in the quarry, the rock weathers in the same peculiar manner as the examples above mentioned, that is, the dark patches resist the weathering to a greater degree than the lighter portion of the rock, and the patches stand out in relief similar to the encrinital limestone of some parts of Derbyshire.

In the Silverdale specimens, so far as I have made out, foraminifera are almost as numerous in the light portion of the rock as in the dark, which contrasts strongly with the specimens from Derbyshire, where the light part is said to be almost void of these remains. The same state of things exists in the Boulder-clay specimens. Other organic remains such as mollusca and corals are rare in the rock.

Now as to the physical conditions which led to the formation of this mottled limestone. Messrs. Barnes and Holroyd in the above cited paper give as their opinion that the dark patches have been removed from the original place of deposition, and intermingled and cemented into the lighter matrix. They further state that—"In the discussion upon a former paper read by us at the March meeting upon the pebbles found in the Windy Knoll conglomerate, Professor Boyd Dawkins threw out the suggestion that the pebbles might possibly be patches of a partially hardened calcareous mud from the sea-floor, and this idea would seem to offer an explanation of the presence of the dark patches in the light matrix, and it is not difficult to believe that their origin is due to one of the volcanic outbursts that are found represented in the limestone, for upon the same or a very near horizon, as far as we are able to make out, there exists a bed of volcanic rock. Given that these outbursts of volcanic activity were preceded by the usual earth shocks and sea disturbances, and the neighbouring presence of calcareous beds of dark foraminiferal mud, we have all the conditions necessary for the turning up from the sea bottom, and consequent removal to another area of the dark parts, together with the redeposition and consolidation, to produce the peculiar mottlings."

This highly interesting explanation of the mottling of the limestone appears to hold good with regard to the Derbyshire beds where there have been contemporaneous lava-flows (e.g. Toadstone) along with the deposition of the limestone; but how are we to account for the same phenomenon of mottled limestone so far away as Grange and Silverdale, where no contemporaneous igneous rocks are known to exist, unless it can be put down to the action of strong currents sufficient to remove the deposit from one part of the sea-floor to another, set up by the volcanic disturbances in the Derbyshire area, or can the area of these disturbances have been more widespread than is at present known? This is certainly a most interesting problem.

Unfortunately, I have been unable so far to investigate the beds immediately below the mottled ones at Silverdale to see if they agree with those in Derbyshire. Necessarily I am unable to give the actual thickness of the mottled beds. With reference to the contained foraminifera of these beds, I am hoping to make further investigations on them before publishing any note on the same. Some of the genera represented are *Nodosaria* sp. (*radicula*?), *Endothyra* spp. (abundant forms, *bowmani*?, *ammonoides*?), *Textularia* sp., *Trochammina* sp.

NOTICES OF MEMOIRS.

The President of the Royal Society on the Acquisition and Advancement of Knowledge.

The following excerpts are from the Address delivered by Lord Rayleigh at the Anniversary Meeting of the Royal Society on November 30th, 1907 (published in Proc. Roy. Soc., Series B, vol. lxxx, pp. 77, 78, 1908).

How to keep pace with the Progress of Science.

"Enough has probably been said to illustrate my contention that much loss has ensued from ignorance and neglect of work already done. But is there any remedy? I think there ought to be. In all principal countries of the world we have now a body of men professionally connected with science in its various departments. No doubt the attention of many of these is so engrossed by teaching that it would be hard to expect much more from them, though we must remember that teaching itself takes on a new life when touched with the spirit of original enquiry. But in the older universities, at any rate, the advancement of science is one of the first duties of Professors. Actual additions to knowledge occupy here the first place. But there must be many who, from advancing years or for other reasons, find themselves unable to do much more work of this kind. It is these I would exhort that they may fulfil their function in another way. If each man would mark out for himself a field—it need not be more than a small one—and make it his business to be thoroughly conversant with all things new and old that fall within it, the danger of which I have spoken would be largely obviated. A short paper, a letter to a scientific newspaper, or even conversation with friends and pupils, would rescue from oblivion writings that had been temporarily overlooked, thereby advancing knowledge generally and sometimes saving from discouragement an unknown worker capable of further achievements. Another service such experts might render would be to furnish advice to younger men desirous of pursuing their special subject."

The Preparation of Scientific Papers.

"Another remedy for the confusion into which scientific literature is liable to fall may lie in the direction of restricting the amount of unessential detail that is sometimes prevalent in the publication of scientific results. In comparing the outputs of the present time, and of, say, thirty years ago, the most striking feature that appears is doubtless the increase of bulk in recent years, coming especially from young workers stimulated by the healthy encouragement of direct research as a part of scientific education. But I think it may also be observed, and not alone in the case of such early dissertations, that there is, on the whole, less care taken for the concise presentation of results, and that the main principles are often submerged under a flood of experimental detail. When the author himself has not taken the trouble to digest his material or to prepare it properly for the press, the reader may be tempted to judge of the care taken in the work from the pains taken in its presentation. The tendency in some subjects to submit for immediate publication the undigested contents of note-books is one that we hear much of at the present time. It is a matter that is difficult for publishing bodies to deal with, except by simple refusal of imperfectly prepared material, with its danger of giving offence to authors of recognized standing, but it seems not unlikely that at present public scientific opinion would endorse such a course of action. A related difficulty and one that contributes to this trouble, is the tendency, noticeable in some public scientific organizations, to imagine that their activity is estimated by the number of pages of printed matter they can produce in the year. Probably no consideration is further removed than this from the minds of the educated public, whose judgment is alone worth considering."

REVIEWS.

I.—Geological Survey of England and Wales. Sheet 125: Derby. Price 1*s*. 6*d*.

Memoirs of the Geological Survey of England and Wales. Explanation of Sheet 125: The Geology of the Southern Part of the Derbyshire and Nottinghamshire Coalfield. pp. 199. Price 3*s*.

On the scale of 1 inch to the mile only one geologically coloured map of this area is published which shows details of both solid and drift geology. We are told in the preface, "the distribution of the drift is not sufficiently great to obscure the general structure of the district."

The map is one of the new colour-printed series, and is full of detail and a great advance on the last edition in every way. Very elaborate legends are given in the margins, and we note a most useful novelty on the lower margin, i.e., an admirable coloured transverse section from west to east across the most important part of the map from a view of structure. Everyone concerned in the production of the map is to be most highly congratulated on its wealth of detail and general accuracy.

The memoir is written by Messrs. Gibson, Pocock, Wedd, and Sherlock, with notes by Mr. Fox Strangways, and the striking note of the volume is the application of palæontological data throughout the parts dealing with the Carboniferous rocks.

The Carboniferous Limestone in the area consists of the portion of the North Staffordshire–Derbyshire anticlinal at Wirksworth and the Crich inlier, which are shown to belong to the *Lonsdaleia* subzone of the *Dibunophyllum* zone. The limestones are succeeded by the

Limestone shales, here only between 400 and 500 feet thick. This term has been adopted for this map to replace the Yoredales of the previous edition, though the reasons given for adopting a different nomenclature for this sheet than was selected for the maps and explanatory remarks of Sheets 123 and 110 are somewhat ambiguous and not obvious. However, the important fact remains that the 'Limestone shales' are recognised to be the equivalents of the Pendleside Series elsewhere. Albeit 'Limestone shales' is somewhat of a misnomer, because the shales have no faunal connection with the limestone deposit, and the amount of limestones found in the shales are only 2 or 3 per cent. of the total. It is, however, non-committal, and gives an opportunity for hedging later if found necessary, and it will be interesting to watch what line is taken in the sheet further north which will not be so far away from the type district.

The chapter on the Millstone Grits is important. These beds are thinning and dying out, and the stratigraphy presents difficulties of its own. It is interesting to note the presence of *Glyphioceras bilingue* above the Kinderscout Grit. This goniatite appears to characterise the upper part of the Pendleside Series and to persist in Lancashire as high as the Sabden shales. The chapters on the Coal-measures are from the pen of Mr. Walcot Gibson, and are excellent and full of detail. He has been careful to chronicle the occurrence of the fossils connected with each bed of coal, both plants and mollusca, and he finds that the distribution of the Lamellibranchiata reveals a general sequence similar, in the main, to that found to obtain in the North Staffordshire Coalfield. He attempts a certain amount of correlation between the Derbyshire and North Staffordshire Coalfields on palæontological data. As in North Staffordshire, certain marine bands have been discovered which will afford great help in fixing horizons, e.g. the Alton coal is considered to be the equivalent of the Crabtree of the Cheadle and Pottery Coalfields. Between the Coal-measures and the Permian series is a great unconformity, and this opens up a large question, as to what was the condition of things on the west side of the Pennine axis which prevented Permian rocks being laid down in Cheshire and Staffordshire.

The Triassic rocks are found not much to exceed 800 feet in thickness, and apparently all the members, which measure several thousand feet thick in Cheshire, are represented.

It is noted on p. 126 that the Bunter gravels contain pebbles with Silurian fossils similar to those found in Staffordshire.

Chapters on folds and faults, the superficial deposits, and economic geology are also included. It is curious that no Chalk flints have been definitely recognised in the drift; these erratics are very common further west at Barrow Hill, Rocester, and at Abbotts Bromley.

An appendix gives a detailed section of the shaft at Kilbourne Colliery, with the fossils found at each depth.

The authors are to be congratulated on the excellent volume they have produced. At last a memoir dealing with a colliery district has palæontological details put in a form which will be useful to the mining engineer who can appreciate them. Wheelton Hind.

II.—Three Geological Survey Memoirs.

The Geology of the Country around Mevagissey. By Clement Reid, F.R.S.; with Petrological Contributions by J. J. H. Teall, D.Sc., F.R.S. pp. vi, 73, with 7 plates and 4 text-illustrations. Price 2*s*.—Colour-printed map, Sheet 353. 1*s*. 6*d*.

The Geology of the Country around Plymouth and Liskeard. By W. A. E. Ussher, F.G.S.; with Notes on the Petrology of the Igneous Rocks, by J. S. Flett, M.A., D.Sc. pp. vi, 156, with 4 plates and 15 text-illustrations. Price 3*s*.—Colour-printed map, Sheet 348. 1*s*. 6*d*.

The Geology of the Quantock Hills and of Taunton and Bridgwater. By W. A. E. Ussher, F.G.S. pp. iv, 109, with 15 text-illustrations. Price 2*s*.—Colour-printed map, Sheet 295. 1*s*. 6*d*.

In the first of these memoirs we have a description of the small but complicated area extending from Tregoney to Veryan Bay and Mevagissey Bay. It is a region made classic by the early discoveries of 'Silurian' fossils by C. W. Peach, and has been more recently referred to in the pages of this Magazine (July and August, 1904, pp. 289, 403, and January, 1906, p. 33) by Mr. Upfield Green with the collaboration of Mr. C. D. Sherborn.

Although fossils had been found by Peach at Porthluney, we owe to Mr. Green the discovery of true Upper Silurian fossils in lenticles of limestone at that locality, probably of both Wenlock and Ludlow age. Interest naturally centres in the palæontological evidence, and we are glad to note the further important material gathered by Mrs. Clement Reid from the Ordovician quartzite of Perhaver Beach. By dint of much labour she obtained six species of trilobites, named by Mr. Philip Lake—

Cheirurus Sedgwicki, Salt.	*Phacops mimus*, Salt.
Calymene Tristani, Brongn.	*Phacops incertus* (?), Desl.
Calymene Cambrensis, Salt.	*Asaphus Powisi* (?), Murch.

These species apparently represent beds of Llandeilo age, as noted by Salter, who first identified the *Calymene Tristani* from the Cornish strata.

The geological map of Mevagissey gives but little idea of the difficulties encountered in determining the structure in the cleaved, crushed, overthrust, and broken sedimentary and igneous rocks; and as Mr. Reid remarks, "there is enough unexplained in this small area to employ a skilled geologist for several years longer, and there is also plenty of work for the fossil collector and petrologist."

The author in describing the "Lower Palæozoic Rocks" takes us along the coast from the Dodman northwards to Gorran Haven and Mevagissey, and westwards to Carne and Veryan. The age of the Dodman Series is not known, but there is evidence of a sequence from the unfossiliferous Portscatho Series (of J. B. Hill) to the Veryan slates, limestone, and radiolarian chert, and the Gorran or Carne quartzite, which are of Ordovician age. Resting unconformably on the older strata are coarse conglomerates, grits, and slates grouped as of Lower Devonian age. Pictures of rock-structure are given, including pillow-lava and slickensided quartzite; also of honeycomb weathering, which is stated by Mr. Reid to correspond with no internal structure of the rock, and is probably "due to some unrecognised organic agency."

In the chapter on Igneous rocks there is a description of the Gneiss of the Eddystone by Mr. H. H. Thomas, while notes on the Basalt, Dolerite, Felsitic Rocks, and Quartz-porphyry are contributed by Dr. Teall. There are short chapters on the superficial deposits and economics.

In his "Geology of the Country around Plymouth and Liskeard" Mr. Ussher points out that "the structure of the Devonian rocks of Cornwall, to which the area comprised in Sheet 348 furnishes the key, remained practically unknown until the year 1890." This topic was discussed by him during the excursion of the Geologists' Association to Plymouth at Easter, 1907.

In a region so complicated it is not surprising that it has taken many years to establish the main structure. Beyond marking in the Plymouth limestone and the various eruptive rocks, De la Beche made no attempt to depict the various types of stratified rock which he recognized in the Devonian area in the course of his comparatively rapid survey on the old one-inch maps; but, as remarked by Dr. Teall in the preface to this memoir, De la Beche's "facts were noted with such precision that the present author, from experience he had gained in the Devonian area of South Devon, was enabled so to interpret De la Beche's observations as to be able to give in 1890 a forecast of the probable structure in the Devonian rocks of Cornwall." Single-handed, Mr. Ussher has been occupied in the detailed mapping of the Devonian rocks from Torquay to Liskeard and St. Austell for a period extending over more than thirty years (though occupied elsewhere during portions of the time), but while gradually establishing the sequence and age of the main rock-divisions it was not until 1900 that he had satisfied himself with regard to the relative position of the Looe Beds and the Dartmouth Slates.

The present memoir embodies the detailed information on which the new geological map is based, and will be an invaluable guide to all who devote themselves to further research.

To the reader who has no personal knowledge of the district a summary of the leading characters and fossils of each division would have been a useful addition to the account of the general geology and structure given in the Introduction.

The Culm Measures appear nearly everywhere to be in faulted relation with the Devonian; but in some places Middle Culm Measures rest, apparently with marked unconformity, on Upper Devonian Slates.

There is a short chapter on evidences of New Red rocks, a brief reference to the possible Eocene deposit on the Hoe described by R. N. Worth, and descriptions of the various superficial accumulations and economics. The petrographical notes by Dr. Flett include accounts of the schalsteins, spilites, proterobases, diabases, and picrites, among the last-named being the well-known rock of Clicker Tor.

In the memoir on the Quantock Hills Mr. Ussher records observations for the most part made many years ago when the area was resurveyed on the old one-inch map, but these are supplemented by notes made recently. The Devonian rocks from the Hangman Grits to the Pilton Beds are described, and the author remarks that "it is unsafe to regard the Morte Slates as anything older than the upper part of the Ilfracombe Group or the beds immediately overlying it."

Dr. Flett contributes a description of the Hestercombe 'syenite' which was discovered in 1814 by Leonard Horner, the rock being now described as a diorite.

The Carboniferous Limestone of Cannington is referred to the *Seminula* zone.

The author discusses the relations of the Carboniferous and Devonian, observing that while there is no evidence of unconformity between the Lower and Middle Culm Measures, yet "the existence of a considerable unconformity in South Devon and Cornwall leads one to think that the appearances of concordance are not to be trusted." The author is here rather more confident of the unconformity than he was in the Plymouth memoir (p. 103), wherein he did not deny the possibility that thrust-faults might explain the phenomena.

In the Quantock area, as in that of Plymouth, there is no proof of unconformity between Upper Devonian and Lower Culm Measures, but the junction "is often faulted and generally obscure."

The cherty beds of Coddon Hill have been regarded as homotaxial with those of Bishopston in Gower, and as equivalent to the so-called "Yoredale Beds," or to the Pendleside Beds of Dr. Wheelton Hind. Mr. Ussher is, however, inclined to regard the Devon-Carboniferous chert-beds as on a lower horizon than those of South Wales, and he adopts the view put forth by Dr. G. J. Hinde and Mr. Howard Fox that the Devon beds represent the deeper-water conditions of the Carboniferous Limestone. The proof of deeper-water conditions is, however, a moot point.

Dealing generally with the effects of great earth - movements, Mr. Ussher argues that "if the Devon Lower Culm-measures correspond to the Carboniferous rocks above the Carboniferous Limestone, and the Upper Devonian in no part represents the latter, the south shore of a strait in the Carboniferous Limestone sea would have been not far south of Cannington Park; and south of this the Carboniferous Limestone would not be found." He, however, adds, "The equivalence of the Lower Culm Chert Beds to Carboniferous Limestone, owing to a more or less uniform deepening of the sea-bed to the south and south-west of Cannington Park, is here advocated."

Full particulars are given of the New Red rocks, including (1) the Lower Sandstones and Marls, grouped as Permian, and (2) the Pebble Beds and Conglomerate, the Upper Sandstones and Upper (Keuper) Marls, grouped with the Trias. Mr. H. H. Thomas contributes petrographical notes on the New Red sands and sandstones. Short descriptions are given of the Rhætic beds and Lower Lias which are exposed along a small portion of the coast which comes in the area of the map, near St. Audrie's, east of Watchet. The work concludes with some account of the Pleistocene and Recent deposits, and of water supply and economic products, including the famous Bath bricks of Bridgwater.

III.—Geological Survey, Western Australia. Bulletin No. 29,[1] Parts I and II: A Report upon the Geology, together with a Description of the Productive Mines of the Cue and Day Dawn Districts, Murchison Goldfield. By Harry P. Woodward, Assistant Government Geologist. 8vo. With maps and sections. Perth, W.A., 1907.

MR. HARRY P. WOODWARD, a well-known pioneer of West Australian geology, has supplied in this report much valuable information respecting the mining districts which it embraces, forming part of the great "Murchison Goldfields."

Part I (Cue and Cuddingwarra Centres) opens with an account (section 1) of the Cue mining district. The township of Cue is the official centre of the Murchison goldfields, and is connected by railway with Perth; it is 1,485 feet above the sea-level, and lies upon the western edge of a broken granite plateau, which extends for a considerable distance to the eastward. Starting in 1891 as a mere digger's camp, it became changed in 1893 into a mining centre; reefs were opened up, of which several passed into the hands of companies with ample machinery to develop them. Nevertheless, it was soon discovered that the production did not justify these preparations, and failure resulted. In spite of adverse conditions, however, the district has yielded since the earliest records appeared from 15,000 to 20,000 ozs. of fine gold per annum.

Geology.—Gold deposits occur in the crystalline series in more or less lenticular-shaped amphibolite belts, surrounded by gneissic granite, the whole being intersected by numerous felspathic dykes. In the district under review the amphibolites are more coarsely crystalline in structure than is usual in the auriferous belts, while the quartz reefs in them are of rare occurrence. In the acidic series, however, instead of gneissic granites there appears to be a magmatic intrusion of granodiorite, a rock intermediate between the hornblende granites and the quartz diorites, and containing numerous productive lodes.

A characteristic feature of the Cue district is the occurrence of table-topped hills rising abruptly about 60 feet above the general level of the country. These hills are the denuded remnants of a once extensive plateau.

Mining.—Section II contains a detailed description of the mines of Cue, with tables showing their yield from about 1896 to 1906, according to the length of time they have been worked.

Numerous illustrations from photographs showing the physical features of the country and coloured geological maps accompany the report.

Part II deals with a portion of the area included in the Day Dawn mining district, which adjoins the Cue district to the southward. Owing to excellent management mining in this area is carried on very profitably, the most productive of the mines having yielded, up to the end of 1906, 778,606 oz. of gold, out of 844,023 tons of ore crushed. Over 95 per cent. of this yield comes from one mine.

[1] See also Geol. Mag., Dec. V, Vol. III (1906), p. 277.

Geology.—The geology of the Day Dawn district differs materially from that of Cue, the granodiorite of the latter being entirely absent. The whole area is therefore classed as greenstone, with its schistose and altered forms due to hydration and the attendant forces, such as compression, elongation, crushing, and shearing. The term greenstone is meant to include not only the normal hornblende schists, amphibolites, etc., but also the diorites, diabases, and andesites which occur in this district, though they are generally so highly altered at the surface as to render the delineation of their boundaries a very difficult task.

The amphibolites are highly foliated and hydrated near the surface. A magmatic igneous intrusion occurs, composed probably of diabase, the augite of which has been changed into hornblende and epidote. The lodes of the district occur in the "igneous zone," in the "contact zone," and in the "amphibolite zone," the principal productive mines being contained in the contact zone, in which, though there are only eight gold-bearing reefs, the production is 97 per cent. of the total yield.

Section II is devoted to a full description of the productive mines of the district, and it concludes with two appendices containing (1) a list of the Cue rocks, (2) notes on some typical Cue rocks, by E. S. Simpson, F.C.S.

This report is also well illustrated.

We must congratulate Mr. Woodward upon the ability with which he has conducted the survey of this important mining area. He has shown no less a grasp of the economic problems presented to him in the course of his work than of the geological ones.

A. H. F.

IV.—Report relating to the Geology of the East Africa Protectorate. By H. Brantwood Muff, B.A. Colonial Reports—Miscellaneous. No. 45, East Africa Protectorate. London: H.M. Stationary Office, 1908. With map and 2 text-illustrations. Price 6*d*.

WE welcome the publication of this important and interesting report, which has been issued at a price that may be regarded as exemplary.

Mr. Muff was engaged between December, 1905, and September, 1906, in investigating the geology of the East Africa Protectorate, mainly with the object of reporting on the prospects of obtaining better supplies of water for drinking and other purposes. The region consists of a long but comparatively narrow belt of country, extending from the Island of Mombasa on the coast of the Indian Ocean to Port Florence on Victoria Nyanza, a distance of 580 miles as measured along the course of the Uganda railway.

This region comprises (1) the *coastal belt* formed of raised coral rock and sands, followed inland by a mass of shales and underlying sandstones, with occasional limestones, that dip towards the coast, and are in great part of Jurassic and in part probably of Triassic age. This coastal belt extends for 57 miles, and rises to over 1,000 feet above sea-level.

The greater portion of the region consists of (2) a broad intermediate tract of gneiss, and (3) a vast area of volcanic rocks which extend to the shores of the Victoria Nyanza.

The author points out that the valleys throughout the coastal belt were eroded when the land stood at least 60 feet above the present sea-level, and after the formation of the coral reef. There have, therefore, been considerable changes in level in comparatively recent geological times.

It is reckoned that an artesian supply of water might be met with in the sandstones below the Jurassic shales at a depth of about 1,600 feet near Mombasa. Other local sources of water, and possible further sources in different parts of the Protectorate, are duly discussed.

Attention has been paid to the soils on the several rock formations. On the gneiss there is much red earth with limestone nodules (Kunkar), the origin of which is explained by the author. He also points out the injury that is done when the forest growth is removed from the natural slopes, as the rains then readily carry off the red earth.

In the volcanic region there are numerous 'fumaroles,' which constantly emit clouds of steam, and there are some warm springs. The superficial deposits include red clay, like the Indian 'laterite,' black cotton soil like the 'regur,' and loam or loess. In places there are thin layers of pisolitic iron-ore, known by its Indian name 'muram,' and this, as the author remarks, is smelted by the natives, who manufacture spears and knives from the iron.

In conclusion, it may be mentioned that throughout the report many other matters of general geological interest are ably treated by the author.

V.—Superficial and Agricultural Geology, Ireland.

UNDER the above general title Mr. G. H. Kinahan, M.R.I.A., etc., has commenced a series of shilling handbooks, "Kinahan's Booklets," published by Messrs. Sealy, Bryers, & Walker, of Dublin. Two are already issued: No. 1, Lime, and No. 2, Soils. In the first work he deals with the utility of lime as a manure, and points out its natural sources in Ireland. That lime is required by many fruit-trees is shown by analyses, although its prime importance in the cultivation of the land is the influence it exerts on the constituents of the soil. Thus peaty lands when well drained can be successfully cultivated with the aid of lime manures. In the second work Mr. Kinahan deals with "Soils, Natural and Augmented," or, in other words, as modified by tillage and manures. The soils on different formations, on upland and lowland, are described, and much attention is given to the drainage and cultivation of the bog lands. The importance of due consideration of the subsoil is rightly urged, and indeed a soil-map which did not indicate the subsoils would have little or no practical value.

As early as 1837 Portlock, who was in charge of the Geological branch of the Ordnance Survey in Ireland, established at Belfast a laboratory for the examination of soils, and he recognized the importance of ascertaining not only the soluble and insoluble ingredients, but also the physical characters of the soils. No one since his time has paid so much attention to questions of economic geology in Ireland as Mr. Kinahan, and he now records, sometimes in very forcible language, his views on agricultural matters gathered during an experience of sixty years of the soils and subsoils of the country.

VI.—Soil Surveys in the United States.

The Bureau of Soils of the U.S. Department of Agriculture issued its seventh report on Field Operations during 1905 (Washington, 1907). The Bureau comprised Mr. Milton Whitney, the Chief, a scientific staff of men, with forty-five Assistants in Soil Survey, a chief clerk, and editor. During the year 1905, 21,289 square miles, or 13,624,960 acres, were mapped, the average cost of the field-work being reckoned at rather less than 9*s.* per square mile. Up to the end of the year soil survey work had been undertaken in all but three of the States, in four territories, and also in Porto Rico.

The general results of the work demonstrate the very varied soil and climatic resources of the agricultural domain of the country; and bring to notice additional soil-types adapted to the production of many kinds of crops. Interesting examples are given of special adaptation of soils to crops, such as tobacco, sugar-beet, sugar-cane, grape, peach, cotton, as well as corn; and tests have been made to determine the manurial requirements of the more important types of soil. It is thus coming to be generally recognized that the soil surveys are very helpful to the farmers of any State, in indicating the adaptation of soil to particular crops, and the means to be taken for their maintenance and increase.

That the soil-maps of the United States, like those of some European areas, represent the subsoils rather than the actual and constantly varying soils, is evident. Taking, for example, one of the published soil-maps, that of the Everett area, in the north-west part of Washington on the eastern shore of Puget Sound, we find it to represent the characters (1) of mountainous uplands which rise to 1,800 feet, (2) of lower hills and bench-lands, which vary from 25 to 600 feet in elevation, and (3) of the valley region, with alluvial bottom-lands and delta-flats, mostly not exceeding 20 feet in elevation.

The mountain region (1) is stated to consist largely of schists with a backbone of diorite and granite, and to be separated from the lower hills and benches in the area by an abrupt escarpment. The soils are due partly to the effects of glaciation, partly to the residual weathering of the schists and igneous rocks, which are exposed in numerous places, sometimes extensively. On the map, however, this mountain area is coloured uniformly of one tint, according to the characteristic soil, termed the *Miami stony loam.*

The remainder of the area has a foundation of Tertiary shales, sandstones, and conglomerates, which have been thrown into folds, and outcrop occasionally along some of the streams. Elsewhere these strata are buried beneath accumulations of till, and stratified deposits of clay, sand, and gravel.

The outcrops of the Tertiary strata are not indicated on the map, but the entire area is coloured according to the distribution of what would ordinarily be termed the main subsoils. Thus there are areas of many square miles coloured simply as *Miami sandy loam.* The surface soil is stated to comprise up to 15 inches "of brown sandy loam of medium texture, containing a good proportion of fine gravel. The subsoil, to a depth of 36 inches or more, consists of a yellow or gray light sandy loam or sand, containing fine gravel. From 5 to 10 per cent. of larger gravel and glacial cobbles is scattered through both soil and subsoil, and occasional glacial erratics of larger size are found. Irregular bands of gravel are found here and there at different depths throughout the type."

Again, the *Galveston coarse sand* "consists of 3 feet or more of medium to coarse loose gray sand, containing gravel of various sizes." The *Muck* "consists of vegetable mold in a more or less decomposed condition, mixed with silt or other earth, and extending to a depth of from 1 to 3 or more feet."

The value of soil surveys so far as the maps are concerned is in the indication they give of the main characters of the subsoil, or weathered geological formation beneath the soil. Added to this information, that relating to the actual depths of soil and subsoil, obtained by means of hand-borers or spade, and the mechanical and chemical analyses of the materials, combine to give data of great practical value.

VII.—Petrology for Students: An Introduction to the Study of Rocks under the Microscope. By Alfred Harker, M.A., F.R.S. Fourth edition. pp. viii, 336, with 91 text-illustrations. Cambridge: at the University Press, 1908.

A NEW edition of this eminently concise and useful handbook will be welcomed not only by students of petrology, but by geologists in general, enabling them, as it does, to keep in touch with the progress of the science and the nomenclature of the rocks.

It is remarkable that the author has revised and brought his book up to date not only without increasing its size, but by a reduction of ten pages compared with the last edition.

Since then Mr. Harker has published the results of his researches on the Tertiary Igneous Rocks of Skye (Mem. Geol. Survey, 1904) and of other investigations among the Inner Hebrides. Thus we find brief reference to his "Mugeary type" of olivine-dolerite, recorded as mugearite in the index, though the author has purposely refrained from using the rock-name in the text. Other varieties of rock are similarly treated, such as the olivine monzonite (Kentallen type) and a connecting link between syenites proper and nepheline-syenites (Pulaski type), which are recorded only in the index as kentallenite (Hill and Kynaston) and pulaskite (J. F. Williams). The value of the index is enhanced by the insertion of the names of the authors responsible for the rock-terms.

The descriptions of the sedimentary rocks and of the effects produced by metamorphism are amplified by references to the more important publications on these subjects.

VIII.—Geology of the Philippine Islands.

The Geology of the Compostela-Danao Coalfield. By Warren D. Smith. Philippine Journal of Science, vol. ii, No. 6, sect. A, Dec. 1907, pp. 377–405, pls. i–xiv, maps and sections.

THIS is a comprehensive paper dealing with climate, vegetation, population, hydrology, topography, physiography, and geology, both stratigraphical and economic. It concludes with a classification of Cebu coal by A. J. Cox. One of the chief points of interest in the paper is the account of the 'upper limestone,' which contains fossils identical with those figured by Martin in his monograph on the Tertiary of Java. A volume on the palæontology is promised later on. Besides a series of molluscan genera quoted Mr. Smith points out that the foraminiferal genus *Lepidocyclina* (*Orbitoides*) predominates, while another characteristic fossil is found in the alga *Lithothamnium ramosissimum*, Reuss. Plates are given of this last form. Following Martin in his work on Java, and Newton & Holland in their paper on Formosa, the author says, "I have been inclined to assign this formation, at least this horizon of it, to the Miocene, although fossils from a very similar limestone which I have also examined in the field in Batan Island have been classified by a European palæontologist[1] as Oligocene." And he thinks that future research may reveal this horizon in Cebu.

IX.—The Life and Work of George William Stow, South African Geologist and Ethnologist.

By Robert B. Young, M.A., B.Sc., Professor of Geology and Mineralogy at the Transvaal University College, Johannesburg. 8vo; pp. vi, 123, with portrait. London: Longmans, Green, & Co., 1908. 3*s.* 6*d.*

IT is well that a record of the remarkable career of G. W. Stow has been written. He was one of the pioneers in South African Geology, associated with Rubidge and Athertone, who followed "the Father of South African Geology," Andrew Geddes Bain. Stow was born at Nuneaton in Warwickshire on February 2nd, 1822. Devoted in youth to engineering subjects, he was nevertheless articled by his father to a medical man in London, "but failed to acquire any love for his profession." History, natural science, and poetry were his favourite studies. In 1843 he emigrated to South Africa and there for nearly forty years he laboured to live, and lived to prosecute researches on the geology and ethnology of his adopted country. As remarked by J. W. Hulke in an obituary notice, "Mr. Stow's work was carried on under circumstances of such continued pecuniary difficulty and personal hardship as nothing but the sacred fire of a pure love of investigation for its own sake, rather than for any monetary emoluments which might ultimately accrue from it, would have enabled him to endure." He began life in South Africa as a Church teacher and catechist, but soon had to take up arms in one of the Kaffir wars. Farming for a while engaged his attention, then he successively became bookkeeper in a merchant's office, broker and

[1] O. H. Reinholt, Engineering Journ., 1906, xxx, 510.

commission agent, manager of a general business, wine merchant, diamond dealer, and auctioneer. Meanwhile he had seized all opportunities for geological studies; he had obtained remains of a Labyrinthodont named *Micropholis Stowi* by Huxley, and had been engaged in an expedition in Griqualand, which led to his most important publication, "Geological Notes upon Griqualand West," read before the Geological Society of London in 1873. Ultimately Stow was officially engaged in geological surveys of the country between the Vaal and Modder Rivers in the Orange Free State, and became the discoverer of the Vereeniging coalfield. He died on March 17th, 1882. The story of his life is full of interest and pathos, and we commend it to our readers.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—*March 4th*, 1908.—Professor W. J. Sollas, Sc.D., LL.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "On *Metriorhynchus brachyrhynchus*, Deslong., from the Oxford Clay near Peterborough." By E. Thurlow Leeds, B.A. (Communicated by Dr. Henry Woodward, F.R.S., F.G.S.)

This species was first described by E. E. Deslongchamps in 1868, and was based on an imperfect skull, obtained from the department of Calvados, Lower Normandy. He was led to distinguish it from other species by the shortness of its snout. He mentions one other mutilated skull found near Poitiers, and there is a third in the Muséum de la Faculté des Sciences at Caen. Two skulls have recently been obtained by Mr. A. N. Leeds, F.G.S., from the Saurian zone of the Lower Oxford Clay, in the neighbourhood of Dogsthorpe, Peterborough. No other parts of the skeleton were found with them, even the mandibles being missing. The two specimens belong to the same species, and after comparison with descriptions, figures, and photographs of the specimens above mentioned, they have been referred to *Metriorhynchus brachyrhynchus*. This is believed to be the first recorded occurrence of the species in England; and the specimens help to throw additional light on the cranial osteology of the species, especially in the parts which are wanting in the type-specimen. They are therefore described in order to amplify Deslongchamps's description. The skulls are neither of them perfect, but one fortunately supplements the other, and both are perfect in one of the most interesting parts—the frontal region and the part from the nasals to the premaxillæ. The specimens are compared and contrasted throughout with *M. superciliosus*. It is found that these specimens possess the main characteristics determining Deslongchamps's species, although the prefrontals, which are in keeping with the general massive development of the skull, are wider than he supposed; and it is possible to reconstruct with almost absolute certainty the region of the posterior nares, showing the bifurcated opening with the vomerine element running back almost to the sphenoid, a feature which the author thinks will prove to be common to all species of *Metriorhynchus.*

2. "The High-level Platforms of Bodmin Moor, and their Relation to the Deposits of Stream Tin and Wolfram." By George Barrow, F.G.S. (Communicated by permission of the Director of H.M. Geological Survey.)

In this area there are three platforms—one, which is marine and of Pliocene age, terminating in a steep slope of 430 feet above the sea; a second, at a height of 750 feet, seen about Camelford and at the foot of Delabole Hill; and a third, a little under 1,000 feet, first recognized on Davidstow Moor. The valleys cutting the lowest platform are found to have been much deepened since the uplift of the platform to its present level; but the features thus caused gradually die out in the higher part of the valleys, disappearing in the River Camel about 22 miles from the sea. At the higher parts of all these platforms, marshes are frequently found.

The superficial deposits which bear tin above the 750 foot platform differ markedly at times from those below it, as here ancient wash is preserved—possibly protected, by a snowfield or by being frozen, from the denudation which has destroyed them below this level. These deposits are not so concentrated as the stream-sorted material below, but they have been frequently worked in past times until the industry languished, in consequence of the difficulty or impossibility of separating the wolfram contained in the enriched portion of these deposits from the tin-ore. This difficulty having been overcome, and the wolfram being even more valuable than the tin-ore, the industry is now reviving. The veins from which the wolfram is derived have been found close to the points where the 'wash' is enriched by their denudation. The method of working is described, and it is shown that the success of it depends to some extent on the slope of the granite floor on which the detritus rests; otherwise the deposit becomes waterlogged, and the method of separation adopted is expensive to carry out.

On Bodmin Moor the larger marshes have a floor of kaolinized granite; but there is a difficulty in working it at many points, in consequence of the waterlogging by peaty water. This difficulty does not exist at Stannon Marsh, which has sloping sides instead of a flat base, the cycle of denudation in this case being incomplete.

2.—*March* 18*th*, 1908.—Professor W. J. Sollas, Sc.D., LL.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Carboniferous Rocks at Loughshinny (County Dublin), with an Account of the Faunal Succession and Correlation." By Charles Alfred Matley, D.Sc., F.G.S., and Arthur Vaughan, B.A., D.Sc., F.G.S.

After an introduction recalling the succession at Rush, already described by the authors, a detailed account is furnished of the various sections in the Loughshinny area. About 1,100 feet of Carboniferous rocks are exposed. They consist mainly of limestone, but also include a thick mass of conglomerate and many intercalated beds of shale and chert. The rocks have been much folded, and to some extent faulted. The lowest rocks belong to some part of the *Dibunophyllum* Zone, the higher range through *Cyathaxonia* Beds into *Posidonomya* Limestones and shales of Pendleside age. The Lane Conglomerate may be on or near the horizon of the Rush Conglomerate. Local decalcification has caused the more or less complete disappearance of some of the *Cyathaxonia* and *Posidonomya* Limestones. The following table gives the position and correlation of various members of the sequence :—

Stratigraphical Zones.	*Thickness in feet.*	*Palæontological Zones.*	*Correlation with the Rush area.*
Loughshinny Black Shales.	110	Upper *Posidonomya* Zone. (P_2)	Not represented.
Posidonomya Limestone Group.	260	Lower *Posidonomya* Zone. (P_1)	Do.
Cyathaxonia Beds (base not seen).	200	*Cyathaxonia* subzone (locally divisible into D 3*b* D 3*a* but overlapping).	*Cyathaxonia* Beds of Bathing Place and Giants Hill.
(Gap)	(Gap)		
Dibunophyllum Limestone	100	Upper *Dibunophyllum* Zone. (D_2)	Curkeen Hill Limestone.
(Gap)	(Gap)		
Holmpatrick Limestone.	180	? D (of unknown position).	? Carlyan Limestone.
Lane Conglomerate.	200		? Rush Conglomerate Group.
Lane Limestones.	60		? Rush Slates (top part only).

The region was close to an old shore-line of the Carboniferous Limestone Sea, the actual position of which appears to have been almost parallel to, and a short distance seaward of, the present coastline between Rush and Skerries.

The paper closes with faunal lists from the various subdivisions and exposures, and an account of the faunal succession and correlation, both by the second author.

2. "A Note on the Petrology and Physiography of Western Liberia (West Coast of Africa)." By John Parkinson, M.A., F.G.S.

The country is low-lying, with a gradual rise northward from shore-level, and rivers mature in character with alluvial flats raised above flood-level. Where the River Tuma falls into the River St. Paul the remnant of a hanging valley can be seen. Flat-topped ridges and isolated hills trending parallel to the foliation of the gneiss are characteristic of the country around Sanoyei and Boporo. There is a striking absence of late deposits of old gravels and sands.

In the southern part of the district there are indications of a series of garnetiferous gneisses, tremolite schists, kyanite schists or gneisses, garnet graphite gneisses, etc., associated with others of granitic type, the latter being apparently free from microcline and containing a pleochroic pyroxene. These rocks are replaced in the north by biotite gneisses and hornblende schists, which have an approximate and singularly constant east and west (magnetic) strike in their foliation. Microcline is common. These old crystalline rocks are cut by an extensive series of basalts and ophitic dolerites, resembling so closely the post-Cretaceous dykes of Southern Nigeria that it is difficult to avoid the conclusion that they are of the same age.

3.—*April 1st,* 1908.—Professor W. J. Sollas, Sc.D., LL.D., F.R.S., President, in the Chair.

A Special General Meeting was held at 7.45 p.m., before the Ordinary Meeting, for the purpose of considering and voting upon the following motion proposed by Mr. E. A. Martin, and duly seconded:—

"That the Council be requested to take the necessary steps, at an early date, in order to allow of the admission of women to full Fellowship of the Geological Society of London."

After discussion, the following amendment proposed by Dr. A. Smith Woodward, and seconded by Mr. H. A. Allen, was voted upon, and passed by 43 to 34:—

"That it is desirable that women should be admitted as Fellows of the Society, assuming that this can be done under the present Charter."

The foregoing amendment having then been declared a substantive motion, the following amendment to it was proposed by Mr. H. B. Woodward, and seconded by Mr. O. T. Jones:—

"That a poll of all the Fellows of the Society resident in the United Kingdom be taken, to ascertain whether a majority is in favour of admitting women to the Society, and, if so, whether as Fellows or as Associates."

This was agreed to by 54 to 24, and was declared a substantive motion by show of hands.

An Associate is defined in the proposed New Section of the Byelaws, submitted to the Special General Meeting held on May 15th, 1907, see Quart. Journ. Geol. Soc., vol. lxiii, Proc. p. lxxiii.

ORDINARY MEETING.

The President announced that the Council had adopted the following resolution:—

"The Council of the Geological Society has heard with much regret of the death of Dr. Henry Clifton Sorby, who served on the Council for many years, and occupied the Presidential Chair during the Sessions 1878–80. The Council desires to place on record its high appreciation of the invaluable services rendered by Dr. Sorby to the Society and to the Science of Geology."

4.—*April* 15*th*, 1908.—Dr. J. J. Harris Teall, M.A., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Geological Structure of the St. David's Area (Pembrokeshire)." By J. Frederick N. Green, B.A., F.G.S.

With a view to the elucidation of controverted points in the geology of the St. David's area, the author has mapped the district in considerable detail on the 6 inch scale. The Cambrian Rocks, the succession of which is well known, were first traced and were found to be greatly faulted. The faults have been followed into the underlying volcanic tuffs (Pebidian), and the succession within the intervening blocks of country determined and pieced together. In this way the Pebidian has been subdivided into fourteen horizons, with a total visible thickness of over 3,000 feet. The tuffs are described in some detail, and the subdivisions classified into four series—the lower two of which are composed chiefly of trachytic pebbles in a chloritic matrix, and are usually separated by a peculiar schistose quartz-felspar-porphyry sill. The third series is composed of fragments of rhyolite and hälleflinta in a silicified matrix, and the topmost now principally consists of highly sheared schistose beds. The volcanic fragments throughout the Pebidian are rolled, and have often undergone changes before deposition; thus the tuffs appear to be mainly, if not wholly, detrital.

By the aid of this succession, an unconformity between the Pebidian and the Cambrian is demonstrated, the position of the basal Cambrian conglomerate on the volcanic series varying by at least 1,000 feet. The red coloration of the beds immediately underlying the conglomerate is due to staining.

The schistose sill has been traced into the porphyritic margin of the St. David's granophyre (Dimetian), to which it is allied petrographically; and it is inferred that the granophyre is a laccolitic intrusion in the Pebidian. The boundaries between the granophyre and the Cambrian are prolongations of faults proved in the latter; except at one point in the well-known Porthclais district, which, on account of its importance, has been mapped on the scale of 25 inches to the mile. A trench specially opened at this point exposed basal Cambrian rocks resting upon a denuded surface of the granophyre, which is therefore of pre-Cambrian but of post-Pebidian age.

The relationships of the basic igneous rocks west of St. David's, which have hitherto been held to be Pebidian lavas, are discussed, and the conclusion is reached that they are all post-Cambrian intrusions. Finally, it is suggested that the word Pebidian should be revived as a general term.

2. "Notes on the Geology of Burma." By Leonard V. Dalton, B.Sc., F.R.G.S. (Communicated by Dr. A. Smith Woodward, F.R.S., F.L.S., V.P.G.S.)

The object of this paper is to present the results of geological expeditions in the Irawadi Valley, carried out by the author and Mr. W. H. Dalton between 1904 and 1906, and to correlate these observations with those made by previous writers, thus summarizing present knowledge of the geology of Burma in general, and of the

Tertiary System in particular. The classification of rocks arrived at is shown in the following table :—

			Feet.	
Irawadi Series			20,000 (?)	Pliocene.
Arakan Series	Pegu Group		7,500	Miocene.
	Bassein Group		8,000	Eocene.
Axial Series	Upper	*Cardita* Beds	......	Cretaceous.
		Halobia Limestone	......	Triassic.
		Shales and grits	......	(?)
	Lower.	Flaggy shales and sandstones ...	......	(?)

The oldest rocks, not comprised in the above synopsis, include representatives of the Silurian, Devonian, and Carboniferous Systems, but little of their detailed geology is known. The *Cardita* Beds may be correlated with the Cretaceous of India. The 'Chin Shales' of Dr. Noetling seem to form part of the Bassein Group, of Eocene age, which is of much greater thickness than hitherto supposed, and the group rests presumably more or less conformably on the beds below. The fauna is chiefly shallow marine in facies. These rocks flank the Arakan Group on both sides, and in the south form the backbone of the range, where they have been considerably metamorphosed. The Pegu Group probably overlaps the preceding, and is regarded as of Miocene age, although the fauna has many relationships with that of the French Eocene. *Lucina globulosa* is described as the first European Miocene species recorded from Burma. Estuarine conditions came on towards the close of Miocene time, and, in the estuary of the Pliocene precursor of the Irawadi, anticlinal islands of partly consolidated Miocene materials were formed. Around and eventually over these islands a great thickness of fluviatile deposits was laid down, corresponding to the Siwalik Beds of the Indian Peninsula. Finally, post-Pliocene denudation and upheaval revealed the Miocene islands as inliers, while the Irawadi has left its gravels in patches throughout the region. A list of fossils is given, and the species new to Burma, some of them new to science, are described.

II.—Mineralogical Society.

March 17*th*, 1908.—Prof. H. A. Miers, F.R.S., President, in the Chair.

(1) On the occurrence of metamorphic minerals in calcareous rocks in the Bodmin and Camelford areas; by G. Barrow and H. H. Thomas. The pneumatolytic action is not contemporaneous with the thermo-metamorphism produced by granite intrusions; the gaseous intrusions are later, and often produce their greatest effect beyond the zone of 'contact-action.' The species of mineral produced depends on the nature of the rock penetrated by the gases. In killas, tourmaline is commonly produced; but in calcareous rocks, axinite and a variety of other minerals result from the pneumatolysis. In the Bodmin area the minerals formed by pneumatolytic action in the calc-flintas are axinite, hedenbergite, epidote, yellow garnet, actinolite, and another amphibole occurring in minute dark-brown needles. In the Camelford area the minerals are mainly due to contact metamorphism. The most conspicuous are yellow garnet, epidote, and idocrase, a mineral which

has not hitherto been recorded from Cornwall.—(2) A protractor for use in constructing stereographic and gnomonic projections; by A. Hutchinson. A short historical account was given of the stereographic projection, and a protractor designed to facilitate its construction was shown. By the aid of this protractor the radii of both great circles and small circles could be readily determined. It can also be applied to the construction of the gnomonic projection and to measuring the angles between planes and zones.—(3) Supplementary notes on the mineral kaolinite; by A. B. Dick. Further observations on the optical characters of kaolinite from Anglesea lead to some alterations in the data given in a previous paper. The refractive index is about 1·563 for sodium light, and the optic axial angle, 2 V, is about 68° instead of 90°. The double refraction is very low. Kaolinite from limestone at Hambleton quarry, Bolton Abbey, Yorkshire, and from sandstone near Newcastle-on-Tyne were described.—(4) An attachment to the goniometer for the measurement of complex lamellated crystals; by H. L. Bowman. The apparatus, consisting of a small screen pierced by a pin-hole, can be attached to a goniometer, and is capable of adjustment so that minute portions of a crystal face can be successively illuminated.—(5) A new form of quartz-wedge, a modification of the Wright-wedge; by J. W. Evans. A quartz-wedge cut parallel to $\mathfrak{c}$ is placed over a gypsum-plate parallel to $\mathfrak{a}$ showing red of the first order, and extending beyond the thin end of the wedge, so that the projecting portions can be used as an ordinary gypsum-plate. The region where the wedge overlies the gypsum is graduated at the position of exact compensation and at each thousand micromillimetres of relative retardation. If when placed over a mineral in the diagonal position the black band is moved towards the thin end of the wedge, the direction of insertion is that of the vibrations which traverse the mineral with the smaller velocity; if towards the thick end, the direction is that corresponding to the greater velocity.—(6) Calculation of the chance that the double refraction of a crystal section cut at random shall exceed a particular fraction of the maximum; by H. Hilton. The problem is soluble completely for a uniaxial and partially for a biaxial crystal.

CORRESPONDENCE.

ON THE DATE OF PUBLICATION OF FREDERICK DIXON'S "GEOLOGY OF SUSSEX."

Sir,—It will be remembered that Frederick Dixon died in 1849, leaving his "Geology of Sussex" in manuscript, and that Richard Owen undertook to see it through the press. John Morris, in his "Catalogue of British Fossils," 2nd ed., 1854, notes that Dixon's book was published in 1852 (not 1850 as stated on the title-page), and this supported by rumour led William Davies to make the same statement in some of his letters (MSS. concerning types of "British Fossil Vertebrata," Geol. Dept. Library, Brit. Mus. (N.H.), Pressmark 16.0. W., p. 29), in which statement he was not alone. A certain amount of uneasiness has thus arisen regarding this book and the numerous specific names it contains, and the following notes would seem to settle the matter in a fairly satisfactory manner:—

On October 13th, 1849, Edward Forbes wrote to Owen saying he had just heard of the death of Dixon and that his part of the MS. could be finished in two or three days. On February 2nd, 1850, G. B. Holmes wrote to Owen asking how Dixon's work is getting on. On December 30th, 1850, George Landseer, the artist, wrote to Owen saying "what a nice book Mr. Dixon's makes, a very useful one . . . I was looking over it the other day, and it seems carried out with great care." W. H. Fitton, on February 4th, 1852, wrote to Owen as follows: "During some weeks of the last summer made an acquaintance with the widow of your late friend Mr. Dixon. I obtained from her a copy of her husband's book on the fossils of the chalk, etc., at the usual bookseller's price of £3 3*s.* 0*d.*" Fitton further notes that her agreement with Longman expired in December, 1851, and with his usual kindness suggests that Mrs. Dixon should not be allowed to be at any loss over its production. Further, Messrs. Longman, Green, & Co. have favoured me with a letter dated 10th March, 1908, in which they say that Dixon's Sussex "was published in December, 1850."

I think we may therefore, on this evidence, safely accept the date 1850, as stated on the title-page. C. Davies Sherborn.

THE NOMENCLATORAL HISTORY OF THE CORAL *CANINIA.*

Sir,—In the April number of the Geological Magazine, pp. 158–171, Mr. R. G. Carruthers, in addition to his admirable description of *Caninia* and of its contained species, enters fully into the question of its nomenclature. Since this question has given rise to some controversy, and is by no means easy of settlement, a consensus of opinion on the subject is desirable. If I venture to intrude on a field outside my own special work, it is only as a student of nomenclature and bibliography, and in response to a definite request for my opinion made last November by Dr. Arthur Vaughan.

After looking up the literature with the help of my colleague, Mr. W. D. Lang, I sent Dr. Vaughan a long letter, which came to the same conclusions regarding the interpretation of *Caninia* and of its genotype as those based by Mr. Carruthers on his independent studies, and thus brought Dr. Vaughan round to the same view. Mr. Carruthers has asked me to publish my confirmation of his conclusion, and to add one or two details that had escaped him.

The species *Caninia cornucopiæ* does not date from the Congrès de Turin. The report of that Congress appeared in *Atti riunione scienziati Ital.*, ii, Torino, 1841, pp. 227–228. *Caninia* was there defined as a fossil ally of *Cyathophyllum*, distinguished by infundibuliform tabulæ. No species was mentioned. The name *C. cornucopiæ* therefore dates from the paragraph by Paul Gervais, Dict. Sci. Nat. (De Blainville), Suppl. I, p. 485. This paragraph is quoted in full by Mr. Carruthers (p. 166). The life of the Supplement was cut short, and the plate therein referred to was never issued. In subsequent editions of the "Dictionnaire des Sciences naturelles," *Caninia* continues to be quoted by Gervais, with mention of *C. cornucopiæ* as the only species.

The date of the original Supplement is given as 1840, but was more probably 1841, since it must certainly have been published after the Congress was held at Turin, although it may have appeared before the actual publication of the *Atti*.

De Koninck (1841, Descrip. Anim. foss. terr. houiller . . . Belg., p. 22) did not accept *Caninia*, and made *C. cornucopiæ* a synonym of *Cyathophyllum mitratum* (Schlotheim). Since *C. cornucopiæ* had not then been published, De Koninck must have obtained his information from Michelin's letters or MS. This is further proved by the fact that De Koninck (loc. cit.) quoted the unpublished *Caninia cornu-bovis* as a synonym of *Cyathophyllum plicatum*. He may have got the name from the legend to the unpublished plate, since he quotes Dict. Sci. Nat., Suppl. II (not I). Anyhow, this citation gave *C. cornu-bovis* no validity.

The date of page 81 of Michelin's "Iconographie Zoophytologique" was probably about 1842. The species *Caninia gigantea* there established is said to be the only species common at Sablé, one of the localities ascribed to *C. cornucopiæ*, although erroneously, in the paragraph of Gervais.

As Mr. Carruthers points out, Michelin, when establishing *Caninia cornu-bovis*, referred to "Michelin, in P. Gervais, Astrée, Dict. des Sci. nat., Suppl. tome I, p. 485 (pour le genre)." By the last words Michelin seems to imply that the description published in Gervais gives the characters of the genus, but not those of the species *Caninia cornu-bovis*. Mr. Carruthers admits the possibility of an alternative interpretation, namely, "that the generic description in the Supplement should be regarded as a specific description of *C. cornu-bovis*." Such a weakening of his case seems to me quite unwarranted.

The reason for taking *C. cornucopiæ* as genotype is briefly that this species was definitely selected as "espèce type" in the Supplement (1840 or 1841); and although *C. cornucopiæ* was not fully described till 1846, no other species was proposed as genotype by Lonsdale or any other intervening writer. In such a case, the rules of the International Zoological Congress leave no room for doubt.

It is hoped that the few notes here given will complete Mr. Carruthers' account, without affecting its main conclusions.

April 7th, 1908. F. A. Bather.

CHANGES OF LEVEL AND RAISED BEACHES.

Sir,—In the May number of this Magazine Dr. Jamieson suggests that the elevation of raised beaches is caused through the lightening of land areas by the ordinary denudation constantly going on. That this denudation may be a *vera causa* of elevation to re-establish equilibrium is highly probable. But there must be counteracting agencies at work, because the elevation of the beaches has been followed by a certain amount of depression, as shown by the submerged forests on our coasts. Denudation has been going on all along, and the land is now at its lightest, and consequently ought to be at its highest, yet on the contrary what was lately dry land is now below high water. O. Fisher.

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JULY, 1908.

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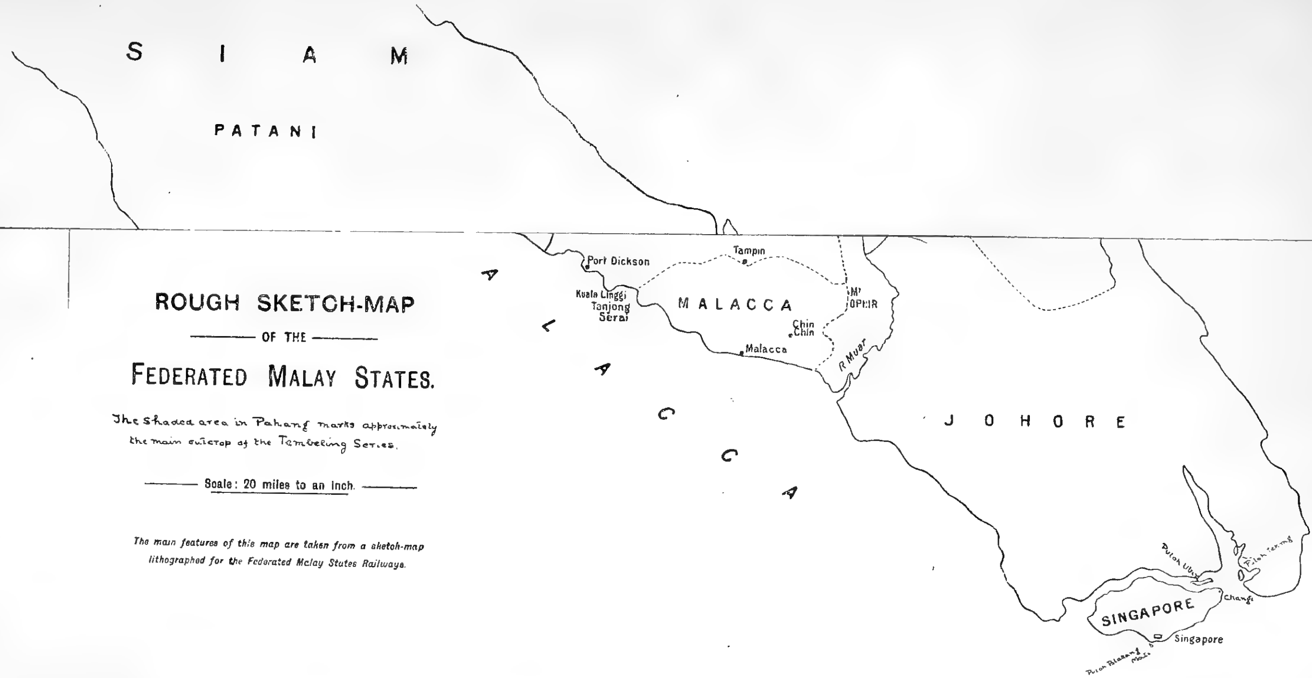

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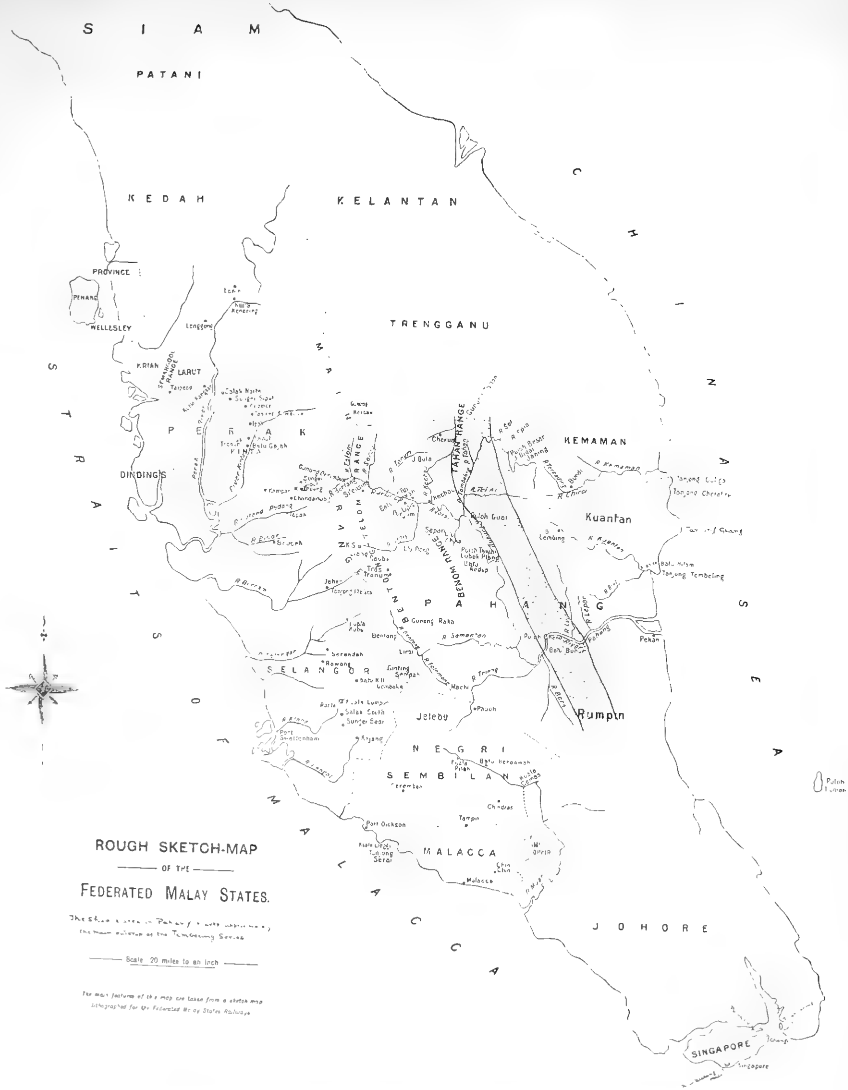

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. VII.—JULY, 1908.

ORIGINAL ARTICLES.

I.—Note on the Sedimentary Rocks of Singapore.

By J. B. Scrivenor, B.A., F.G.S.,
Geologist to the Federated Malay States Government, and formerly of H.M. Geological Survey of Great Britain.

(PLATE XI.)

UNTIL Mr. R. B. Newton described certain fossils from Singapore found by the writer and Dr. Hanitsch of the Raffles Library and Museum,[1] very little was known of the geology of this island, which is the nearest of the British Malayan possessions to those parts of the Netherlands Indies that have been so ably described by Verbeek, Fennema, Molengraaf, Wing Easton, Martin, and others. This proximity to the islands of the archipelago renders the study of the geology of Singapore doubly interesting, since here may be expected data that will eventually assist materially in connecting the geology of the Malay Peninsula with that of the Malay Archipelago, and more particularly with that of Borneo. The object of the present paper is to show that the sedimentary beds of Singapore may be referred to one of the series of rocks which enter into the structure of the Federated Malay States.

At the time of the publication of the writer's "Report of Progress"[2] a few opportunities of collecting notes in Singapore had been obtained, and a similarity between the sedimentary rocks and the Tembeling Series of Pahang, the main outcrop of which is on the same line of strike as the Singapore rocks, had been noticed.[3] A glance at the accompanying sketch-map (Plate XI) will show, however, that between Pahang and Singapore there intervenes the large native State of Johore, the interior of which is unbroken ground to geologists; and it was felt

[1] "Fossils from Singapore": Geol. Mag., 1906, pp. 487–496. A list of the early literature dealing with Singapore will be found in Mr. R. B. Newton's "Notes on Literature bearing upon the Geology of the Malay Peninsula," etc., Geol. Mag., 1901, pp. 128–134. The subject does not require further notice here.

[2] "Geologist's Report of Progress," September, 1903 – January, 1907. Government Press, Kuala Lumpur. A table showing the results of the Geologist's work is reproduced in Geol. Mag., 1907, p. 566.

[3] Geol. Mag., 1907, p. 567.

that under the circumstances it would be unsafe to assume an extension of the Tembeling Series in Singapore until more definite evidence was forthcoming.

The Tembeling Series consists of shale, sandstone, and conglomerate. The shales are sometimes deep red, sometimes grey; while the sandstone and conglomerate are remarkable for containing derived fragments of chert, and sometimes of black carbonaceous shale also. In Singapore the sedimentary rocks consist chiefly of fine sandstone and deep red and grey shales.

Prior to the discovery of the fossils described by Mr. Newton only a little coarse sandstone had been seen by the writer in Singapore, and it seemed essential to prove the presence of chert pebbles in either sandstone or conglomerate before including the Singapore rocks in the Tembeling Series.

Early in 1907 an opportunity presented itself of devoting several days to a further examination of the Singapore beds, with the result that the presence of chert pebbles was proved in both sandstone and conglomerate. The best sections were found at the west end of Blakang Mati, a fortified island guarding Singapore Harbour. Access to these sections was kindly permitted by the military authorities. The west end of Blakang Mati is composed of red and grey shales, sandstone and conglomerate. The beds are vertical. The general strike is N.W.–S.E. There are several bands of fine conglomerate, all showing chert pebbles; and near a point marked "Chupa Rock" on the 1904 map of Singapore, by the Colonial Engineer and the Surveyor General, a band of coarse conglomerate is exposed in a deep cleft between a large isolated mass of rock and the cliff. This also contains chert pebbles and other pebbles to be noted later.

Again, in the grounds of the municipal filter beds, behind Government House, grey and red shales and sandstone are exposed. Here also fresh specimens show that the sandstone contains fragments of chert.

In the writer's Report of Progress it is assumed that the presence of the chert pebbles in the conglomerate of the Tembeling Series in Pahang shows an unconformity between the Tembeling Series and the Raub and the Chert Series. It was pointed out, however, in this report, that pebbles of the Pahang Volcanic Series, which one would expect in the conglomerate also, had not been found, but that little time had been spent in searching for them. In the "Chupa Rock" section on Blakang Mati several pebbles of pale-green partially decomposed lava were found (probably andesite or dacite), agreeing with some of the Pahang rocks; and a subsequent comparison of these pebbles with the material of specimens of sandstone from Pahang showed that small, soft, pale-green fragments in the sandstone are probably decomposed lava also. The pebbles in the Singapore conglomerate were well enough preserved for microscopic examination.

It may be noted here that Pahang Volcanic Series rocks are known to occur in Singapore as rough boulders which are probably hard 'cores' left from beds now weathered away. The writer has not yet seen any such rocks in Singapore clearly *in situ*.

One large chert pebble from the "Chupa Rock" section was cut for microscopic examination. The slides show abundant obscure organic remains; but it is remarkable that whereas in other cases radiolaria are commonly recognizable, in these slides no structure was observed that could be definitely referred to this group.

While the writer feels no hesitation now in regarding the Singapore rocks as an extension of the Pahang Tembeling Series, he nevertheless thinks a word is necessary regarding the palæontological evidence in order to meet a possible objection. Mr. R. B. Newton, to whom the writer is greatly indebted for assistance in this direction, when describing the fossils found by Mr. Bellamy near Kuala Lipis, in Pahang, as Rhætic, emphasized the fact that *Myophoria* is exclusively Triassic.[1] The same author, referring to *Estheriella radiata* (Salinas), var. *multilineata*,[2] found in Tembeling Series rocks in Perak, and described by Professor Rupert Jones,[3] also remarks that the genus *Estheriella*, "so far as can be ascertained, is only known to have existed in Triassic times"; while, writing of the Singapore fossils, Mr. Newton says that the beds containing them "may be of Middle Jurassic age, and about the horizon of the Inferior Oolite of England or the so-called Bajocian of Continental geologists."[4] The presence of *Goniomya* and *Podozamites* leads the author to this conclusion, but he remarks that *Goniomya* has also been found in Palæozoic rocks, although exceedingly rare;[5] and the range of *Podozamites* in Europe is described by Nicholson & Lydekker as "from the Rhætic into the Lower Cretaceous."[6]

It is far from the writer's purpose to suggest any amendment to these remarks on the fossils he had sent to England. His object is to show that the palæontological evidence does not make it necessary either to separate the Singapore and Pahang beds, or to assume that a series of estuarine deposits of unknown thickness covers at least part of the Rhætic, the whole of the Lias, and part of the Inferior Oolite.

Mr. Newton has suggested that the Singapore rocks may be an extension of the Upper Gondwana of India, and the writer has made a similar suggestion regarding the Tembeling Series. It will be very interesting in this connection to see the result of the examination of the Shan States Rhætic fossils collected by Mr. De la Touche.

II.—Sedgwick Museum Notes: New Fossils from Girvan.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XII.)

Ischadites Königi, Murchison.

In the list of fossils from the Silurian rocks of the South of Scotland in the collections of the Geological Survey[7] the two species of *Ischadites*, *I. antiquus*, Salter, and *I. Königi*, Murchison, are entered

[1] "Marine Triassic Lamellibranchs from the Malay Peninsula": Proc. Malac. Soc., vol. iv, part 3, October, 1900, p. 130.
[2] Geol. Mag., 1905, p. 49.
[3] Ibid., pp. 50–52.
[4] Ibid., 1906, p. 488.
[5] Ibid., pp. 487–8.
[6] "A Manual of Palæontology," vol. ii (1889), p. 1526.
[7] Mem. Geol. Surv., Silurian Rocks of Britain, vol. i, Scotland, 1899, p. 668.

as occurring in the Llandovery rocks, while a third unnamed species is recorded from the Caradoc. In the list of fossils prepared by Mrs. Gray from the collection made by her from the Silurian rocks of the Girvan district,[1] *I. Königi* is recorded from the Llandeilo beds of Balclatchie, *I. antiquus* from the Upper Llandovery of Penkill and the Middle Llandovery of Woodland Point, and *I.* sp. from the Middle Llandovery of Newlands. Nicholson & Etheridge[2] mentioned only two specimens of *Ischadites*, one from Balclatchie and the other from Penkill; both were referred to under the name *I. Königi*, but it was remarked that one of them appeared to possess more the characters of *I. antiquus*. The first discovery of *I. Königi* in the Girvan area was made by Mr. Robert Gray and was noticed by Professor J. Young[3] in 1868, and in 1876 the same author recorded it from Penkill in his "Catalogue of Western Scottish Fossils," p. 13. Dr. Hinde[4] gives both the localities, Balclatchie and Penkill, for the occurrence of *I. Königi*, but he regards the species *I. antiquus* as indistinguishable from it. The only other British species mentioned by this author (loc. cit.) is *I. Lindströmi*, Hinde.

The specimens submitted to me by Mrs. Gray comprise portions of four individuals with the external impression of one of them. All come from the Upper Llandovery of Penkill, and are in a poor state of preservation. The slightly concave base is seen in two of them, the smaller specimen measuring only 11 mm. in diameter and the larger one 35 mm.; the central 5–6 series of summit plates are arranged in fairly definite concentric circles. In another of the specimens the horizontal rays of the spicules number only three, the proximal ray being absent, as Hinde has explained is sometimes the case.[5]

There is only one specimen from Balclatchie which Mrs. Gray has sent me, and this closely agrees with Salter's *I. antiquus*[6] from the Llandeilo of Garn Arenig, Wales. The four horizontal rays of the spicules are well seen on the narrow transversely rhomboid summit plates, which also seem rather more numerous than in the Penkill examples of *I. Königi*. Only the basal portion of the sponge is preserved, and the central portion seems to have been somewhat elevated into a short obtuse boss; but the whole organism has been crushed and more or less flattened out, thus increasing the apparent diameter, which measures about 38 mm.

Receptaculites Grayi, sp. nov. (Pl. XII, Figs. 1, 2.)

Amongst the material which Mrs. Gray has recently sent me for determination there are several very fragmentary specimens from the Middle Llandovery of Woodland Point which must be referred to the genus *Receptaculites*, and they probably represent a new species. They consist of portions of the upper and lower surfaces, but no

[1] Mem. Geol. Surv., Silurian Rocks of Britain, vol. i, Scotland, 1899, pp. 510, 543, 686.
[2] Nicholson & Etheridge: Mon. Silur. Foss. Girvan, pt. i (1878), p. 20.
[3] Young: Proc. Nat. Hist. Soc. Glasgow, ser. I, vol. i (1869), p. 197.
[4] Hinde: Quart. Journ. Geol. Soc., vol. xl (1884), p. 836.
[5] Ibid., p. 814, pl. xxxvi, fig. 1*j*.
[6] Salter: Mem. Geol. Surv., vol. iii (1866), p. 282, fig. 4.

perfect individual occurs amongst them. Some of these fossils have a slightly convex or domed surface composed of small plates, which much resemble in appearance those described and figured by Rauff [1] as belonging to the wall of *R. orbis*, Eichwald, as preserved in a limestone pebble of Ordovician age from Wartin in Pomerania. The Girvan organism must have been elliptical or subcircular in shape, and the more or less marked convexity of the upper surface, which these plates cover, seems to be an original and natural feature and not due to distortion or pressure. The plates themselves on the upper surface are small, numerous, of regular rhomboidal shape, and of equal size, about seven plates measuring 10 mm. along their greater diameters, and about nine plates measuring also 10 mm. along their shorter diameters. The plates are fitted closely together into a pavement, as usual in the genus; the boundaries of the individual plates are not very sharply marked, being partly obscured by their ornamentation and perhaps fused to a certain extent along their edges. In one specimen there is a pore at each angle between the plates, as Hinde [2] has shown in his figures of *R. occidentalis*. Each plate is gently convex, rising slightly towards the centre, in which is a more or less indistinct small depression, from which radiate to the sides a number of short, broken, irregular, and sinuous ridges and vermiculate grooves, interspersed with or replaced by small closely-set pits and tubercles of the same size and elevation, which by their fusion seem to produce the above-mentioned ridges and grooves (Pl. XII, Fig. 1). On many of the plates only pits and tubercles are present, and no radial arrangement is noticeable. From the examination of both the natural casts and the external impressions of the same specimens which have been carefully collected by Mrs. Gray, and from the regular occurrence of these surface-features, it becomes clear that they are not due to weathering, though Rauff was in some doubt on this point in connection with his specimen of *R. orbis*. Our Girvan species differs from the latter by the less distinct character of the radial ornamentation, by the more traversely rhomboidal shape of the plates, and by their reduced overlapping.

A fragment of the lateral (lower) surface and margin of the same species comes from the same horizon and locality. It shows a few of the outer series of upper plates, apparently similar to those above described but rather larger, situated near the edge of the upper dome, and passing over into the flattened, smooth, and larger subquadrate plates of the lower surface. These plates decidedly overlap, like tiles, from above downwards, the lower overlapping angle being generally rather prominent and thickened. A shallow median depression or pit is generally noticeable on each plate, indicating the point of attachment of the vertical ray or column of the spicule. Rauff has figured closely similar plates (op. cit., t. i, fig. 10) from the upper surface of *R. Neptuni*. Occasionally traces of tubercles seem to be visible on the surface of these plates, but this is doubtful.

[1] Rauff: Abhandl. k. bayer. Akad. Wiss. Math. Phys. Kl., Bd. xvii (1892) p. 688, t. iv, figs. 2–6.

[2] Hinde, op. cit., pl. xxxvii, figs. 3*d*, 3*e*.

The plates decrease in size gradually downwards towards the base or lower pole, but the specimen is very imperfect. However, the distinction between the small convex, radially pitted plates with depressed sutures on the upper surface, and these large, smooth, almost flat, tile-like, overlapping plates of the lower surface, is most marked, as Hinde has pointed out in *R. occidentalis*.

As for the actual shape of this sponge from Woodland Point, the evidence certainly suggests that the upper surface was domed; the base is imperfectly known, and whether it was concave like *Ischadites Königi* or convex or conical must remain at present an open question.

No British species of *Receptaculites* appears to have been described with the above characters, and the Scandinavian and Russian *R. orbis*, Eichwald,[1] from the Lower Silurian, appears to possess the nearest affinities.

The cast and impression of the specimen from the Middle Llandovery of Newlands which has been entered in Mrs. Gray's list as *Ischadites* sp. may probably belong to this same species. But it is in a poor state of preservation, and consists of a mere fragment of the upper surface. The plates are of regular rhomboidal shape, measuring about 2 mm. along their longer diameter, and 1 mm. along their shorter diameter; their surface appears to be channelled and pitted, and pores are found at their angles in the suture-lines, with 3–4 additional pores, usually smaller in size, along their sides. But the surface of the fossil is much weathered and imperfect, so that it is difficult to know which of these characters and structures are original.

Receptaculites girvanensis, sp. nov. (Pl. XII, Figs. 3–6.)

Shape crateriform, low, conical, with broad thick rounded lip and obtusely pointed base. Plates very numerous, rhomboidal to quadrate, all four sides being almost of the same length, very small near base, increasing very gradually in size from base to lip of cup, arranged in regular series of strongly curved intersecting rows in the usual 'engine-turned' fashion; towards the lip the series run almost horizontally owing to the strong curvature of the rows, and the plates of successive series seem to lie in vertical rows. Lower plates near base sub-quadrate, with surface flattened and overlapping slightly in tile-like manner; but becoming more and more convex towards lip, where no imbrication is present, and a large pore lies in the grooves at each angle between the plates. Surface of flattened lower lateral plates smooth; surface of convex lip plates ornamented with small irregular pittings.

Dimensions.—Diameter of cup, about 47 mm.; height of ditto, about 22 mm.; size of plates on lip, 8 plates to every 10 mm.

Remarks.—One large specimen, of which the dimensions are given above, affords the principal means of diagnosing the characters of this form, but there is another smaller example broken off below the lip which has a diameter of about 20–25 mm. and a height of 9–10 mm. Both come from the Starfish Bed of Thraive Glen. The larger one is fairly well preserved, though the surface of the plates is somewhat

[1] Rauff, op. cit. supra.

weathered and the concavity of the cup is hidden by matrix. It seems to be a new species, but the arrangement of the plates and general characters ally it to *R. occidentalis*, Salter,[1] of the Trenton and Galena Limestones of North America, and to *R. orbis*, Eichw.,[2] from the Orthoceras Limestone of the Baltic regions.

It cannot, however, be identified with either of these species, nor with any other previously described from the British Isles, and though its characters are somewhat imperfectly known a specific designation seems necessary, and that of *R. girvanensis* is suggested.

Spongarium ardmillanense, sp. nov. (Pl. XII, Figs. 7, 8.)

Corallum subcircular, discoidal, or saucer-shaped, flattened, thin, composed of small, contiguous, low, rounded, subequal ridges, radiating to margin regularly and horizontally in one plane from small smooth central area, and increasing in number by bifurcation at a little more than half their length with a considerable amount of regularity (and by less frequent intercalation) to the number of 100–110 on the margin. Ridges crossed by 3–4 strong concentric wrinkles and by numerous fine, regular, equidistant, closely-set, impressed lines. Inferior, surface of corallum not visible.

Dimensions.—Major diameter, 30 mm.; minor ditto, 25 mm.; about twelve ridges to every 10 mm. round margin.

Remarks.—The counterpart of this specimen has precisely the same appearance, the disc or flattened saucer having been split regularly in one plane. Probably the base was covered with a thin epitheca, and it seems to have had a small central knob for attachment. The substance of the corallum appears to have been of a black corneous nature.

This peculiar fossil may best be referred to the genus *Spongarium*, the true affinities and zoological position of which are unknown. The species which approaches it most closely is *Sp. æquistriatum*, McCoy,[3] from the Upper Ludlow rocks; the elliptical shape and coarseness of the closely-set radiating ridges are features in common, but in the bifurcation of the ridges in our species there is an obvious difference. No British member of this genus appears to have been recorded except from the Ludlow beds. Ours comes from the Balclatchie Group of Ardmillan.

Annelidan Tube (?). (Pl. XII, Figs. 9, 10.)

Body forming a regularly cylindrical (?), straight, jointed tube, composed of a number (+ 15) of thin, calcareous, nearly flat rings of regular and equal size, successively overlapping to a slight extent those behind, and somewhat thickened towards the overlapping (posterior) edge. Each ring has a length approximately equal to one-third the diameter of the tube, and is marked by fine regular longitudinal plications, causing a weak serration of the posterior edge; a very delicate longitudinal striation is also present. Length of rings, 1·5–1·6. Diameter of tube, about 5 mm.

[1] Hinde, op. cit., p. 842, pl. xxxvii, figs. 3, 3*a*–*m*.
[2] Rauff, op. cit., pp. 654–691, t. iii, figs. 7–10; t. iv, figs. 1–6.
[3] McCoy: Brit. Pal. Foss. Woodw. Mus., 1855, p. 42, pl. 1B, figs. 15, 15*a*.

Horizon and Locality.—Drummuck Group: Thraive Glen, Girvan.

Remarks.—The three specimens in Mrs. Gray's collection are somewhat crushed and the tube is flattened, supposing it to have been once cylindrical; and it is to crushing that we may attribute two continuous longitudinal grooves running down the side of one specimen across several rings; and possibly in another specimen a narrow flattened longitudinal ridge traversing uninterruptedly six or seven consecutive segments is also due to the same cause.

This curious jointed tubular fossil is most probably of an annelidan nature, and allied to *Cornulites* and *Conchicolites*.[1] It differs from the former by its cylindrical instead of conical shape, but agrees in the overlapping of the flat rings and longitudinal striation, as well as in its solitary habit and non-attachment to foreign objects. *Conchicolites* is gregarious, attached, and curved, with thin walls and no longitudinal striæ, but is not so markedly conical as *Cornulites*. The latter is known only from the Silurian, but *Conchicolites* is an Ordovician genus. It does not seem possible to refer it to either of these genera sens. str., though its affinities with them are suggested.

EXPLANATION OF PLATE XII.

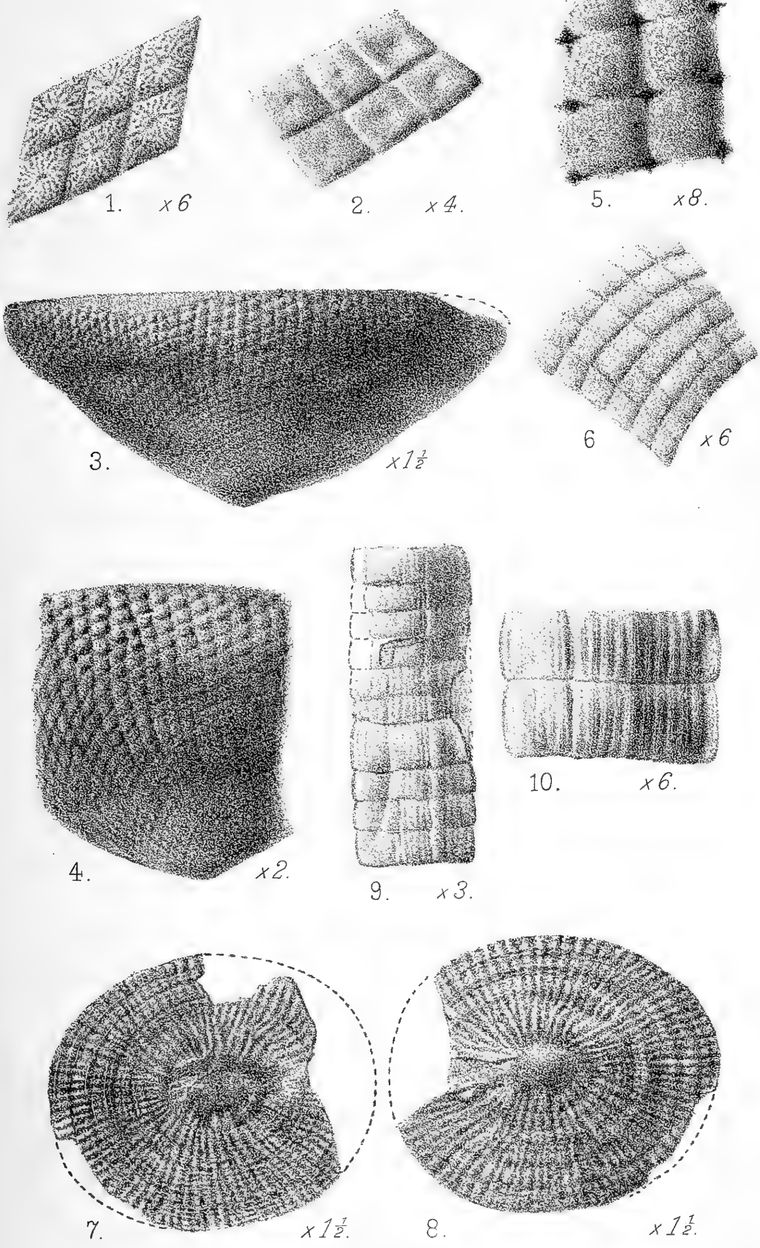
Fig. 1.—*Receptaculites Grayi*, sp. nov. Plates of upper surface, showing ornamentation. × 6.
,, 2.—Ditto. Plates of lower surface. × 4.
,, 3.—*Receptaculites girvanensis*, sp. nov. General view of specimen. × 1½.
,, 4.—Ditto. Portion of lateral surface of same specimen, showing arrangement of plates. × 2.
,, 5.—Ditto. Plates near lip of same specimen. × 8.
,, 6.—Ditto. Plates near base of same specimen. × 6.
,, 7.—*Spongarium ardmillanense*, sp. nov. × 1½.
,, 8.—Ditto. Counterpart. × 1½.
,, 9.—Annelidan tube (?). × 3.
,, 10.—Ditto. Two segments. × 6.

III.—On some minor British Earthquakes of the years 1904–1907.

By Charles Davison, Sc.D., F.G.S.

The four years 1904–1907 were marked by the occurrence of three considerable earthquakes, one of which (the Derby earthquake of July 3rd, 1904) disturbed an area of about 25,000 square miles, another (the Doncaster earthquake of April 23rd, 1905) an area of about 17,000 square miles, while the third (the Swansea earthquake of June 27th, 1906) was felt over an area of 66,700 square miles, and, with the exception of the Hereford earthquake of 1896, was the strongest felt in this country during the last twenty years. Besides these, there were 56 others of less intensity, 9 of which originated in England, 44 in Scotland, and 3 in Wales. The total number for the nineteen years 1889–1907 is thus 214, or 50 in England, 137 in Scotland, and 27 in Wales.

[1] Nicholson: Amer. Journ. Sci., vol. iii, ser. III (1872), p. 202.



A. H. Searle del. et lith. West, Newman imp.

Receptaculites, etc. from Girvan.

List of Earthquakes.

1904.

March 3, about 1.5 p.m. Penzance.
June 21, about 3.30 a.m. Leicester.
—— 5.28 a.m. Leicester (principal earthquake).
July 3, 2.28 p.m. Derby.
—— 3.21 p.m. Derby (principal earthquake).
—— 11.8 p.m. Derby.
Sept. 18, 4.7 a.m. Dunoon (Argyllshire).
Oct. 21, about 6.5 a.m. Beddgelert (Carnarvonshire).

1905.

Jan. 20, 1.50 a.m. St. Agnes (Cornwall).
April 23, about 1.30 a.m. Doncaster.
—— 1.37 a.m. Doncaster (principal earthquake).
—— about 4 a.m. Ochil.
July 23, 12.15 a.m. Ochil.
July 26, about 6.3 p.m. Ochil.
Sept. 21, 11.33 p.m. Ochil (principal earthquake).
Sept. 22, about 1.30 a.m. Ochil.
Sept. 25, early morning. Ochil.
Sept. 30, 9.45 p.m. Ochil.
Oct. 28, 10.53 a.m. Ochil.
Dec. 22, 9.15 p.m. Ochil.

1906.

May 7, 8.20 p.m. Fort William.
June 27, 9.45 a.m. Swansea.
June 29, 3.2 a.m. Carnarvon.
July 3, 2.15 p.m. Ochil.
July 4, 3.45 p.m. Ochil.
July 7, 5.29 a.m. Ochil.
Aug. 24, 5.25 p.m. Ochil.
Aug. 27, 5.56 a.m. Derby.
Sept. 28, 12.25 p.m. Ochil.
Oct. 3, 4.32 a.m. Ochil.
Oct. 8, 7.24 a.m. Ochil.
—— 8.16 a.m. Ochil.
Oct. 12, 7.20 a.m. Ochil.
Oct. 20, 7.15 a.m. Ochil.
Oct. 24, 7.11 p.m. Ochil.
Oct. 26, 7.15 p.m. Ochil.
Oct. 30, 12.15 p.m. Ochil.
Dec. 28, 4.12 p.m. Ochil.
Dec. 29, 1.30 p.m. Ochil.
Dec. 30, about 1 a.m. Ochil.
—— 2.10 p.m. Ochil.
—— 4.15 p.m. Ochil.
Dec. 31, 1 a.m. Ochil.

1907.

Jan. 17, 1.54 p.m. Oban.
Feb. 10, 5.40 p.m. Ochil.
March 19, 7.33 p.m. Ochil.
April 7, 11.11 p.m. Ochil.
—— 11.19 p.m. Ochil.
April 8, 6.45 a.m. Ochil.
April 11, 5.30 a.m. Ochil.
—— 5.40 a.m. Ochil.
—— 6.5 a.m. Ochil.
June 14, 1.59 a.m. Ochil.
June 20, 3.36 p.m. Ochil.
July 3, 3.40 a.m. Swansea.
July 5, 9.48 p.m. Ochil.
July 21 or 28, afternoon. Ochil.
Sept. 18, about 5.30 p.m. Ochil.
Sept. 27, 8.12 a.m. Malvern.

The more important of these earthquakes have been described in the following papers:—

"The Penzance Earthquake of March 3rd, 1904": Geol. Mag., Vol. I (1904), pp. 487–490.
"The Leicester Earthquakes of August 4th, 1893, and June 21st, 1904": Quart. Journ. Geol. Soc., vol. lxi (1905), pp. 1–7.
"The Derby Earthquakes of July 3rd, 1904": ibid., pp. 8–17.
"The Doncaster Earthquake of April 23rd, 1905": ibid., vol. lxii (1906), pp. 5–12.
"The Swansea Earthquake of June 27th, 1906": ibid., vol. lxiii (1907), pp. 351–361.
"The Ochil Earthquakes of September, 1900, to April, 1907": ibid., vol. lxiii (1907), pp. 362–374.

The remaining earthquakes form the subject of the present paper. I have also added brief notices of some earth-shakes in mining districts, and of doubtful or spurious earthquakes, the occurrence of which was reported in newspapers, without any subsequent statement of their artificial origin.

1. *Dunoon Earthquake: Sept. 18th*, 1904.—Time of occurrence, 4.7 a.m.; intensity, 5; centre of isoseismal 5, in lat. 55° 54·5′ N., long. 5° 10·4′ W.; number of records 79, from 28 places, and negative records from 4 places.

The disturbed area is traversed by two isoseismal lines of intensities 5 and 4. The former is 26 miles long, 15 miles wide, and about

300 square miles in area, its centre being 9 miles west of Dunoon. The latter is 36 miles long, 21 miles wide, and 564 square miles in area, the direction of its longer axis being E. 40° N. The distance between the two curves is 2·1 miles towards the south-east and 3·7 miles towards the north-west.

The shock consisted of a continuous series of tremors, lasting on an average of 2½ seconds, and gaining in strength towards the close.

The sound was heard by all of the observers, and was compared in 38 per cent. of the records to passing waggons, etc., in 31 per cent. to thunder, in 6 to wind, in 5 to the fall of loads of stone, in 2 to the fall of a heavy body, in 17 to explosions, and in 2 per cent. to miscellaneous sounds. The beginning of the sound preceded that of the shock in 71 per cent. of the records, coincided with it in 23, and followed it in 6 per cent.; while the end of the sound preceded that of the shock in 21 per cent. of the records, coincided with it in 28, and followed it in 52 per cent. The duration of the sound was greater than that of the shock in 89 per cent. of the records, and equal to it in 11 per cent.

So far as we can judge from the seismic evidence, the mean direction of the originating fault is about E. 40° N., and its hade towards the north-west. Several of the faults laid down on the Survey map have approximately this direction, but I do not feel that the elements are determined with sufficient accuracy to justify its connection with any particular fault.

2. *Beddgelert Earthquake: October 21st*, 1904.—Time of occurrence, about 6.5 a.m.; intensity, 4; number of records 5, from 4 places.

I am indebted to Mr. E. Greenly and Mr. J. R. Dakyns for all the records of this earthquake, which seems to have been chiefly perceptible in the district lying to the south of Snowdon. The shock was felt at Blaenau Ffestiniog, Plas Gwynant, and Croesor, the last two places being respectively 3 miles north-east and 4 miles south-east of Beddgelert. The shock was accompanied by a noise somewhat like thunder at these places and also at Beddgelert. Thus the earthquake was perceptible over a district measuring at least 7 miles from east to west and 3½ miles from north to south.

3. *St. Agnes Earthquake: Jan. 20th*, 1905.—Time of occurrence, 1.50 a.m.; intensity, 5; centre of isoseismal 4, in about lat. 50° 22′ N., long. 5° 18′ W.; number of records 44, from 24 places, and negative records from 9 places. (Fig. 1.)

Most British earthquakes are connected with foci, which lie beneath the land-area of the country. A few, however, are due to displacements that are partly or entirely submarine. The epicentres of the Pembroke earthquake of August 18th, 1892, and the Carnarvon earthquake of June 19th, 1903, appear to have been in part beneath the sea. On March 3rd, 1904, a submarine earthquake occurred in the neighbourhood of Penzance, and this was followed within less than a year by another, with its epicentre on the opposite side of the Cornish peninsula, and distant not more than 22 miles from that of the Penzance earthquake.

As will be seen from the accompanying map (Fig. 1), only portions of the isoseismals 5 and 4 can be drawn, and from their form it is evident that the epicentre is situated several miles from land.

Continuing the isoseismal 4 in what appears to be its probable course, it includes an area 31 miles long, 22 miles wide, and containing about 530 square miles; the centre of the curve being about 6 miles north-west of St. Agnes, while the longer axis runs from north-east to south-west, or roughly parallel to the adjoining coastline. Too small a part of the isoseismal 5 lies on land to allow its dimensions to be even approximately determined. On the south-east side the distance between the two curves is 3 miles.

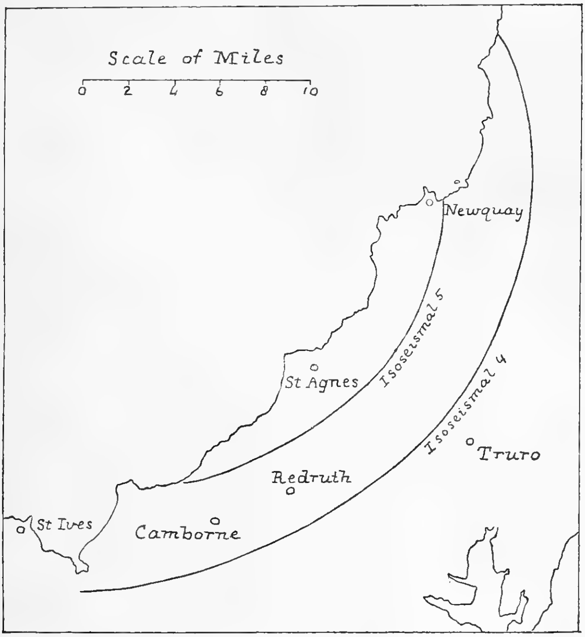


Fig. 1.—St. Agnes Earthquake, Cornwall, January 20th, 1905.

The shock was of the simple character common to all slight earthquakes. It consisted of a single prominent vibration, resembling a thud or blow, accompanied by a brief series of rapid tremors. The estimates of the duration range from 2 to 5 seconds, the average of five estimates being $3\frac{1}{2}$ seconds.

The sound was heard by all the observers. It was compared to passing waggons, etc., in 27 per cent. of the records, to thunder in 42 per cent., to wind in 3, to loads of stones falling in 3, to the fall of a heavy body in 9, to explosions in 12, and to miscellaneous sounds in 3 per cent. The beginning of the sound preceded that of the shock in 69 per cent. of the records, and coincided with it in 31 per cent.; the end of the sound preceded that of the shock in 54 per cent. of the records, coincided with it in 38, and followed it in 8 per cent.

It follows, from the incomplete seismic evidence, that the mean direction of the originating fault is about north-east and south-west, its distance from land being about 5 or 6 miles. The fault-slip was probably several miles in length, and that its depth was inconsiderable is shown by the closeness of the isoseismal 5 and 4. The rapid decline in the intensity of the shock, of which this closeness is indicative, also characterised the submarine Penzance earthquake of 1904.

4. *Fort William Earthquake: May 7th,* 1906.—Time of occurrence, 8.20 p.m.

A slight shock felt at Fort William, lasting about 2 seconds, and preceded by a rumbling noise. The earthquake was probably due to a small slip of the northern boundary fault of the Highlands.

5. *Carnarvon Earthquake: June 29th,* 1906.—Time of occurrence, 3.2 a.m.; intensity, 4; centre of disturbed area in lat. 52° 9·2′ N., long. 4° 10·7′ W.; number of records 23, from 15 places, and 17 negative records from 13 places. (Fig. 2.)

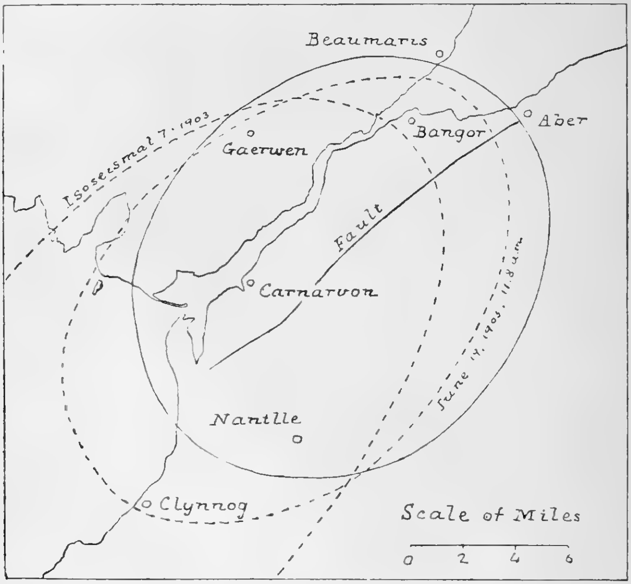


FIG. 2.—Carnarvon Earthquake, June 29th, 1906.

The continuous line on the map (Fig. 2) represents the boundary of the disturbed area, which is 16 miles long from north-east to south-west, 14½ miles wide, and contains about 182 square miles. Its centre is about 4 miles E. 15° N. of Carnarvon, and 11 miles E. 40° N. of the centre of the isoseismal 7 of the principal earthquake of June 19th, 1903. The curve is too nearly circular in form, and is not drawn with sufficient accuracy to enable the direction of its longer axis to be given more approximately than north-east and south-west.

The shock consisted of a single series of vibrations, lasting as a rule only a few seconds.

The sound, which lasted about 5 seconds, was heard by all the observers, and was compared to passing waggons, etc., in 32 per cent. of the records, to thunder in 53 per cent., to wind in 5, to loads of stones falling in 5, and to miscellaneous sounds in 5 per cent.

The chief interest of this earthquake consists in its relation to the Carnarvon earthquakes of June 19th, 1903. The isoseismal 7 of the principal earthquake (which occurred at 10.4 a.m.) is an elongated ellipse, $33\frac{1}{2}$ miles long and 15 miles wide, with its centre 4 miles west of Penygroes, and its longer axis directed N. 40° E. The earthquake was probably caused by a slip along a submarine continuation of the Aber-Dinlle fault, part of the course of which is shown in Fig. 2. Shortly afterwards, on June 19th at 10.9 a.m. and 11.8 a.m., and June 21st at 8.6 a.m., three after-shocks occurred with their foci near the north-east margin of the principal focus. The boundary of the disturbed area of the second of these shocks is represented by the broken line in Fig. 2. It is 20 miles long, 13 miles wide, and contains 219 square miles, its centre being 8 miles north-east of that of the principal earthquake and $2\frac{3}{4}$ miles south-west of that of the earthquake of 1906, and the direction of its longer axis N. 47° E. This line may also be taken to represent approximately the boundaries of the other two after-shocks referred to above.

It is clear that the earthquake of 1906 must be regarded as an after-shock of the earthquake of 1903, its focus being situated within or slightly beyond the region displaced in 1903.

6. *Derby Earthquake: August 27th,* 1906.—Time of occurrence, 5.56 a.m.; intensity, 5; centre of isoseismal 5, in lat. 53° 0·8′ N., long. 1° 42·3′ W.; number of records 131, from 79 places, and 85 negative records from 79 places. (Fig. 3.)

Time of Occurrence.—The number of records of the time of occurrence is 72, and the mean of 13 records, which are considered by their observers as accurate to the nearest minute, is 5.56 a.m.

Isoseismal Lines and Disturbed Area.—The continuous curves on the map (Fig. 3) represent isoseismals of intensities 5 and 4, and the broken line the isoseismal 7 of the Derby earthquake of July 3rd, 1904. The isoseismal 5 is elliptical in form, 17 miles long, 11 miles wide, and 147 square miles in area. The longer axis is directed about N. 25° E. The centre of the curve lies 1 mile south-east of Ashbourne and is less than a mile from the centre of the isoseismal 7 of the earthquake of 1904. The isoseismal 4 (which is not so accurately drawn) is 48 miles long, 36 miles wide, and contains about 1,360 square miles. The distance from the isoseismal 5 both to the north-west and south-east is 13 miles. The shock was also felt at eight places outside the isoseismal 4—at Sheffield, 3 miles to the north; Wollaton, Nottingham, Sherwood, Ruddington, and Calverton, which lie east of the isoseismal at distances of $1\frac{1}{2}$, 4, 4, 5, and $5\frac{1}{2}$ miles respectively; and at Thrumpton and Kingston-upon-Soar, which are respectively $2\frac{1}{2}$ and 3 miles to the south-east. The whole disturbed area must therefore contain about 2,100 square miles.

Nature of the Shock.—To the great majority of the observers the shock appeared to consist of a single series of vibrations, with a mean duration of 2·7 seconds. According to 11 observers, however, the shock consisted of two distinct parts, separated by an average interval of $2\frac{1}{2}$ seconds, one part being so much weaker than the other that it generally escaped notice. The first part was the stronger at Breaston, Clifton, Edlaston, and Morley, and the second at Bradbourne and Kirk Ireton. Of these places, Morley lies on the minor axis of the isoseismals, Breaston, Clifton, and Edlaston on the south side of it, and Bradbourne and Kirk Ireton on the north side. As the two parts differed considerably in strength, the observations on the relative intensity of the two parts are more accurate than usual, and it may therefore be concluded that a second focus lay a few miles north of the Ashbourne focus, the concavity of the synkinetic band facing the second focus. Thus the impulse in the Ashbourne focus was much the stronger and occurred slightly before the other, but the interval between the two impulses was less than the time required to traverse the interfocal region. The earthquake was thus a true twin earthquake.

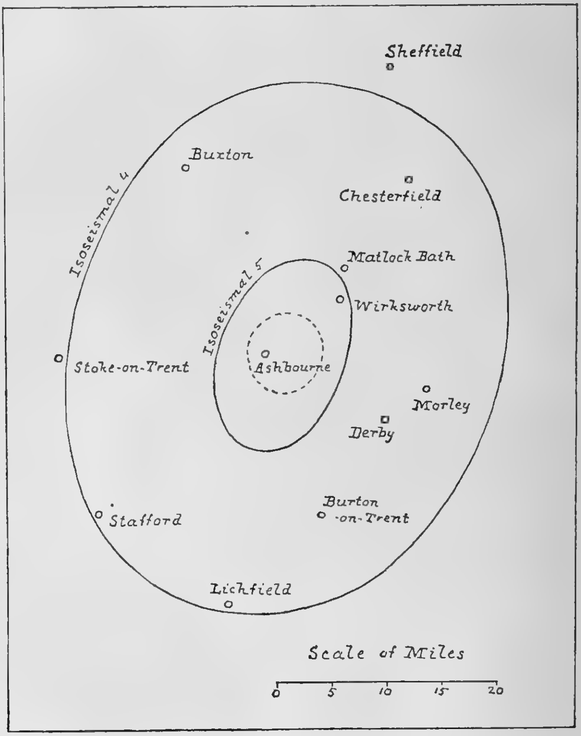


Fig. 3.—The Derby Earthquake, August 27th, 1906.

The evidence is insufficient to determine the position of the second focus. The mean interval between the two parts was, however, almost exactly the same as in the earthquake of 1904 (2·6 seconds as compared with 2·1 seconds), and it is therefore probable that the second focus coincided with the northern focus of 1903 and 1904, lying about three miles west of Wirksworth.

Sound-phenomena.—Towards the east the sound-area extends as far as the isoseismal 4, but in other directions the observations are not sufficient to determine the course of its boundary. The sound was heard by 88 per cent. of the observers within the isoseismal 5, and by 64 per cent. in the zone between the isoseismals 5 and 4; altogether by 71 per cent. of the observers. It was compared to passing waggons, etc., in 61 per cent. of the records, to thunder in 13 per cent., to wind in 4, to loads of stones falling in 10, to the fall of a heavy body in 9, and to explosions in 4 per cent. The beginning of the sound preceded that of the shock in 54 per cent. of the records, coincided with it in 35, and followed it in 11 per cent.; while the end of the sound preceded that of the shock in 24 per cent. of the records, coincided with it in 48, and followed it in 28 per cent. The duration of the sound was greater than that of the shock in 59 per cent. of the records, equal to it in 37, and less than it in 4 per cent.

Origin of the Earthquake.—The three Derby earthquakes of March 24th, 1903, July 3rd, 1904, and August 27th, 1906, in all probability originated in the same twin foci, the epicentre of one being about a mile east of Ashbourne and that of the other about three miles west of Wirksworth, and the distance between them about seven or eight miles. The earlier earthquakes were followed by slighter shocks, the first after 40 days (on May 3rd, 1903) and the second after eight hours, both originating in the interfocal region of the fault.

The longer axes of the inner isoseismals of the principal earthquakes were directed N. 33° E. in 1903 and N. 31° E. in 1904; while those of the inner isoseismals of the after-shocks were directed N. 25° E. in 1903 and N. 27° E. in 1904. In each of the principal earthquakes the hade within the south-west or Ashbourne focus is to the north-west. Now, if the hade within the north-east or Wirksworth focus be towards the south-east, the greater expansion of the isoseismals for each focus on the side towards which the fault hades would cause a displacement of the north ends of the longer axes of the compound isoseismals towards the east. Thus, the divergence between the isoseismal axes of the principal earthquakes and the after-shocks shows that the fault changes hade in the interfocal region, and that the true mean direction of the originating fault is about N. 26° E. This agrees almost exactly with that deduced from the earthquake of 1906, namely, N. 25° E., the isoseismals of this earthquake being unaffected by the impulse within the Wirksworth focus.

In each of the three earthquakes the impulse within the south-west focus was the stronger; but in 1903 the impulses occurred simultaneously, in 1904 the north-east focus, and in 1906 the south-west focus, was first in action. The existence of a synkinetic band in each case shows that all three were true twin earthquakes, the interval between the impulses being less than the time occupied by the earth-waves in traversing the interfocal region.

7. *Oban Earthquake: January 17th*, 1907.—Time of occurrence, 1.54 p.m.; intensity not less than 6; centre of disturbed area in about lat. 56° 26′ N., long. 5° 21′ W.; number of records 57, from 36 places.

The area disturbed by the earthquake is for the most part sparsely inhabited, and I have not been able to obtain sufficient records for drawing any isoseismal lines. So far as I can ascertain, the boundary of the disturbed area is an ellipse, passing to the north of Fort William and Inverlochy, some miles to the west of Aros in Mull, and to the south of Ardrishaig, Lochgilphead, Glendaruel, and Carrick Castle in Argyllshire. This curve, which I have not reproduced on account of its approximate nature, is about 69 miles long, 58 miles wide, and contains about 3,100 square miles. Its centre is about 5 miles east of Oban, and its longer axis is roughly parallel to the north-western boundary fault of the Highlands. The intensity of the shock was probably 6, but it was strong enough to cause some slight damage to buildings at Kilninver and Cuilfail Hotel (Kilmelford).

The shock consisted of two distinct parts, of which the first was regarded as the stronger at Aros and Kilmore (near Oban), and the second at Delavich and Inverinan (near Kilchrenan) and Port Appin. The mean duration of the shock was $5\frac{1}{2}$ seconds, and that of the interval between the two parts 2·3 seconds.

The sound was heard by 98 per cent. of the observers, and was compared to passing waggons, etc., in 44 per cent. of the records, to thunder in 23 per cent., to wind in 2, to loads of stones falling in 10, to the fall of a heavy body in 4, and to explosions in 17 per cent. The beginning of the sound preceded that of the shock in 67 per cent. of the records, coincided with it in 29, and followed it in 4 per cent.; while the end of the sound preceded that of the shock in 8 per cent. of the records, coincided with it in 38, and followed it in 54 per cent. The duration of the sound was greater than that of the shock in 81 per cent. of the records and equal to it in 19 per cent.

The earthquake may have been caused by a slip along the great northern boundary fault of the Highland district, but the evidence is so scanty that nothing more than the possibility of such a connection can be suggested.

8. *Ochil Earthquake: June 14th*, 1907.—Time of occurrence, 1.59 a.m.

A slight shock felt at Menstrie, consisting of two vibrations, and accompanied by two banging noises.

9. *Ochil Earthquake: June 20th*, 1907.—Time of occurrence, 3.36 p.m.; intensity, 4; number of records 2, from 2 places.

A rather strong shock, felt at Alva and Menstrie, and preceded and accompanied by a loud rumbling noise.

10. *Swansea Earthquake: July 3rd*, 1907.—Time of occurrence, 3.40 a.m.; intensity, 4; centre of isoseismal 4, in lat. 51° 38·1′ N., long. 4° 2·8′ W.; number of records 21, from 14 places, and 13 negative records from 12 places.

The boundary of the disturbed area is an isoseismal of intensity 4, and is 23 miles long, 14 miles wide, and about 250 square miles in area. Except towards the east, it coincides with the isoseismal 8 of the earthquake of June 27th, 1906. Its centre is 5 miles west of Swansea, and 2 miles west of that of the isoseismal 8 of the earthquake of 1906. The direction of the longer axis is approximately E. 4° N.

The shock consisted of a single series of vibrations, with an average duration of $3\frac{3}{4}$ seconds. The sound was heard by all the observers, and was compared to passing waggons, etc., in 27 per cent. of the records, to thunder in 45 per cent., to the fall of a heavy body in 9, and to miscellaneous sounds in 18 per cent. The beginning of the sound preceded that of the shock in 86 per cent. of the records, and coincided with it in 14 per cent.; while the end of the sound preceded that of the shock in 14 per cent. of the records, coincided with it in 28, and followed it in 57 per cent.

Since the direction of the longer axis is parallel to that of the isoseismal 8 of the earthquake of 1906, and the line joining the epicentres of the two earthquakes is very nearly parallel to the longer axis, it follows that the Swansea earthquake of 1907 was caused by a slip of the fault that was in action the year before, the region of maximum displacement being about two miles farther to the west.

11. *Ochil Earthquake: July 5th*, 1907.—Time of occurrence, 9.48 p.m. A slight shock, consisting of a single vibration, felt at Menstrie.

12. *Ochil Earthquake: July 21st or 28th*, 1907.—A slight shock felt early in the evening (between 5 and 7.30) at Menstrie. The day was one of the last two Sundays in July, but which of the two, unfortunately, cannot be ascertained, as the information was communicated some time after the occurrence of the shock.

13. *Ochil Earthquake: September 18th*, 1907.—A very slight shock felt at Menstrie at about 5.30 p.m.

14. *Malvern Earthquake: September 27th*, 1907.—Time of occurrence, 8.12 a.m.; intensity, 5; centre of isoseismal 5, in lat. 52° 6·6′ N., long. 2° 16·8′ W.; number of records 107, from 40 places, and negative records from 6 places.

Of 89 estimates of the time of occurrence, 14 are regarded by their observers as being accurate to the nearest minute, their average being 8.12 a.m.

The isoseismal 5 is 9 miles long, 7 miles wide, and contains 48 square miles. Its centre lies 1½ miles east of Great Malvern station, and its longer axis is directed N. 6° E. The outer isoseismal, of intensity slightly less than 4, is 18 miles long, 14½ miles wide, and 206 square miles in area. The distance between the two isoseismals is 3½ miles on the west side and 4 miles on the east. Outside the latter curve the earthquake was perceived at six places by persons under favourable conditions, the shock and sound at Longworth (8½ miles west of the isoseismal) and Preston (2½ miles south-west), the sound only at Redmarley D'Abitot (½ mile south), and the shock only at Elmbridge (6½ miles north-east), Cheltenham (8 miles south-east), and Charlton Kings (9½ miles south-east). Thus the total disturbed area must contain about 800 square miles.

At most places the shock consisted of a single violent jerk, like that caused by the fall of a heavy body or an explosion of dynamite. Close to the centre the thud was followed by a slight vibration. At three places (Mathon, Welland, and Worcester) two vibrations were felt, the second being the stronger. Near the boundary of the disturbed area the shock was felt as a slight tremor or quiver. The mean duration of the shock was 2 seconds.

The sound-area coincides nearly with that contained by the outer isoseismal, but overlaps it towards the west. The sound was heard by

94 per cent. of all the observers, by 95 per cent. within the isoseismal 5, and by 93 per cent. in the zone between the two isoseismals. Within the isoseismal 5, the sound is compared to passing waggons, etc., in 29 per cent. of the records, to thunder in 9 per cent., to wind in 5, to loads of stones falling in 12, to the fall of a heavy body in 26, and to explosions in 19 per cent.; in the area between the isoseismals, the sound is compared to passing waggons, etc., in 44 per cent. of the records, to thunder in 11 per cent., to wind in 3, to loads of stones falling in 17, to the fall of a heavy body in 8, and to miscellaneous sounds in 3 per cent. Thus, references are made to types of short duration in 57 per cent. of the records within the isoseismal 5, and in 40 per cent. of the records in the surrounding zone.

The beginning of the sound preceded that of the shock in 46 per cent. of the records, coincided with it in 46, and followed it in 8 per cent.; while the end of the sound preceded that of the shock in 5 per cent. of the records, coincided with it in 58, and followed it in 37 per cent. The duration of the sound was greater than that of the shock in 56 per cent. of the records and equal to it in 44 per cent.

From the seismic evidence it may be inferred that the mean direction of the originating fault is N. 6° E., that its hade (as determined by the relative position of the isoseismals and the westerly overlapping of the sound-area) is towards the east, and that the fault-line passes a short distance to the west of the centre of the isoseismal 5, i.e. not far from Great Malvern. Now, the mean direction of the fault that runs along the east side of the Malvern Hills is N. 4° E. near Great Malvern, its hade is to the east, and it passes through Great Malvern.

There can thus be little doubt that the earthquake was caused by a small slip of this fault in the neighbourhood of Great Malvern. That the depth of the focus was small is shown by the sharp, abrupt character of the shock near the central area, fading away to a tremor near the outer margin.

This is the only movement along the Malvern fault with which I am acquainted, and certainly none of any consequence has taken place during the last 19 years.[1]

Earth-shakes in Mining Districts.—Earth-shakes resembling those so frequently felt in mining districts were observed at and near Abercarn (Monmouthshire) on February 11, 1904, Camborne on September 5th, 1904, Eastwood (Nottinghamshire) on September 17th, 1904, and Pendleton (near Manchester) on November 25th, 1905. The Pendleton earth-shake has been described in a recent paper in this Magazine.[2]

Abercarn: February 11th, 1904.—A smart shock, accompanied by a noise like a distant explosion, occurred at 2.30 a.m. In the colliery districts it was thought that a disaster had occurred in one of the mines. The shock was evidently local, for it was not felt at three

[1] I do not think that the occurrence of this slight earthquake lends any support to the suggestion (Quart. Journ. Geol. Soc., vol. lvi, 1900, p. 196) that *perceptible* displacements have recently occurred along the line of fault.

[2] Geol. Mag., Dec. V, Vol. III (1906), pp. 171–176.

places (Henllys, Machen, and Risca), which lie about 3 or 4 miles from Abercarn.

Camborne: September 5th, 1904.—Time of occurrence, 1.55 a.m.; intensity, 4; number of records 7, from 6 places, and negative records from 3 places.

The earth-shake was felt chiefly in the district between Camborne and Redruth, but, owing partly to its occurrence shortly after midnight, it was not so widely observed as the stronger shake of June 4th, 1902. The boundary of the disturbed area is similar to that of the earth-shake in 1902,[1] but falls short of it by about half a mile towards the north, west, and south. It is thus about 3½ miles long, 2½ miles wide, and 7 square miles in area, its longer axis being roughly parallel to that of the earlier shake, and consequently to the principal faults of the district. The shock was brief, its duration being not more than 2 seconds, and was accompanied by a noise which was supposed by one observer to be due to a fall of ground in Dolcoath Mine.

Eastwood: September 17th, 1904.—At about 5.30 p.m. a shock was felt at Eastwood, a mining village about 8 miles north-west of Nottingham. The shock was strong enough to shake crockery and make windows rattle loudly. It does not appear to have been felt at other places in the surrounding district.

Llwynypia: May 17th, 1907.—Time of occurrence, 3.15 p.m.; intensity, 5; centre of disturbed area in lat. 51° 38·2′ N., long. 3° 26·6′ W.; number of records 22, from 13 places, and negative records from 7 places; number of observations made in mines, 6.

During the last twenty years earth-shakes have occurred in the Rhondda valleys on June 22nd, 1889, April 11th and May 2nd, 1894, October 16th, 1896, and May 17th, 1907, but many others in all probability have escaped record. The epicentres in 1894 were situated about three-quarters of a mile east of Porth, the other three in the neighbourhood of Pentre and Llwynypia.[2]

The earth-shake of May 17th, 1907, occurred at 3.15 p.m. Near the centre of the disturbed area its intensity was 5, very nearly 6. The boundary of the disturbed area is an isoseismal of intensity 4, and is very nearly circular in form, about 4 miles in diameter and 13 square miles in area. Its centre is situated half a mile east of Llwynypia.

The shock in all parts of the disturbed area consisted of a single series of vibrations, lasting on an average for 1½ seconds. Close to the centre of the area, as at Llwynypia, it began with one or two strong vibrations, followed by others rapidly decreasing in intensity; while near the boundary, at Gelli and Cymmer, only a tremulous motion was felt. The sound was much louder near the centre of the area than near the boundary; at Llwynypia it was described as a violent report and a great crash, or compared to a locomotive charging a building; near the boundary it was either not heard at all or described as a dull thud or like a distant explosion. It was heard by 86 per cent. of the observers. In 62 per cent. of the records it is compared to the fall or banging of a heavy body or to an explosion or blasting; in the

[1] Geol. Mag., Dec. V, Vol. II (1905), pp. 221–2.
[2] Ibid., Dec. III, Vol. VIII (1891), p. 371; Dec. V, Vol. VII (1900), pp. 124–5.

remaining cases generally to thunder. The beginning of the sound coincided in every case with that of the shock, while the end of the sound and shock were also as a rule simultaneous.

The earth-shake was observed in pits at Llwynypia, Wattstown, Gelli, and Ynyshir; in the two first at a depth of 500 yards. Gelli is close to the boundary of the disturbed area, and Ynyshir about half a mile distant, so that the disturbed areas on the surface and in pits were roughly coincident. At Llwynypia the sound was described as a terrific crash, followed by low, deep rumbling.

The centre of the disturbed area lies close to the termination (as mapped) of the Cymmer fault, and on its downthrow side. The earth-shake was thus in all probability due to a slip of this fault, brought about by the withdrawal of coal, etc., from the mine below.

Doubtful Earthquakes.

Church Stretton: October 22nd, 1904.—Time of occurrence, about 10.50 p.m.; intensity, 4; number of records 13, from 5 places, and negative records from 5 places.

The five places at which the shock was felt (Church Stretton, Shelve, Stapleton, Stiperstones, and Woolstaston) lie within an oval curve, $10\frac{1}{2}$ miles long from north-east to south-west, $8\frac{1}{2}$ miles wide, and containing about 70 square miles. The centre of the area is about 10 miles south-west of Shrewsbury. The shock was brief and slight, and was accompanied by a loud noise, which was compared to the roar of a train passing close at hand, the fall of a heavy body, or an underground explosion.

Holyhead: June 26th, 1907.—At 9.5 a.m. a shock of intensity 4, consisting of a single series of vibrations, was felt at Holyhead. It was preceded by a sound like the passing of a heavy vehicle.

Reported Earthquakes.

A large number of disturbances, supposed to be those of earthquakes, have been reported during the years 1904–1907. In the present section are included only those of which accounts have been inserted in newspapers. If they are not all due to artificial disturbances, the evidence seems to me insufficient to entitle them to the rank of doubtful earthquakes.

Napton (Warwickshire): January 26th, 1904.—At 12.4 a.m. a slight shock was felt, followed by tremors that were distinctly perceptible for 15 to 20 seconds. Inquiries made in the local newspapers elicited no further accounts.

Aberystwith: July 13th, 1904.—At 8.10 a.m. a rumbling sound was heard, and at 10.28 a.m. a rather strong shock, accompanied by a loud rumbling sound, was felt. Inquiries made in the district around Aberystwith show that the disturbances were confined, or practically confined, to that town.

Newbury: November 25th, 1904.—Shortly before noon, and again after 3 p.m., dull reports, accompanied by the shaking of windows, were heard near the borders of Hampshire and Berkshire, to the east of Salisbury Plain. The area from which I have received records is 24 miles long from east to west, 22 miles wide, and contains about

415 square miles. Gun practice was, I am informed, being carried out on the Plain, and there can be no doubt, I think, that this was the origin of the disturbances, for the following reasons:—

(i) The wind at the time was from west and north-west.

(ii) The disturbances occurred at nearly regular intervals, on each occasion lasting from 15 to 20 minutes.

(iii) The impulses obviously travelled through the air, shaking windows, etc., but in no place giving rise to a characteristic earthquake-shock.

(iv) The sound was compared either to thunder or gun-firing (in several instances to gun-firing on Salisbury Plain)—in the west part of the area always to gun-firing, in the centre more frequently to gun-firing than to thunder, and at the east end more frequently to thunder than to gun-firing. The area over which the disturbances were observed stops short of Salisbury Plain by several miles; for, as usual, in the immediate district the reports would be at once assigned to their true origin.

Barnet: March 15th, 1905.—A sharp shock was felt at 1.59 p.m., shaking doors and windows, and a loud sound was heard. The disturbance was also heard at Hadley (near Barnet).

Llangollen: May 1st, 1905.—At 1.40 a.m. a shock was felt at the Shropshire Militia encampment near Llangollen. The vibrations lasted 4 seconds and travelled from east to west, and were accompanied by a dull rumbling sound resembling thunder. Though I can assign no definite cause for the disturbance, it is quite improbable that a shock of such intensity should not have been felt in the surrounding country.

Ashbourne: April 23rd, 1907.—A slight shock is said to have been felt during the early hours of the morning in the Ashbourne district and at Uttoxeter. Numerous inquiries have resulted in negative evidence only, with the exception of one account from Church Broughton, where a shock of intensity 5 was felt at 12.40 a.m. If this disturbance were of seismic origin it could not fail to have been more widely felt.

Dochgarroch (near Inverness): July 29th, 1907.—The *Inverness Courier* reports three shocks at 3.20 a.m., 4.35 a.m., and 6.15 a.m., of which the second was the strongest. Dochgarroch lies close to the epicentres of most of the earthquakes of September, 1901, and it is possible that slight local shocks may still be felt there. The evidence on this occasion, however, probably rests on the experience of a single observer.

IV.—Carboniferous Fish-Remains in North Derbyshire.

By J. Wilfrid Jackson (of the Manchester Museum).

SOME time ago Mr. R. Cairns, of Ashton-under-Lyne, sent me for identification a large collection of fossil fish-teeth, which he had obtained in a limestone quarry near Sparrowpit, in North Derbyshire, not far from the celebrated "ebbing and flowing well."

Later on, at his request, I went through his large collection and made a further selection, and also paid a visit to the quarry myself and obtained other examples. The quarry is evidently that from which Mr. T. Parker, of Oldham, obtained the large series described by Mr. J. W. Davis in the Geological Magazine, 1886, p. 148.

The majority of the teeth are free from matrix, having been carefully broken out. They are, however, very much rolled and abraded, which rendered their ready identification a very difficult matter, and I have to thank Dr. A. Smith Woodward for his kindness in helping me to name most of them.

By far the greater number belong to *Psephodus magnus* (M'Coy), and consist largely of thick dental plates of moderate size with the outer border slightly inrolled, some specimens exhibiting strong vertical plications on the sides of the crown. The lateral margins of some individuals are cleft at one or both sides. Along with the larger teeth are a number of small narrow oblong specimens with one end usually wider than the other, the middle being slightly wider than the widest end. The surface is polished and quite smooth, and there is no osseous base attached. Some of the specimens have the sides of the crown strongly plicated vertically. These smaller teeth appear to agree with the so-called *Helodus planus*, L. Agassiz.

Psammodus rugosus, Agassiz, is represented by several more or less worn and broken crowns, the largest being $1\frac{3}{5}$ inches in breadth and the portion of the length remaining measures $1\frac{2}{5}$ inches. Amongst the numerous specimens from this quarry are a few examples of a species not hitherto recorded from this part of Derbyshire, viz. *Petalodus acuminatus*, Agassiz. It is given as "rare in the Carboniferous Limestone of Derbyshire" in M'Coy's "British Palæozoic Fossils," but no locality is stated. In the "British Museum Catalogue of Fossil Fishes," pt. i, p. 43, several references are made to its occurrence at Ticknall, South Derbyshire.

The examples from the Sparrowpit locality are very fragmentary and of small size, and are difficult to extract from the matrix. Along with the various teeth, and free from matrix, were one or two fragments of bone-like tissue which Dr. Woodward kindly identified as selachian cartilage. Some facts about the quarry and matrix are worth noting. As mentioned by Davis, the matrix is a "light-coloured crystalline limestone," but further than this it is found on close examination to be a conglomerate of small round and oval pebbles and comminuted shells, a point unobserved by Davis. Messrs. Barnes & Holroyd, in their very excellent papers[1] "On the Occurrence of a Sea-beach at Castleton, Derbyshire," note this fact and say that in the beds at Bolt Edge quarry, Sparrowpit, the pebbles are very much smaller than those at Castleton. They also put forward the question as to whether the numerous cestraciont fishes, the teeth-remains of which are very common at Bolt Edge, played any part in reducing the shells to smaller fragments. This, of course, is highly probable, but in my opinion the fish-teeth have also been thrown up on the old sea-beach, judging from their numbers and their rolled and abraded condition.

[1] Trans. Manch. Geol. Soc., vol. xxv, p. 119. See also vol. xxv, p. 181; vol. xxvi p. 466; vol. xxvii, p. 82.

V.—The Tygerberg Recumbent Fold.

By Dr. C. Sandberg, Arnhem, Holland.

After a prolonged and very careful study of the region on the spot as well as from existing literature, I summarised my observations and conclusions, in 1906, in a paper on the interesting and peculiar formation of the Tygerberg range in the Cape Colony.[1]

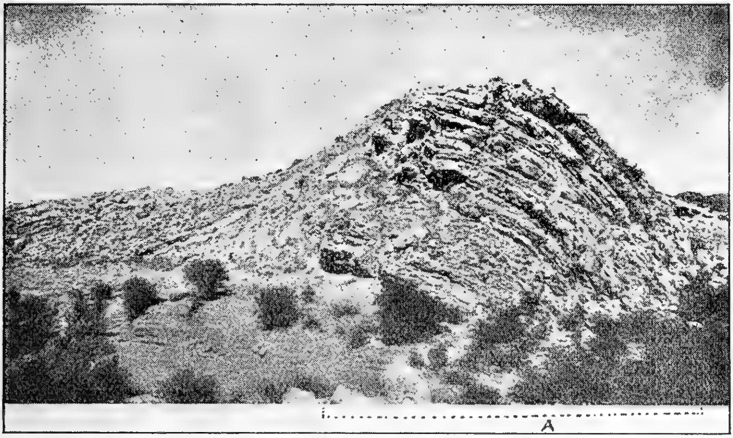


Fig. 1.—Reproduction of photograph of the western side of the Tygerberg-poort (= gap), Tygerberg range, Cape Colony. (The dotted line A corresponds with the dotted line A in the diagram, Fig. 2.)

The first question to be decided here is: Can we explain the peculiar mutual stratigraphical relations between the Witteberg quartzites and the Lower Dwyka and Ecca Series and their tectonic behaviour by assuming that this range represents a squeezed-up anticlinal fold? A second question might naturally follow, viz.: How are we to explain the occurrence of this range should field evidence be in contradiction with the above assumption? It would seem that Professor E. H. L. Schwarz presumes to settle this intricate geological problem by the simple exhibition of a single photograph[2] and the reference to another one,[3] in favour of his 'squeezed-lead' theory. To these I may be allowed to oppose my photograph (Fig. 1) of the western side of the Tygerberg-poort (=gap) and my ideal section (Fig. 2), the north corner of which is simply a copy of the behaviour of the strata as reproduced on the above-mentioned photograph.

Another photograph taken by me some two hundred yards to the north of the Tygerberg range represents a small 'lambeau' of Witteberg quartzites *in sitû* (Fig. 3). This 'lambeau,' whilst reposing on Lower Dwyka, is separated from the Witteberg quartzite range

[1] See Trans. Geol. Soc. South Africa, vol. ix, 1906, pp. 82–89, pl. xxi.
[2] Geol. Mag., Dec. V, Vol. IV, 1907, No. XI, p. 487, Pl. XXII.
[3] Loc. cit., p. 489, and Geol. of Cape Colony, by A. W. Rogers, 1905, p. 141.

(Tygerberg) by Lower Dwyka, which again is supported by younger Dwyka and Lower Ecca, dipping first slightly to the south, then becoming vertical, and finally, further north still, assuming a northerly dip.

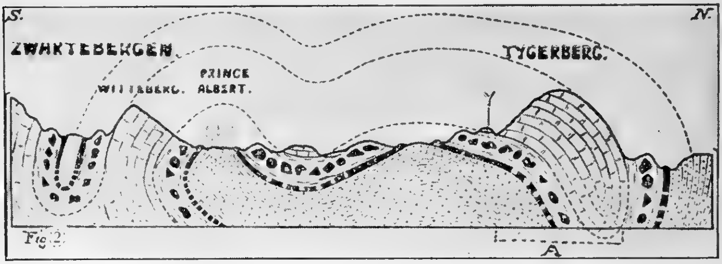


Fig. 2.—Diagram of Tygerberg range to show the behaviour of the strata seen in the photograph, Fig. 1, at the point A.

The strata are thus lying here in reversed stratigraphical order. A similar occurrence was observed by Professor Schwarz at the western end of the Tygerberg range, and to it he draws special attention, adding that a little further on he found the normal succession again.[1]

Fig. 3.—A small 'lambeau' of Witteberg quartzites *in sitû*, 200 yards north of the Tygerberg range, reposing on Lower Dwyka Beds.

[1] "Geol. Survey of Parts of Prince Albert, etc.": Report Geol. Surv. Cape of Good Hope, 1904, p. 91.

North-east of the Tygerberg farm-homestead the Dwyka and Lower Ecca Series stand nearly vertical; east and west along their strike (parallel to and north of the Tygerberg) they become more and more inclined, and finally about 6 miles to the east and 4 miles to the west they are lying nearly flat. Some five hundred yards south-west of this farmhouse (and due south of where the Upper Dwyka and Ecca Series are still inclined close on to the vertical) the Shales (Upper Dwyka or Lower Ecca) can be seen, right down at the bottom of the river, to dip towards the main range (south) and under the Dwyka conglomerate. These shales are lying very near the horizontal.

To the south of the range the Dwyka and Ecca Series are lying practically horizontal, carrying numerous fragments of Witteberg quartzites *in sitû*. North and south of the central part of the Tygerberg range the Dwyka and Ecca Series are consistently lying asymmetrical, namely, nearly horizontal to the south and nearly vertical to the north of the Witteberg quartzites, after the way illustrated in my sections.[1] I fail to see how this behaviour of the strata is reconcilable with the squeezed-lead-vice theory.

Going over to the larger mass of Witteberg Beds, south of the Tygerberg, facing the Zwartebergen, we again find fragments (lambeaux) of Witteberg quartzites lying in such positions to the north of the main range as to clearly point to an overfold. When, therefore, Professor Schwarz declares[2] that "the difficulty which the Tygerberg presents is that although the quartzites tower up in a narrow vertical anticline, the Dwyka shales and conglomerate around it are only moderately inclined, and indeed in some places lie actually flat," the question, for the mere pleasure of being able to put it into a nutshell, is so disfigured and cut down as to render it entirely unrecognisable.

Finally, I fail to understand either the strength or the meaning of the argument that "there is no break in the succession [of the beds in the larger mass of Witteberg Beds fronting the Zwartebergen] whence the root of the supposed overfold could have originated." Professor Schwarz surely does not mean to convey the impression that the Witteberg Beds here form a closed anticlinal. He knows the region too well to make a statement which is in actual contradiction to the evidence in the field.

Summarising, we must conclude that in and near the Tygerberg range the mutual relations (*lagerungs Verhältnisse*) between the Dwyka-Ecca Series and Witteberg quartzites are in contradiction to the squeezed-lead or mushroom-fold theory; they are, on the other hand, in harmony with the occurrence of a recumbent fold; therefore, even at the risk of endangering the present conception of the structure of the coast-ranges, I must adhere to the latter explanation of the Tygerberg phenomena until more serious contradictory evidence is forthcoming.

[1] Trans. Geol. Soc. South Africa, loc. cit.
[2] Geol. Mag., loc. cit.

REVIEWS.

I.—The Port of London and the Thames Barrage, a series of expert studies and reports, by T. W. Barber, M.Inst.C.E., and others. Issued by the Thames Barrage Committee. 8vo; pp. 193, with maps and other illustrations. London: Swan Sonnenschein & Co., 1907. Price 12*s.* 6*d.* net.

ONE of the difficulties which hampers the Port of London is the insufficient depth of water in the river for the increasing size and tonnage of ships, and the deepening of the river by dredging has been recommended as a remedy. Another and effective plan, if it could be carried out, is the one discussed in the very interesting work before us. As stated in the Introduction, "The Committee formed in 1903 to promote a public enquiry into the proposed Barrage across the Thames in the neighbourhood of Gravesend—thus converting the whole of the lower river into a freshwater lake—having so far failed to attain its main object, has instituted a series of expert enquiries and studies into the various questions which have arisen and are involved in the Barrage proposal."

The chief purpose of the volume is to deal with the objections that have been raised to the above scheme; and the most important are the questions of drainage and percolation.

The proposed barrage or dam would be made between Gravesend and Tilbury, and consist "of a straight monolith wall of Portland cement concrete, faced with granite, founded on the Chalk and carried up to six feet above the highest known tide." Further, the upper surface of roadway and foot-pavements would be 100 feet wide, flanked with granite parapets, and the base or foundation width would be 175 feet, with tunnels for road and rail traffic.

The proposed level at which the Thames would be maintained is Trinity High Water or 12 ft. 6 in. above Ordnance Datum. The area upheld would be between Gravesend and Teddington, a distance of 46½ miles.

The main factor of geological import, and the most serious one for the inhabitants along the valley bordering this long portion of the river, is the infiltration and uprise of water that would take place in the adjacent porous strata.

This subject is dealt with in an able and candid manner by Mr. Clayton Beadle, who points out that large volumes of water would pass in from the river at different points, into the Chalk and Gravels, and, in addition, much flood-water from direct rainfall on the marsh lands would have to be dealt with. In another report Mr. T. Hennell estimates that more than one and a quarter million pounds would be required for pumping works and walls, and £33,000 per annum for the maintenance and working of pumps.

II.—THE FALLS OF NIAGARA, THEIR EVOLUTION AND VARYING RELATIONS TO THE GREAT LAKES; CHARACTERISTICS OF THE POWER, AND THE EFFECTS OF ITS DIVERSION. By JOSEPH WILLIAM WINTHROP SPENCER, M.A., Ph.D., F.G.S. 8vo; pp. xxxi, 490, with large map (in pocket), 43 other maps and pictorial plates, and 30 text-figures. Ottawa, 1907.

THIS monograph on the geology and physics of Niagara Falls was prepared under a commission from Dr. Robert Bell, Acting Director of the Geological Survey of Canada, and it has been issued under the Department of Mines connected with that establishment.

The leading conclusions of the author were brought last year before the British Association, and were printed in the GEOLOGICAL MAGAZINE for 1907 (pp. 440–1). We have now the satisfaction of calling attention to the completed work, in which the details of Dr. Spencer's long-continued and painstaking researches are published.

Lyell, during his visit to Niagara in 1841–2, came to the conclusion that the average rate of erosion of the chasm below the falls had been about one foot annually, and that "it would have required 35,000 years for the retreat of the Falls, from the escarpment of Queenstown to their present site." At the same time, as he pointed out, "we cannot assume that the retrograde movement has been uniform."[1]

These views are to a certain extent confirmed by Dr. Spencer, who estimates a total of 39,000 years as the age of the Falls, but he differs materially from Lyell in the evidence he brings forward to show that the recession of the first three miles occupied 35,500 years, and of the last four miles only 3,500 years.

Dr. Spencer now claims that "The recession of the Falls, from their birth to the present day, and for the future, has been determined, as well as their age." His investigations include soundings at all the changing points of the gorge, borings to ascertain the character of buried channel-beds, surveys of the old river banks, and observations on lake fluctuations. Thereby has he been enabled to estimate the changes that have occurred at different periods in the volume and currents of the river, and in the height of the Falls; gathering evidence from a study of the buried valleys, and of other phenomena that have influenced erosion far from the great cataract. Thus he concludes that originally the overflow from Lake Erie alone was discharged over the Falls, and progress in excavation was comparatively slow. Through subsequent earth-movements the drainage of Lakes Huron, Michigan, and Superior was added, and erosion was intensified.

The upper part of the Niagara Gorge has been excavated along the line of a pre-Glacial feature, within which the drainage was formerly in the opposite direction to that of the present day. The account given by the author of this "Falls-Chippawa channel" is, he believes, the first suggestion of its existence. Out of this trough the falls are now beginning to emerge, with consequent retardation of their recession.

[1] "Principles of Geology," 11th ed. (1872), vol. i, pp. 356, etc.

III.—Memoirs of the Geological Survey (England and Wales). The Geology of the Country round Oxford. By T. I. Pocock, M.A.; with contributions by H. B. Woodward, F.R.S., and G. W. Lamplugh, F.R.S. London: Wyman & Sons, 1908. Price 2*s.* 3*d.*; price of quarter-sheet 1*s.* 6*d.*

The Ordnance Survey of England has published a quarter-sheet having Oxford for a centre, with topography revised up to 1902. The Board of Agriculture desire to give notice of a colour-printed special geological map of Oxford and district, of which the memoir is an explanation. This special sheet includes Abingdon, Eynsham, Islip, Brill, and Great Milton. The superficial deposits have been for the first time represented. "They include the broad alluvial tracts of Ot Moor and of the Thames and its tributaries; also the valley-gravels, and certain tracts of plateau-gravel regarded as Glacial Drift. Details are given of these deposits, and in connection with them the development of the rivers and origin of the scenery are discussed. The various Jurassic and Cretaceous rocks are also described, and there are notes on the economic products and water-supply, with records of deep borings."

The original Geological Survey was conducted by Messrs. Hull, Whitaker, Polwhele, and others during the years 1857 to 1863, and published on two separate sheets, of which the northern belonged to Banbury and the southern to Abingdon. The country was resurveyed by the late J. H. Blake and the authors of the present memoir, which has been published under the direction of J. J. H. Teall, D.Sc., F.R.S. The preparation of the memoir was entrusted to Mr. Pocock, who has dealt very fully with the Pleistocene and Recent deposits. The chapters dealing with the Jurassic rocks have been partly written by Mr. Woodward, those on the Lower Cretaceous rocks have been contributed by Mr. Lamplugh, and that on the Upper Cretaceous rocks is based on the published observations of Mr. Jukes-Browne.

The general history of the Middle and Upper Oolitic rocks of England by Mr. Woodward formed, it will be remembered, the fifth volume of "The Jurassic Rocks of Britain," published in 1895 and reviewed in the Geological Magazine for 1896. In that volume the Jurassic rocks of the neighbourhood of Oxford naturally came in for their share of attention, and full justice was then done to this important subject. But the opportunity afforded by the publication of an entirely new map, with Oxford as centre, has been utilized by the Geological Survey for the production of a special memoir.

There are many reasons to justify this course; for, apart from the celebrity of the ancient city as a seat of learning and as the nursery of some of the earliest English geologists, its situation in the heart of a great number of Mesozoic formations has served to render Oxford classic ground in the annals of geology. There is a charming variety within the area delineated, and the introduction of superficial features, such as Alluvium, Valley-gravel, and Plateau-gravel, in a region so admirably sculptured by atmospheric agencies, has enabled the chartographer to produce one of the brightest geological maps that has hitherto been published. Most of the Mesozoic formations are represented within the area, though none occupy any great extent of surface with the exception of the Oxford Clay, of whose original outcrop nearly one-half is masked by the alluvium and gravels of the Thames River system. Large collections of Jurassic fossils from the immediate neighbourhood enrich the Oxford Museum, but the Corallian rocks cannot vie in development and palæontological wealth with those of Dorset and North-East Yorkshire, neither do the scattered Portlandians in the south-east corner yield such a suite of fossils as may be found in Wilts and Bucks.

In dealing with the solid geology of the area a very comprehensive sequence of the Jurassic rocks is shown, whilst boring operations have yielded some interesting details respecting those beds which do not actually appear on the surface within the limits of the map. Thus, at Fawler the Inferior Oolite has already shrunk from the fine display on the Cotteswold escarpment to a thickness of 37 feet, whilst underneath Oxford the thickness of the Inferior Oolite is only 16 feet, and we may strongly suspect that it thins out to a feather-edge a little farther to the eastward. The easterly attenuation of the Lias is equally remarkable. Its thickness in the Northern Cotteswolds was proved to be 1,361 feet, and of this the Upper and Middle Lias account for 400 feet. Yet these two subdivisions are held to be absent under Oxford, where the actual thickness of the Lower Lias is at present unknown. These facts may be further confirmed from a study of the east and west section which accompanies the map, where both the chief borings about Oxford are represented as terminating in the Lower Lias, whose thickness at Burford was found to be 447 feet.

Bathonian beds, consisting of Great Oolite, Forest Marble, and Cornbrash, come to the surface in the extreme north-west corner of the map. It is probable that the Great Oolite, as a limestone series, attains its maximum development in Oxfordshire and the adjacent parts of Gloucestershire. With the Cornbrash the Lower Oolites are held to terminate, and on this rests the chief feature of the map, viz. the Oxford Clay with its Callovian base. The arenaceous features of this horizon must be feebly developed near Oxford; thus the rule that clays predominate hereabouts in the Middle Oolites may be said to prevail. Hence there is no special sandstone coloured in the map or column of explanation, merely a reference to "sand and clay" towards the base. On the scale attached to the map the thickness of the "Oxford Clay and Kellaways Beds" works out at about 450 feet, whilst on p. 23 the authors speak of the Oxford Clay as being "nearly 400 feet thick in this region." It is difficult to understand how such can be the case when the well at the city brewery only shows 210 feet of Oxford Clay down to the Cornbrash. There may be two reasons for this excessive estimate: first, the notion originally derived from Phillips' interpretation of the Wytham boring, which was corrected by Prestwich; second, the extraordinary thickness of the Oxford-Kellaways formation at Swindon, estimated at 572 feet. There is also another circumstance in connection with the Oxford Clay of this district which excites surprise, viz., that within the space of a 40 feet section in the Summertown pit *Cardioceras cordatum* occurs in the upper part, lower down there is *Cosmoceras Duncani*, and likewise *Kepplerites calloviensis*, together with *M. macrocephalus*. "Thus portions of the chief zones of the Oxford Clay are here represented." If that can take place within 40 feet of beds, of what value are these particular ammonites for zoning 400 feet of beds?

The Corallian beds within the area receive their share of attention, and, being for the most part accessible and fairly fossiliferous in places, their history is not difficult of interpretation. Measured on the scale it would seem that the average development does not exceed 50 feet, including the Calcareous Grit at the base with the Coral Rag and Coralline Oolite at the top. In the explanatory column a wedge of Ampthill Clay is driven into the Corallian Series, which as a calcareous body disappears a little to the north-east of Oxford. The chartographer has also ventured to represent a considerable extent of Ampthill Clay in this quarter, separating the Oxford from the Kimeridge Clay. The adjacent Arngrove stone by its fauna seems to represent the Calcareous Grit. It is in this direction perhaps that the greatest change in the solid geology of the map occurs; since a very considerable area in the north-east corner formerly coloured as Lower Calcareous Grit, in the region between Boarstall and Waterstock, now appears as Ampthill Clay.

The Kimeridge Clay of the district probably nowhere exceeds 100 feet, a remarkable falling off from its development on the Dorset coast. One is tempted to speculate as to how far the Kimeridge Clay of Oxfordshire is the exact equivalent in time of the Kimeridge Clay of Dorset. Certainly there is no passage to be seen between the Kimeridge Clay and the Corallian, such as may be well observed in Ringstead Bay. The question then arises as to how far the basal beds of the Kimeridge Clay are developed in Oxfordshire. Good specimens of *Rhynchonella inconstans* are quoted from Sandford, and this fossil is characteristic of the lowest beds in Dorset; moreover, Sowerby figured *Ostrea deltoidea* from Headington, and this is also indicative of a low horizon, though not to be relied upon like the other fossil. Phillips is stated to have observed in the section on Shotover Hill, about 15 feet from the base of the Kimeridge Clay, a septarian band yielding *Rh. inconstans*, etc., whilst lower down there are layers of *Ostrea deltoidea*, and near the base *Thracia depressa* and *Exogyra virgula* are fairly abundant. Hence the relative position of these fossils is the reverse of that in Dorset. But there are exceptional features in the fauna of this region, for we note that *Perisphinctes plicatilis* is quoted from quite the top of the Kimeridge Clay in a boring at Baldon, and the same species of ammonite is quoted with a query from the Lower Portlandian of Shotover.

These considerations, however, do not materially affect the mapping, which must proceed mainly on lithological lines. Hence there is not much difficulty in determining the several Portlandian outliers which give such variety to the south-east corner of the map. In this connection, also, we observe that a considerable portion of the district, comprising the Baldons, formerly mapped as Lower Greensand, is now added to the Lower Portlandian. The thickness of the Portlandian at Shotover is estimated at rather over 100 feet. "This group," Mr. Woodward observes, "consists mainly of sandy strata with beds of limestone, as well as sand and thin clay-bands in the upper part. The conventional division into Portland Sand and (overlying) Portland Stone appears applicable only to portions of this area, and even then it is better to use the terms Lower and Upper Portland Beds, as both divisions contain beds of sand, and in certain tracts the Lower beds pass into a loamy clay equivalent to the Hartwell Clay." In the explanatory column the Hartwell Clay is shown as part of the Lower Portland Beds, though on the map it is not possible to separate it from the Kimeridge Clay.

From the upper beds (sands and limestones) of Shotover the following are amongst the fossils quoted, viz., *Perisphinctes bononiensis*,[1] de Lor., *Cerithium portlandicum*, *Natica elegans*, *Pecten lamellosus*, and *Trigonia gibbosa*, all characteristic Upper Portlandian species. From the lower beds the following are amongst the fossils recorded, viz., *Perisphinctes pectinatus*, Phil., *Pholadomya tumida*, and *Trigonia Pellati*. This is rather a scanty list, but the Clavellate *Trigoniæ* are characteristic Lower Portlandian species almost as much as the *Glabræ* are characteristic of the Upper Portlandian, where some palæontologists would lump the several varieties under *Trigonia gibbosa*, Sow. In the outlier at Brill the boundary drawn at the base of the Portland Beds is in reality at the junction of the Upper Portlandian with the Hartwell Clay (Lower Portlandian), which merges downwards into the Kimeridge Clay. The base of the Upper Portlandian here is the highly fossiliferous glauconitic bed, in which J. F. Blake in 1893 found a series of what he regarded as Lower Portlandian fossils, including *Ammonites biplex*,[2] though some of the fossils quoted are likewise characteristic of the higher beds.

It may be said with a considerable degree of truth that, when correlation is attempted, the faunal history of the Kimeridge-Portland period does not tally with its lithology, although, if we confined our attention solely to the area included in the Oxford map,

[1] This form is sometimes taken for *Am. giganteus*, Sow., which fossil Blake showed to be restricted to the highest Portlandian beds of Portland Isle. Was Blake justified in altering *bononiensis* into *boloniensis*?

[2] It is interesting to observe that fifteen years ago so good a palæontologist as the late Professor Blake continued to call this characteristic Lower Portlandian fossil by the name of *biplex*. An equally distinguished palæontologist, de Loriol, gave a very good figure of it, but unfortunately also referred the Boulogne fossil to *A. biplex*, Sowerby. The Russians Nikitin and Pavlov, when they were over here twenty years ago, had pointed out that our Portlandian fossil was identical with *A. Pallasianus*, d'Orb. (in Murchison's "Russia"), which Pavlov then classed under *Perisphinctes*. Blake (Q.J.G.S. for 1902, p. 300) referred to a *Perisphinctes* (like *Pallasi*, usually called *Am. biplex*). Subsequently Miss Healey (Q.J.G.S. for 1904) threw much light on Sowerbian nomenclature, and gave two excellent figures of *Olcostephanus Pallasianus*, d'Orb., in which we recognize a striking likeness to our old Kimeridge-Portland friend—a very *biplex* ammonite, but not Sowerby's species.

It must not be supposed, however, that the stratigraphist in search of a name for a zonal fossil is quite out of his difficulties. If palæontologists had been content not to subdivide the ammonites, there would have been no further cause for doubt. But are we quite certain that the "true *biplex*," i.e. *Am. Pallasianus*, belongs to the genus *Olcostephanus*? Many of the specimens of "*biplex*" in our rocks, owing to their evolute character and the presence of strictures, more resemble *Perisphinctes*. Moreover, we know that Neumayr, who is responsible for *Olcostephanus*, essentially a Cretaceous group, admitted that there were intermediate forms. It is significant also that he did not include *Am. Pallasianus*, d'Orb., amongst the *Olcostephani*.

this generalization might not be fully realized. Within this particular area there is not much difficulty in drawing the line between the attenuated representative of the Kimeridge Clay and the several Portlandian beds above it. But a question which may not trouble the chartographer arises, as to how far these lithological distinctions hold good over all that part of the South of England, from Dorset to the borders of Bedfordshire, where Kimeridge-Portland rocks are developed. If we are to judge by the invariant fossils, it seems probable that a given fauna was in one place being buried in clay, yet elsewhere in sand or even in calcareous deposits. Hence, what is regarded as Kimeridge Clay in the Isle of Purbeck may represent an horizon classed as Portlandian elsewhere. This is too large a question to be discussed within the limits of a review beyond intimating a belief that possibly the complete sequence at Swindon is the most likely place to afford a clue to the mystery. It is well known that J. F. Blake suggested the idea of a difference in the age of the several groups classed as Portland Stone (Upper Portlandian), those in the north-east being regarded as possibly older than those in the south-west, and particularly in Portland Isle.

The development of Purbecks within the area is so slight as to call for no comment, but the Ironsands of Shotover, including the Brill and Muswell Hill outliers, are of considerable interest, more especially from the circumstance that these were previously mapped by the Geological Survey as of Lower Greensand age. This was certainly contrary to the opinion of the older geologists, and also of Professor Phillips, who in the "Geology of Oxford," pl. xvi, figures species of *Paludina*, *Unio*, and *Cyrena* from these beds, some of them being new species, but, as usual, without description. There seems to be but little doubt that these Shotover Sands represent the marginal deposits of the great Wealden basin, and are themselves probably on the horizon of the Hastings Beds. By way of accounting for the previous interpretation of the Survey, it is stated that a ferruginated portion of the Portland Stone, containing *Trigonia Damoniana* and other marine fossils, had in some way led to the idea that there might be a passage from Portlandian to Ironsand conditions. This view seems to leave the intervening Purbecks out of consideration altogether. Sandy beds south of Newnham possess a scanty fauna of a Lower Greensand character, and these are succeeded in the south-east corner by the Gault.

The Superficial Deposits of the area are classed under the heading "Pleistocene" and "Recent," but since the writer (Mr. Pocock) regards it as probable that the country has been subjected to subaerial denudation "ever since the Eocene period," there seems to be a possible margin for deposits anterior to the Pleistocene, such for instance as some of the Plateau-gravel, in their memoir called Plateau Drift. Without entering into this subject, a glance at the history of the River-gravels may be of interest. There are four terraces in the Oxford district, of which the highest has not hitherto been found to contain fossil remains. The other three, which together constitute the low-level group, not rising more than 50 feet above the present rivers, contain the bones of *Elephas antiquus*, of the mammoth, woolly rhinoceros, hippopotamus, and other mammalia, together with a good number of land and fresh-water shells of existing species, and flint implements regarded as early Palæolithic.

It is upon the second of these terraces that Oxford and most of the villages of the Upper Thames valley are built. These gravels are occasionally cemented by iron-oxide into a rock hard enough to be used for a building-stone. It is in this terrace that important finds of the large Pleistocene mammalia have been made. The changes in the courses of the rivers since the epoch of the second terrace have not been very great, the most important being in the case of the Cherwell. The third terrace has also yielded Palæolithic implements and mammalian remains. Eleven species of fluviatile shells have been obtained from the sand included in one of the gravel beds. There is also a peat bed, where about two-thirds of the mosses, as well as the flowering plants, are still found living in the neighbourhood; some of the others are Arctic or Alpine.

The gravels hitherto described may be classed as the low-level group, but between them and the Fourth Terrace there occurred a marked epoch of erosion, during which the Thames cut down its valley to the extent of about 50 feet. It has already been stated that no fossils have been found in this terrace, and the same rule applies to the Plateau-gravel, which Mr. Pocock describes as the Northern Drift. It will be readily understood that mere fragments of this once extensive formation remain, capping portions of the higher grounds, where its presence is indicated on the map by the usual pink colour. It is thought that this drift has an eastern as well as a northern source, but the subject is a too extensive one to be dealt with in a local notice. We must leave the Plateau-gravel and the development of river valleys for the present, merely remarking that, according to Prestwich, since the beginning of the Pleistocene period, when the so-called 'Westleton Beds' were formed, there has been erosion of the valleys to a depth of 450 feet, the greater part of which was accomplished in Glacial times. Maps showing denudation of valleys since the formation of the High Terrace, and since the epoch of the Wolvercot Terrace, are supplied in the text. There can be no doubt that speculative physiography is a very popular branch of geology, and one which has come to the front enormously of late years. Mr. Harmer's paper on "Lake Oxford and the Goring Gap" is a testimony to the interest which the subject has evoked.

The question of water supply is dealt with in the latter part of the memoir. The original supply of water to Oxford was obtained from wells sunk in the Valley-gravel. There are also numerous springs which are thrown out where the water in the various sands, principally of Jurassic age, is held up by the underlying clays. Hence the supply of surface water may be deemed fairly adequate, and it is fortunate that this is the case, since artesian boring in the valley of the Upper Thames cannot be regarded as a success. This is due to the salinity of water from strata below the Great Oolite, which is not as yet satisfactorily explained; but it will be remembered that even the Forest Marble in the Swindon deep well yielded a water almost as saline as that of the sea. We fully concur in the remarks of Mr. Fisher that "the study of Oolite waters leads to the general conclusion that the uncovered beds of limestone yield calcareous waters of a hard character, while the deep beds, and especially the beds covered by clay, yield saline or alkaline supplies." To a certain extent this rule holds good even in such a homogeneous formation as the Chalk, and may be explained on the principle that the higher and more exposed beds receive a larger charge of carbonic acid: where this does not penetrate, the carbonate of lime is not dissolved. The source of such large quantities of a saline matter is probably the stagnant condition of the waters in the hydrostatic basin, which require bleeding by springs or else by continuous pumping, which latter process might be prolonged indefinitely.

W. H. H.

IV.—The Geology of Coal and Coal-mining. By Walcot Gibson, D.Sc., F.G.S. pp. x, 341, with 8 plates and 16 text-illustrations. London: Edward Arnold, 1908. Price 7*s.* 6*d.* net.

The present volume is the first of a series on Economic Geology, to be issued under the general editorship of Dr. J. E. Marr, who remarks that the subject is "yearly receiving more attention in our great educational centres." This is gratifying, as the practical applications of knowledge must ever be one of the aims of those scientific workers who have at heart the welfare of mankind.

To instruct the mining student, the prospector, surveyor, and mine-manager on those questions which affect the occurrence of coal, is the main object of the book before us, and it is happily written by a geologist who has had a large experience in problems of coal and coal-mining, and who has spared no pains in the preparation of his work.

The publication comes at an opportune time, when, owing to the vast amount of coal that has already been raised from our principal coalfields, deeper sinkings in some of them and trial borings in unproved areas on their margins become more and more necessary.

Here, as pointed out by Dr. Gibson, intimate knowledge of the structure of each coalfield, and of the strata composing the coal-measures, is of the utmost importance. In many regions there are considerable thicknesses of red rocks that overlie the productive measures, in some cases conformably, in others with great discordance. The discrimination between these has not yet been satisfactorily made in all areas on our geological maps.

Moreover, the days are not over when black shales or lignite tempt the ignorant to fruitless enterprise, and we have known a deep and useless boring made in red rocks in an unpromising area, because it was thought from coal being worked under red rocks at Bristol it would be met with elsewhere under similar rocks at no great depth.

The information acquired in recent years of the horizons marked by certain fossil plants, mollusca, fishes and other organic remains has proved to be of considerable importance, at any rate locally. Thus a knowledge of the succession of rock-types in conjunction with the evidence of the fossils is of signal service in determining horizons in trial borings outside the exposed limits of a coalfield.

The author, from his personal experience, speaks guardedly about the testimony of the fossils: thus plants "are of service to the miner, only in a broad, general sense," whereas mollusca "in many coalfields fix the horizon of a particular bed." Much yet remains to be done, as we have yet to learn to what extent the vertical distribution of fossils in the Midland coal-basin holds good for other British coalfields. The fact, however, of their local importance should stimulate the interest of mine-managers, and induce them to collect and carefully record the horizons of fossils. The illustrations given of fossil plants are so excellent that they may well stir up enthusiasm.

While knowledge is required in the extension of workings beyond the limits of a coalfield, so also is it wanted in unknown areas. Coal-seams are very rarely exposed in cliffs and other natural sections, and even in trial borings they may be missed, because it is difficult with present contrivances to bring up good cores of coal, as it may be ground to powder.

An acquaintance with the characters of coal-bearing strata here comes to the help of the prospector, to whom the author gives much useful and judicious advice. Here also the occurrence of certain fossils may prove of ready assistance in negativing the prospect of coal or in encouraging enterprise.

The author gives brief accounts of the British coalfields and of those in various parts of the world. If he devotes more space to the Somerset and Gloucester coalfield than to that of South Staffordshire, it may be because in the latter the available quantity of coal that remains is estimated to be little more than one-third of that remaining in the Somerset and Gloucester area. The Yorkshire, Derbyshire, and Nottinghamshire coalfield "contains the largest reserve of coal in the British Isles"—*presumably*, we should add, for there are still large unproved areas in the south and east of England.

There is an ambiguity (on p. 44) where the author speaks of the chief coal-seams in the Southern Hemisphere and in India as belonging either to the Mesozoic or Tertiary period, because (on p. 46) he places the coalfields of South Africa, India, and Australia in the Palæozoic (Permian and Permo-Carboniferous).

We have left no space to refer to the many other matters of interest dealt with in this volume, such as the characters of coals and coal-seams, their origin and extent, the depth of mines, the faults and folds, and general structure of coalfields, illustrated by diagrams, but we may note that the map on p. 117 requires a further explanatory legend.

In all these matters above-mentioned, the author gives sound practical information, in which the doubts and difficulties and exceptions are very freely stated. In fact, one might conclude that with the increasing knowledge and importance of the subject a geological coal-mining expert must be a necessary officer in every coalfield.

REPORTS AND PROCEEDINGS.

I.—*May* 6*th*, 1908.—Professor W. J. Sollas, Sc.D., LL.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Solution Valleys in the Glyme Area of Oxfordshire." By the Rev. E. C. Spicer, M.A., F.G.S.

A triangular area whose sides are defined by the converging Evenlode and Cherwell with a strike valley, containing the upper Swere for its base, contains a smaller triangular area defined by the confluent Glyme and Dorn. This area is part of the gently tilted Great Oolite limestone plateau, which is indented by a number of sunken valleys running in various directions, principally with a strike and dip trend, that show no marks of erosion but appear to be subsidence valleys. They begin suddenly at any part of the area, and descend with sinuous curves to a main valley into which they open quietly without disturbing the main valley's contour, and without bringing any surface débris. The main valley likewise enters a stream valley in a similar manner. The stream valley quietly develops into a broad sinuous river valley, with a floor, level in transverse section, over which a small river stream aimlessly meanders with the Evenlode characteristics. A gradation is shown from the plateau dry valleys to the meander valleys, which are sometimes flooded from bank to bank with soakage water. The plateau area is quite free from drift or gravels, and from any of the usual marks of surface denudation, although the valleys have strongly marked cross sections. There are no marks of marine currents, of fluvio-glacial scour, or of ice. There are no wind-gaps suggesting beheaded streams, nor any evidence of vanished heights that could produce torrents sufficiently strong to carve out the present surface. At the mouths of several of these dry winding valleys issue streams strongly impregnated with carbonate of lime. It is suggested that percolating water forming an underground course along joint lines removes enough material in solution to weaken a long, narrow, winding area over which the surface subsides until the underground stream is revealed. Solution then constantly widens the stream banks into bowls of soakage, and leaves insoluble material to build up a broad, level valley floor, which rises gradually above and obscures the dry valley outlet streams, these then forming marshes. It does not appear possible to reconstruct any local conditions that could have produced these valleys by mechanical erosion, and it is suggested that they are formed by underground solution, and are therefore called joint valleys or solution valleys. Prestwich (Quart. Journ. Geol. Soc., vol. xxviii, 1872, p. lxvii) estimates that 140 tons of carbonate of lime are annually removed from every square mile of the limestone area drained by the Thames. This would give an annual amount removed by solution from the small Glyme area of over 10,000 tons.

2. "On the Stratigraphy and Structure of the Tarnthal Mass (Tyrol)." By Alfred Prentice Young, Ph.D., F.G.S. With a "Note on two Cephalopods collected on the Tarnthal Köpfe (Tyrol)." By George C. Crick, Assoc. R.S.M., F.G.S.

The immediate occasion for this paper is the discovery of fossils which appear to throw new light on the relations of the rocks of this mountain. The rock series may be divided into three parts. (*a*) The lowest portion consists of dolomite, and the Lias is in normal position, the upper beds being the youngest; this portion is scarcely disturbed. (*b*) A middle section, consisting of calcareous schists, with a band of massive dolomite and dolomite breccia, shows marks of violent disturbance and crushing. (*c*) The uppermost part, a mass of more or less altered quartzite schists, calcareous schists, and serpentine, retains most of its original character and form, having undergone little mechanical distortion since it left its 'root.' The succession is summarized as follows:—

3. { Serpentine.
Ophicalcite.
Tarnthal quartzites, etc.

2. { Calcareous schists with green bands.
Dolomite breccias.
Calcareous schists.

1. { Liassic limestone.
'Principal dolomite' (Rhætic).

The explanation of the structure now suggested is as follows:— The line between 1 and 2 marks approximately the lower loop of a big fold, the dolomite breccia being a repetition in an attenuated form of the 'principal dolomite' below. The interpretation of the relations of 2 and 3 is not so clear. Either the whole series 2 and 3 is in inverted sequence, or else the dolomite breccia represents the whole of the 'principal dolomite' in a flattened fold (*nappe* of Termier), the serpentine and quartzite having been brought into their present position by a long overthrust, representing the *traîneau écraseur* of the French geologists. The question whether the lower dolomite and the Lias are *in sitû* or not is left undecided. A petrographical note is furnished on the amphibolite of Gufidann.

II.—*May* 20*th*, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Daniel Pidgeon Fund for 1908 had been awarded to Mr. James Archibald Douglas, B.A., F.G.S., who proposes to investigate the zonal succession of the Lower Carboniferous rocks of Western Ireland.

The President read out the result of the poll taken to ascertain the opinion of the Fellows resident in the United Kingdom as to the admission of women to the Society, as follows:—

Papers sent out	870
Answers received	477

Analysis of Replies.

(1) Are you in favour of the admission of women to the Geological Society of London?

Yes	342	
No	133	
Not specified	2	
	——	477

(2) Are you in favour of the admission of women as Fellows, or as Associates only? The 342 in favour of admission voted—

As Fellows	248	
As Associates	84	
Not specified	10	
	——	342

(3) If there should not be a majority of those voting in favour of women as Fellows, are you in favour of their admission as Associates?

Yes	304		
No	35		
Not specified	3		
	——	342	
Add votes of those against the admission of women at all		133	
And those who are neutral...		2	
		——	477

The foregoing analysis shows that there were:

In favour of the admission of women as Fellows	248	
Against the admission of women as Fellows	217	133 against the admission of women at all. 84 in favour of the admission of women as Associates only.
Majority in favour of the admission of women as Fellows	31	

The following communications were read:—

1. "On some Fossil Fishes discovered by Professor Ennes de Souza in the Cretaceous Formation at Ilhéos, State of Bahia (Brazil)." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., V.P.G.S.

This paper proves that the Lower Cretaceous formation of Bahia extends along the coast to a point at least 130 miles south of the area previously described. The fish-remains are referable to new species of the genera *Mawsonia*, *Lepidotus*, and *Scombroclupea*. *Mawsonia* seems to have been scaleless, and differs from all known Jurassic and Cretaceous Cœlacanth fishes in lacking denticles on the fins. The *Lepidotus* closely resembles the European Wealden *L. Mantelli* in proportions, but is more strongly ornamented. The *Scombroclupea* is peculiar, in exhibiting only scales where the anal finlets usually occur.

2. "The Bala and Llandovery Rocks of Glyn Ceiriog (North Wales)." By Dr. Theodore Groom, M.A., F.G.S., and Philip Lake, M.A., F.G.S.

In the district around Glyn Ceiriog, which the authors have mapped on the 6 inch scale, the following succession is given:—

Denbighshire Slates.	
Ty-Draw Slates, with *Monograptus Marri*	Tarannon and Llandovery.
Fron-Frys Slates, with *Pentamerus undatus*, *Meristina* cf. *crassa*, *Nidulites favus*, etc.	

Glyn Valley Series.	(*b*) Glyn Grit and Limestone	Bala.
	(*a*) Ddolhir Beds, with *Phyllopora Hisingeri*, *Ramipora Hochstetteri*, *Trinucleus seticornis*, species of *Cybele*, *Cheirurus*, *Remopleurides*, and numerous Cystids, Corals, Brachiopoda, etc. ...	
	Graptolite Slates, with *Dicellograptus elegans*	
	Gap.	
Pandy Series.	(*e*) Pen-y-Graig Ash	
	(*d*) Bryn Beds, with *Tetradella complicata*, *Phacops apiculatus*, *Trinucleus concentricus*, *Triplesia spiriferoides*, *Rafinesquina ungula*, etc. ...	
	(*c*) Craig-y-Pandy Ash	
	(*b*) Teirw Beds, with *Lingula tenuigranulata*, *Bellerophon nodosus*, *Asaphus Powisi*, etc. ...	
	(*a*) Cwm-Clwyd Ash	

In the Pandy Series the beds *a*, *c*, and *e* consist essentially or wholly of ashes and tuffs (no lava-flows having been detected). Movements have often taken place along the two surfaces of the Craig-y-Pandy Ash, and the rock is commonly foliated, and locally converted into a white or blue china stone, in which good columnar jointing is sometimes shown. The authors have failed to detect any traces of thermometamorphic action of these bands on the adjoining slates, such as has been recently asserted. It is otherwise with an intrusive sill, which has been commonly mistaken for the uppermost ash.

The Teirw Beds are compared with the Roman Fell Group of the Lake District. The Bryn Beds agree most nearly with the Sleddale Beds of the same district.

The Graptolite Slates are separated from the underlying Pandy Series by the Ddolhir Fault, which has cut out a considerable part of the succession.

The Ddolhir Beds are extremely rich in fossils, which prove their equivalence with the Ashgillian formation of other districts. They appear to pass up into the Glyn Grit and Limestone, which is essentially a sandy and calcareous facies of the series. The Glyn Grit corresponds in position with the Corwen Grit; but, recognizing that it belongs to the Bala Series, the authors are no longer prepared, without further evidence, to assume the equivalence of the two grits.

The Fron-Frys Slates show the lithological characters of the Grey Slates of Corwen, but belong rather to the shelly than to the graptolitic facies of the Llandovery Series.

The Ty-Draw Slates resemble the pale Tarannon Slates of other districts. They appear to pass up into the Denbighshire Slates.

The authors find no indication of the overlap or overstep of the Wenlock, Tarannon, and Llandovery Beds mapped by the officers of the Geological Survey, or described by previous observers, although there is probably an unconformity at the base of the Fron-Frys Slates.

The beds of the district dip northwards at an almost uniformly low angle, but the structure is considerably complicated by a series of faults, most of which have hitherto escaped notice, some being very elusive. They include—(1) east and west faults, (2) north-north-west and south-south-east, or north and south faults, and (3) north-north-west and east-south-east faults.

Of the first series the most important is the Ddolhir Fault, which dips at an angle of 20°, nearly with the bedding, and may be either a thrust-plane or a lag-fault. Of the second series, the most remarkable is the Caemor Fault, on the east side of which the rocks have been raised nearly a mile, and shifted horizontally to the south for nearly three miles. Most of the remaining faults have a simple downthrow on the east.

III.—*June 3rd,* 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council had passed the following resolutions:—

"The Council of the Geological Society desires to express the profound regret with which it has heard of the death of Sir John Evans, K.C.B., F.R.S. Sir John Evans served the Society for many years in the Council, occupied the Presidential Chair from 1874 to 1876, being the Senior President living, and subsequently discharged the duties of Foreign Secretary for twelve years. Geological Science has gained much from the researches of Sir John Evans, and the place which he has occupied in the Society and the Council will be hard to fill."

"The Council also desires to express its regret at the loss of Professor Albert de Lapparent, who had been a Foreign Correspondent and Member of the Society since 1887, and who, as recently as last year, attended the celebration of the Society's Centenary and contributed no little to the proceedings on that occasion."

The President announced that, in accordance with a requisition "signed by five or more Fellows" of the Society (Byelaws, Sect. xi, Art. 4), a Special General Meeting would be held at the Society's Apartments on Wednesday, June 17th, 1908, at 7.45 p.m., in order to consider the following resolution, which would be proposed by Dr. J. Malcolm Maclaren and seconded by Mr. A. Gibb Maitland:—

"That Fellows non-resident in the United Kingdom be invited to express an opinion concerning the admission of women to Fellowship or Associateship of the Geological Society of London."

The following communication was read:—

"On the Fossiliferous Rocks of the Southern Half of the Tortworth Inlier." By Frederick Richard Cowper Reed, M.A., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S.

This paper is a continuation of that on the igneous rocks of this area published in 1901 (Quart. Journ. Geol. Soc., vol. lvii, p. 267). The following succession is that adopted by the authors:—

		Thickness in feet.
Old Red Sandstone.		
Ludlow Rocks.		
Wenlock Rocks.	5. Fissile red and yellow sandstones with gritty and calcareous bands	?
	4. Upper limestone band ... ... about	25
	3. Variable non-calcareous beds, according to Phillips about	500
	2. Highly fossiliferous red clay or shale, with rubbly limestone and celestine band	12 (seen)
	1. Lower limestone band, somewhat sandy thickly bedded limestone	50
		625

LLANDOVERY ROCKS.	6. Shales with grit and highly fossiliferous calcareous sandstone	?
	5. Highly fossiliferous ashy limestone ...	$2\frac{1}{4}$ to $3\frac{1}{2}$
	4. Upper trap band ... ... about	60
	3. Sandy limestone and calcareous sandstone and grit, crowded with fossils, about	500
	2. Lower trap band ... maximum about	185
	1. Micaceous sandstone, with *L. Symondsi*	?
		800 to 850

The rocks are affected by the Hercynian flexures which produced the Bristol coal-basin, and the outcrop of the beds in the main follows the horseshoe-shaped outcrop of the Old Red Sandstone. This regularity is lost at Daniel's Wood and Middlemill. Two important transverse faults traverse the outcrops, which are further obscured by the overlap of unconformable Trias. The trap-bands are found to be confined to the Llandovery, the number of recorded fossils has been largely added to, and previous statements as to the thinness and imperfect development of the Ludlow rocks and as to the probable exposure of the district to erosion in Ludlow and Lower Old Red Sandstone times are confirmed. The typical Ludlow fauna of Herefordshire and Shropshire has not been met with, and the series is clearly much attenuated. General remarks on the fossils are appended, and the paper contains lists of fossils in various collections (Bristol Museum, Sedgwick Museum, Earl Ducie's collection, and the Museum of Practical Geology, Jermyn Street), as well as those collected by the authors from the Llandovery and Wenlock formations.

CORRESPONDENCE.

CHANGES OF LEVEL AND RAISED BEACHES.

SIR,—I read with great interest Dr. Jamieson's paper on the above subject in the issue of the GEOLOGICAL MAGAZINE for May (pp. 206–209).

I was, however, surprised to learn that Dr. Jamieson's views were expressed as original, for I laboured under the impression that they were long ago accepted by the majority of British geologists, and I have myself been teaching them for many years.

Professor Sollas (" The Age of the Earth," p. 35) clearly illustrates how such a state of affairs can take place, though not drawing specific attention to this as the cause of the phenomena of raised beaches.

WALTER BALDWIN.

ROCHDALE.
May 22nd, 1908.

THE MAMMALIAN FAUNA OF THE FOREST BED.

SIR,—In a cursory survey of fossil Voles,[1] chiefly from the so-called Forest Bed, I arrived at conclusions which in several respects are at variance with those of former writers on the subject. The

[1] Proc. Zool. Soc., 1902, p. 102.

supposed recent Voles of the Forest Bed I have come to consider as extinct species; the Pliocene Crag types, on the other hand, while entirely absent from the West Runton Fresh-water Bed, were found in the East Runton Forest Bed mixed with types of the former; this leads to the assumption that the Crag types have been washed into the East Runton deposit. The latter explanation, which I did not explicitly formulate at the time, receives strong support from the fact that at East Runton we find likewise a West Runton species of Beaver, together with a Pliocene species (*Castor plicidens*, Maj.), the inference to be drawn being that the provenance of the latter is the same as that of the Pliocene Voles, mingled at East Runton with the West Runton types.

If I am right in my deductions, it follows that the Vole fauna of the Forest Bed will, by the elimination of recent as well as of Pliocene types, prove to have been much more homogeneous than hitherto supposed. This being the case with one restricted group, it appears to call for a revision of all the other mammalian remains.

For many years I have entertained the suspicion that there must be something wrong with our lists of the Forest Bed Mammals. In plain language, the association of recent with Pliocene mammalian species, culminating in the assumption of the musk-ox having been a contemporary of the prototypes of the Upper Pliocene Val d'Arno fauna, is a faunistic impossibility. I therefore deny such an association of which there is no analogy in any other part of the world, although this has been assumed on erroneous determinations, e.g. with regard to the mammalian fauna of Leffe (Upper Lombardy).

I very much doubt whether in the end a single one of the supposed 24 recent species, out of a total of 45 Forest Bed Mammals, will remain, though in some cases it is not possible, for the present, to detect differences between a fragmentary fossil and the corresponding living species. C. I. Forsyth Major.

AN *ORTHIS* FROM LADOCK QUARRY, CORNWALL.

Sir,—In the Memoirs of the Geological Survey, England and Wales, Explanation of Sheet 346, 1906, p. 35, the following paragraph occurs:—"A fossil has been found in the Ladock Quarry and placed in the Truro Museum. It is an *Orthis*, which Dr. Ivor Thomas, who examined it, thinks is probably new." The occurrence of a fossil in this quarry was so interesting and unlooked for that it seemed impossible to accept it without further evidence. Opportunity for investigation did not occur until April last, when I spent ten days with Mr. Upfield Green working over his promised section of the country between Newquay and Porthluney. The fossil in question was found by Bennett, a stonebreaker, on a pile of stones midway between Ladock and Grampound Road, and *not in the quarry at all.* He told me himself that his son broke the stone, and he noticed this fossil with the remains of several other impressions of shells. He preserved only this one specimen, which was an internal cast, and gave it to Mr. Minard, of Grampound, who afterwards deposited it in the Truro

Museum. The specimen has since been sent to London for examination, and casts were made for the British Museum and for Jermyn Street, as it was felt that the specimen might become of importance in future discussion. Bennett was positive in his assertion that the material on the stone heap came from Ladock Quarry, but Mr. J. O. Clemmow, of Ladock, who has been at some trouble in the matter, writes me as follows, under date 30th May, 1908:—"As a large quantity of stone from the South Coast, near the Helford River, has been brought into the immediate neighbourhood and broken for the roads, I should say that considerable doubt exists as to where the stone which produced this fossil was quarried."

The fossil seems to me to be the internal cast of a species of *Spirifer* of Taunusian age, and its appearance is suggestive of some southern locality, possibly the Looe area, and certainly not such as one would expect from the Ladock stone. A sharp look-out is now being kept for any trace of life from the Ladock Quarry, but the men working it have never seen a single shell. Nor has any sign of life ever been seen by either Mr. Uptield Green or myself in numerous visits, except some black flat grass-like markings, which Mr. Newell Arber would not venture even to call 'plant-remains.'

As the occurrence of this fossil has been so definitely given in print, it seemed worth while to investigate the story while those concerned in the statement were accessible, as endless trouble is occasioned by these records in after years when it is impossible either to prove or disprove them. C. Davies Sherborn.

A NOTE ON GRANITE AND A NOTE ON RIPPLEMARK.

Sir,—Since the appearance of my letter on granite in the March number of the Magazine, I have submitted to a physicist the drawings of inclusions in two Dartmoor rocks, which appeared in my paper in the Magazine in March, 1904. (Copies enclosed.) I sought to ascertain the significance of their disproportionate contents of chlorides and of water. This is the reply:—

"At the temperature when the water, with salt, etc., is above its critical point, the salt and water vapour would form a homogeneous mixture, and enclosures of this homogeneous mixture should show on cooling the same proportions of dissolved salt, crystallized salt, and liquid water."

The inference is that the enclosures referred to caught up their contents when the temperature was under the critical point of the salt and water, whatever that may exactly be. It would be higher, I am told, than that of plain water.

From the above it would appear that the chlorides of the western granites are as good records of the temperature of crystallisation as the carbonic acid inclusions of some other rocks.

To turn to a totally different subject, I should like to point out that in the paper by the late Dr. Sorby, just published in the Q.J.G.S., an incidental remark will clear up nearly sixty years of uncertainty. Dr. Sorby mentions that the depth of water in which he observed the ripplemarks discussed in his classic paper, published in 1859 in the *Geologist*, was from one to eight inches. Hitherto Dr. Sorby's views could not be reconciled with the results obtained by other workers at much greater depths. We now know that there is no need to attempt to do so, and that Dr. Sorby's observations were accurate for the special case studied. He tells us that before he recorded his conclusions he had made 20,000 observations! The pity is that the results were compressed into ten pages of print.

A. R. Hunt.

THE KRAAI RIVER VERTEBRA REFERRED TO *EUSKELESAURUS.*

Sir,—Dr. A. Smith Woodward (Geol. Mag., June, 1908, p. 251) reprinted a paper on *Scaphonyx Fischeri*, which in 1907 was said to be a short-necked Dinosaur allied to *Euskelesaurus*. In a postscript (p. 255) it is remarked—"From new specimens submitted to me by Dr. I. C. White, I am now of opinion that *Scaphonyx* is an Anomodont." The publication of this evidence will be interesting, for the figured Brazilian bones, although very imperfect, make approximations to Saurischians, and show little in common with known Anomodonts.

Dr. A. Smith Woodward figured a cervical vertebra (Fig. 1, l.c., p. 252), and it is on this evidence that *Scaphonyx* was affiliated to *Euskelesaurus*, and compared with the cervical vertebra collected by myself and presented to the Natural History Museum. I do not see any close affinity between them. I was not quite certain of my own determination, and (Ann. Mag. Nat. Hist., Nov. 1894, p. 340) remarked upon the vertebra as "indicating, *if correctly referred*, that *Euskelesaurus* was a short-necked type." The determination therefore was questioned by myself when it was first made. This appears to have been overlooked, for Dr. A. S. Woodward says in his postscript—"The preceding paper was written in 1904, when Professor Seeley's determination of the cervical vertebra of *Euskelesaurus* had not been questioned." The paragraph continues—"Since that time Baron F. von Huene . . 1906 . . has expressed the opinion that the vertebra in question does not belong to a Dinosaur, but to an Anomodont." I am under the impression that I had mentioned verbally to v. Huene that I had ceased to refer the vertebra to *Euskelesaurus*, but the reference of it to an Anomodont is entirely his own. The interest of the quotation from the postscript is in Dr. A. Smith Woodward's conclusion that *Scaphonyx* is an Anomodont; for it would appear that he adopts v. Huene's conclusion concerning the Kraai River vertebra, from which I dissent.

In 1905 I deposited in the Natural History Museum for development, with a view to eventual presentation after description, a skeleton which I had known for ten years to be referable to the animal type from the Kraai River, which had been doubtfully referred to *Euskelesaurus*. In 1907 these bones were exhibited by me at a conversazione of the Royal Society under Dr. Broom's name, *Erythrosuchus Africanus*. The animal is not an Anomodont. In superintending the removal of the matrix, I took occasion to draw Dr. Smith Woodward's attention to the identity of one of its cervical vertebræ with the vertebra from the Kraai River, and the label on the exhibited specimen, giving the name, was turned down at my request. My responsibility for reference of the specimen to *Euskelesaurus* ceased. There is no evidence for making the correction other than that in my possession and under description. Hence no publication seemed necessary in anticipation of final account of the animal.

In his postscript Dr. Smith Woodward states that "Dr. R. Broom has described similar vertebræ from the Upper Beaufort Beds of the Karoo Formation under the new generic name of *Erythrosuchus*." This scarcely represents the facts. If my new unpublished skeleton is omitted, there is no evidence to connect the Kraai River vertebra with Dr. Broom's types. Dr. Broom states that in *Erythrosuchus* "there is one well-preserved vertebra, which is either lower cervical or upper dorsal," compared to the dorsal vertebra of a carnivorous Dinosaur, and said to show that the rib was single-headed. On comparison of this vertebra (Ann. S. Afr. Mus., vol. v, pt. 4, figs. 8, 9) with the Kraai River fossil, it is difficult to recognise any near approximation. There is no room for doubt, for the Trustees of the South African Museum have given me, with the assistance of the Geological Department of the British Museum, the opportunity of studying Dr. Broom's *Erythrosuchus* in the description of my own materials.

Finally, the postscript remarks, "According to Dr. Broom's description this reptile is not a Dinosaur, but exhibits many resemblances both to Belodonts and to Anomodonts." Dr. Broom does not use the term Dinosauria, but refers his animal to the Phytosauria, because the ilium is like that of *Belodon*, and the other bones are said to be somewhat like; but he exhibits caution in not speculating on the nature of the skull. In 1892 (Quart. Journ. Geol. Soc., vol. xlviii, p. 189) I published the view that *Belodon* is a primitive Cetiosaurian, to be classed under the Saurischia. Therefore it makes little difference in my estimate of the wider ordinal affinities of the Kraai River fossil whether it is referred to the typical Saurischian *Euskelesaurus* or transferred to the subdivision Phytosauria and named *Erythrosuchus*. It is stated (Phil. Trans. Roy. Soc., 1892, pt. B, p. 346) that "Saurischian Dinosaur reptiles alone among Reptilia approximate towards the Anomodont types in pelvic characters," and I am not aware that these views have been elaborated by any subsequent writer, though I have repeatedly referred to the affinities of the two groups (l.c., p. 366; 1895, pt. B, pp. 41, 112, etc.). H. G. Seeley.

CRETACEOUS AND EOCENE DEPOSITS OFF THE SOUTH-WEST OF THE BRITISH ISLES.

Sir,—The publication of the remarkable papers by Mr. L. R. Crawshay and Mr. R. Hansford Worth, on the rocks dredged from the English Channel since 1906 (Journ. Marine Biol. Assoc., vol. viii, No. 2, May, 1908), marks a very distinct step forward in our knowledge of submarine stratigraphy. It seems of interest to state that the Cretaceous specimens therein recorded and illustrated are paralleled by a considerable series of flints and chalk fragments recently dredged from about 500 fathoms off the Kerry coast by the Fishery Branch of the Department of Agriculture for Ireland. At two points, moreover, *Miliolina*-limestone has been found. This is at once distinguished from the specimens of Cretaceous Chalk by the naked eye, and it affords an unexpected extension of the material described by Mr. R. H. Worth from a dredging off the south of Cornwall. The Irish specimens will be dealt with in a forthcoming memoir of the Geological Survey of Ireland, in which Mr. T. Crook and myself have brought together what we know of the rocks forming the sea-bottom off the coast from Donegal to Kerry. The small part played in this area by ice-borne material agrees with the discoveries of Herr Bøggild off the coast of Greenland. We are now fortunate in having Mr. Worth's work for consultation and guidance, since it not only includes his previously published observations of 1899, but affords a valuable review of all rocks that have been recorded from the English Channel area.

GRENVILLE A. J. COLE.

GEOLOGICAL SURVEY OF IRELAND,
14, HUME STREET, DUBLIN.
June 13*th*, 1908.

OBITUARY.

ALBERT AUGUSTE DE LAPPARENT.

BORN DECEMBER 30, 1839. DIED MAY 5, 1908.

IT is with profound regret that we record the decease of M. de Lapparent, one of the most eminent geologists of France, who since 1875 has been Professor of Geology and Mining in the Catholic Institute at Paris. To geologists in this country he has been, perhaps, most widely known for his excellent "Traité de Géologie," of which the first edition was published in eight parts (1881–83), and the fifth edition in three volumes (1906). It is a work of great labour and research, and gives the best summary we have had of European geology, especially in the portions relating to stratigraphical palæontology.

Of other works, his "Cours de Minéralogie," published in 1884, reached its fourth edition during the present year; and mention should also be made of "Le Globe Terrestre," published in 1899. Interested largely in earth movements and earth sculpture, de Lapparent contributed original articles on these and other subjects to the Bulletin of the Geological Society of France, and he assisted in the preparation of the geological maps of La Manche and other areas.

A suave and fluent speaker, he was in much request at scientific gatherings, and his visits to this country at the time of the International Geological Congress in 1888 and during the recent centenary celebrations will be long remembered by those who had the privilege of listening to his eloquent speeches. He was elected a Foreign Member of the Geological Society of London in 1887.

SIR JOHN EVANS, K.C.B., D.C.L., F.R.S., F.G.S.,

A TRUSTEE OF THE BRITISH MUSEUM.

BORN NOVEMBER 17, 1823. DIED MAY 31, 1908.

WE regret to announce the death of Sir John Evans, the distinguished antiquary and geologist, an account of whose life and labours in the cause of science we published, with a portrait, in the GEOLOGICAL MAGAZINE for January, 1908 (pp. 1–10), together with a list of his writings. For some time past he had been suffering from an internal complaint, which became critical, necessitating an operation. He died on the 31st May in his 85th year. Sir John Evans was from 1864 a constant supporter of the GEOLOGICAL MAGAZINE, to the pages of which he was also a frequent contributor.

CALEB BARLOW.

BORN JULY 7, 1840. DIED MAY 8, 1908.

AMONGST those who in the latter part of the last and the beginning of the present century had been attached to the staff of the Geological Department, no one has left a more indelible record of long and excellent work performed than Caleb Barlow, the able formatore, developer, and modeller of extinct animals in the British Museum. Caleb Barlow, like Hugh Miller, was a mason and the son of a mason. He was born at Alton, Staffordshire, in the country of the New Red Sandstone, the Coal-measures, and the Carboniferous Limestone, where stone-quarrying or stone-cutting is the natural business of a large number of its inhabitants. Doubtless his early acquaintance with organic remains of various kinds in the rocks, as was the case with William Smith, Hugh Miller, and many others, led Barlow to take so great an interest in fossils in his later years.

He spent his youth and early manhood working at various places in Staffordshire and Shropshire, living for a year or two at Shifnal, and coming to London in 1864. Here he was engaged as a mason on several important public buildings, and was intimately associated with Mr. Henry Broadhurst, M.P. (who was also a working mason), and Mr. Richard Hall, afterwards a co-worker with Barlow during twenty-eight years in the Geological Department.

C. Barlow entered the Geological Laboratory on November 16th, 1874, serving for five years at the old British Museum, Bloomsbury, prior to the removal to the new building in Cromwell Road, assisting during 1880 with Dr. Henry Woodward, Mr. William Davies, Mr. R. Etheridge, and Mr. R. B. Newton, in the task of removing the great collection of fossils to Cromwell Road, and with Richard Hall placing all the larger objects in the exhibition galleries ready for the opening in April, 1881.

It was largely due to the skill and knowledge previously acquired in moving of large and heavy stones that the great series of remains of extinct animals were safely and successfully transported to their present home. Some idea may be conceived of the work accomplished between June and October, 1880, when it is stated that the collections when packed furnished upwards of 300 two-horse van loads, the whole being transferred without loss or injury or a single hitch. Years have, of course, been spent since then in developing, mounting, and arranging the vast series of objects now exhibited, many of which have been added to the collection since 1901, under the present energetic and able Keeper, Dr. Arthur Smith Woodward, F.R.S.

Among the long list of specimens prepared by C. Barlow some of the most notable may be enumerated:—Setting up of *Scelidosaurus Harrisoni*, a Dinosaur from the Lias of Charmouth; the development and mounting of *Omosaurus armatus* from the Kimmeridge Clay, Swindon, the skeletons of *Cryptoclidus oxoniensis* from the Oxfordian of Peterborough and the great *Cetiosaurus* from the Leeds Collection, the Bernissart *Iguanodon* from Belgium; the modelling of the great skull of *Phororhachos*, a giant bird from Patagonia; the restoration of the skulls of *Miolania* from Queensland, from Lord Howe Island, and Patagonia; the mounting of the *Glyptodon* and *Mylodon*, and the setting up a new cast of *Megatherium* from South America; the mounting of some six skeletons of *Dinornis* from New Zealand, the Dodo from Mauritius, the *Æpyornis* and pigmy hippopotamus from Madagascar, the *Toxodon* from South America, Steller's 'sea-cow' from Behring Island, the skeletons of the gigantic Irish deer, of *Machairodus* from South America, and *Triceratops prorsus* from North America,—these are but some of the many works performed by Caleb Barlow during his 34 years of service to the Trustees of the British Museum. Mr. Barlow has moreover prepared duplicates of many of the large objects in the Museum to be sent abroad as exchanges, so that his reproductions of skeletons of extinct animals exist in many museums. C. Barlow accompanied Dr. Henry Woodward to Florence Court, Enniskillen, Ireland, and to Tarporley, Cheshire, to pack and bring back to London Lord Enniskillen's great collection of fossil fishes, and that of Sir Philip de Malpas Grey Egerton, also to remove Mr. John E. Lee's collection from Torquay, and in several other similar undertakings.

During his strenuous and active life-work Mr. Barlow yet found leisure to acquire a correct knowledge of music. He had a good tenor voice, and was for some time one of a quartette at a church in Swallow Street, Piccadilly. He then became organist at Hinde Street Wesleyan Chapel, Manchester Square, a post which he held for thirty years. During the past five years he had been the organist at Munster Park Chapel, Fulham.

His son, Frank Oswell Barlow, succeeds to his father's post in the Museum, and gives promise to equal him in skill as a formatore, having studied drawing and modelling at a School of Design, and been already Assistant Formatore in the Department for over eight years. After a short illness, followed by an operation, Mr. Caleb Barlow died on the 8th May, leaving a widow, one son, and a daughter, besides numerous friends—many of whom are men of science—to mourn his loss.—H. W.

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ASSISTED BY

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AUGUST, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. VIII.—AUGUST, 1908.

ORIGINAL ARTICLES.

I.—On the Evidence for Desert Conditions in the British Trias.

By Professor T. G. Bonney, Sc.D., LL.D., F.R.S.

A PAPER by Mr. J. Lomas on "Desert Conditions and the Origin of the British Trias" appeared last year in the Proceedings of the Liverpool Geological Society,[1] and was reprinted, with some slight abridgement, in the November and December numbers of this Magazine. Valuable and suggestive as it is, I venture to think that its author, as is not unfrequent with enthusiastic advocates, is attempting to prove too much. I have more than once expressed my belief[2] that the pebble beds of the Bunter, perhaps also its Upper and Lower Sandstones, were deposited on a lowland by mountain-fed rivers, and think it very probable that this lowland, in consequence of its geographical position, may have been generally arid, and its temperature rather extreme, as is the case in Turkestan and parts of Persia; the occasional wind-worn sands being due to the one cause and the angular breccias to the other.[3] But I think the Keuper Marls, on the whole, aqueous rather than æolian in origin, and the Lower Keuper Sandstones, with the Water-stones, indicative of the gradual setting in of inland sea conditions. From time to time, before the salt lake attained its greatest dimensions, the wind might blow the lowland dust into dunes or carry it away from the shore till much of it settled down beneath the water, but I still think that a large part of the material, which now forms the red marl, was brought down as river mud to this magnified Dead Sea, by the streams which had formerly transported sand and pebbles.[4] In regard to this, however, we cannot at present speak dogmatically. More study is needed of the constituents of the Keuper Marl, of fluviatile, lacustrine, and even marine muds, as well as of the lighter

[1] Proc. Liverpool Geol. Soc., 1906–7, p. 172.

[2] See for instance Quart. Journ. Geol. Soc., vol. lvi (1900), p. 288.

[3] See for a fuller statement Quart. Journ. Geol. Soc., vol. lviii (1902), p. 201. [Also paper on "Wind-worn Pebbles in the British Isles," by F. A. Bather, M.A., F.G.S.: Proc. Geol. Assoc., vol. xvi (1900), pp. 396–420, pl. xi and text-figures (with numerous references to the literature of the subject).—Edit. Geol. Mag.]

[4] See for a general statement of my views Proc. Yorkshire Geol. Soc., vol. xvi (1906), pt. 1, on the origin of the British Trias.

æolian deposits, before we can determine what parts wind and water have respectively taken in making this member of the Trias. Here, however, I may remark that neither Professor Watts nor Mr. Walcot Gibson was the first[1] to observe that in the Charnwood Forest region the Keuper fills up hollows in the older rocks.

This, however, is a small matter, like all questions of priority, so I pass on to the points in regard to which I cannot wholly agree with Mr. Lomas. The following extract from his paper may serve as a summary (p. 196): "The pebble beds of the Midlands, although originally of fluviatile origin, do not exhibit the characteristics of river action. The individual pebbles show no orientation in the arrangement of their longer axes, but are wedged together in a tumbled mass as if they had dropped into their present situations by the removal of material about them. The insecurity of their positions is evidenced by the pitting which has resulted from their successive readjustments. The interspaces between the pebbles are almost free from sand, but lenticular seams of sand occur, which may have been protected from removal by wind, when the pebbles formed a continuous covering. There are places in our own district where it does not appear that concentration took place, and the sand with pebbles marking the situations of temporary streams still persist as originally laid down."

Of these points I will take the pitting first, since it needs only a brief notice. As the depressions, though generally very shallow on hard quartzites, may be almost a quarter of an inch deep, and correspondingly large on mudstones, they must have been rather slowly formed (compare those on the pebbles in the similar but indurated deposits of the Swiss nagelfluhe). Hence I should regard them as more probably indicative of a long and continuous pressure (often associated with solution[2]) than of one successively applied to new parts. Moreover, the readjustments demanded by Mr. Lomas must be brought about by the withdrawal of material from below, for we cannot suppose the impression to have been made during the brief time when the pebbles in any one layer were exposed (in simple contact, without an overlying weight) to the action of the wind. Such withdrawal could perhaps be effected by subterranean water washing away the finer material from some underlying gravel, but, as will be seen, I have found no real evidence that this has actually occurred, and it would give no help to Mr. Lomas' hypothesis.

The other points may best be answered by a brief summary of observations made last December at three places on Cannock Chase in order to verify my recollections of past work,[3] and study some sections in the light of this new interpretation. As my time was necessarily short, I selected three places sufficiently far apart to be fairly representative of the whole district. One was at the top of Style Cop, another near Baland's Pool (by the road from Rugeley to Hednesford), and the third on the Satnall Hills. The first was about

[1] Lomas, *ut supra*, p. 184, cf. 193. See Hill & Bonney, Quart. Journ. Geol. Soc., vol. xxxiii (1877), p. 754. But it was also noticed by earlier writers.

[2] See T. Mellard Reade, Geol. Mag., 1895, p. 341, and Plate XI.

[3] Since 1895 I have but seldom visited this moorland.

$1\frac{3}{4}$ miles from the second and nearly 300 feet vertically above it,[1] and both of them were about five miles from the third. The following is an abstract of my notes:—

(1) Near the top of Style Cop. The pit is on two levels. The face of the upper one, about 7 feet high,[2] showed a mass of pebbles embedded in sand, generally uniform, but with local indications of false-bedding and one or two horizontal streaks of sand. That of the lower pit (practically continuing the other and about the same vertical height) displayed alternating bands of pebbles (the thickest, with an intermittent sand-parting, being about 3 ft. 6 in.) and false-bedded sands with occasional stones. The pebbles throughout range up to about 4 inches in diameter, but the majority are considerably below this. The flatter specimens usually lie with their longer axes horizontal. Commonly there is plenty of interstitial sand, amounting perhaps to one-third of the whole mass, the larger pebbles as a rule not touching one another.

(2) Pits near Baland's Pool: (*a*) Near the Waterworks. Section about 18 feet in height; practically continuous gravel, sand-bands being almost absent: stones varying from small to large, the latter in a few cases exceeding 6 inches in diameter. False-bedding of coarse and fine gravel, or 'pockets,' two or three feet across, of small stones, with little interstitial sand, occur in places, but the latter are quite local, and, except in them, there is plenty of a rather muddy-looking sand between the stones.—(*b*) By the side of the Rugeley and Cannock railway. A cutting, perhaps 200 yards from end to end, and over 40 feet in the highest part, its base being concealed by talus. At the top is a continuous mass of pebbly gravel, about 5 yards thick; beneath it, for about 8 yards, is a gravel similar, but interrupted by sand-bands, sometimes extending horizontally for dozens of yards and attaining a maximum thickness of about 4 feet. There is plenty of sand among the pebbles. The whole mass has a conspicuous 'horizontal' aspect, and very closely resembles some of the old river gravels in the outer zones of the Alps.

(3) Pits on Satnall Hills, northern side of the Rugeley and Stafford road: (*a*) Nevett's pit.[3] Vertical section at highest point more than 30 feet. At the top is a thick bed of gravel, with occasional thin bands of sand. Below that is a well-defined band of the latter (maximum thickness about half a yard). Then come about 5 feet of well-bedded, rather sandy gravel, resting on another sand-band, nearly 2 feet in greatest thickness, and under it about 7 feet of gravel (pebbles as a rule under 3 inches), generally conspicuously false-bedded, but less so in the last foot, after which another thick bed of gravel, with larger pebbles and more or less definitely horizontal

[1] The height of Style Cop is 721 feet (the pit is slightly lower). The road by the Waterworks, a few feet below the second pit, is 418 feet above sea-level. I should estimate the altitude of the Satnall Hills pits to be about the same.

[2] The measurements throughout these notes are only estimates. It would not always have been possible to apply a tape, and as the weather was cold it was not worth risking a chill for the sake of a useless precision.

[3] In this pit my nephew, (now) Lieut. F. G. C. Wetherall, found that fossiliferous pieces of Carboniferous Limestone were less rare than usual.

layers of sand, extends to the pit floor.[1] This is varied occasionally by irregular seams of fine gravel (stones not bigger than a walnut) or by lenticular streaks of sand, not exceeding a few inches in thickness. Ovoid pebbles generally lie with their longest axis horizontal, but in false-bedded parts this follows the dip. Plenty of sand is usually present in the gravel.—(*b*) Pit nearer to the enclosure of Shugborough Park. The beds exposed (probably just underlying those seen in the other pit) afford a section about 18 feet at thickest. It will suffice to say that we find in this a gravel, like that in the other pit, with long thin lenticular beds of sand, horizontally intercalated. Here also the longer axes of the stones are horizontal, sometimes conspicuously so; the whole mass, like that in the other sections, suggesting a fluviatile origin.

Several times, while making the above observations, I examined the sand with a strong lens, and found my recollections to be correct,[2] viz., that, while rounded grains occasionally occur, the majority are more or less angular: hence material, presumably water-borne, dominates considerably over wind-borne. Thus, while I do not deny that the conditions in the British lowlands during Triassic times resembled those of a desert region more nearly than they do at present, I think that the Liverpool district, to which Mr. Lomas's observations refer, must be a rather exceptional one. Unfortunately, my acquaintance with this is slight, but my studies of Triassic deposits, both in Central Staffordshire and in other parts of England, have led me to believe that, even in Keuper times, water played a larger part than wind in their formation.

P.S.—This paper was written early in the year, but as I was leaving England for some weeks in the spring it was kept back, because I wished to add a few words on some pebbles which I had not previously noticed in the Bunter. They occurred in the Style Cop pit and in that near the Waterworks. In each case they were restricted in vertical range, not at all common, the longest diameter generally under two inches, flattish, but fairly well rounded, less than the ordinary weight, damp, soft, and dark-coloured (becoming paler when dry), with an amber-brown streak. At the time I thought they might be a rotten cannel, or at any rate rather rich in some hydrocarbon. On examining under the microscope, after my return to Cambridge, the powder from one of them, I found no traces of organic structure, though some translucent brown particles suggested the presence of a bituminous constituent among the ordinary mud-like material. But Professor Seward, who kindly made a more complete investigation, informed me that he could not detect any traces of plant tissue, and Mr. A. Hutchinson, University Demonstrator in Mineralogy, to whom I am indebted for examining a fragment during my absence, writes: "It does not contain carbon, but appears rather to have resulted from the oxidation of some metallic ore. In the main it consists of hydrated iron oxide together with a certain amount

[1] A few of the largest stones even exceed 6 inches in diameter.

[2] See Quart. Journ. Geol. Soc., vol. lvi (1900), p. 288; Proc. Liverpool Geol. Soc., 1901–2, pp. 230–233.

of silica and a fair quantity of oxide of manganese. I have not found any certain indication of arsenic, but small quantities of antimony are present, and I have detected a trace of copper." Possibly, then, these pebbles may have been derived from the 'blackband' (beds impregnated with iron-carbonate) of the Coal-measures, much of the metal having been removed and the rest altered to limonite by the action of water.

II.—The Red Zone in the Basaltic Series of the County of Antrim.

By Grenville A. J. Cole, F.G.S., Director of the Geological Survey of Ireland.

One of the most beautiful features at the Giants' Causeway, from an artistic as well as a geological point of view, is the broad red zone that divides the Lower from the Upper Basalts. As is well known, this zone of lithomarge, bole, and laterite is remarkably persistent in north-eastern Ireland, and represents an interval of Eocene time when volcanic activity was lessened and when the basalts ceased to appear at the surface. At the same time, however, sporadic eruptions of rhyolite occurred, and some of the cones of acid lava supplied material for an interbasaltic conglomerate of rhyolite pebbles, which was discovered several years ago by Mr. A. McHenry near Glenarm.[1]

The occurrence of leaf-beds, lignites, pisolitic iron-ores, and pale bauxitic muds on this horizon has led to the prevalent opinion that the whole red zone and the associated rocks of lighter colour are of detrital origin. Portlock[2] seems to have laid the foundation for this view in 1843, when he regarded the amygdaloidal basalt as an alteration-product derived from a compacter form, and suggested that some of the amygdaloids were poured out "rather in the state of volcanic mud than of lava." But at the same time he regarded the bole as resulting from the induration of amygdaloids that "have been decomposed on the surface," and pointed out the intimate association of the hard and soft rocks in the uppermost portion of the Lower Basalts.

From Portlock's time onward, the tendency has been to emphasise the appearances of stratification and fragmental structure along this zone; and John Kelly,[3] in 1869, in his remarkable paper on the geology of Antrim, refers to the deposits as "volcanic ashes thrown up in the eruption, and disseminated in the water, making literally a red sea." On the other hand, Messrs. Tate and Holden,[4] almost in the same year, maintained that the lithomarge and bole are but decomposed basalts, and traced the passage from unaltered blocks into the soft rock round about them. They held that the basalt was poured out under water, and rotted there, so as to produce the red zone, and went so far as to

[1] See Sir A. Geikie, Anniversary Address, Quart. Journ. Geol. Soc. London, vol. xlviii (1892), Proc., p. 168; and McHenry, Geol. Mag., 1895, p. 260.

[2] "Report on Geology of Londonderry, etc.," Dublin, 1843, pp. 145–6.

[3] "On the Geology of the County of Antrim, with parts of the adjacent Counties," Proc. R. Irish Acad., vol. x, p. 307.

[4] "On the Iron-ores associated with the Basalts of the North-East of Ireland," Quart. Journ. Geol. Soc. Lond., vol. xxvi (1870), pp. 155 and 158.

urge that the pisolitic layer was produced by contact-action proceeding from the subsequent Upper Basalts. This suggestion may have affected the reception accorded to their views on the decomposition of basalt *in situ*; and the larger ovoid blocks of basalt embedded in the lithomarge came to be treated as "bombs of rounded and exfoliating basalt,"[1] while the series generally was spoken of[2] as "beds of tuff or ash, together with bole, lithomarge, and pisolitic iron ore, which always occur below the Upper Basalt." Much of this material was believed to have accumulated in lakes.[3]

The appearance of bedding in the 'pavement'—a name for the variegated ferruginous rock underlying the rich pisolitic ore—is certainly clear, and seems highly conclusive in hand-specimens. But successive visits to the famous sections at the Giants' Causeway, which are now rendered so accessible by the railed and carefully constructed path, have convinced me that there, at any rate, tuffs and ashes played no part in the red zone. The neighbourhood of true ash and tuff, splendidly displayed at Carrick-a-rede, served to prevent hasty generalisation; and I confess I was hardly prepared, when arranging for a general examination of the interbasaltic beds by the staff of the Geological Survey of Ireland, for the way in which section after section declined to show us more than is revealed along the cliff-path at the Giants' Causeway.

In that typical locality every kind of 'red rock' that is found in what has been claimed as a stratified interbasaltic series occurs in intimate association with unmistakable basaltic lava. Red bole, without a trace of original structure, is found in, and not merely on the surface of, the basalt. At times this bole is pisolitic, showing that the structure most readily conceded to be of lacustrine origin may also arise by concretion in a decomposing mass. The jointing of the basalt is continuous with that of the overlying jointed lithomarge, and the 'onion structure' between the main joints of the latter is clearly a relic of that which arose from contraction in the basalt. This onion structure occurs in very fresh basalt near Carrick-a-rede, and is evidently only emphasised, and not originated, by decomposition. The lithomarge, of strange purple-grey and violet tints, now and then retains pseudomorphs of the felspars of the original basalt, and consequently traces of the mesh-structure of the basaltic ground. Unreddened iron-ores remain as black specks; but this type of rock passes into one recognisable only in the field as the product of decay of basalt. The great 'bombs' of residual lava are surrounded by zones of red and brown and orange, which are the same as those that stripe the lithomarge and 'pavement,' and thus give it an appearance of lamination. At the Causeway such colour-bands run in various directions, and often a concentric group of them alone represents the site of a 'bomb' that has completely decomposed.

The alleged 'bombs' can be nothing else than unweathered cores of basalt, in a zone of deep lateritic decomposition, which spread

[1] Mem. Geol. Surv. to Sheet 14 (1886), pp. 20 and 22. Cf. Sir A. Geikie, "Ancient Volcanoes of Great Britain," 1897, vol. ii, p. 204.

[2] Mem. Geol. Surv. to Sheets 7 and 8.

[3] Ibid. to Sheets 21, 28, and 29, p. 29.

downwards from the surface of the flow. Every stage can be traced, from tough dark ovoid masses to those that have left a crumbling greenish residue, or have vanished altogether in a sort of sunset glory of brilliant stripes and bars. If anyone, after a careful visit to the Causeway area, remains unconvinced of this, an inspection of the shore at Brown's Bay, Islandmagee, a locality probably well known to Messrs. Tate and Holden, will assure him of the correctness of the views of those authors, so far as the general origin of the red zone is concerned.

The whole matter of basaltic decomposition has, of course, received new elucidation in the last few years from the studies on the production of laterite in tropical climates, which have been published in the Geological Magazine and elsewhere. Basalt, like almost any rock containing salts of iron, will, under tropical conditions, rot downwards from an ordinary terrestrial surface, giving rise to red aluminous iron-ores. Seasonal rainfall doubtless helps this action; but it naturally goes on subaerially, and not, as Messrs. Tate and Holden suggested, under cover of permeating waters. There is now no difficulty in realising the formation in Eocene times of ten or forty feet or more of red material, rich in iron and alumina and relatively poor in silica, during the resting-stage in the volcanic activity of our islands. The comparatively thin layers of pisolitic iron-ore on the surface of the red zone may be conceived as formed from time to time in pools that gathered during the rainy seasons. The evidence for the existence of a warm climate in the Eocene period over the area of the British Isles is considerably strengthened by the presence of the red zone in Northern Ireland.

In 1895[1] I suggested that the pale bauxites of the county of Antrim were derived from rhyolitic material. They appear typically above the pisolitic iron-ore, thus effectually disposing of the idea that the concretionary structure in the latter is due to metamorphism by the Upper Basalt. John Kelly[2] acutely noted "clear quartz crystals . . . with double pyramids complete" in the red zone at the Bull's Eye Waterfall, some miles south of Glenarm. Mr. A. McHenry has now (1908) observed these crystals and other quartz fragments, which are clearly detrital, over a wide area between Glenarm and Straid Hill; they sometimes occur in a reddened bed, sometimes in typical pale bauxite. The recent work of the Geological Survey tends strongly to connect the pale bauxites with the decay of local rhyolite of the Tardree type; and in many places we have to conceive the formation of a sandy deposit, blown from crumbling rhyolitic surfaces, and spread out as a comparatively thin layer over the lateritic Lower Basalt. The parallel between this deposit and the sands accumulated by wind on the surface of the basalts in the bush-land of the Central Zambesi is one that appeals to the geologist, as affording a picture of our own area in early Cainozoic times.

The present paper, urging that the red zone was essentially formed

[1] "The Rhyolites of the County of Antrim; with a note on Bauxite," Trans. R. Dublin Soc., vol. vi, p. 108.

[2] Op. cit., Proc. R. I. Acad., vol. x (1869), p. 303.

by the decay of solid basalt *in sitû*, and that the so-called 'volcanic bombs' in reality afford the best evidence of this decay, is, after all, but an echo from the thunders of the old Neptunist controversy. Long before Messrs. Tate and Holden wrote, the Rev. Dr. W. Richardson, a determined opponent of the Vulcanists, stated, in a memoir sent to the Royal Society of Edinburgh, that the red strata had "been once pure basalt." This memoir does not seem to have been published, but the argument is emphasised in a paper printed in 1803 [1] and in several subsequent publications. The most important of these is Richardson's "Letter on Zeolite and Ochre," [2] in which he rightly denies that the ochres are "*pozzolana* or *tufo*," and quotes St. Fond in support of his opinion. On p. 14 he says, "we find this ochreous substance in its natural situation in every intermediate stage between sound blue basalt and ochre red as minium; and we see that the passage from one extreme to the other is by shades perfectly insensible." He does not like to say whether the change into ochre, the cause of which he does not specify, has now come to an end or is still in progress.

Berger and Conybeare [3] describe the bole as occurring in beds, but do not commit themselves as to its mode of origin. It is fairly clear that Richardson's uncompromising opposition to Hutton's theory of terrestrial changes, and his denial of the existence of ash-beds in association with true basalts, led to the rejection of his views on the relations of the red zone of North-East Ireland. These views, however, prove to be far better founded than those maintained a century later by the successors of the Vulcanist school.

III.—A remarkable instance of Rock Differentiation.

By Harford J. Lowe, F.G.S.

(PLATE XIII.)

Upon Sheet 339 (Devonshire) of the new Geological Survey maps, one instance out of the very numerous outcrops of igneous rocks thereon indicated proves to be of unusual interest by reason of its peculiar constitutional modifications in different parts of the same mass. The rock in question occurs about four and a quarter miles 15° north of west from Newton Abbot, near to the hamlet of Bickington, within the limits of a farm named Lurcombe. It is an intrusive amidst the shales and grits of the Culm, occurring almost on the junction-line between that series and the Devonian, whose massive limestones and volcanics dominate it in elevation within a quarter of a mile on the south-east.

[1] "Inquiry into the consistency of Dr. Hutton's theory, etc.," Trans. R. Irish Acad., vol. ix (1803), p. 458. See also "On the alterations . . . in the Structure of Rocks, on the surface of the basaltic Country in the counties of Derry and Antrim," Phil. Trans. Roy. Soc. (1808), pp. 195 and 200.

[2] Appendix I, p. 11, in Dubourdieu, "Statistical Survey of the County of Antrim," Dublin, 1812.

[3] "On the Geological Features of the North-Eastern Counties of Ireland," Trans. Geol. Soc. London, vol. iii (1816), p. 186.

A small stream with south-east course has cut a narrow valley through the softer Culm material contiguous to the igneous rock on the west, and sweeping round the mass to form nearly a right angle continues its course in a north-east direction into the Bovey depression. Thus the igneous mass is cut out of its enveloping sedimentaries on both the west and south sides, presenting precipitous slopes in those directions. The top and slopes of the rock are grass-covered, but at the shoulder two or three bare masses protrude through the sward, and a small quarry has been worked in it at a lower elevation to get road-metal for the farm tracks.

The position being near to the edge of the Bovey basin the rocks decline eastward, dipping towards and beneath the Bovey deposits, so that the intrusive, taking the inclination of the invaded strata, becomes immediately buried therein in that direction. In a hollow or combe, however, of the adjoining farm called Stancombe, an adit has been driven in connection with some unsuccessful mineral researches, and among the débris some pieces of a similar igneous rock occur showing that the intrusive had been reached in the excavation and is continuous in that direction. The declivity at the bend of the stream measures some 120 to 140 feet in vertical height, which would also appear to indicate the thickness of the intrusive rock.

The first specimens of the rock obtained were not found *in sitû*, but from masses used to support a hedge bank along the shoulder of the hill in the usual Devonshire way. Some of these blocks showed a nodular structure, were much weathered, and required considerable labour to obtain a piece sufficiently fresh to be of service for microscopical examination. Regarded as another variety of the diabase so common in the neighbourhood, a surprise was in store, when from a number of sections obtained one proved to be entirely different from any of the others. This section from the Lurcombe specimen contained no augite, but in place of it original brown hornblende. My surprise and interest led me to trouble Dr. Teall in respect to my interpretation of the rock as having the composition of a camptonite, which he kindly confirmed. Several subsequent visits have led to the discovery that the rock is of still further interest by giving examples in micro-sections of not only hornblende as the ferro-magnesian mineral, but of both hornblende and augite in idiomorphic form; of augite predominating with hornblende as a growth upon it; and another variation with augite alone having the ophitic habit. These peculiar variations in constitution in the same igneous mass are sufficiently remarkable to receive special notice, if indeed they do not characterize it as a unique instance of differentiation in mass without any evidence of dynamic deformation.

The sections described in the following detail occur in descending order from the higher to the lower elevation of the rock-mass as they could be obtained *in sitû*, and represent the varying constitution from the upper to the lowest parts of the intrusion as near as can be ascertained. They are classed as I, II, III, and IV, to distinguish the grades of (i) hornblende alone, (ii) hornblende and augite, (iii) augite predominant, and (iv) augite alone.

Grade I is a coarsely grained rock, weathering a rusty brown, with long dull reddish-brown crystals, some attaining a length of 15 mm. Fresher rock in hand-specimen is of greyish-blue colour. A micro-section displays hornblende and felspar as the chief constituents of the rock, with iron-ores and apatite as accessories. The secondary minerals comprise chlorite, calcite, mica, and leucoxene. The hornblende is of a rich brown colour, and is in well-developed crystals of varying sizes, showing crystal faces and cleavages very perfectly. Constitutionally, however, the hornblende has much suffered by decay. The crystals are frequently traced with chlorite, and are met with in all stages of chlorite transformation, even to a complete paramorph of the secondary mineral, with the original crystal outlines remaining perfect. The pleochroism of the hornblende is very pronounced from a very pale brown to a rich red brown, with birefringence colours ranging from bright yellow, golden brown, to a greenish-red lustre in moderately thick sections. Twinning is seen occasionally in the better preserved crystals.

The felspar presents anomalistic relations. Some appears in irregular plates with very indefinite boundaries; part in lath shapes, in sheaf or fan arrangement, with still smaller forms in curved and feathery microliths. The lath-shaped felspars are frequently attached in an irregular way to the phenocrysts, giving them an appearance of frayed out edges, not always in crystalline continuity. They sometimes, however, occur in sheaves or single laths in spaces filled with a groundmass material, which is nearly isotropic. This interstitial matter is mainly resolved by higher power into minutely crystalline material, probably of a felspathic nature, amidst which the curved and feathery shapes are intermediate in size to the laths. Here also occur occasional small imperfect hornblendes, partially decomposed coloured mica flakes, as well as chlorite and calcite granules. The larger felspar plates which frequently enclose the hornblende are much altered, the secondary product therefrom appearing as brilliantly polarizing flecks of colourless mica. These being formed along the cleavage planes, their consequent parallelism permits series to extinguish together. Occasionally a cleavage trace may be seen in these larger felspars, indicating simple twinning, but the evidence of polysynthetic albite twinning is too rare and faint to deem it a habit in the development of these phenocrysts. Marginal differences, noticeable in the partial extinction, declare zonal variation in original constitution. The extinction obtainable in the larger felspars is most often within very small angular distance of available lines of measurement, occasionally identical therewith; while in the laths extinction takes place almost invariably with the cross line parallel to the long axis of the crystal. These indications correspond to those of a plagioclase of varying constitution, related to the acid end of the series, oligoclase and andesine, the lath crystals being probably of a more acid character than the larger felspars.

Of secondary minerals, chlorite is the most abundant in its common form of strings of fan-like concretions, and calcite is common in both compact and granular condition. Pyrites is sometimes present, though rare, and ilmenite is a sparingly common accessory, often assuming the semi-translucent condition, indicating its change to leucoxene.

Apatite in long prisms of varying stoutness is sometimes abundant, in other instances rare. The constitution of this variety of the Lurcombe rock-mass corresponds with that called camptonite (Rosenbusch) or hornblende lamprophyre (Harker).

The varieties of the rock classed as grades II and III are those in which augite is associated with the hornblende. In grade II both these minerals are found in idiomorphic form, sometimes in about equal proportions, though in most instances obtained the augite predominates, and these merge into grade III, where very little hornblende is met with, and that almost entirely attached peripherally to the augite, a way in which it also occurs in grade II.

In these varieties the hornblende is exactly similar to that of grade I, though not in such well-developed crystals, and varies in relative quantity to the augite from a slightly preponderating proportion to insignificant attachments to the augite, with occasional patches contained within the augite crystals. The augite is in well-formed idiomorphic crystals giving varying flesh tints with rotation, and brilliant double-refringence colours, showing occasionally hour-glass structure and other zonal markings. Twinning also occurs. This mineral is in a better state of preservation generally than the hornblende, though chloritization has frequently taken place in patches and lines within the crystals, with the usual accompaniment of calcite, its related decomposition product.

The felspar diminishes in relative amounts with the increase and predominance of the augite. It however maintains the characteristics already described, there being still platy, lath-shaped, and minute curved forms; the larger irregularly shaped plates are much micaized and occasionally have partial surroundings of fresher material and of more acid constitution. In these two grades of the rock a difference is noticeable frequently, in the feebly translucent interstitial material before mentioned. Clear spaces are to be seen containing an almost isotropic mineral, detected by faint lines of cleavage in the shadowy illumination got by rotation. This additional secondary mineral was doubtfully considered to be analcite, but by Dr. Flett's kindly assistance a certainty in the matter has been established. In no instance has the analcite definite boundaries, but it merges into the surrounding material, the apparent bye-products of its formation. Calcite is always associated with the analcite bordering and veining it, and chlorite is occasionally seen partially surrounding it. There is also an instance of analcite with its usual border and veins of calcite grains occurring within an augite crystal.

Besides the mica which mosaics the felspar plates some small crystals of a coloured variety are occasionally seen in the interstitial material. The accessories are the same as noted in grade I. These varieties of the rock-mass, distinguished as grades II and III, thus have a mineral constitution to which petrographical nomenclature has ascribed the term Teschenites.

The Lurcombe mass presents still another variation, which follows the direction of differentiation indicated by those already described. This variety, distinguished as grade IV, contains no hornblende, the only original ferro-magnesian being augite, which assumes a sub-ophitic relation towards the larger felspars. In this instance the augite does not appear in idiomorphic form, but is seen in plates with irregular boundaries surrounding and enclosing some of the felspar; while the opposite change has taken place in the felspar, it occurring in crystal form, though of only small dimensions. In this grade the interstitial matter is mainly analcite with calcite and chlorite, the two latter secondary products occurring also in the decomposing augite. In this section analcite is seen enclosing lath felspars, and some glassy clear grains, with apparent cleavage traces, may be secondary felspar. Ilmenite and apatite continue as accessories.

Grade IV is thus an instance of a rock, with the original composition of a dolerite, that has undergone the changes which constitute it a diabase, except for the presence of the mineral analcite. This additional mineral presumably will necessitate the variety being given either a specific name or a differentiating prenomen such as analcite-diabase or augite-teschenite.

Pieces of the same intrusive obtained from the output of the mining operations on Stancombe farm show a rock more altered than any from the Lurcombe exposure. This might be expected, as the fact of a metalliferous vein being sought for there arose from alterations in the appearance of the surface material, due doubtless to some local changes or disturbances that were misinterpreted by the miners. A hand-specimen of the igneous rock obtained from the mining débris shows long grey crystals and spots of white in a dark-grey base. Sections present neither hornblende nor augite. Both have entirely disappeared and their places taken by paramorphs of an opaque fibrous mineral threaded occasionally with chlorite. Chlorite and calcite occur in other parts of the sections, as well as fairly well-formed plates of a coloured mica, occurring sporadically, and most frequently not fresh but considerably chloritized. The felspars are in much the same condition as before described, and analcite has been detected in only one section. The accessories ilmenite and apatite do not appear to have suffered any change.

Considering the varieties of rock described above as the products of the same mass and of a single intrusion, the association of such differences is so unusual that no general or current explanation of rock differentiation seems to apply in this instance. As far as my acquaintance with the literature of igneous rocks extends, I am aware of no similar or analogous case, and in endeavouring to find a solution for what appears an extremely rare, if not unique, occurrence, I can suggest no explanation which seems to so fully and simply account for the facts as by considering the variations due to a differentiation of magmatic constitution by gravitation. It has been remarked that there is no evidence in hand-specimen or section of dynamic deformation within any part of the mass, and though not far from the granite it is outside the marginal area influenced thereby. The camptonite variety occurs at the top or upper side of the intrusion, and the evidence points to the decrease and even disappearance of the hornblende as the lower part of the mass is reached. This suggests the following explanation:—Assume a homogeneous magma to be intruded between horizontal strata. It is so constituted that the first important mineral to crystallize out is augite. This would take place earliest in the upper part of the magma, which would presumably be the region first reduced to crystallizing condition. The augite crystals thus generated, having a specific gravity higher than their liquid matrix, would sink therein until the consistency of the matrix prevented further gravitational progress. Such movement taking place would render a zone in the upper part of the magma free of augite, and cause some slight upward flow of the more liquid matrix. This augite-free area would contain eutectic material differing somewhat in constitution to that from which the augite arose, and it may be inferred from the circumstances that the differentiation was such as to superinduce the formation of hornblende during the final stages of consolidation. Such possibilities being granted, it is obvious that less favourable conditions for the formation of hornblende would prevail deeper in the mass, and its mode of occurrence there as well as absence in the lowest parts is consistent with the above hypothesis.

In seeking for accounts of rocks similar to those under consideration, in order to make comparisons therewith, I have been particularly interested in a description by Messrs. R. Campbell, M.A., B.Sc., and Andrew G. Stenhouse, F.G.S., of the "Geology of Inchcolm."[1] On this island there is a sill composed of picrite and teschenites, the latter forming the upper and lower portions of the sill. There, as at Lurcombe, the teschenite varies considerably in respect to the relative quantities of hornblende and augite appearing together, and the varieties are distinguished as augite or hornblende types as either mineral may predominate. The hornblende type preponderates on the upper side of the sill, and the augite type, the hornblende occurring with it, on the lower side. Their mode of occurrence in relation to the picrite is that of 'merging' as well as that of 'banding.' There is "a well-developed 'rolling over' of hornblende teschenite and augite teschenite along with the picrite—which, in a remarkable way, is suggestive of flow structure," as explained by Mr. Harker for the Skye peridotites, a "result of fluxion in a magma which was heterogeneous at the time of intrusion."[2] A similar suggestion has been made to account for the remarkable acid and basic banding in the 'granulitic' of the Lizard area.[3] But there can be no question of the small Lurcombe mass being other than a single flow of a homogeneous magma differentiated *in sitú*. The teschenites of Inchcolm merge into each other in respect to the relative amounts of augite and hornblende, but there do not appear to be any portions of that rock quite free from either augite or hornblende.

The analcite of the Inchcolm teschenites is a prominent feature, occurring apparently in larger quantity relative to mass and crystal development than is found in the rock described above. It is considered by the authors to be an original mineral. I have regarded the analcite of the Lurcombe rock, which is quite subordinate in quantity, as a secondary mineral. This has been suggested by its non-appearance

[1] Transactions of Edinburgh Geol. Soc., vol. ix, pt. 2, 1908.

[2] Tertiary Igneous Rocks of Skye: Mem. Geol. Survey, p. 75, p. 123, 1904, and op. cit.

[3] Transactions of Royal Geol. Soc. of Cornwall, vol. xii, pt. 6, p. 440, 1900.

in the camptonite variety, and by its only occasionally occurring in place of the so-called interstitial material of grades II and III, as though only a partial change of that material into analcite had taken place. It is considered to be a derivative from felspathic matter as represented by Van Hise, though all the appearances do not accord with that supposition; for lath felspars can be detected buried in the analcite substance, and one instance is met with of analcite occurring within a crystal of augite. It is interesting to note, in reference to the relation of the analcite to the mass, that in the Inchcolm teschenites it is described as "filling up the spaces between the other minerals as if it were playing the part of groundmass."[1]

It is an interesting coincidence to find that both the Inchcolm and Lurcombe intrusions, which appear to be nearly related in constitution, should also belong to the same geologic age, the Culm being of early Carboniferous formation. Now if it could be shown that the analcite of the Lurcombe mass is an original mineral, it would give to the whole series of rock variations another bond of relationship. They would then be considered as gradations in teschenite types and composition. The camptonite variety could be regarded, unless disproved by analysis, as a purely hornblende teschenite with material of analcite constitution, but of imperfect crystalline development, the same material showing better crystal form in the true teschenites of grades II and III, and appearing in still better condition in the purely augite variety of grade IV. If, however, such a probable relationship between the varieties was determined, the remarkable sequence of changes and perfect gradations met with in the rock-mass would demand some such hypothesis as gravitational differentiation to account for its exceptional condition.

EXPLANATION OF PLATE XIII.

FIG. 1.—Grade I. Parts of three hornblende crystals on N.E., S., and S.W. borders. Lath and micro-felspars in intervening cloudy groundmass. The light patch on N.N.E. border is a portion of a felspar plate which partly encloses the larger hornblende-needles of apatite and a black spot of pyrites S.E. × 25 diameters.

,, 2.—Grade II. Hornblende idiomorphic and attached to augite. Groundmass of felspars, chlorite, and grains of calcite. Hornblende in dark shade. In top right-hand quarter augite bordered and terminated by hornblende. Light spots in crystals chlorite. Black pointed patch S.S.W. edge ilmenite. × 25 diameters.

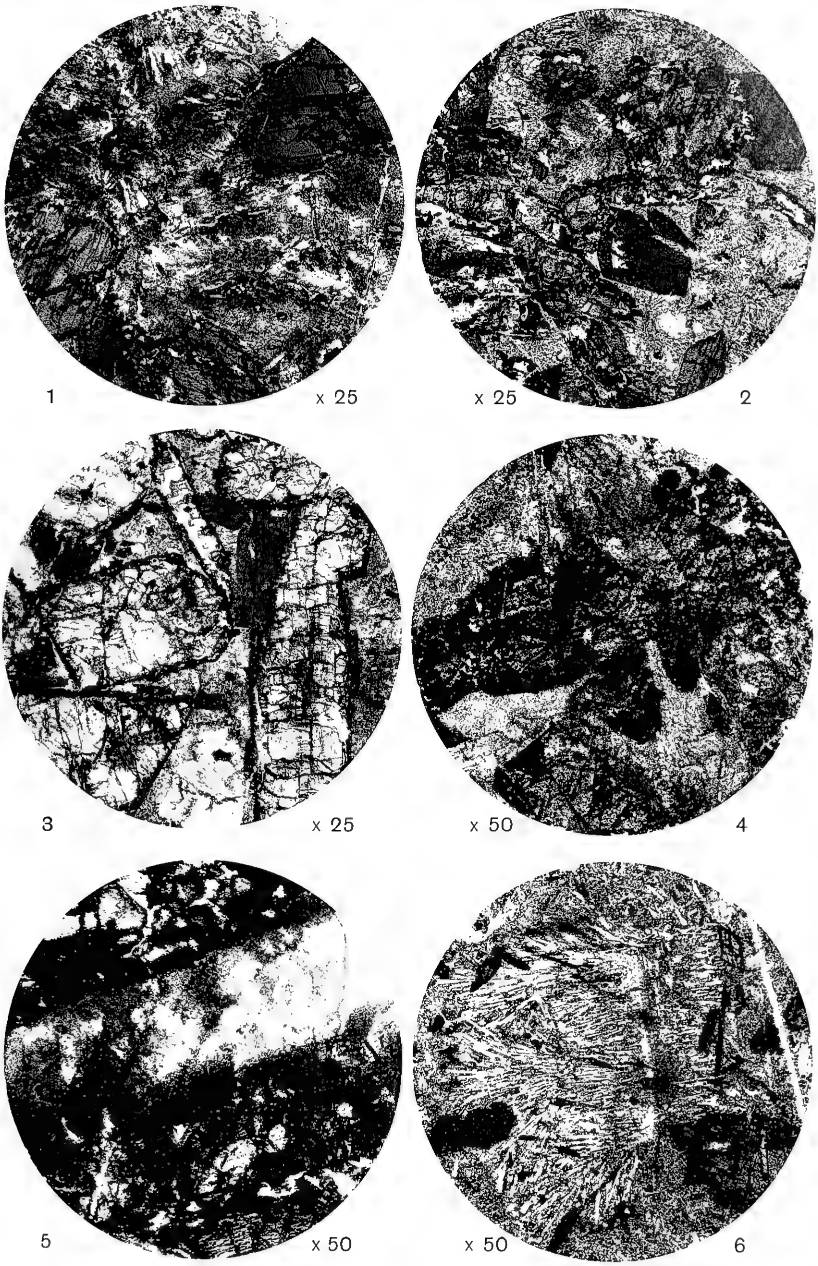
,, 3.—Grade III. Augite with interstitial and peripheral hornblende. H. in dark shade. Light patch at bottom chlorite, with calcite immediately above it. × 25 diameters.

,, 4.—Grade IV. Augite (in dark shade) ophitic to felspars. Clearest spots chlorite. × 50 diameters.

,, 5.—Analcite in a crystal of augite. The bar of white is analcite bordered and veined by calcite grains. The augite is much decomposed into calcite and chlorite, giving dark shades. The lightest patches are fresh augite. A part of a fringe of hornblende is seen at the bottom of the figure where the boundary of the crystal is nearly reached. × 50 diameters.

,, 6.—Felspar in sheaves of laths or skeleton form. All of dark shade is brown hornblende. Lightest patches calcite. Some of groundmass chlorite. A long needle of apatite to right. × 50 diameters.

[1] Op. cit., p. 127.



Bemrose, Collo., Derby.

ROCK SECTIONS FROM LURCOMBE, NEAR BICKINGTON, NEWTON ABBOT, DEVON.

IV.—On a New Species of *Pollicipes* from the Inferior Oolite of the Cotteswold Hills.

By L. Richardson, F.G.S.

FOUR species of *Pollicipes* have been recorded from the Rhætic and Lower Jurassic Rocks of Great Britain.

1.—*Pollicipes rhæticus*, Moore. *Pteria - contorta* - Zone, Rhætic [Rhætian]. Hapsford Mills, Vallis Vale, near Frome, Somerset. Quart. Journ. Geol. Soc., vol. xvii (1861), p. 512, and pl. xvi, fig. 30.

2.—*Pollicipes rhomboidalis*, Moore. "Lias [Hettangian] at Ewenny and at Langan, Glamorganshire." The type-specimen came from the Sutton Stone [Hettangian] of Shepton Mallet, Somerset. Quart. Journ. Geol. Soc., vol. xxii (1867), p. 539, and pl. xvi, fig. 31.

3.—*Pollicipes alatus*, Tate. "Zone of *A. angulatus*," Lower Lias [Hettangian]. Island Magee, Antrim. Trans. Belfast Nat. F.C. (1870), p. 23, and pl. i, fig. 6.

4.—*Pollicipes ooliticus*, J. Buckman. Stonesfield Slate, Great Oolite [Bathonian]. Eyeford, near Cheltenham. "Outline of the Geology of the Neighbourhood of Cheltenham," by Sir R. I. Murchison, 2nd ed., by H. E. Strickland and James Buckman (1844, Cheltenham; 1845, London), p. 95, and pl. iii, fig. 7.

A fifth species has now to be added:

5.—*Pollicipes aalensis*, L. Richardson, sp. nov. Lower Limestone, Inferior Oolite (Aalenian). Well House, Haresfield Hill, near Gloucester.

The specimen was found by Miss H. M. Hutton, of Harescombe, in a small section near the Well House on the northern slope of Haresfield Hill, whence she has also procured a large number of specimens of a pentacrinite.

Examples of the plates of the capitula of *Pollicipes* are none too common in the Rhætic, Lower Lias, or Inferior Oolite rocks of Great Britain. Charles Moore has recorded that they are not infrequent in a clay-bed of Rhætic age, which rests unconformably upon the Carboniferous Limestone at the Hapsford-Mills section in Vallis Vale, near Frome, but that is the only locality I know of in these Isles where they have been found in the Rhætic.

Charles Moore has also obtained specimens of a species, which he called *Pollicipes rhomboidalis*, from the Lias of Glamorganshire and from the equivalent beds near Shepton Mallet.

Ralph Tate obtained another species from beds of about the same date (Hettangian) at the Island Magee, and named it *Pollicipes alatus*. I have found several examples of plates belonging to a species inseparable from this one in the Lias of *oxynoti-armati* hemeræ that was exposed when excavations were being made for a new gas-holder at the Gloucester Gas Works.

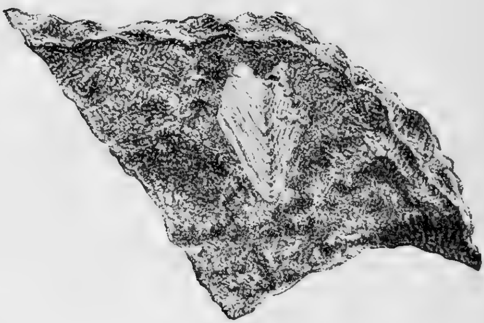
To represent the Inferior Oolite form there is only the portion of the tergum described below; but it is very distinctive, and leaves no room for doubt about its zoologic relations.

In the Stonesfield State of Eyeford, near Cheltenham, and Stonesfield, near Blenheim, the plates of *Pollicipes ooliticus*, scuta, terga, and carinæ—particularly the scuta—are relatively quite common, and are to be found in most local collections that were made from forty to sixty years ago.

The Stonesfield Slate has been worked principally at three localities—Stonesfield, Eyeford, and Sevenhampton Common, near Cheltenham. At Stonesfield there is now (1908) but one pit in work, and only two men engaged in making the slates that were formerly in such demand. At Eyeford the industry is still carried on, not so actively as previously, but the industry has not decayed to the same extent as at Stonesfield. At Sevenhampton Common all the pits are closed down, but one—in a field at the south-eastern end of the common—was open until the last two years.

SUBCLASS EUCRUSTACEA.
SUPER-ORDER CIRRIPEDIA.
ORDER THORACICA.
FAMILY LEPADIDÆ.

POLLICIPES AALENSIS, Richardson, sp. nov. (Figure.)



Pollicipes aalensis, Richardson, sp. nov.

Type-locality.—Well House, Haresfield Hill, near Gloucester.

Horizon.—Lower Limestone: Aalenian.

Hemera.—*Murchisonæ.*

Collection.—Miss H. M. Hutton, Harescombe, near Stroud.

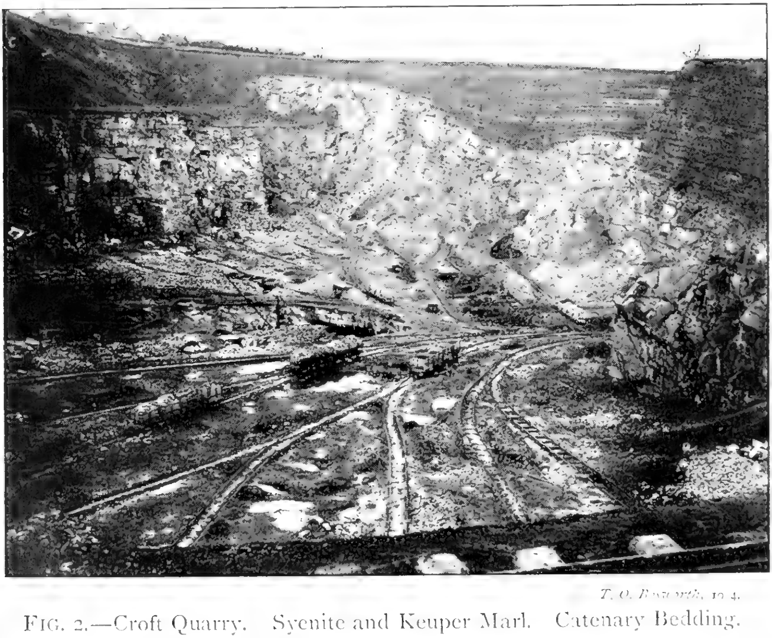
Description.—The material available is the lower portion of the tergum, of which the lower carinal margin is slightly crushed.

Plate rhomboidal, slightly convex, with a central obtuse carina running the whole extent of the portion preserved. The occludent and upper carinal margins would probably have been found to stand, had the specimen been better preserved, at right angles to each other, and to have been shorter than the scutal and lower carinal margins.

The surface ornamentation consists of a number of well-marked lines of growth, which form an acute angle with the carina and cross it, giving it a nodulous appearance. These growth-lines are traversed by fine longitudinal lineæ, which may have been formed by the so-called epidermis.

T. O. Bosworth, 1905.

FIG. 1.—A curiously fretted rock buried in Keuper Marl. Croft Quarry.



T. O. Bosworth, 1904.

FIG. 2.—Croft Quarry. Syenite and Keuper Marl. Catenary Bedding.

V.—The Origin of the Upper Keuper of Leicestershire.[1]

By T. O. Bosworth, B.A., B.Sc., F.G.S.

(PLATES XV AND XVI.)

THE following observations on the Upper Keuper are mainly from the Charnwood district, wherein the relations of the Keuper to the older rock beneath are easily studied. The observations are arranged under three heads.

1. *Condition of the Rocks beneath the Keuper.*—For the purpose of contrast the extensive weathering produced by our present moist climate may be first mentioned. This is well seen at Mountsorrel in the section on the east side of the main quarry. Here the granite has been denuded of its Keuper covering and has been exposed to the existing climate. It is disintegrated down to several feet below the surface, and is weathered to a considerable depth. Another good example may be seen at Huncote Quarry, where the South Leicestershire granite is so decomposed that the sand-martins nest in it. Spheroidal weathering occurs here. At Enderby also the Keuper has been removed by denudation, and spheroidal weathering is seen to a depth of 50 feet.

The Coal-measure climate also had a destructive action on these rocks. I know of no section showing Coal-measures deposited on Charnian rocks, but in 1904 I was able to watch boring operations near Peckleton in search of coal. Beneath the Coal-measures, at a depth of some 200 yards, syenite of South Leicestershire type was reached. About 45 feet of this were pierced, all of which was intensely weathered, resembling the South Leicestershire rocks where exposed to this climate.

In marked contrast is the condition of these rocks where they are overlain by Keuper. Everywhere beneath the marl the Charnian rocks are in sound condition right up to the very surface and often indistinguishable from the best stone at the bottom of the quarries. Indeed, the best stone is usually quarried from beneath the Keuper, and older workings in the surface rocks have been abandoned. From what I have seen in the Mendips and South Wales I believe the same surface freshness occurs in the Carboniferous rocks under the Keuper. This remarkable freshness suggests that, while the Charnian Hills were being buried by the Keuper deposits, a desert climate prevailed.

2. *The Surface Features of the Rock beneath the Keuper.*—It has been shown by Professor Watts that the subaerial features of the buried Charnian Hills are very perfectly preserved, with peaks, pinnacles, and precipitous slopes intact. Where the Keuper rests on massive homogeneous igneous rocks, their surfaces are generally smoothed, fretted, and curiously carved. Beautiful examples of wind-worn rocks at Mountsorrel have been described by Professor Watts. But in many other places also there are surfaces highly suggestive of wind erosion, as at Croft, Sapcote, Groby, etc. They are usually

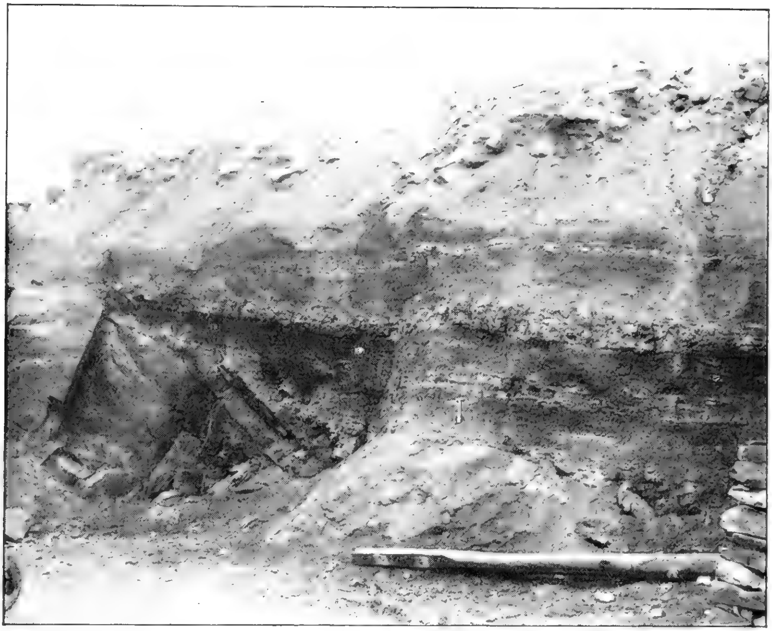
[1] Reprinted by permission from Transactions of the Leicester Literary and Philosophical Society, vol. xii, part 1, 1908, pp. 28–34.

smoothed and pitted, and bear projecting carved knobs which are often coated with a red crust. At Narborough, where the rock is fine-grained and contains no evident quartz, the surface has taken a high polish. At the north-east corner of Croft Quarry a large surface of rock bared for quarrying may now be seen. Part of this was covered by Keuper Marl, and part had been denuded of Keuper by glacial agency and covered by Boulder-clay. The two parts are quite different: the former is comparatively very fresh, and from it project knobs of fretted stone covered with red crust containing round quartz grains; the latter is undulating, bare, and striated (Pl. XV, Fig. 1). At Groby, in the Sheet Hedge Wood Quarry, a precipitous slope was bared about a year ago, on which a vein of quartz projected, whose pitted and fretted surface looked very unlike the work of water, but rather as though blown sand had played upon it, picking out the druses and chloritic grains.

Another curious example I unearthed at Croft, two years ago (see Pl. XV, Fig. 1). It has since been quarried away. Along the joints in this rock fissures had been formed, which widen downwards, the undercutting being greatest on their south sides. This suggests the action of dew. But there is a conspicuous line, above which the surfaces are fretted and the crevices widen upwards. It may be that the rock was subsequently buried in desert dust up to the level of this line, while the part above it was exposed to the wearing action of drifting sand. At Bardon, Shepshed, and generally along the northern border of Charnwood, and also at Woodhouse and Swithland, where the rocks are broken or cleaved, the floor beneath the Keuper is rough and craggy, though the rocks are still comparatively fresh.

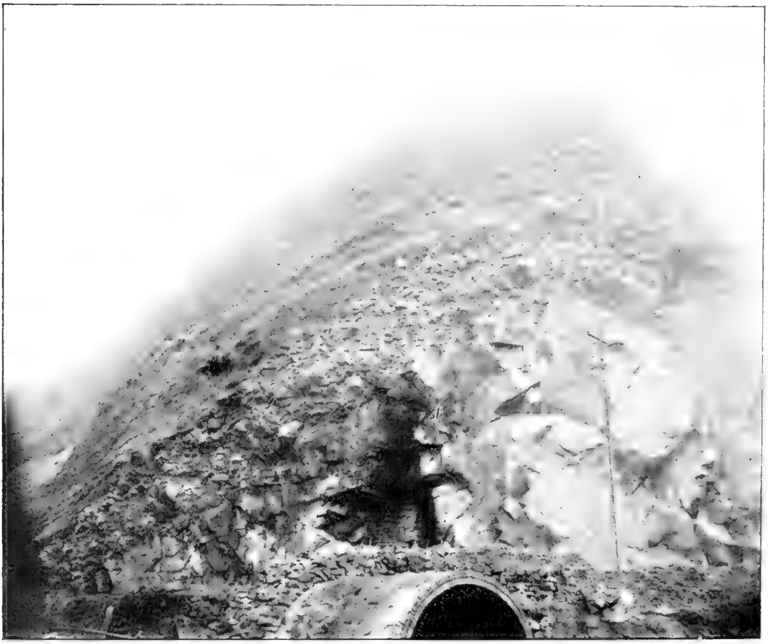
Worn slopes occur facing all points of the compass, and their distribution seems to depend most upon the nature of the rocks. Isolated rocks would be more favourably placed for wind-carving, and they would more easily be grooved by sand brushing through narrow gaps between them. Again, only massive and homogeneous stone would stand long enough to become carved, while rocks with cleavage or many divisional planes would crumble too quickly, and would moreover give rise to talus slopes. This may account for the possible wind effects being almost confined to the granitic rocks of Mountsorrel, Groby, and South Leicestershire.

3. *The Nature of the Keuper Deposits.*—In the open country the Keuper beds are almost horizontal, but around Charnwood they are often steeply inclined, and dip everywhere in the direction of the surface slopes on which they lie, the amount of dip depending on the steepness of the slope. Thus there is a radial direction of dip around the Charnian peaks, and where the Keuper is seen occupying depressions in the ancient land surface catenary bedding often occurs, e.g. at Croft and at Groby (Pl. XV, Fig. 2). And from the way the Keuper dips away from the hills it seems probable that the large valleys were filled in the same manner. This inclination of the beds might to some extent be explained by great contraction of the marl on solidification. But we should in that case expect the bending to be accompanied by fractures and slickensides. This, however, is not



T. O. Bosworth, 1906.

FIG. 3.—Bardon Hill Quarry. Stone band in Keuper Marl starting from a buried crag.



T. O. Bosworth, 1906.

FIG. 4.—Triassic Scree resting against the Syenite at Croft. Croft Quarry.

the case. Except at a distance from the older rocks, any traces of fractures in the Keuper are extremely rare, and there has apparently been little or no post-Triassic faulting in Charnwood. So that it seems probable that the beds were deposited with their present inclinations, somewhat in the manner of the loess.

Near the rocks the marl contains grit and stones, and there is generally a breccia at the base. The stones are of varied sizes; in some cases worn and in some cases very angular, but never smooth like ordinary pebbles. They are in a remarkably fresh condition, and often occur in bands in the marl, recalling the stone beds in the Persian deserts described by Blanford. In South Leicestershire they are much worn and fretted, and of very irregular shapes. They are generally pitted and sometimes polished. A year ago the section along the south end of Croft Quarry showed a 10 foot layer of these stones lying in a matrix of gritty marl. Similar stones occur throughout the 30 feet of marl above, and they are often situated with their grooves and ridges parallel with the bedding, as though they had been carved *in sitû*. Each stone is surrounded by a thin red skin consisting largely of sulphates and carbonates of calcium and magnesium. This skin may be due to mineral matter filling up small spaces between the stone and the marl. Such spaces might well be caused by alternate expansion and contraction of volume, under the influence of temperature changes so marked in desert regions.

The grit particles at Croft are subangular, and some of the green bands are almost entirely composed of them. At Mountsorrel and at Groby there are both worn and angular stones in the Keuper, and some of them are very large. In Cocklow Wood very rounded examples are seen in the bed of a pre-Triassic gully. Considering that the summit of the hill on whose side they occur must have been within 200 yards, their shape is somewhat remarkable. The position of this gully has evidently been determined by a belt of shattered rock beneath. A similar example occurs at Groby, but in this case the stones are angular. At Bardon and Shepshed the stones are angular, and sometimes they lie in bands which may be traced to some crag projecting from the underlying rock slope (Pl. XVI, Fig. 3).

In the most easterly quarry at Groby a coarse breccia rests upon the rock, composed of angular fragments cemented together by white calcareous matter. Here, also, large and very angular blocks of beautifully fresh stone occur a few feet up in the marl. Their edges are extremely sharp, and they bear no traces of water action, but look rather as though they have been splintered off by frost action, and have certainly received no rough treatment since.

A scree sometimes forms the base of the Keuper when the slope beneath is steep. The best example is seen in the quarry incline at Croft, adjacent to an almost precipitous slope which faces south and is seen in section to a depth of some 20 feet. The stones are subangular and fresh (Pl. XVI, Fig. 4). The marl above also dips steeply to the south, but the angle of rest was apparently less for the fine material than for the stones.

All the material in the Keuper which has so far been mentioned is of purely local origin; and the screes, breccias, stone bands, and the grit in the marl are entirely derived from the rocks which they surround. Thus at Narborough these are all of the peculiar Narborough stone; at Mountsorrel they are all granite fragments; at Swithland they are chips of slate, and so on. Nowhere is there any mixture such as would occur in a beach, nor any evidence of shore drift. In this matter the Keuper breccias differ greatly from those of Permian age. Traced away from the hills the marl soon becomes free from grit, and no coarse local detritus seems to have travelled far. But at Woodhouse in a green band there is fine grit which can just be recognised as granite from Mountsorrel, two miles distant. Also at Swannington in marls low down in the Keuper there are sand beds with scraps of slate and quartz which must have travelled about $1\frac{1}{2}$ miles.

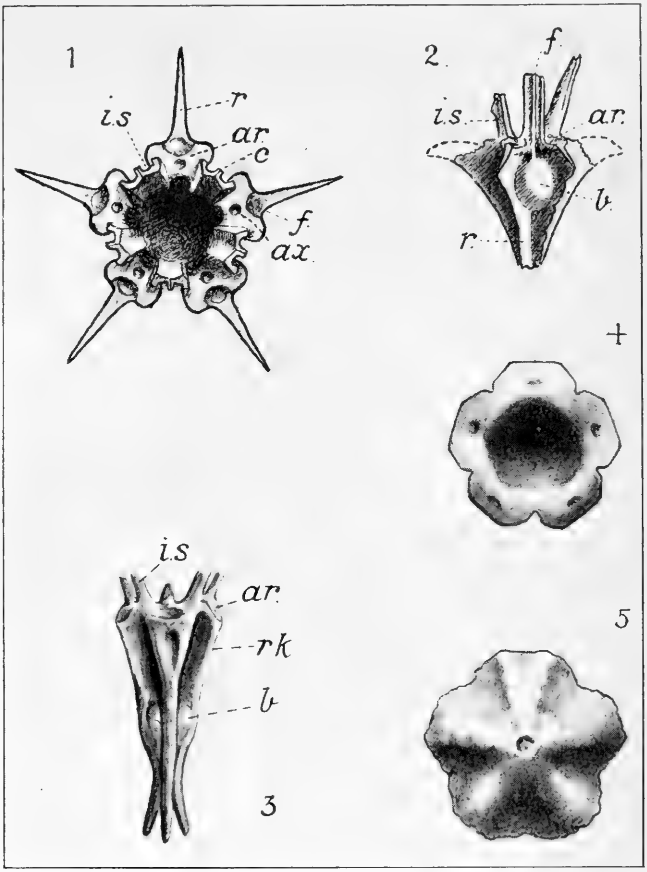
Of the normal Keuper marl there are many varieties. At Sileby both the green and the red beds are sandy, but more usually the red marl is of very fine texture and breaks with conchoidal fracture. Sometimes this has a kind of nodular structure and shows the bedding, and more rarely true laminated beds occur. The colour also varies greatly.

All the evidence of water action I have seen is confined to the green bands in the Keuper, and this evidence points only to shallow streams and salt pools. These green bands always contain quartz sand, and it is my experience that when suitably weathered they almost invariably show ripple-marks, and salt pseudomorphs which are sometimes clustered along the crests of the ripples. The ripple-marks vary greatly in size and character. If they are due to waves controlled by the wind they may indicate its direction.[1] For example, at Nottingham they strike N. 20° W., and at Gipsy Lane, near Leicester, they strike N. 40° W. But I have seen them striking in different directions in layers of the same green bed only half an inch apart.

Upper Keuper Sandstone occurs in lenticular beds at various horizons. It is usually grey and coarse. Near Leicester at the Dane Hills it is nearly 20 feet thick and is very uniformly false-bedded from the south-west. *Estheria* and fish-scales and fragmentary plant-remains lie on the false-bedding planes, which dip at 30 degrees. Very similar beds occur in Warwickshire and Worcestershire. Beds of similar sand dip steeply away from the Charnian inliers of Enderby, Croft, and Stoney Stanton, and they contain nuggets of the local rocks. Some beds consist of almost spherical grains and are apparently desert sand. Rounded grains are also plentiful in the marl, and at the base of the marl in South Leicestershire, resting upon the worn rock surfaces. In South Leicestershire there are no quartz rocks from which these coarse sands could be derived. Along the north and north-east boundaries of Charnwood, the sands are finer.

The heavy minerals also point to a distant source for the material.

[1] The author is collecting data, and would be greatly obliged for any information as to strike of ripple-marks.



New Chalk Crinoids from the '*Micraster cor-testudinarium* zone' of the Upper Chalk, Seaford Head, Sussex; from Dr. Arthur Rowe's Collection.

FIG. 1.—Oral view of *Roveacrinus alata* (gen. & sp. nov.), restored. × 17.
„ 2.—Lateral view of *R. alata*. × 10.
„ 3.—Lateral view of *R. communis*. × 10, restored.
„ 4.—Oral view of *R. communis*. × 14 (the interradial spines are broken off).
„ 5.—Aboral view of *R. communis* (var. *rugosa*). × 16.

r. radial wing; *ar.* radial articular facet; *f.* ligament fossa; *ax.* axial canal; *i.s.* interradial spine; *c.* carina; *b.* basal; *r.k.* radial keel.

Heavy mineral separations have been made from a large number of localities throughout the country. The same minerals occur alike in sands and marls, in the grits in contact with the Charnian rocks, in the basal breccias, in the Dolomitic conglomerate, and in the Rhætic sandstones of South Wales.

The most notable feature is the abundance of garnet, particularly in the coarser sands, and in the basement beds resting on the Charnian rocks. This mineral varies in colour between pink and mauve, and contains a large percentage of iron. In some beds the garnets occur as almost perfect spheres, but in others as very angular fragments with conchoidal fractures. In South Leicestershire the heavy minerals often consist chiefly of garnet, but approaching Charnwood the amount of zircon increases, and on the north and north-east borders of Charnwood the proportion of garnet is very small. Tourmaline and rutile occur in smaller quantity, but are a constant constituent of all the separations; they vary much in size and are sometimes very round and smooth. Staurolite is also common. To these heavy minerals the Charnian rocks no doubt have made their contribution, especially in the case of zircon; for powdered South Leicestershire syenite yielded rutile and zircon, and abundant perfect zircons were obtained from decomposed Mountsorrel granite; also the Millstone Grit contains tourmaline. But in the main the heavy minerals of the Keuper must have come from some distant source.

Thus it seems that the Upper Keuper accumulated in a continental basin under desert conditions. Shallow pools and occasional water-flows were a feature of this desert, and much of the greatly worn dust and sand had doubtless been long drifted to and fro, both by wind and by water.

VI.—A Note on some new Chalk Crinoids.

By J. A. Douglas, B.A., F.G.S., University Museum, Oxford.

(PLATE XVII.)

THE following is a brief account of some minute Crinoid calyces, which appear to have been hitherto undescribed, sent me by Dr. Arthur Rowe, who obtained them from the *Micraster cortestudinarium* zone of the Upper Chalk.

From the number of specimens it would appear that they are fairly common at certain localities, but I have been unable to detect any traces of arm or stem plates. The calyces are well preserved, and that they are full-grown individuals seems evident from their uniformity in size and solidity.

Mode of Occurrence.—As I am indebted to Dr. Rowe for all my information as to the localities and horizons at which they have been found, I cannot do better than quote his letter to me on the subject:—

"A fossil so minute can only be seen on a well-weathered surface of a hard rock, and the only zones where I have found them *in situ* are those of *Rhynchonella Cuvieri* and *Holaster planus* in the Isle of Wight and at Dover. The best way to get them is from flint meal. Practically all I have, with the above-mentioned exceptions, are from that source. It is necessary, of course, to have hollow flints, and these only occur in quantity at a few favoured localities in the zones of *Micraster* *cor-testudinarium* and *Micraster cor-anguinum*. In none of the other zones are the flints of a suitable nature. The actual range of the calyces is, in ascending sequence:—

4. Zone of *Rhynchonella Cuvieri* } *in situ*. Dover and Isle of Wight.
3. ,, *Holaster planus* ... }
2. ,, *Micraster cor-testudinarium*. Chatham and Seaford (flint meal).
1. ,, *Micraster cor-anguinum*. Chatham, Keston, and Northfleet (flint meal).

I have no doubt that they have a wider range, but the necessary hollow flints are not forthcoming, and it is useless to look for them on soft rock surfaces.

The reason for their great abundance in the *Micraster cor-testudinarium* zone in my collection is that at Seaford Head there is an abundance of the peculiar hollow flints which alone yield flint meal."

Description.

General Characters.—Calyx minute, funnel-shaped, pentagonal or stellate in oral view. Radials five, long, with relatively large articular facets, which are bounded on either side by upright projections given off from their inner lateral margins. These projections are grooved externally, and the lateral projection of one radial fuses with that of the next adjoining to form a single interradial spine, which has a slight inclination outwards, and exhibits a median external carina bounded by two grooves.

The outer, i.e. aboral, face of each radial is provided with a distinct flange. This may be in the form of a rounded keel, the lower end of which is produced downwards and outwards below the base of the calyx, or of a thin wing-like process. In a single instance the flanges were partially obliterated by regular nodular thickening.

Situated between the radials may be seen, in lateral view, rounded or oval thickenings, which from their analogous position to well-marked plates in *Extracrinus* probably represent basals fused into the cup.

The radial articular facets are horizontal, or with a slight outward slope; they usually exhibit external fossæ and central axial canals.

Tegmen, arms, and stem unknown, though the articulation for the latter was observed in one form.

Average dimensions of the common form—

Total length of calyx with radial projections ...	·133 inch.
Length of interradial spines...	·013 ,,
Length of downward prolongation of radial ...	·02 ,,
Diameter of calyx without projections	·06 ,,

Affinities.—This minute crinoid possesses certain characters in common with the Liassic '*Extracrinus briareus*,' namely, radials with an external keel and downward prolongations; the latter, however, in *Extracrinus* are jointed, whilst no trace of this is observable in our form. The keels, on the other hand, are developed to a much greater extent.

The fusion of the plates renders comparison difficult, but the unusual development of the radials above mentioned seems to furnish sufficient grounds for the foundation of a new genus, for which I propose the name *Roveacrinus*, after Dr. Rowe, their discoverer.

Two distinct species appear to be well marked.

Roveacrinus alata, sp. nov. (Pl. XVII, Figs. 1, 2.)

Calyx stellate in oral view, the rays of the star being formed by the thin wing-like processes of the five radials (Fig. 1, *r.*). The breadth of the calyx + wings is greatest just below the level of the radial articular surfaces, and is approximately equal to the length; it diminishes rapidly towards the base.

The interior of the calyx is deep, and is bounded by the five compound interradial spines (Figs. 1, 2, *i.s.*). These are slightly concave internally, whilst externally they bear two deep grooves, separated by a median carina (Figs. 1, 2, *c.*). The spines are very long, being more than half the length of the calyx; they have only a slight inclination outwards, and consequently the angle between two adjacent spines is small.

The wings of the radials are visible in an oral view (Fig. 1), and give a characteristic pointed appearance to the external margins of the radial articular facets (Fig. 1, *ar.*). The latter are nearly horizontal, and lie outside the ring of interradial spines. Each bears a distinct external ligament fossa (*f.*), below the general level of the facet and a central axial canal (Fig. 1, *ax.*). Basals five, oval, situated more than half-way up the calyx (Fig. 2, *b.*). Tegmen, arms, and stem unknown.

Roveacrinus communis, sp. nov. (Pl. XVII, Figs. 3, 4.)

In this form the radial flanges are not visible in an oral view; the external margins of the articular surfaces are straight, and consequently the calyx appears pentagonal. Calyx long, narrow, funnel-shaped. The radial flanges are in the form of rounded keels, bifurcating below the articular facet, but produced downwards into single cylindrical projections. The radial articular facet has a slight outward inclination and shows a distinct central axial canal; the interradial projections are shorter and more widely divergent than in *R. alata*. Basals indistinctly marked, situated at a greater distance from the radial articular facets than in *R. alata*. Tegmen, arms, and stem unknown.

R. communis, var. *rugosa*, var. nov. (Pl. XVII, Fig. 5.)

In one specimen, which I regard as a variety of *R. communis*, the radial flanges are partially obliterated by regular nodular thickening, which gives the aboral surface of the calyx a rugose appearance. The articulation for the stem is distinctly visible and appears to be circular.

The specimens figured are from Dr. Rowe's collection from Seaford Head, Sussex.

VII.—The Gavarnie Overthrust, and other Problems in Pyrenean Geology.

By E. E. L. Dixon, B.Sc., F.G.S.

(PLATE XVIII.)

In view of the interest which *charriages* and extensive overthrusts of low inclination are exciting in various parts of the world, an interest which has steadily increased since Nicol first put forward his explanation of the anomalous position of the Moine gneisses, it may be worth while to place before readers of the Geological Magazine a brief account of a remarkable structure in the Pyrenees, which has been noticed by various geologists, but only recently explained, by

Bresson,[1] as another example of overthrusting, and named by him the "nappe de recouvrement de Gèdre-Gavarnie," after two villages in the neighbourhood. I have the less hesitation in doing this because the phenomena, considering their importance and their setting amidst the magnificent scenery of the lofty central parts of the range, appear to have received less attention from English geologists than they deserve. For these reasons also, other questions in Pyrenean geology are afterwards discussed in the light of some recent observations.

In so far as the account relates to the overthrust, it is merely that part of Bresson's work which I was able, in the short time available, to verify three years ago when my friend, Mr. MacAlister, to whom I am greatly indebted for help in preparing these notes, and myself had the pleasure of visiting the ground under the guidance of Mr. Stuart-Menteath. It is difficult to express adequately our gratitude to Mr. Stuart-Menteath for his kindness in putting himself at our disposal, strangers as we were, and though we cannot follow him in some of his conclusions, to him are due many of the observations on which this account is based.[2] Finally, it should be mentioned, Carez has recently described and illustrated by some admirable photogravures the geology of the whole district in a work[3] which will be referred to again in the sequel.

The Franco-Spanish frontier in the Gavarnie district (Hautes-Pyrénées) follows the chief watershed of the range, and is an important boundary, geographically, geologically, and politically. To the south, under a semi-tropical sun, extends a great area of plateaux, gashed by winding, cañon-like gorges; to the north lies a zone of peak and pinnacle, hanging-valley and cirque, which, though narrower, stretches far beyond the horizon, along which it has the appearance of an angry sea turned to stone. The more immediate cause of this difference has been the great rainfall on the northern side, both now and in the past, when the valleys on that side were occupied by glaciers, but at the same time the geological difference is as profound as the geographical.

The southern plateau-blocks have been carved out of gently-inclined beds, thousands of feet thick in all, chiefly Cretaceous and Eocene. Near the frontier the former system is seen to commence with Campanian Hippurite-limestone, correlative with the zone of *Belemnitella mucronata* of the Chalk, and to overlie, with apparent conformity, a comparatively thin representative of the Permian or

[1] "Etudes sur les formations anciennes des Hautes- et Basses-Pyrénées": Bull. Carte Géol. France, tome xiv (1903), No. 93, pp. 238–68, pl. iv, maps.

[2] Mr. Stuart-Menteath's discoveries in this part of the Pyrenees have provided a starting-point for much of the more recent work; an idea of the development of his own views during the controversy over the Gavarnie rocks may best be obtained by referring to his book on "Pyrenean Geology" (parts 1–8, London, 1903–7), especially to the following pages:—Pt. 3, pp. 14–15; pt. 4, p. 26; pt. 5, pp. 5–7, 17; pt. 6, pp. 7, 12, 15–17, 26, 29, 30; pts. 7 and 8, pp. 2, 25–26. In the same work he deals also with the general question of *charriages* on lines to which we shall have occasion to refer later. He has increased my indebtedness to him by checking the statements of fact made in this paper, and by adding an appendix.

[3] "Géologie des Pyrénées Françaises": Mém. Carte Géol. France, fasc. ii (1904).

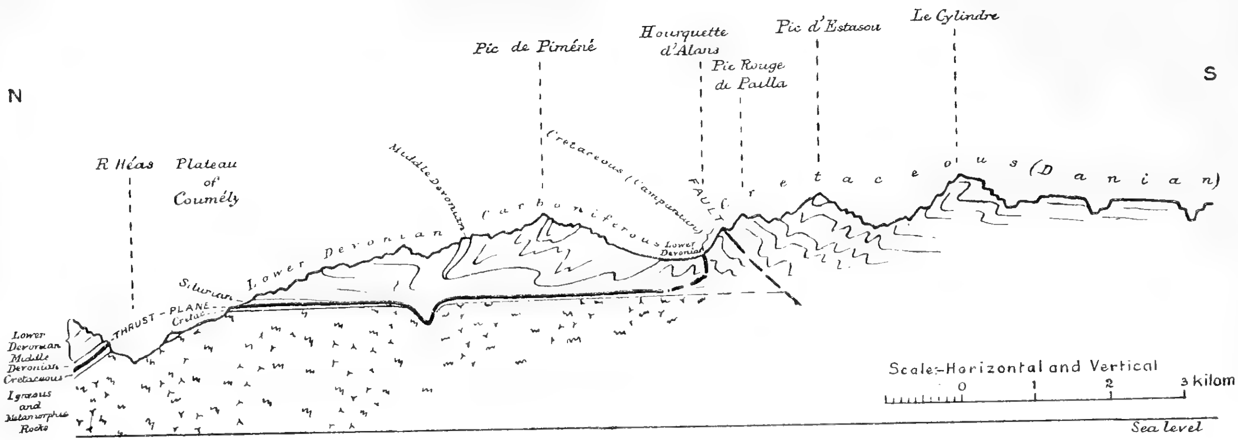


FIG. 1.—Section across the Gavarnie Overthrust, along the line shown in Fig. 2. (Chiefly after Bresson.)

Trias, which in its turn rests with the strongest possible unconformity[1] on a wide, even platform of far older rocks, notably crystalline schists and granite. But on the northern side the formations and structures are as varied as the surface-features, including, as they do, a practically complete sequence of stratified rocks, pierced by igneous intrusions of all kinds, and thrown into apparently hopeless confusion by innumerable faults and folds. Under these circumstances it is especially interesting to find that, according to Bresson's views, near the frontier itself, in the Gavarnie district, the northern side overlaps the southern. Exposures in deep valleys in that neighbourhood show clearly, as we shall see, that a wide sheet made up of a complex of Palæozoic rocks, which, by various characteristics, are linked with those forming the northern zone, has been forced southward, by intense tangential pressure, for several miles over the southern plateau. In its progress it has cleared away almost the whole of the beds which once rested on the underlying, apparently immovable platform of crystalline rocks, but has left still in place, and almost unaffected, a thin layer, generally 10–15 m. thick, of the basement-beds of the Hippurite-limestone, but has crumpled up to a prodigious extent higher horizons in the region immediately beyond where it came to rest. In somewhat the same way a snow-plough leaves a thin layer of snow on the ground and heaves up what lies immediately in front. The analogy is the more complete, as the overthrust mass appears to have come to a standstill with its front still buried deeply, and possibly even somewhat overhung by the beds opposing its advance. (See Fig. 1.) The basal platform has not, however, entirely escaped distortion, for several sharp 'tucks' along the top testify to the intensity of the compression it has undergone. One of these, shown diagrammatically beneath the words 'Middle Devonian' on Fig. 1, has been described and figured by Bresson (op. cit., pp. 247–8, pl. iv, fig. 2) and Carez (op. cit., pl. viii, fig. 1), whilst another, discovered by Mr. Stuart-Menteath, will be mentioned later.

In some such way as this we may interpret Bresson's conclusion that a sheet of Palæozoic rocks has been thrust from the north over the Hippurite-limestone. That conclusion is based on the following evidence.

The valleys in which the structure is exposed, those of the Géla, Héas, and Pau on the French side, and various branches of the Pinède valley on the Spanish side, are shown on Fig. 2, reduced from the French Geological Survey map,[2] together with the rocks of the basal platform, the Trias and Cretaceous above, and the Palæozoic complex which is supposed to have been thrust over all.

The relationships of the outcrop of the Trias and Cretaceous to that of the Palæozoics and to the course of the valleys throughout the area are seen at once from the map and Pl. XVIII, Fig. 1, which illustrates the essential features of almost any part of the district. It represents the Gavarnie (Pau) valley, just above Gavarnie, as seen

[1] As will be seen later, Carez would probably regard one or both of these junctions as overthrusts.
[2] Carte Géol. Dét. 251, feuille de Luz, 1906.

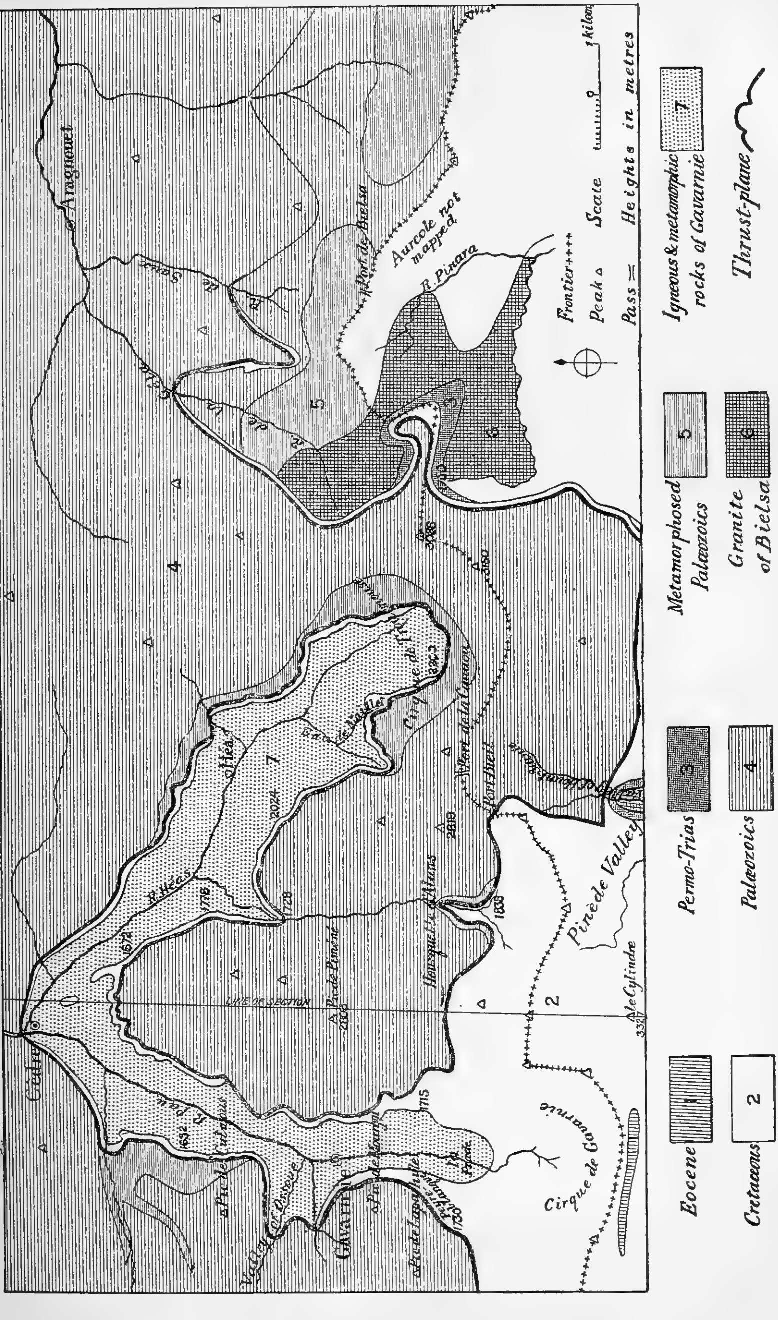


FIG. 2.—Map of the Gavarnie District, reduced from the French Geological Survey. The subdivisions of the Palæozoics and Cretaceous, and also faults, dykes, etc., have been omitted. The Cretaceous outcrop, where narrow, is generally exaggerated.

from the path leading to the Hourquette d'Alans by an observer looking westward toward Vignemale (3,298 m.), which, with its glaciers, appears in the distance. The lower declivities of the valley, below the gentle slopes stretching into the middle distance, form a deep, steep-sided trench in the crystalline rocks of the basal platform. The western (further) side of this trench is seen as a steep slope streaked by light-coloured talus. At the top the thin sheet of Cretaceous limestones resting on the platform appears in the middle of the view as a dark, discontinuous band, falling gently northward (see also Fig. 3). It turns into the side valley, the valley of Ossoue, which drains the slopes of Vignemale itself, and on the northern side it is conspicuous on the ground, though barely distinguishable in the figure, beneath two dark bands in the lower slopes of the Pic de Culaous. Outside the view it swings round again and continues down the main valley. On the eastern side it is not seen in the figure as it crops out along the brink of the deep trench. Above it the contours on both sides are more irregular, the Palæozoic rocks which give rise to them exhibiting great variety of hardness and structure. Thus the Pics de Mourgat and Lapahule seen immediately above the western side of the main valley, have been found by the French geologists to be composed respectively of Middle Devonian limestone and Carboniferous limestones, etc., separated by Lower Devonian slates across the intervening *col.*

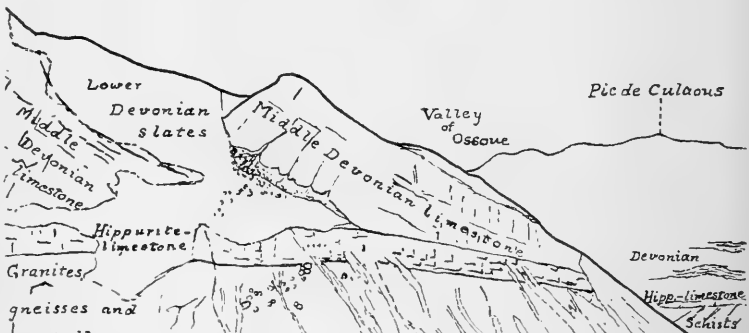


Fig. 3.—Structure of the lower part of the Pic de Mourgat. The summit is hidden. (From a photograph.)

The structure, according to their mapping, of the lower part of the Pic de Mourgat, as well as the outcrops of the Cretaceous and crystalline rocks below, is more clearly seen in Fig. 3, drawn from a photograph. In Pl. XVIII, Fig. 1, the dark bands in the northern slopes of the valley of Ossoue indicate infolds of Lower Devonian (in a complex of other Devonian rocks), and on the observer's side of the main valley the gentle slopes above the deep trench mark a wide outcrop of soft slates of the same age.

It is clear, then, from this evidence alone, that there is a *primâ facie* case that the Palæozoics overlie the narrow outcrop of limestone, but to prove that they have been overthrust further evidence on the following questions is necessary. (1) Has the limestone been correctly identified as Cretaceous and the rocks of the higher ground as Palæozoic? (2) Do the latter really overlie the limestone? (3) Is the junction of the two a plane of movement, or can their relative positions, if abnormal, be explained by a recumbent fold? Further, the question of the root of the overthrust should be considered.

The first point is readily settled. At various places the limestone yields an abundance of typical hippurites, which not only demonstrate its Cretaceous age, but have enabled the French geologists to assign it definitely to the Campanian subdivision. Stratigraphical evidence is also forthcoming, for in Spain, in the Pinède valley, as already pointed out by Stuart-Menteath,[1] it is visibly continuous with the Campanian of the plateau-region, where the sequence up to the highest beds (Eocene) is normal. As regards the rocks of the high ground between the valleys, there has never been any doubt as to their age. They are sufficiently fossiliferous to show, according to all who have worked on them, that they constitute a complex of Silurian, Devonian, and Carboniferous rocks. By means of its fossils, that part which is shown in Pl. XVIII, Fig. 1, has, with the rest, been unravelled by Bresson, Stuart-Menteath, and others. The unanimity with which the rocks had been regarded as Palæozoic by Pyrenean geologists led to our devoting our time chiefly to other questions, especially as their aspect throughout was quite in keeping with that view. In connexion, however, with what follows, it may be mentioned that Bresson's statement that Lower Devonian rocks form a great part of the high frontier-ridge separating the cirque de Troumouse from the valley of Hount-Sainte in Spain, was seen to be justified on the occasion of our traverse when Mr. Stuart-Menteath identified as Coblentzian forms some trilobites, etc., which we found near the pass of la Canaou.

Turning next to the order of superposition, it is at once obvious in the field that the band of Campanian in its course along the valleys generally contours the slopes in a way which is explicable only on the assumption that it is the outcrop of a thin sheet of great extent but slight (northerly) inclination which has been dissected by erosion but still exists beneath the Palæozoic rocks forming the high ground. A closer examination confirms this conclusion, and at the same time shows that the dip of the bedding in the limestone is, in general, equally slight, and conforms with the junction with the basement-platform of old rocks below. Steep inclinations are few and local, except near Gèdre where the land disappears northward, plunging steeply, according to Bresson (loc. cit., pp. 243, 249, 250, figs. 65, 69, 79), beneath the Palæozoic rocks which bound it in that direction. The

[1] "Pyrenean Geology," pt. 6 (1906), p. 26.

sporadic occurrences of folding in the Cretaceous sheet and the basement-platform below do not militate against Bresson's theory of overthrusting, as they do not explain the occurrence of Palæozoic rocks in the higher ground, and, in fact, may be regarded as 'tucks' in the otherwise undistorted floor of the overthrust.

At some places such as Peyreblanque, a short distance to the south of the scene of Pl. XVIII, Fig. 1, the Cretaceous sheet, horizontal and yielding abundant hippurites, gives rise to a distinct terrace along the side of the valley, below the higher ground formed of Palæozoic rocks. But its relations to the latter are most strikingly shown in the neighbourhood of the cirque de Troumouse, at the head of the Héas Valley. There the high, wide ledge which constitutes the floor of the cirque is formed essentially of the approximately horizontal basement-platform of crystalline rocks, in part still covered with a thin, gently undulating veneer of hippurite-limestones, on which, near the steep walls enclosing the cirque on three sides, rests chiastolite-slate. This slate has been proved to be Silurian by Bresson's discovery in it of a characteristic *Orthoceras*-limestone (op. cit., p. 246). Its superposition on the hippurite-limestones is equally unquestionable, for in the left bank of the Maillet stream it visibly overlies limestones, which on the opposite side have been bared over a wide, flat area, and contain typical hippurites. The position of affairs may be gathered from Pl. XVIII, Fig. 2, in which in the foreground is seen the wide area (its surface parallel to the bedding) of white, hippurite-limestone, whilst behind the figure rises a low, vertical cliff of dark chiastolite-slate, at the top of which the ground recedes at a gentle gradient to the steep bank just visible in the background. This bank is really the foot of the northern slope of the frontier-ridge, the crest of which rises two to three thousand feet above the floor of the cirque, and which is made up entirely of various Palæozoic formations, including, near the Port de la Canaou as already mentioned, Lower Devonian to a great extent. Nevertheless, on crossing by the 'port' into the valley of Hount-Sainte, it is found that, on the southern side also, these old rocks rest on a thin sheet of hippurite-limestone, at a level which is not greatly different from that on the northern side, four kilometres distant. When we consider further that the limestone on both sides is but slightly inclined and is underlain by an even basement-platform of far older rocks, from which it is separated on the southern side by a thin group merely of Permo-Triassic beds, we are forced to conclude that the platform with its thin covering of hippurite-limestone forms the foundation of the ridge from side to side, and underlies the whole Palæozoic mass above. This conclusion being precisely similar to that drawn from the evidence of outcrops along the valleys on the French side, we are justified in saying that a complex of Palæozoic rocks rests on a sheet of Cretaceous limestones, dipping slightly north, over an area which extends at least from the latitude of Gèdre to an irregular line near the frontier, a width of ten kilometres, and from the valley of Saux in the east to beyond that of the Pau in the west, a length of more than 18 kilometres.

As regards the issue between overthrust and recumbent fold, Bresson has shown (op. cit., p. 246, etc.) that both the thin group of Cretaceous limestones and, in some places, the Palæozoics immediately above, retain, *intra se*, their original order of superposition, and have not been reversed, thus putting a recumbent fold out of court. Also the junction itself bears witness to a lateral thrust of the most powerful kind. This is clearly the case in the cirque of Troumouse at the exposure previously mentioned. The chiastolite-slate has suffered most, as it has been 'pugged up' or mylonised for some distance above the junction, but, though it has proved such an excellent lubricant that undistorted hippurites may be found in the limestone a short distance below, nevertheless the latter has also had a rough time. This is evident from the occurrence in the 'pugged up' slate of large and small 'augen' (shown in Pl. XVIII, Fig. 2) of limestone torn from the sheet below, and from the presence of shear-zones in the limestone itself, even down to its base. Along these zones the limestone has been reduced to a fine-grained, platy mylonite. Unfortunately on the occasion of our visit slickensiding of the upper surface of the limestone was not accessible and the direction of movement of the slates, therefore, not directly determinable, on account of weathering along the junction.

Finally, Bresson points out that the overthrust Palæozoics must have moved in a southerly direction; this is obvious from the fact that there is, or has recently been, an unbroken mantle of younger rocks for a great distance to the south, whereas to the north, in which direction the thrust-plane is inclined, Palæozoic rocks, similar in facies to and continuous with the overthrust mass, extend far beyond Gèdre and the valley of Saux, where the underlying Cretaceous limestone disappears, and with it evidence of the movement. In fact, as the rocks and structures above the exposed portion of the thrust-plane are similar to those of the disturbed zone to the north, it is difficult, if not impossible, to say where the overthrust begins or by how much its full width may exceed the 10 kilometres which, as we have seen, is exposed. The view that it came from the north is fully borne out by the inclination of the folds (Fig. 1) in both the overthrust rocks themselves and the Cretaceous mass piled up in front. The folding of the latter is remarkable, and is beautifully figured by Carez. That the southward movement encountered great resistance is suggested by this folding and confirmed by the remarkable form of the front of the thrust-plane, which instead of sloping steadily upward ends southward as a steep fault with an irregular east-and-west course, and, in places, with possibly even a southerly hade like a normal fault.[1]

The evidence which has been cited amply justifies, I think, Bresson's *charriage*. In fact, although it forms but a part of what has been worked out with much care by Bresson himself, it would not have been given at such length were it not that the truth of parts of it have been questioned and, more particularly, that another and much larger overthrust has been stated to exist, in the same region but on the strength of evidence which, in contrast to that of Bresson, appears to me so slight as not to justify such sweeping conclusions.

The discussion of this second problem has been prompted by some

[1] Bresson, op. cit., fig. 75.

recent publications on the Pyrenees.[1] In the first two, Mr. Stuart-Menteath, unfortunately, introduces disparaging references to Darwin and others, which are as germane to the case as "the flowers that bloom in the spring," and only serve to repel proper consideration of his other contentions. These last are directed against the degree to which the theory of overthrusting has been pushed in the Pyrenees, for he maintains that in the western part of the range (feuilles de Bayonne et de St. Jean-Pied-de-Port) gigantic overthrusts have been invoked in order to explain anomalies which do not in reality exist, as they arise from the incorrect identification of various outcrops. He particularly challenges some of Termier's conclusions. As Termier has cited[2] as corroborative evidence the existence at Gavarnie of a *charriage* which has 'carted' the Upper Cretaceous from the Spanish side across a strip of country 200 kilometres long, a consideration of the latter instance is evidently of more than local interest; as Termier says " . . . s'il y a *charriage*, le phénomène est général et embrasse tous les dépôts crétacés, de part et d'autre, de l'axe pyrénéen, et même toutes les Pyrénées."

To Carez is due this view that the Cretaceous at Gavarnie has been thrust from the south over the crystalline rocks on which they now rest. Stuart-Menteath, Bresson, and others, have maintained that the hippurite-limestone of the Gavarnie district is in its original position relative to the platform below. In the work previously cited, though the Palæozoic rocks are shown by Bresson to have been thrust over the Cretaceous from the north, the latter is stated to be in place because its basement-bed contains not only pebbles of quartz and, occasionally (op. cit., p. 247), of the subjacent schists, but also a littoral fauna (oysters, etc.). He apparently regards the even plane on which it rests as worn down by the Cretaceous sea. Carez, on the other hand, gives nine reasons, under the following heads, for regarding the Cretaceous as overthrust from the south :—[3]

1. Absence of any litoral band at the base of the Cretaceous.

2. Existence of an even, planed surface, forming the 'substratum' of the Cretaceous.

3. Absolute difference of facies between the Cretaceous of Gavarnie and neighbouring places, and the beds of the same age in the northern plain.

4. Absence of the Jurassic and the Lower Cretaceous at Gavarnie.

5. Impossibility of admitting the simultaneous deposition of the Upper Cretaceous at Gavarnie and in the northern plain.

6. Almost horizontal position of the Cretaceous of the frontier.

7. Priority of the folding of the rocks of the 'substratum' to the attainment by the Cretaceous of its present position.

8. Junction by a fault of the Palæozoics and the Cretaceous at

[1] P. W. Stuart-Menteath: "Sur les Méthodes de la Nouvelle Géologie," 1907; "La Nouvelle Géologie à Biarritz" (Extrait de 'Biarritz-Association'), pts. 1 and 2, (1907 and 1908). P. Termier, "Sur la Structure Géologique des Pyrénées occidentales," C.R. Ac. Sc., tome cxli (1905), p. 966. L. Carez, "Géologie des Pyrénées françaises," Mém. Carte Géol. Fr., fasc. i–iv (1903–6).

[2] Op. cit., p. 966.

[3] Op. cit., fasc. ii (feuilles de Tarbes et de Luz) (1904), p. 1156.

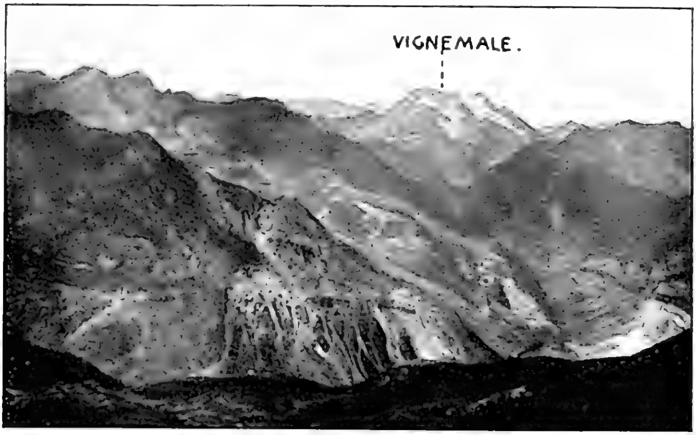


FIG. 1.—The Pau Valley, from the Hourquette d'Alans.

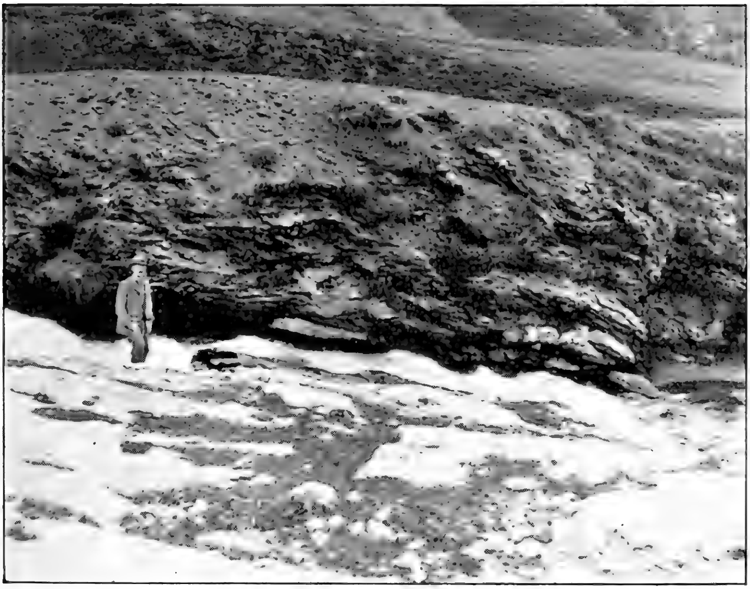


FIG. 2.—Silurian Slates (S.s.) thrust over Hippurite Limestone (H.L.), Maillet brook, Cirque de Troumouse. Fr.P.=foot of the frontier ridge (Palæozoics). The almost horizontal limestone in the foreground is bared over a considerable area; behind the figure rises a low vertical cliff of the slates with 'augen' torn from the limestone in the lower part (H.L.a.).

Port-Bieil and other places along the southern margin of the overthrust Palæozoics.

9. Intensely folded nature of the Upper Cretaceous.

The following is a summary of his expansion of these arguments, with comments in square brackets:—

1. He has "not seen a single pebble at the base." In places the lowest beds contain quartz grains or some subangular fragments of quartz, but the latter are very rare and disseminated also throughout the limestone. The subangular fragments of the 'substratum,' which are found, though also very rarely, at the base, are more easily explained on the hypothesis of an overthrust than on that of a transgression of the Cretaceous sea. [It appeared to us, on the contrary, that quartz-fragments were frequent at the base of the limestone, but rare or absent at higher horizons. Their evidence, however, is inconclusive, though the hypothesis of an overthrust leaves unexplained the general absence of fragments of other hard rocks, which make up a large part of the 'substratum.']

As regards the basal fauna, Carez doubts whether it is littoral, as that of the Lower Danian is deep-sea, but in any case it merely indicates a slight depth of water, not the proximity of a coastline. [Here again the evidence is inconclusive, though the persistence, apparently admitted by Carez, over a wide area of an exceptional fauna in the 'sole' of the supposed overthrust is remarkable.]

2. Carez says that the surface of the 'substratum' is "planed down, I will even say polished." He further remarks, as opposed to Bresson's idea that this surface is a sea-bottom, that "the erosive action of the sea is exercised on its coasts, but never on the bottom." On the other hand, the smoothing of the 'substratum' of an overthrust is to be expected, and "the presence of a plane surface beneath the Cretaceous, so far from proving the latter's deposition in place, is one of the best arguments in favour of the theory of *charriage*." [This argument would, in fact, be almost conclusive, were the surface of the 'substratum' everywhere polished. But though this may be the case in places, it certainly is not universally so, and the occurrence of even a single place yielding clear evidence that the limestone has been deposited on the 'substratum,' such as that described later (pp. 372–3), is sufficient to disprove Carez' *charriage*. Instances of movement and polishing along the junction are to be expected in view of the great overthrust, previously described, a short distance above. Nevertheless, at the cirque de Troumouse (p. 366), where mylonisation was noticed at the base of the limestone, the evidence pointed, not to a general movement along the junction, but to a local one crossing it.]

3. Carez remarks that the Upper Cretaceous of Gavarnie and neighbouring places belongs to the southern or hippurite-limestone facies, whereas contemporaneous beds to the north, though at one place distant merely a mile, yield a northern fauna which is completely different, an abruptness of change which cannot be original. [Other disturbances, known to exist in the neighbourhood, may account for this abruptness of change. Of the minimum distance necessary to have effected the change in the Cretaceous sea our knowledge is probably uncertain.]

4. Carez draws a similar conclusion from the fact that although Jurassic and Lower Cretaceous rocks are absent from Gavarnie, etc., they are represented to the north, at one place at a distance of a mile, by more than 2,000 metres of rocks (compact limestones, etc.) which were "certainly deposited far from a coast-line." [This argument is a variation of the preceding. When Carez remarks that everywhere in the southern region the Campanian rests on Palæozoic rocks he overlooks the fact, previously pointed out by Bresson and others, that in that part of the region which lies in Spain it is separated therefrom by Permo-Trias. On Carez' view this is explicable only on the supposition that in that district his overthrust separates the Campanian from the Permo-Trias, a point to which we shall return later. The discordance at the base of the Campanian to which he alludes has been explained by the above authors as the result of a widespread hydrocratic movement. This view is much more probable than Carez', which involves the supposition that a thrust-plane has persisted at one horizon throughout its visible extent of many miles.]

5. As it is difficult to follow Carez here I will quote his argument in full (pp. 1157–8): "La différence d'altitude actuelle entre les dépôts crétacés de la crête frontière et ceux de la plaine [septentrionale] dépasse 3,000 mètres. Or, si le Campanien n'a pas le même facies dans les deux zones, en revanche le Danien est identique, tant au point de vue de sa composition pétrographique que de sa faune. Leymerie avait déjà été frappé de ce fait, et il en avait conclu, avec raison, que le soulèvement de la zone frontière était postérieur au dépôt du Crétacé qui la constitue. C'est ce qui me parait démontré : les fossiles daniens ne vivaient pas à Montgaillard et dans la Haute-Garonne sous une profondeur d'eau de plus de 3,000 mètres, et cette colossale différence d'altitude entre des sédiments identiques est indubitablement le résultat de mouvements postérieurs à leur dépôt." [Undoubtedly, but as a whole series of mountain-structures of Tertiary age separates the two areas where contemporaneous deposits differ in altitude by 3,000 metres, it would seem that this difference of level demands no further explanation.]

6. After referring to the gentle inclination of the Campanian sheet and to the Tertiary age of the principal orogenic movement in the Pyrenees, Carez asks, "How explain, on the theory of deposition in place, that this gigantic movement has not affected the Cretaceous rocks?" [As already pointed out by Bresson, the Cretaceous sheet is folded or sheared at several places, phenomena which are doubtless connected with the Tertiary overthrust of Palæozoic rocks from the north, previously described. On the whole, however, it is undistorted, a fact which is not only difficult of explanation on the hypothesis that the Cretaceous sheet has been overthrust in the opposite direction to that taken by the overlying Palæozoics, but is readily explicable if we regard the sheet and its basement-platform as part of the base of the plateau-blocks of the Spanish side, which has been buried, over an area of many square miles, beneath the overlapping northern rocks. Again, the Permo-Trias beneath the Cretaceous sheet in the valley of Hount-Sainte cannot, in the absence of any internal or external evidence of movement, be supposed to have been overthrust, as it is

too soft to have stood the journey without a trace of fatigue, and yet it is practically unaffected by the Tertiary movements. Why, therefore, suppose the equally undisturbed Cretaceous rocks which rest on it to have been overthrust? And if the latter be admitted to be in place, the whole case for the overthrust of the Cretaceous sheet at Gavarnie fails.]

Carez further remarks that at the entrance of the cirque of Gavarnie the bedding of the Campanian is not parallel to the surface of the underlying 'Primary' rocks. [This is true of the upper part at the place indicated by Carez, where the Campanian sheet thickens beneath the margin of the overlying Palæozoics, but not of the base, the part which counts; the latter remains parallel to the underlying platform.]

7. Carez considers that the Tertiary upheaval has been the only movement of importance evidenced in the Pyrenees, to the exclusion even of Hercynian and older crust-creeps. If this were true the junction of the undistorted Cretaceous in the Gavarnie district, etc., with the contorted rocks of the basement-platform would obviously be a fault, but as he admits that his views are not shared by the majority of geologists he does not press the point. [*En passant* it is interesting to note that the structures of the rocks in the basement-platform are, by different observers, regarded as Archæan, Hercynian, or Tertiary!]

8. Carez points out that at certain places [along the southern margin of the overthrust Palæozoic mass] the Cretaceous abuts against that mass, though generally passing below it. He explains this fact by unequal advancement of the Cretaceous from the south against resistance. [It is more simply explained by unequal advancement of the Palæozoic mass from the north against resistance, a movement which is admitted by Carez and is independent of his overthrust. In fact, the abutting merely proves relative movement between the juxtaposed Palæozoic and Cretaceous rocks, and has no bearing on the relations of the latter to the underlying platform. Also it appears from his statement that he supposes the Cretaceous to have forced its way *beneath* the Palæozoic mass, and that in the form of an apparently undisturbed sheet, several miles wide at least, but only a few yards thick.]

9. Carez says, "Although the contact of the Upper Cretaceous with its 'substratum' is remarkably plane, the former is itself strongly folded." Proceeding to his application of the argument in the Gavarnie district we read, "At Gavarnie the Cretaceous beds are intensely folded, and their structure contrasts singularly with that of the same horizons on the Spanish side, notably in the valley of Arasas. These are indeed the characters of an overthrust mass of which the front is folded several times on itself, although, at a certain distance behind, the beds have preserved a relative regularity." [Passing over the discrepancy between this argument and No. 6, we would point out that although the Cretaceous sheet is folded in places, yet its 'substratum' of crystalline rocks has been folded with it. The folding, in fact, proves not that there has been relative movement between the Cretaceous and its 'substratum,' but merely that they (i.e. really the 'substratum') have not been absolutely rigid under

powerful lateral compression, the former play of which is sufficiently evidenced by Bresson's overthrust. The intense folding to which Carez refers is confined, so far as is known, to the higher horizons of the Cretaceous near the frontier. His figures are beautiful views of the conspicuous folds in the Danian of the upper part of the cirque of Gavarnie, whereas the beds which rest on the platform are invariably the underlying Campanian. Not only is it clear that these folds do not point to relative movement between the Campanian and its 'substratum,' but also the only possible direction of such movement, i.e. from the south, is non-suited, by the inclination of the folds, which lean towards the south instead of the north, and by the fact that the 'front' of the supposed overthrust mass would be, not the folded beds of the frontier as stated by Carez, but the comparatively undisturbed sheet of Campanian, which extends for miles to the north. The folds, as previously mentioned, are readily explained as the result of the southward advance of the Palæozoic mass against resistance.]

Thus it appears that the various facts brought forward by Carez in support of his view that the Campanian rocks have been thrust from the south over the basement-platform can all be explained in other ways. It will have been noticed that he adduces no direct evidence of movement along the supposed thrust-plane, though he remarks (p. 1155) that the surface of the basement-platform is "rabotée, je dirai même polie." Very likely this surface in places is a plane of movement, seeing that it separates rocks of very different rigidities and occurs but a short distance below the great overthrust previously described, but, as we shall now see, there is every reason to believe that it is generally a surface of original deposition.

It may be readily examined near Gavarnie in the valley-side to the south-west of the bridge at La Prade de Saint-Jean, where the basement-platform appears to have been forced by intense lateral pressure to take in one of the sharp 'tucks' previously mentioned (p. 366), in which has been nipped a crushed syncline of the overlying Campanian limestone, in the form of a long tongue passing down obliquely for a considerable distance into the mass of crystalline schists. This tongue, which had been previously discovered by Mr. Stuart-Menteath, we found to be bounded along its southern wall by a shear-zone which had affected schists and limestone alike, but at the bottom it was evident that the junction left the plane of shearing, and along the other wall showed its character that it was a surface of deposition unmodified by shearing or friction-brecciation. The limestone adhered closely to the schists, filling inequalities in their surface, and showed no trace of subsequent movement, either in its matrix, which was similar to and continuous with the rest of the Campanian, or in the included fragments of hippurites, which would have at once betrayed shearing by their distortion, even though the intermingled quartz-fragments retained their original form. Also the latter were certainly more numerous than at higher horizons of the Campanian, where, Carez says (p. 1154), they also occur "disséminés dans toute la hauteur de la couche."

Although it is sufficient, in order to disprove Carez' overthrust, to show at any place that the junction of the Cretaceous limestone with the underlying crystalline rocks is original, and not due to movement, it may be mentioned that it presented similar features at most of the other exposures which were examined. These lay along the even upper surface of the basement-platform, where, on Carez' hypothesis, pronounced evidence of overthrusting would be expected. And even in the banks of the Maillet stream in the cirque de Troumouse (Pl. XVIII, Fig. 2), where the junction is disturbed by shearing, accompanied by mylonisation of the limestone, it does not coincide in direction with the movement, which is probably connected with the adjacent overthrust previously described.

(*To be concluded in our next Number.*)

NOTICES OF MEMOIRS.

I.—The Geology of the Tahan Range.[1] By J. B. Scrivenor, Geologist, F.M.S.

THE following account of the geology of the Tahan Range is based chiefly on notes collected during an ascent of Gunong Tahan in May, 1906, and subsequent journeys in Pahang.

The Tahan Range is remarkable in being composed almost entirely, as far as is known, of a series of estuarine rocks—comprising shale, sandstone, grit, and conglomerate—which is provisionally named the Tembeling Series. The main range of the Peninsula, which, although greatly more extensive in length, rises very little higher than Gunong Tahan, is believed to be all granite and its modifications, but for occasional areas of schistose rocks, representing altered sediments.

Two ranges, similar to the Tahan Range, but on a smaller scale, are known in the Federated Malay States. One of these is a long range of low hills in the west of Pahang, parallel to the main range, and referred to elsewhere as the Bentong-Telôm Range; the other is the small isolated Semanggol Range, forming the border between Larut and Krian in Perak.

No direct evidence of the age of this series of estuarine rocks has yet been derived from the Tembeling District of Pahang; but fossils discovered elsewhere point to a range in time dating from the Rhætic to the Inferior Oolite. The collections made, however, are not numerous, either in specimens or species.

The breadth of the outcrop of the Tembeling Series in the typical district is about thirty-five miles. The strike is roughly N.N.W.-S.S.E., and there is reason to suppose that the series extends into Johore, reappearing as far south as Singapore. The Tahan Range lies on the western side of the outcrop. It would appear that the Tembeling River, whose general course in the upper reaches is to the west, has been turned south by this enormous barrier.

[1] From the Journ. Federated Malay States Museum, vol. iii, January 29th, 1907 (printed April, 1908).

On either side the Tembeling Series is flanked by a wide outcrop of calcareous rocks and associated igneous rocks, named provisionally the Raub Series and the Pahang Volcanic Series respectively. One of the remarkable ranges of limestone hills belonging to the Raub Series was seen from the top of Gunong Tahan and visited later by the writer. It lies to the west of the range and is situated near Kampong Cherual in the Ulu of the Tanum, a left tributary of the Julai. From a peak in this limestone range a magnificent view of the Tahan Range, about fifteen miles distant, was obtained; and it appeared to the writer that it would be easier to ascend Gunong Tahan from this side than from the east.

Petrologically the conglomerate is remarkable for containing numerous pebbles of chert and carbonaceous shale with Radiolaria and Foraminifera. It is believed that these pebbles were derived from beds of similar chert and carbonaceous shale in the west of Pahang. The majority of the pebbles in the conglomerate are sandstone and quartz. The matrix is quartzose. The sandstone afforded andalusite on separating the grains by means of heavy liquids, and also a few grains of zircon and other minerals. In the Tahan River greenish schistose grits were found to contain a little tourmaline. The shale is generally red, owing to surface weathering.

On the gravel banks of the Tahan River there are found pebbles of quartz-porphyry and of a basic rock, which is of the same composition as dolerite. No outcrops of either rock *in sitû* were found here; but elsewhere data have been collected which make it probable that this rock is younger, not only than the Tembeling Series, but also than the granite of the Federated Malay States.

In the Rivers Tekai, Tembeling, and Tahan there is abundant evidence of the Tembeling Series having been thrown into a series of anticlines and synclines. In the part of the Tahan Range visited the predominant dip is about 45° W.S.W.

Malays can still be found who hint vaguely and mysteriously at mineral wealth in the Tahan Range. That small quantities of gold occur is extremely probable, and the presence of tourmaline makes it necessary to admit the possibility of tin ore being found also. To the prospector, however, the indications are most unattractive. The range would make an ideal health station.

II.—The Tenth Meeting of the International Geological Congress, held in the City of Mexico, 1906.

THE Compte Rendu de la Dixième Session (du) Congrès Géologique International, Mexico, 1906, has now been published. It consists of two parts, each measuring 11 inches by 8 inches, containing in all 1,358 pages, 56 plates or maps outside the text, and 42 figures in the text. The first 184 pages are devoted to the record of the preparations for the meeting, the social meetings, list of members, minutes of proceedings, and reports of commissions. Pages 185 to 1286 contain the scientific memoirs (forty-six in number) read at the meetings. Their titles, somewhat abbreviated, are as follows:—[1] J. G. Aguilera, on the Geology of Mexico,* and on the Volcanoes of Mexico*; three papers by Professor R. J. Anderson, on the Drift, Granite, and Metamorphic Rocks of Galway; a paper by Dr. Tempest Anderson on the West Indian Eruptions, and another on the Eruption of Vesuvius; H. F. Bain, on Ore Deposition in the Mississippi Valley; Professor F. Becke, on Crystallization Schistosity and Piezocrystallization †; Professor W. Branca, on Volcanoes and Fissures †; Professor S. Calderon, on Contact Phenomena ‡; Professor L. Cayeux, The Structure of Sandstones and Quartzites,* Insect Eggs of Lakes Chalco and Texcoco and the Formation of Oolites*; Professor A. P. Coleman, Interglacial Periods in Canada; Professor T. W. E. David, Glaciation in Lower Cambrian, possibly in Pre-Cambrian Time; Australasia, Climate at different geological epochs*; Climate at different Geological Epochs, with special reference to Glacial Epochs; Occurrence of Diamonds in Matrix near Inverrell, New South Wales; Professor G. De Lorenzo, The Bases of the Volcanoes Vulture and Etna §; Professor S. Diaz, Diary of the behaviour of the Volcano of Colima, 1893 to 1905 ‡; Professor F. Frech, on Climatal Changes of the Geologic Past †; Aviculidæ of Palæozoic habit from the Trias of Zacatecas †; Professor J. W. Gregory, Climatic Variations, their Extent and Causes; Professor U. Grubenmann, The Classification of the Crystalline Schists †; Professor Heilprin, Interrelation of Volcanic and Seismic Phenomena; Professor E. W. Hilgard, The Causes of the Glacial Epoch; Dr. E. O. Hovey, The Western Sierra Madre of the State of Chihuahua*; B. de Inkey, The Relation between the Propylitic state of Andesitic Rocks and their Mineral Veins*; Dr. K. Keilhack, The occurrence of Onyx at Etla †; Professor J. F. Kemp, Ore Deposits at the Contacts of Intrusive Rocks and Limestones; Professor J. Koenigsberger, on the Influence of Mountains, Lakes, etc., on the Geothermal Gradient †; Dr. G. F. Kunz, Gems and Precious Stones of Mexico; General L. de Lamothe, The Climate of North Africa in the Upper Pliocene and the Pleistocene*; Professor L. de Launay, The Genesis of the Metals of Italy*; Notes on Mines in Tuscany and Elba; W. Lindgren, The Relation of Ore Deposits to Physical Conditions; Dr. M. Manson, Climates of Past Geologic Epochs and their Cause*; Professor S. Meunier, A Theory of Volcanic Phenomena*; Professor A. G. Nathorst, Upper Jurassic Flora of Hope Bay, Graham Land; T. Ogawa, The Geotectonic of the Japanese Islands; Dr. C. Renz, The Older Mesozoic Rocks of Greece †; V. Sabatini, The last Eruption of Vesuvius*; Professor G. Stefanesca, *Dinotherium gigantissimum**; J. D. Villarello, on the infilling of certain Metalliferous Deposits*; Bailey Willis, The Geological Map of North America*. The brief account of the excursions made in connection with the Congress occupies pages 1289 to 1350, and a table of contents is given at the end of the second volume.

B. Hobson.

[1] Memoirs in English except those marked * in French, † in German, ‡ in Spanish, § in Italian.

REVIEWS.

I.—Geological Survey of Canada. A. P. Low, Deputy Head and Director. Report on the Geology and Natural Resources of the Area included in the North-West Quarter-Sheet, No. 122, of the Ontario and Quebec Series, comprising Portions of the Counties of Pontiac, Carleton, and Renfrew. By R. W. Ells. [With a Palæontological Appendix, by H. M. Ami.] 8vo; pp. 71, with map. Ottawa: S. E. Dawson, 1907.

THE area here described, the "Pembroke Sheet" of the map, lies to the west of No. 121, the "Grenville Sheet," and has an area of 3,456 square miles. Its eastern boundary is not far from the Gatineau river, north of Ottawa city, and its south-western portion is traversed by the Ottawa river from a point about thirty miles west of Pembroke to within ten miles of the city of Hull. The rock formations comprised in it are as follows:—

Palæozoic Formations.

Trenton Limestone.
Black River Limestone.
Chazy Limestone and Shales.
Calciferous Dolomite.
Potsdam Sandstone.

Crystalline Rocks, including:—

Granite and Granite-gneiss.
Gneiss, Quartzite, and Limestone of the Grenville Series.
Anorthosite and other Igneous Rocks.
Post-Pliocene Deposits.

The crystalline rocks, which fill the most important place in the area surveyed, comprise the so-called fundamental gneiss and associated granite, and the upper series of banded gneiss with quartzite and crystalline limestone, the latter having the greatest development in the eastern half of the area surveyed, the older series in the western. Here the limestone is generally absent, but when present it is in the form of narrow bands resting on well-bedded quartzose gneiss, which in some places, the Coulonge river, for instance, forms cliffs, in which it presents the bedded aspect of the Potsdam Sandstone.

The fundamental gneiss is well seen in the western part of the area, where it has, in some places, a well-defined gneissic structure, but the rock is often granitic. These rocks apparently represent the oldest known geological formation of the Ottawa district. In that portion of the gneiss associated with the quartzite and limestone in the area adjacent to the Gatineau river, deposits of mica, apatite, and graphite are numerous and valuable. The limestones generally occur in basins and represent the upper part of the Archæan rocks. They usually rest upon well-bedded masses of white quartzite.

In summing up the results of his investigation of these crystalline rocks Dr. Ells remarks that "from an examination of all the features of the problem it has now been generally accepted that the Laurentian should be confined as far as practicable to the fundamental granite-gneiss, that the rocks of the Grenville and Hastings series should be regarded as a portion of the Huronian and represent the lowest members of that system in Eastern Ontario and in Quebec adjoining, and that the upper part of the Huronian is represented by the more schistose portion seen in the area farther south and west. In this manner much of the difficulty hitherto experienced in interpreting satisfactorily the great problem of the crystalline rocks disappears."

The Palæozoic rocks extend, according to the map, from the Potsdam Sandstone to the Trenton, both inclusive, but in the text they are said to range from the Calciferous to the Trenton Limestone. They form the remnant of the western margin of the great Ottawa basin, and are found at intervals along the Ottawa river, and also as scattered outliers in some of the neighbouring townships. They occur also on the north shore of the river near Ottawa city, as well as in places on the south shore.

Large collections of fossils were made, chiefly from the Black River Formation, lists of which are given.

The chief features in the surface geology of the district are large areas of clays, sands, and gravels, some of which show their marine origin by their containing the remains of fishes, etc.

The economic minerals do not appear to be of much importance, with the exception, perhaps, of iron and mica.

In the Appendix to the report (pp. 49–71) Dr. H. M. Ami gives preliminary lists of fossils from the Chazy, Black River, Trenton, and Pleistocene Formations. The best collections from within the area are those from the Black River Formation. The lists include the names of species long familiar to workers in the field of North American palæontology. They will prove an invaluable index to the interpretation of the age of the rocks in which they may be found wherever stratigraphical data might, without confirmatory evidence, be unconvincing. A map coloured geologically and on a scale of 4 miles to 1 inch accompanies the report.

A. H. F.

II.—Palæocene Strata in Denmark, near Copenhagen. By Karl A. Grönwall and Paul Harder.

Paleocæn ved Rugaard i Jydland og dets Fauna; af Karl A. Grönwall og Poul Harder. Danmarks geologiske Undersøgelse, II Raekke, Nr. 18. 1907.

EXPOSURES of Palæocene strata are scarce in Denmark, but by a careful study of the fossils from the neighbourhood of Copenhagen considerable additions have been made to our knowledge of the Palæocene fauna. These strata belong, the authors think, to a zone older than that of the Thanet Sand, and tending to fill up the gap between Cretaceous and Tertiary. A considerable number of new species are figured and described; the rest are mainly referred to forms already known in North Germany. The deposit yielding these fossils is a glauconitic sand, with a conglomeratic base containing derivative Cretaceous fossils. The Cretaceous rock below is Senonian, the higher Cretaceous zones being there absent.

The authors consider that towards the close of the Cretaceous period a general rise of the land took place in northern Europe, the Danian being deposited in the south and west part of the Baltic. At the beginning of the Palæocene epoch they think that this sea of the North German plain entered into free communication with the sea over South Russia, which spread to meet it from south-east towards the north-west and north. Still later the western ocean overspread the Anglo-Parisian basin, thus entering into communication with the Eocene sea of the West Baltic and North Germany. During the same epoch rises of land towards the east completely severed the communication between the sea of South Russia and that of the West Baltic.

The Palæocene fauna described in this memoir is very different from that of the Thanet Sand, and is probably older. It is not clear why the authors consider that this Palæocene sea and the Danian sea did not extend across Britain. The fauna of the Trimingham Chalk shows us that the absence of the higher zones over most of Britain is only due to denudation. Why should not the same cause account for the absence of the earliest Eocene deposits?

C. R.

III.—Mexican Ammonites.

The Instituto Geólogico de México has recently published Boletin Número 23 (dated 1906), "La Faune Jurassique de Mazapil, avec un appendice sur les fossiles du Crétacique Inférieur, par le Dr. Carlos Burckhardt" (13 by 9¼ inches), in 2 parts, text 216 pages, 43 plates.

Fifty-nine species of Ammonites are described from beds of Kimeridgian age, including *Oppelia flexuosa costata*, Qust., *Aspidoceras contemporaneum*, E. Favre, *Aspidoceras bispinosum*, Qust., sp., *Idoceras* (*Perisphinctes*) *laxevolutum*, Font., sp., *Idoceras Balderum*, Oppel, sp., *Haploceras Fialar*, Oppel, sp., *Aspidoceras avellanoides*, Uhlig. Twenty-six species of Ammonites are described from beds of Portlandian age, including *Phylloceras apenninicum*, Canavari, *Perisphinctes Nikitini*, Michalski, *Aspidoceras cyclotum*, Steuer. Forty-six new Jurassic (Kimeridgian or Portlandian) species are described, and eleven species of Ammonites from the Lower Cretaceous. The plates from photographs have been beautifully executed by Werner & Winter, of Frankfort o/M.

B. H.

IV.—Summary of Progress of the Geological Survey of Great Britain and of the Museum of Practical Geology for 1907. pp. iv, 175, with 1 plate and 8 text-illustrations. London: printed for H.M. Stationery Office, 1908. Price 1*s*.

We have received from the Board of Agriculture and Fisheries the above-mentioned memoir of the Geological Survey, which has been issued somewhat earlier than was the case with the volume for the previous year. It contains, as usual, particulars of the field-work carried on in different parts of England, Wales, and Scotland.

In two districts of England the Survey has been occupied. (1) In Cornwall, where the eruptive rocks of the Lizard have engaged special attention; elsewhere work has been carried on in the country about Padstow, Wadebridge, Callington, Camelford, and Bodmin Moor, and we have notes on the Delabole slates and other Devonian rocks, on the Devonian and Carboniferous rocks near Callington, and on the granite of Bodmin Moor, the rock-platforms and their relation to stream-tin deposits. (2) In the Midland district the Survey has been occupied at Matlock, Alfreton, Mansfield, and Ollerton, including parts of Sherwood Forest and the Trent Valley. The zones in the Carboniferous Limestone, the Coal-measures, Permian, Trias, Lias, and Drift deposits receive due attention.

In Wales the survey of the western end of the South Wales Coalfield has been continued in a complex area, where igneous rocks possibly of pre-Cambrian age, and Cambrian, Ordovician, Silurian, Old Red Sandstone, and Carboniferous rocks are developed. We note (on p. 39) that the Llandilo Flags are, by mistake, grouped with the Arenig. The disturbances in the Carboniferous rocks are specially mentioned.

In Scotland field-work has been carried on in the northern and western Highlands, in Caithness, the valley of the Findhorn, near Ben Nevis, and in the islands of Mull and Colonsay. Various schistose rocks, Torridon sandstone, Jurassic strata and Drifts, as well as igneous rocks, are dealt with. The Survey has also been occupied in the central portion of the Scottish coalfields.

The Appendix contains articles on the Mugearites, one of the Tertiary igneous rocks of the Inner Hebrides (illustrated by plate); on the Marine beds near the base of the Upper Carboniferous in Scotland, on the eastern extension of the Nottinghamshire and Yorkshire Coalfields, accounts of sections opened up on new branches of the Great Western Railway in Oxfordshire and Somerset, notes on the dates of some of the earlier published Geological Survey Maps, and a list of manuscript maps and sections in the Library of the Museum of Practical Geology.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

June 17*th*, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Hornblendic Rocks of Glendalough and Greystones (Co. Wicklow)." By J. Allan Thomson, B.A., B.Sc., F.G.S.

Both these rocks are intrusive into Ordovician strata in the east of County Wicklow: the former occurring as a small boss in the south side of Camaderry, a ridge which separates the Vale of Glendalough from the valley of Glendrosan; while the latter occur as three dykes traversing the sedimentary rocks on the shore at Greystones. The Glendalough rock is older than the Great Wicklow Granite, and exhibits much heterogeneity in composition. The chief varieties are the following:—(1) A hornblende-peridotite, made up mainly of amphibole with apatite, magnetite, pyrite, olivine, augite, chlorite, and calcite; an analysis of this variety is given; (2) amphibolite, with larger hornblende crystals separated by fine-grained amphibole; (3) actinolite rock, mainly made up of actinolite, but bearing also zoisite, sphene, and sulphides; (4) zoisite-amphibolite, made up of pœcilitic hornblende enclosed in a granular matrix which is white with zoisite; and (5) 'quartz-mica diorite,' containing quartz and felspar. The last variety is conceived to be a mixed rock, formed by the absorption of the amphibolite by an acid magma; an analysis of one of the most acid types is given. The Ordovician sediments are converted into hornfels at the contact with the igneous rock, and this type of rock has resisted the dynamic metamorphism which occurs elsewhere in the district. The Greystones rock shows a transformation from peridotite into amphibolite, but with a greater development of talc. Olivine and rarely mica are present in the original rock.

2. "On the occurrence of Footprints in the Lower Sandstones of the Exeter district." By Principal Arthur William Clayden, M.A., F.G.S.

Suitable exposures in the 'Lower Sandstones' of the Geological Survey map are very rare. Dr. Shapter has recorded 'claw-like footmarks,' etc., from a locality about half a mile north-east of Broadclyst. Another quarry has been recently reopened here for building stone; and, on a search being made, slabs with footprints were found by the author and his students. Later, a slab with a track containing thirty pairs of footprints was found. In all, five specimens have been secured; and three of the sets of prints may have been made by the same individual, one with fore and hind feet about the same size and bearing about the same weight. The two other sets of prints were made by smaller and different individuals. In one case the prints of the manus are slight, and those of the pes heavy, although the hind and fore feet were of about the same size. There is no trace of the tail being dragged. In the other the animal had all the characters of the last, except that the digits 5 and 2 were nearly equal. This track also shows that the animal sometimes threw nearly all its weight on the right side and sometimes on the left. In no case is there anything to suggest either claws, a sole to the foot, or a fifth digit. They are least unlike Cheirotheroid prints, but differ from them in the absence of a divergent digit. The specimens have been presented to the Exeter Museum.

3. "The Basic Intrusion of Bartestree, near Hereford." By Professor Sidney Hugh Reynolds, M.A., F.G.S.

The Bartestree dyke, which has a thickness of about 35 feet, strikes in an east-north-easterly direction through the Old Red Marls and Sandstones, which for a distance of at least 10 feet from the contact are strongly metamorphosed, the marl being converted into a hard purplish-grey rock with yellow patches, while in the sandstone the felspars are recrystallized and the quartz grains corroded.

The dyke itself is not a single uniform intrusion, but a multiple dyke composed of several allied though differing types of dolerite and basalt. While the major portion consists of basalt, the marginal portion is chiefly doleritic. Dolerite and basalt are, however, intimately intermingled, patches of basalt occurring in the predominantly doleritic portion and *vice versâ*. The relations are clearly such as to point to the invasion of an earlier doleritic intrusion by a later one of basalt. Two types of dolerite further occur, a teschenite with fresh analcime and abundant augite and serpentinized olivine being the prevalent type. This closely resembles the Clee Hill rock, and it may be suggested with some probability that the Bartestree dyke is of the same age as the Clee Hill intrusion. The basalt in places shows patches with an imperfect variolitic structure.

Admission of Women to Fellowship or Associateship in the Geological Society of London.

A Special General Meeting was held before the Ordinary Meeting on Wednesday, June 17th, at 7.45 p.m., in order to consider the following resolution, proposed by Dr. J. Malcolm Maclaren and seconded by Mr. A. Gibb Maitland:—

> "That Fellows non-resident in the United Kingdom be invited to express an opinion concerning the Admission of Women to Fellowship or Associateship of the Geological Society of London."

This resolution was passed by 30 votes to 11.

The next Ordinary Meeting of the Society will be held on Wednesday, November 4th, 1908.

II.—Mineralogical Society.—*June* 16*th*, 1908. Professor H. A. Miers, F.R.S., President, in the Chair.

On a nickel-iron alloy ($Fe_5 Ni_3$) common to the meteoric iron of Youndegin and the meteoric stone of Zomba, by L. Fletcher. In the case of the Zomba meteoric stone the gradual increase of nickel in the residue after repeated extraction of the nickel-iron with mercuric ammonium chloride was previously attributed to rusting. It is now explained by the presence in the nickel-iron of a component not easily affected by the mercuric solution, and containing 38·50 per cent. of nickel. This component is identical with the 'tænite,' containing about the same percentage of nickel, which was separated from the Youndegin iron by its insolubility in dilute hydrochloric acid.—On Kaolinization and other changes in West of England rocks, by F. H. Butler. The author pointed out that the gaseous emanations of a granitic magma, which are carried upwards and discharged externally, gradually bring about considerable pneumatolytic changes. Notable among these are increased vesicularity in the quartz of the peripheral part of granitic intrusions and their offsets, the elvans, also the assumption by that mineral of the idiomorphic form, and the production of tourmaline. The occurrence of tourmaline in rocks exemplifying various stages in metasomatism indicates long-continued supply of boron compounds from abysmal regions. The primary, usually brown, tourmaline in the altered acidic rocks is commonly found to have been eroded, doubtless owing to alkalinity of the kaolinizing solution, before dekaolinization and the consequent formation of acicular schorl ushered in a final deposition of quartz. The view of Professor Vogt and other authorities that kaolinization was effected by the rise of solutions of carbon dioxide from among calciferous rocks receives support from the occurrence of calcium sulphate in underground waters and of numerous calcium compounds in mineral veins and lodes. The unchanged condition of some topaziferous granite is one of various indications that the action of hydrofluoric acid on rocks has been low down rather superficial. It, or hydrofluosilicic acid, appears to have played a part in the following sequence of events in the West of England:—(1) Decomposition of deep-seated calcite-bearing rocks, and consequent kaolinization of neighbouring granite by evolved carbon dioxide. (2) Local and variable dekaolinization, fluorization, and tourmalinization of china-clay rock and china stone by borated waters carrying dissolved fluor-spar, resulting in the formation of schorlaceous rocks and greisen. (3) Lastly, supply to the metasomatized rocks of tin stone and wolfram from solution, and then of silica. The author concluded with a brief summary of facts subversive of the popular notion that the kaolin of commerce is the result of subaerial action upon granite. — On Schwartzembergite, and the drawing of light figures, by G. F. Herbert Smith. The author described the crystals occurring on three specimens in the British Museum, the locality being San Rafael, Chili. They are formed of four low pyramido-faces above and below, eight in all, with nearly square contour, the angle from the centre averaging 20° with range 15°–25°, and simulate tetragonal symmetry; steep pyramids are occasionally present also. The mean refraction is 2·350. The optical characters are remarkable: through each pyramid face appears in convergent light a biaxial interference-figure ($2E = 16°$) with negative birefringence, the axial plane being parallel to the edge of the contour; but through intermediate sectors appears another biaxial interference-figure with larger angle ($2E = 33°$), the axial plane being in this case radial; the number of different directions of single refraction in the crystal is, however, only four. The pyramids give, with pin-hole object, a continuous band of light. Since there was no well-defined image from which to measure, it was necessary to draw these figures direct on to a projection. The author described a camera-lucida attachment for the goniometer, which would allow of the preparation of projections of different sizes and of the relative variation required by the distortion in a projection. — The chemical composition of Seligmannite, by G. T. Prior. The results of two analyses show that this new mineral from the Binnenthal is a sulph-arsenite of copper and lead ($Pb\,Cu\,As\,S_3$) corresponding to the sulph-antimonite, bournonite, with which it is crystallographically similar.

III.—Zoological Society of London.—*June* 16*th*, 1908. Dr. Henry Woodward, F.R.S., Vice-President, in the Chair.

Dr. A. Smith Woodward, F.R.S., F.Z.S., exhibited photographs and fragments of skin and bone of a Mammoth and a Rhinoceros discovered in an ozokerite mine at Starunia, Galicia. The carcases of these animals appeared to have found their way into an old marsh saturated with petroleum, which had completely preserved them.

The photographs and specimens had been received from Dr. George von Kaufmann, who intended to present them to the British Museum.

Dr. C. I. Forsyth Major, F.R.S., F.Z.S., exhibited the lower jaw of a young Canadian Beaver in which there was present on each side a small conical tooth anterior to the deciduous premolar. He considered the supernumerary premolar to be a case of atavism. He also exhibited a set of drawings made from examples of two species of *Castor* from the East Runton Forest-bed, and remarked that truly Forest-bed species were found in association with Pliocene species. He discussed incidentally the numerous species of recent European Beavers admitted by Professor Matschie. Lastly, he exhibited photographs of Pliocene *Bovinæ* from specimens in the Florence Museum, stating that these unpublished figures showed the great variability of the Pliocene *Bovinæ*. He added that he endorsed Falconer's opinion that these Pliocene *Bovinæ* were nearly related to the primitive Buffaloes from the Siwaliks.

OBITUARY.

HENRY CECIL MOORE,

PRESIDENT OF THE WOOLHOPE NATURALISTS' FIELD CLUB.

BORN 1835. DIED JUNE 21ST, 1908.

THERE are perhaps two main ways of forwarding scientific knowledge. The one is by contributing original work; the other is by instilling a liking for such work by means of personal energy and enthusiasm, and the publication and dissemination of popular resumés and interesting accounts of excursions made in the field. The former method is naturally essential, but the indirect support given the former by the latter is perhaps frequently lost sight of. Therefore it is fortunate indeed that there are men, imbued with energy and enthusiasm, and what is more important the property of imparting such, who arise from time to time to carry on this great work of popularization. Few there have been in the West Country and Borderland who have been more worthy of fame on this account than H. C. Moore, who died on Sunday, June 21st, 1908, while in office as President of the Woolhope Naturalists' Field Club.

Like the great geologist who trod Siluria long years before, Moore led with characteristic enthusiasm and energy his bands of Woolhope Club members over the hills and dales of Herefordshire and the adjacent counties on the west. Moore's early life was spent in the Army as a Royal Engineer. Son of Brigadier-General G. Moore, of the Bengal Army, he was born at Lucknow in 1835; was educated at Wem, Leamington College, and privately; and at the age of 18 entered Addiscombe College. At the end of two years there he became a lieutenant in the Royal Engineers, and was temporarily attached to Sir Hugh Rose's Field Force for the suppression of the Indian Mutiny. On March 17th, 1858, he arrived at Aden, and was present at the capture of the fortified village of Shaikh Othman on the following day. During parts of the years 1858 and 1859 he was Assistant Engineer, Public Works Department, Aden

(Reservoirs, Tunnel, and Military Works); and from 1859 to 1861, Commanding Engineer and Governor of Perim Island, at the entrance to the Red Sea. On this island he superintended the construction of the tanks and defensible lighthouse. Twice he received the thanks of the Government; but in 1861 he was invalided to England. In 1862 and the following year he was Commanding Engineer at Alderney; and in 1863 and 1864 at the Royal Engineer Establishment, Chatham, on the Military Pontoon Commission (Austrian detachment). The next two years were spent in Ireland, at Templemore, where he received the thanks of Sir Hugh Rose—who had become Commander of the Forces in Ireland—for reconnaissance and proposed military defences of the district. The year 1866 saw Moore's retirement from the Army on half-pay, being invalided. This, however, did not terminate an even then active career, indeed it did not half fulfil it, for having spent a few years in studying at Sydenham and Queen's College, Birmingham, he became resident on the Staff of the General Hospital—a position he held until 1870, in which year he was appointed Assistant House Physician and Assistant House Surgeon. In that year he moved to Hereford, having been appointed House Surgeon at the General Hospital. From 1893 to 1900 he was Honorary Surgeon of the Hereford Dispensary; from 1898 to 1900 Medical Officer of Health for the City and five Rural Districts; and was still Medical Officer of Health for Hereford at the time of his death.

Moore was Honorary Secretary of the Free Library and Museum from 1886 onwards, and Honorary Secretary of the Woolhope Naturalists' Field Club from the same year until 1908, with the exception of the years 1896, 1897, and the present one, when he was President of the Club. The editing of the Transactions of this well-known Club is a no mean task, and the fact that Moore performed this duty from 1877 until his death is sufficient evidence, to those who know, of his untiring zeal. In the field he was a stimulating leader, always ready to teach and be taught, and in him the Woolhope Club and a larger circle has lost a true friend and a genial companion, which it will be impossible to replace.

L. Richardson.

MISCELLANEOUS.

London University: The New Principal.—At a meeting of the Senate of London University on July 22nd Professor Henry Alexander Miers, M.A., D.Sc., F.R.S., Fellow of Magdalen College, Oxford, and Waynflete Professor of Mineralogy in that University, was appointed to be Principal as from October 1st next on the resignation of Sir Arthur Rücker, D.Sc., F.R.S. In addition to his professorship, Dr. Miers holds various administrative offices in the University of Oxford, being a member of the Hebdomadal Council, a Delegate of the Clarendon Press, a Delegate for the Inspection and Examination of Schools, and Secretary to the Delegates of the Museum.—*Morning Post*, July 23rd, 1908.

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., Dr. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

SEPTEMBER, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. IX.—SEPTEMBER, 1908.

ORIGINAL ARTICLES.

I.—Some Coal-Measure Crustaceans with Modern Representatives.

By Henry Woodward, LL.D., F.R.S., F.G.S.

AMONG the numerous fossils obtained by Dr. L. Moysey from the clay-ironstone nodules of the Coal-measures near Ilkeston, Derbyshire,[1] is one referred to by its discoverer as "a shrimp-like animal," in a recent note published by him in the Geological Magazine for May last.[2] Dr. Moysey was so fortunate as to secure several well-preserved examples of this very interesting Schizopod Crustacean from a disused brickfield on the Shipley Hall Estate, owned by E. M. Mundy, Esq. These he most liberally placed in my hands to examine and describe. Dr. Moysey also commended me to the Rev. C. Hinscliff, M.A., of Craig Royston, Bickley, Kent, who had in his possession another specimen of this crustacean obtained from the same locality. Mr. Hinscliff not only sent me his fossil to study, but generously presented it to the Geological Department of the British Museum (Natural History Branch), Cromwell Road, where it will be preserved and exhibited.

Præanaspides præcursor, H. Woodw., gen. et sp. nov.

Description of the fossil.—One of the largest and most perfect of these Schizopod-like Crustaceans measures 57 mm. in length (see Fig. 1). A second specimen is 30 mm. in length. A third, showing the dorsal aspect, is 40 mm. long (Fig. 2). Mr. Hinscliff's specimen (Fig. 3) is 30 mm. in length, but the head is imperfectly preserved. A nearly complete small individual is 15 mm. long; it is associated with a fifth, but less perfect, example measuring only 10 mm. in length. The two last-named are exposed on the split surface of a nodule, lying one on either side of a Calamite stem.

The head is extremely small, being only 6 mm. long, or equal in length to the two anterior thoracic segments; the rostral portion is slightly produced and bent a little downwards; the inferior margin

[1] "Two New Species of *Eurypterus* from the Coal-Measures, Derbyshire," by H. Woodward: Geol. Mag., 1907, pp. 277–82, Pl. XIII.

[2] "On a Method of Splitting Ironstone Nodules by Freezing them," by L. Moysey: Geol. Mag., 1908, pp. 220–2.

is shorter than the dorsal and slightly emarginated behind the base of the antennæ. About one-fifth of the head is strongly marked off behind by the cervical furrow or groove which runs parallel to its posterior border, or it may represent the union of the first thoracic segment coalesced with the cephalon.

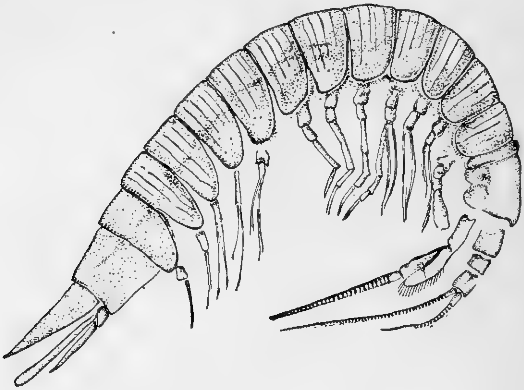
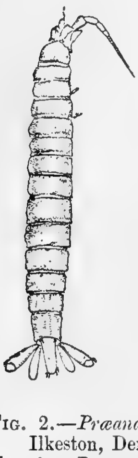


Fig. 1.—*Præanaspides præcursor*, H. Woodw., gen. et sp. nov. (Clay-ironstone) Coal-measures: Ilkeston, Derbyshire. From Dr. L. Moysey's collection. About twice nat. size.

Eyes.—The presence of a pedunculated eye seems indicated—though not very clearly—by a small rounded hollow at the base of the antennule.



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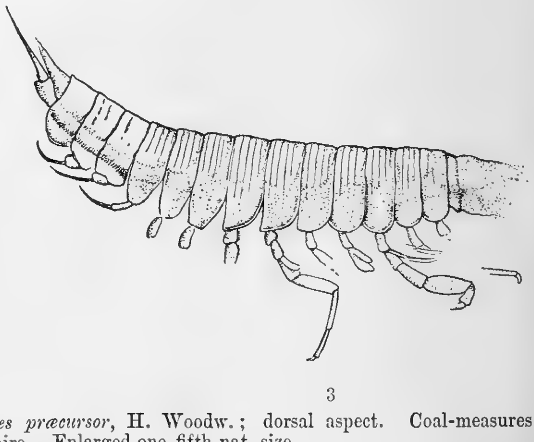

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Fig. 2.—*Præanaspides præcursor*, H. Woodw.; dorsal aspect. Coal-measures: Ilkeston, Derbyshire. Enlarged one-fifth nat. size.

Fig. 3.—*Præanaspides præcursor*, H. Woodw., gen. et sp. nov. Coal-measures: Ilkeston, Derbyshire. Collected by Rev. C. Hinscliff, M.A., and presented by him to the Geological Department of the British Museum (Natural History). × $2\frac{1}{2}$ nat. size.

Antennules.—These have three stout basal joints, measuring together 5 mm. in length, of which the first is the broadest, the second is very short, while the third, or distal one, is the longest; each bears a pair of multi-articulate flagella, the outer one being 10 mm. in length, and the inner and smaller one is only 5 mm. long.

Antennæ.—The antennæ are more robust than the antennules; the three basal joints together are 7 mm. in length, and the third joint bears a large oblong spatulate scale, or exopodite, fringed with setæ. The single flagellum is fully 8 mm. in length.

Mandibles and maxillæ.—The mandibles and maxillæ cannot be seen in the fossil; if preserved, they are hidden from view by matrix.

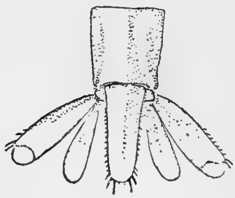
Post-cephalic segments.—Assuming that the first thoracic segment is coalesced with the head, there are seven free thoracic segments behind the head, the three most anterior of which are each about 3 mm. long and 3 mm. deep; those which follow gradually increase to 4 mm. in length and 5 mm. in depth. The lateral margins of the anterior segments are broadly rounded, while the five abdominal ones which succeed them gradually increase in depth and become more pointed and slightly falcate posteriorly.

Appendages.—The first free (= to the second) thoracic segment carries a pair of legs or maxillipeds (endopodites), the three first joints of which are short, followed by a larger one (the *meros*), which is about equal to the three proximal joints in length, and is broadest at its distal end; two smaller joints and a claw follow. Apparently there was no exopodite developed on this limb, or, if present, it may have been rudimentary, but it cannot be detected. Each of the four segments which follow carries a pair of appendages about 10 mm. in length, having a short, broad coxal joint, followed by a basipodite, which supports on a slender joint or branch a multi-articulate setose exopodite, and an endopodite in the form of a seven- or eight-jointed slender leg, of which the carpus appears to be the longest joint, ending in a single claw or nail. The basal joint of each of these four pairs of appendages probably also bore a pair of ovate-oblong branchial lamellæ, but these, being exceedingly delicate structures, are not clearly discernible in the clay-ironstone matrix, but of their actual existence in the fossil I have little doubt.

The two pairs of limbs, borne upon the hindmost (seventh and eighth) thoracic segments, do not appear, like the earlier four which preceded them, to have possessed the multi-articulate setose exopodites, but only the slender limbs (the endopodites), similar in character to those borne by the more anterior segments.

Abdominal series.—The five most anterior segments of the abdomen, as already stated, are deeper and have more pointed lateral margins than the thoracic ones which preceded them. These had each a pair of slender, bifid, many-jointed, setose swimming appendages, borne upon a stronger basal joint, articulated with the antero-lateral border of each of the five segments. The sixth segment is more or less cylindrical in form, being 5 mm. in depth and 5 mm. in length, and slightly narrower posteriorly, somewhat ridged dorsally, and grooved and ridged laterally to give firmer attachment to its appendages; these form, with the 'telson,' the tail-fan or uropods. On the central line the 'telson' or seventh segment is articulated, which is 7 mm. in length, and, seen in profile, appears to be strongly acuminate, but when viewed dorsally it is found to be 3 mm. broad, narrowing to its rounded distal end, which is armed with spines along its lateral borders, and has three or four larger spines on either side near its extremity. On either side a short basal joint articulates with the segment, giving attachment to two ovate-oblong uropods, thrice as long as they are broad, the outer of which is much the larger, and has a semicircular transverse suture or articulation near its distal extremity, and its lateral outer margin fringed with spines, of which the largest are developed near the extremity; the inner uropod is smooth, narrower, and destitute of spines upon its margin (see Figs. 4 and 5). (The spine-like appearance of the telson and the narrowness of the uropods in Dr. Moysey's and Mr. Hinscliff's specimens (Figs. 1 and 3) is due to these appendages being seen in profile, the broad, flat surfaces being buried in the matrix, and only the edges exposed.)

Each segment of the body is scored by three to four fine vertical parallel lines passing down from the dorsal line to the lateral margin; there is evidence also of a delicate minute articulation between each of the segments on its lateral median line, and a row of extremely minute moniliform ornamentation on the posterior border of the last four or five segments (see Fig. 5).



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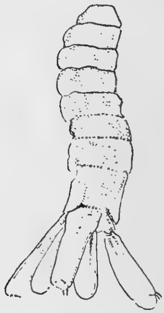

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FIG. 4.—*Præanaspides præcursor*, H. Woodw., showing sixth abdominal segment and telson with the uropods (tail-fan).

FIG. 5.—*Præanaspides præcursor*, H. Woodw., showing eight posterior body segments and telson, with the uropods of the sixth segment forming the tail-fan.

The most striking features in this Coal-measure Crustacean, for which I venture to suggest the name *Præanaspides* (on account of its close affinity to the living genus *Anaspides*[1]), are the extreme smallness of its head, there being no extension backwards of a carapace over the body, only the first thoracic segment being blended with the head, all

[1] Founded in 1894, Trans. Linn. Soc. Zool. (2), vi, 3. A preliminary account, without figures, was published in Proc. Roy. Soc. Tasmania, 1892. "A Memoir on the genus *Anaspides* and its affinities with certain Fossil Crustacea," by W. T. Calman, D.Sc., F.L.S., F.Z.S., appeared in the Trans. Roy. Soc. Edinburgh, vol. xxxviii (1896), pt. iv, No. 23, pp. 787–802, pls. i and ii, 4to, to which we shall refer again later on.

the others being distinct and bearing each its own separate tergum and serial paired appendages, similar to those of the succeeding abdominal somites, the head being no larger than in an Amphipod (which latter it also somewhat resembles in the general form of its body). The eyes are not clearly preserved in the fossil, but they appear to have been borne upon a short penduncle close to the base of the antennules. These antennules were supported upon three stout basal joints, and carried a long outer and a shorter inner flagellum ; the antennæ support on their distal joint an elongated, setose, rounded scale and a single stout flagellum. Of the mouth appendages there is no evidence in the fossil, but the second thoracic (the first free segment) no doubt carried a pair of maxillipeds, as they differ in being stouter and broader distally at the fourth or fifth joints than those which follow, and consist only of an endopodite or walking limb (or a simple claw-like organ ?). Four at least of the six appendages which follow are true Schizopod limbs, having a well-developed, setose, many-jointed exopodite attached to each leg (the endopodite), and probably also carrying branchial lamellæ on their basal joints.

The two hindmost pairs of thoracic limbs may not have been provided with exopodites. The five abdominal segments following bear true bifid swimming-feet (multi-articulate and setose); the sixth segment is longer and more cylindrical, and bears on each side, upon its distal, lateral extremity, two rounded, scale-like uropods, or swimming organs, resembling the lateral lobes of the tail-fin in the Macroura, and a rounded central telson or terminal joint.

Allied Fossil Genera.[1]

1. *Gampsonyx fimbriatus*, Jord. & v. M.—A form was described under this name by Jordan & von Meyer in 1854[2] from the Coal-measures

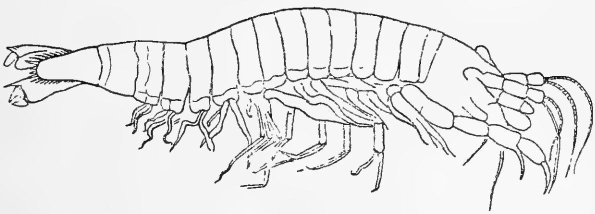

Fig. 6.—*Gampsonyx fimbriatus*, Jordan & v. Meyer. Permo - Carboniferous: Saarbrück, Rhenish Prussia. Drawn from Jordan & v. Meyer's plate in the *Palæontographica*, vol. iv (1856).

[1] The three forms referred to here have been discussed by Dr. Packard and form his groups Syncarida and Gampsonychidæ (American Naturalist, vol. xix (1885), pp. 790–2 ; Mem. Nat. Acad. Sci., Washington, vol. iii (2), 1886 ; Proc. Boston Soc. Nat. Hist., vol. xxiv (1889) ; see also Packard's "Textbook of Zoology," 5th ed., 1886. He here uses the term Syncarida as including *Gampsonyx*, *Acanthotelson*, and *Palæocaris*. Dr. Calman has also figured and noticed them in his memoir on *Anaspides* (see Trans. Roy. Soc. Edinb., 1896, already quoted). The figures of these here given are reproduced from Dr. Packard's restorations.

[2] "Ueber d. Steinkohlenformation von Saarbrücken": *Palæontographica*, vol. iv (1856).

of Saarbrück, which are probably of Permo-Carboniferous age like the Gaskohle of Bohemia.

The eyes in *Gampsonyx* are said to be pedunculated; the bases of the antennules are three-jointed and have two nearly equally long flagella; the antennæ support a large rounded scale, and they have a three-jointed peduncle and a flagellum. The head is short, and the hinder part has a strongly marked division as seen in *Præanaspides*, and may be a distinct eighth segment, but more probably its separation as a distinct segment is a matter of interpretation of the fossil. *Gampsonyx* has a pair of powerful raptorial limbs belonging (Dr. Calman believes) to the first or second thoracic legs. The other thoracic limbs (though obscure) appear to agree nearly with the Schizopod type in having an exopodite and endopodite present in each (although the drawing is not very clear). Dr. Anton Fritsch has described two forms[1] under the genera *Gasocaris* and *Gampsonychus* which may also belong to this group of Palæozoic Crustacea of late Coal-measure age.

2. *Acanthotelson stimpsoni*, Meek & Worthen, 1865 (Fig. 7).—This crustacean was obtained from the Coal-measures of Illinois (Proc. Acad. Nat. Sci., Philadelphia, 1865, p. 41). Two species are described, viz. *A. inæqualis* and *A. stimpsoni*. Packard, who has given a restoration of this genus, considers the head to be composed of two segments, the second being separated by an impressed line from the first; there is not a true articulation between them. (The eyes are unknown.) The antennules have a three-jointed peduncle which carries two flagella[2]; the antennæ have also a three-jointed peduncle and a moderately long flagellum. The seven separate thoracic segments each bears a pair of long, robust, seven-jointed walking-legs, the first and second pairs being the largest, and having their penultimate joints armed with stout spines. No exopodites appear upon the thoracic limbs. *Acanthotelson* has five pairs of well-developed setose swimming-feet upon the abdominal segments. The uropods of the tail-fan are slender in form and bordered by spines or bristles, and so also is the telson (see figures of this genus and of *Palæocaris* in Geol. Mag., 1881, p. 533,

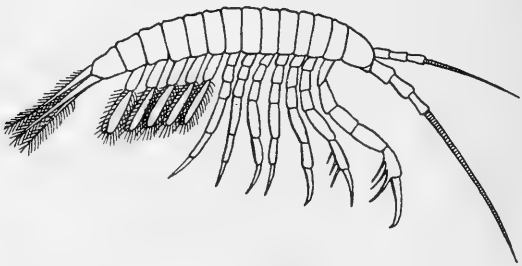

Fig. 7.—*Acanthotelson stimpsoni*, M. & W. Coal-measures: Illinois. Copied from Dr. Packard's figure.

[1] Dr. Anton Fritsch, "Fauna der Gaskohle und der Kalksteine du Permformation Böhmens," Bd. iv (1901), Heft 3.

[2] Packard only represents one flagellum in his figure (see Fig. 7).

Pl. XIV, Fig. 4, and text-fig.; also of *Palæocaris Burnettii*, H. Woodward, sp. nov., p. 533, Pl. XIV, Fig. 3*a*, *b*, Coal-measures, Irwell.

3. *Palæocaris typus*, Meek & Worthen, 1865 (Fig. 8) (Proc. Acad. Nat. Sci., Philad., and Report Geol. Surv., Illinois, 1868), was obtained by its original describers from the Coal-measures of Grundy Co., Illinois. It was afterwards redescribed by Packard in 1866.[1] The head is represented as truncated in front and is quite small; the body uniformly segmented; there are seven distinct thoracic segments, but over these there is no backward extension of the head-shield; the first five abdominal segments have downwardly projecting pleuræ; the sixth segment is elongated and cylindrical in form. The tail-fan and telson are similar to those of the Palæmonidæ, or of a Mysis-like shrimp. The eyes are not seen in the fossil, but the antennules have a stout three-jointed peduncle strongly developed, and each carries a pair of flagella, the outer one longer than the other. The antennæ carry a broad scale, or exopodite, and a long multi-articulate flagellum. The thoracic appendages (as represented in Packard's restoration) have each a three- or four-jointed exopodite borne upon a slender walking- or swimming-limb, the distal extremity of which latter is not shown. Each of the five (abdominal) segments which follow carries a pair of pleopods of the usual slender, setose, multi-articulate form.

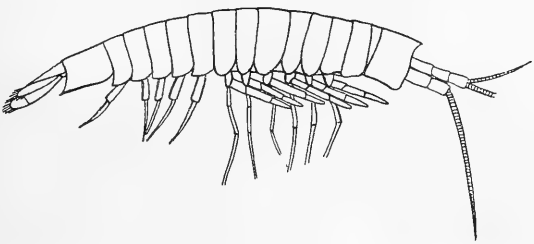

FIG. 8.—*Palæocaris typus*, M. & W. Coal-measures: Illinois. After Dr. Packard's figure.

Living analogues of Coal-Measure Schizopods.—In the examination of fossil forms from the older rocks, we are seldom so fortunate as to find a living analogue by which to interpret these too often rare and imperfect organic remains; nevertheless, amongst the discoveries made in Australasia in recent years, two forms have attracted considerable attention, as indicating very early and primitive types of Crustacea, and throwing an important light on several remarkable Coal-measure Crustaceans, previously without any very near existing representative.

1. The first of these living Schizopod Crustaceans was noticed, under the name of *Anaspides tasmaniæ*, by Mr. G. M. Thomson, of Dunedin, in 1894.[2] Its describer discovered it it in a freshwater pool, at an

[1] Mem. Acad. Nat. Sci., Washington, vol. iii (2), 1886. Abstract in Amer. Naturalist, vol. xix (1885), pp. 790–2.

[2] Trans. Linn. Soc. Lond., Zoology (2), vol. vi (1894), p. 3. A preliminary account, without figures, has been previously published in Proc. Roy. Soc., Tasmania, 1892.

altitude of 4,000 feet, on Mount Wellington in Tasmania.[1] The very striking peculiarities of the animal, the absence of a carapace, the presence of plate-like gills attached to the bases of the thoracic legs, and the possession of an auditory organ in the penduncle of the antennules, led Thomson to regard it as the type of a new family of Schizopods, the Anaspidæ, while suggesting that it might be entitled to even higher specific rank.[2] Fresh specimens of *Anaspides* having come into Dr. Calman's hands, when studying at the Museum of University College, Dundee, he was enabled to add some important points to Mr. Thomson's previously published account of the external anatomy of the animal, and to compare it with some already described fossil forms. This he has done in an admirable memoir communicated to the Royal Society of Edinburgh in 1896,[2] from which we venture to make some extracts.

ANASPIDES TASMANIÆ, G. M. Thomson, 1896.

Dr. Calman points out that Thomson (in his original description) attributes to this Crustacean the possession of eight free thoracic segments, but Calman shows that the first of these is not actually a separate segment, being a part of the head, the supposed division being in reality only a superficial groove in the integument, corresponding no doubt to the "cervical sulcus," which in the Mysidæ crosses the carapace immediately above the mandibles, and he accordingly identifies it with this sulcus. It is also homologous with the cervical groove in the Decapods, behind which the segments bearing the two pairs of maxillæ would morphologically be placed.

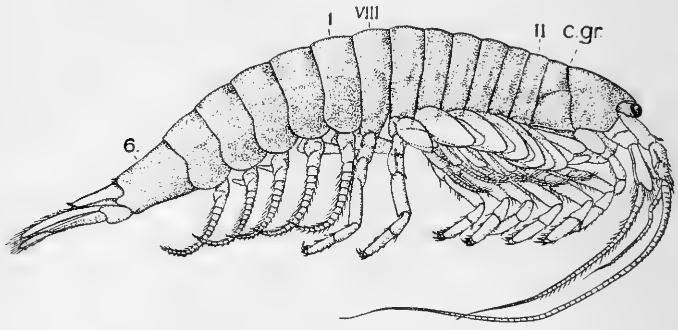

FIG. 9.—*Anaspides tasmaniæ*, G. M. Thomson (living), from freshwater pools 4,000 feet above the sea, on Mount Wellington, Tasmania. c.gr. = cephalic groove; II–VIII, the seven free thoracic segments; 1–6, the six abdominal segments; the seventh is the 'telson' or tail-spine. Drawn from a specimen in the British Museum (Nat. Hist.) under Dr. Calman's direction. (All the figures have been drawn from nature by Miss G. M. Woodward, except Figs. 6, 7, and 8, which were copied by her from Dr. Packard's restorations.)

[1] Mr. G. M. Thomson has since added another locality, namely, "Lake Field," a spot forty miles from Hobart Town, Tasmania, also at an elevation of about 4,000 feet above the sea (Trans. Roy. Soc., 1897, op. cit., p. 802).

[2] Trans. Roy. Soc. Edinb., vol. xxxviii (1897), pt. iv, pp. 787–802. 4to.

From this he infers that in *Anaspides*, in the Mysidæ, and in the Decapods a primary sulcus exists, delimiting an anterior region, or head, to which three pairs of appendages, antennules, antennæ, and mandibles belong[1] (the region of the three-paired appendages of the Nauplius, the "primary head-region" of the Crustacea, according to Claus).

Dr. Calman has observed what appear to be a group of 'ocelli' on the head just in front of the cervical furrow; as no similar larval eyes exist in any known adult Malacostracan, this is indeed a most embryonic character. He is also able to confirm Thomson's discovery of an auditory organ in the base of the antennule of *Anaspides*, a fact of very great interest, such organs having at one time been considered as almost confined to the Decapoda. But the discovery of paired otocysts in the head of certain Amphipoda (*Oxycephalus*), being regarded by Claus as probably homologous to the auditory organs in the Decapods, he thinks they may have been a character of the primitive Malacostraca, a further indication of the more generalized and primitive type presented to us in *Anaspides*.

The compound eyes are pedunculated, and placed at the base of the antennules in an emargination of the head which forms a slight rostral prolongation above the eye-stalk.

The antennules are supported on a stout three-jointed peduncle, of which the first is the longest, while the third joint bears a short inner and a long outer flagellum.

The antennæ, the peduncle of which is composed of two stout basal joints, while a third distal joint bears an elongate-oval, setose scale or exopodite, and also a long multi-articulate flagellum armed with minute spines or bristles. Dr. Calman describes the mandible, the lower lip (labium or prognatha), the first and second maxilla, and then passes to the thoracic limbs,[2] the first pair being maxillipeds, the endopodite developed as a stout seven-jointed leg, bearing on its inner face two flattened setose lobes and two branchial lamellæ on the outer face of its basal joint, and a rudimentary slender exopodite on the second narrow joint (the basipodite), the leg terminating in a single claw.

Each of the four pairs of thoracic legs which follow bears two broad, delicate, oval, branchial lamellæ on the coxal joint, and a well-developed, many-jointed, setose exopodite on the second joint of the endopodite, which forms a strong walking-leg fringed with hairs. Of

[1] In this arrangement the eyes are apparently not admitted as representing a separate segment, although they have been so considered by Milne-Edwards, Bell, Dana, Charles Darwin, Spence-Bate, Sars & Lang, Huxley, H. Woodward, and others. Charles Darwin writes: "If that part of the larva in front of the mouth bearing the eyes, the prehensile antennæ, and in the earlier stage two pair of antennæ, be formed, as is admitted in all other Crustacea, of three segments, then beyond a doubt, from the absolute correspondence of every part . . . the peduncle of the Lepadidæ is likewise thus formed" (Mon. Cirripedia, Ray Soc., 1851, "The Lepadidæ," p. 25).

[2] In Dr. Calman's figure of *Anaspides* (Fig. 9, *ante*, p. 392) the segments are numbered on the assumption that the first is welded with the head, and the free segments commence with the second thoracic somite, thus the number of the thoracic segments would actually be eight.

the two legs which represent the next succeeding segments the anterior has a smaller branchial lamella on its basal joint and only a rudimentary exopodite, while the posterior pair have neither any branchial lamella nor exopodite developed, but only the walking-leg or endopodite.

The five succeeding (abdominal) segments each bear a pair of setose many-jointed pleopods, and the margins of the segments have their epimera more developed; the sixth segment is tapering, cylindrical in form, and bears upon its median dorsal line a short rounded telson, or seventh terminal joint, fringed with minute spines, and two lateral, much longer oval uropods fringed with hairs forming the tail-fan, the outer exopodite of which has a transverse suture crossing it nearly midway.

2. *Koonunga cursor*, O. A. Sayce, 1907.[1] — The second living analogue of the Coal-measure Schizopods under consideration was discovered by Mr. J. A. Leach, M.Sc., in some small freshwater reedy pools beside a tiny runnel which joins the Mullum Mullum Creek, Ringwood, near Melbourne, Australia. (The name *Koonunga* is derived from the aboriginal name of a creek which runs near where the specimens were collected.)

Koonunga resembles *Anaspides* in general appearance. Cephalon about equal to the following two segments combined, possessing a short transverse sulcus on each side at about the middle distance, posteriorly to which the margins are produced downwards and inwards. Frontal margin of cephalon scarcely produced, incised above the attachment of the second antennæ, forming a small lateral lobe. Eyes sessile, small, round, situated on the dorsal surface near the frontal margin and close to the base of the antennules.

Antennules with three stout basal joints to the flabella, of which latter the upper branch is the longer. The antennæ, with a single flabellum borne on three basal joints, are more slender than the antennules, and somewhat shorter (they are not furnished with a scale). Mandibles with a single, dentate, broad, cutting plate and molar expansion. Eight (?)[2] segments to thorax, the anterior segment fused to the head, leaving seven distinct subequal free segments. Maxillipeds without gnathobasic lobes, endopodite similar to but longer and larger than in *Anaspides*. The thoracic legs which follow carry branchiæ and swimming branches or exopodite, like *Anaspides*. The pleopods are uniramous, except the first two pairs in the male.

The abdomen is of equal length to the thorax, the last segment not longer than the preceding. Anterior portion of body subcylindric in form, becoming gradually rather broader and deeper and cylindrical posteriorly. All the segments of the thorax and abdomen subequal.

Telson entire, slightly broader than long, of triangular form and rounded distally, fringed with spines. Uropoda with peduncle extending to half the length of the telson, its endopodite and exopodite somewhat

[1] See "Description of a new remarkable Crustacean with Primitive Malacostracan Characters," by O. A. Sayce, in the "Victorian Naturalist," Melbourne, vol. xxiv, No. 7 (Nov. 7th, 1907), pp. 117–20; and Ann. and Mag. Nat. Hist. (London), ser. VIII, vol. i (April, 1908), pp. 350–5. [No figure of *Koonunga* has as yet been published.]

[2] This is, of course, a matter of interpretation.

longer than the peduncle supporting them, the inner branch fringed with spines. The largest specimen found measures 9 mm. in length.

The foregoing six genera, comprising two living freshwater forms, namely, *Anaspides* and *Koonunga*, and four fossil forms, namely, *Præanaspides*, *Gampsonyx*, *Acanthotelson*, and *Palæocaris*, notwithstanding various points of difference in details, seem, on general grounds, entitled to be referred to Dr. Calman's order Anaspidacea. They all possess a small head (there is no extended carapace). There is evidence that with the head the first thoracic somite was usually coalesced. The eyes were generally pedunculated (as in *Anaspides*),[1] but in *Koonunga* they were sessile, and perhaps in some fossil forms they may have been so also, or even wanting (?).[2]

The antennules are generally large, with two flagella, supported on a stout three-jointed peduncle. The antennæ usually had three basal joints, the third supporting a single flagellum and also an oval scale (exopodite).

Assuming the first thoracic segment to be coalesced with the head, there remain seven free subequal segments each with a pair of walking-legs (endopodites), of which the first was usually much the longest and stoutest; the four succeeding pairs each carried a setose exopodite, and probably also two branchial lamellæ on the basal joint, as in the Schizopoda; but the two hinder pair of legs seem to have been devoid of these appendages. The abdomen consisted of six free subequal segments and a 'telson' or terminal joint; five of these carried pairs of setose pleopods on stout basal joints. The sixth segment (usually a little longer than the preceding, and more or less cylindrical in form) bears the uropods, and to the centre of its posterior margin is articulated the 'telson' or terminal segment, which, with the uropods of the preceding segment, forms the 'tail-fan.'

Summing up on the question of the fossil genera, referred by Dr. Packard to the Syncarida, namely, *Palæocaris*, *Acanthotelson*, and *Gampsonyx*, Dr. Calman writes (Trans. Roy. Soc. Edinb., 1897, vol. xxxviii (4), p. 801): "We find, then, that *Anaspides* agrees with the extinct genera above enumerated in the essential point in which they have hitherto stood alone: the combination of Podophthalmate characters with a completely segmented body, and the lack of a carapace. We have seen that some at least, probably all, of these genera show characters of the *Schizopoda*, to which group *Anaspides* is most closely

[1] *Anaspides* had also ocelli present on the cephalon; we may therefore consider the eyes in these primitive forms were affected by variable conditions, and we need not necessarily split up the group on that account if the other characters tend to hold them together.

[2] The genus *Koonunga* was not known when Dr. Calman's paper was printed in 1897, nor has a figure of it yet been published (I have, however, been favoured by being allowed to see an unpublished drawing). The absence of pedunculated eyes, etc., has led its author, Mr. Sayce, to propose for it a separate family (the Koonungidæ, under the order Anaspidacea), but it seems desirable to await the fuller publication and figure of this interesting crustacean before discussing its separation from the other members of the group. (See Mr. Sayce's preliminary paper, republished in the Ann. and Mag. Nat. Hist., ser. viii, vol. i (April, 1908), pp. 350–5, with Dr. Calman's note thereon at the end.)

allied. We find probable agreement in such points as the apparent division of the head-region into two segments as by the 'cervical groove' in *Anaspides.* Such differences as have appeared are readily explicable as comparatively unimportant differentiations which might be expected to occur within the limits of the group, or as due to the present imperfect state of our knowledge of the fossil forms. We conclude, therefore, that *Anaspides* is to be regarded as the representative of a group of primitive *Malacostraca*, which had already in Palæozoic times attained a certain degree of specialization and a very wide distribution."

The palæozoologist naturally expects to meet with more generalized and primitive types of structure among the early forms of life discovered in the Palæozoic rocks, but he less frequently hopes to find actual representatives of these ancestral forms surviving at the present day. When such is the case, however, these persistent forms have a more or less worldwide distribution, there being apparently always a corresponding amplitude of measure between the length of past geological time during which a type has existed and its present geographical distribution.

Take, for instance, the 'king-crabs' (Xiphosura), we have evidence of their existence from the Upper Silurian to the present time, and they attain the same wideness in their life distribution now. The Scorpionidæ also enjoy equal geological antiquity and even wider modern geographical extension.

The common 'River Cray-fish,' *Astacus fluviatilis*, with its marvellous worldwide distribution,[1] had its undoubted representatives in the Chalk, Jurassic, and Trias, which in turn derived their origin from the more generalized forms of Anthrapalæmonidæ of the Coal-measures.

After the discovery by G. M. Thomson of *Anaspides* living in freshwater pools on Mt. Wellington, Tasmania, at an elevation of 4,000 feet above the sea, and of *Koonunga cursor* by O. A. Sayce near Melbourne, Australia, we may probably learn of the existence of similar persistent simple congeneric Schizopod-like forms in the freshwaters of remote and widely separated parts of the globe, just as we know of their past life-history in the widely distributed Carboniferous strata of Britain and the continents of Europe and America.

II.—The Old Red Sandstone of Forfarshire, Upper and Lower.

By George Hickling, B.Sc., Lecturer in Geology in the University of Manchester.

(PLATES XX and XXI.)

Introduction.

During the past ten years I have spent much time on the cliffs of the Forfarshire coast, and to the magnificent sections of the Old Red Sandstone therein displayed I owe very largely my interest in geology. In the neighbourhood of Arbroath the well-known unconformity between the upper and lower members of that series is admirably

[1] See "The Cray-fish," by T. H. Huxley, F.R.S. (1880), pp. x and 372, with 82 illustrations. Kegan Paul & Co. 8vo.

exposed. The magnitude of that break has been insisted on by many writers, but no description, I think, could be quite so impressive as those cliff-sections. Moreover, of late years, there seems to have been a tendency in many quarters to minimise its importance. In most localities the relation between the two sets of rocks is a matter of inference rather than observation. This fact at once explains the willingness to pass lightly over this unconformity, and at the same time makes it the more desirable to have an adequate description of a locality where its magnitude can be clearly seen.

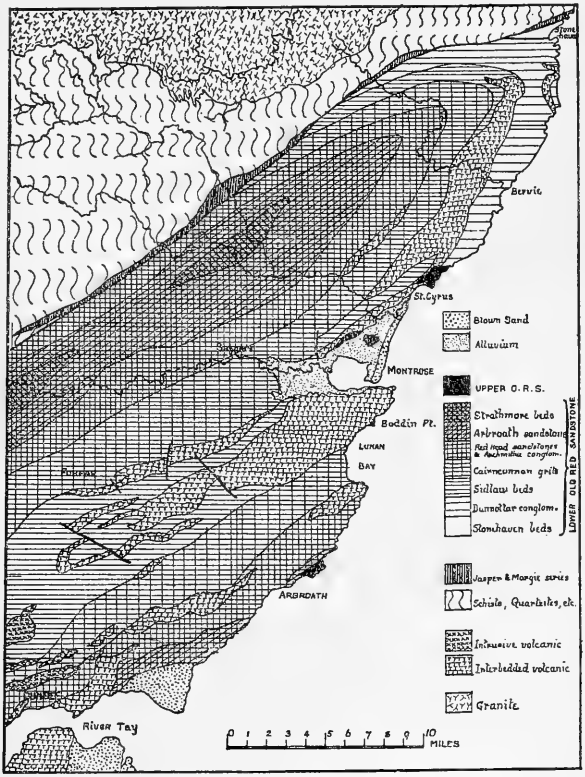

Fig. 1.—Sketch-map of the Geology of Forfarshire.

Note.—This map is to a considerable extent hypothetical, especially in Kincardine, but I believe the general distribution of the various subdivisions is in the main correct.

The attempt to collect and review the published work bearing on this question soon proved that no satisfactory result could be attained without a complete investigation of the wide and involved question of the relation of the Old Red Sandstone and Carboniferous deposits. This carried me far beyond the limits I had originally conceived for this communication, and it became obvious that the subject must be treated in at least two distinct parts—the present one, dealing with the rocks in Forfarshire, and a subsequent one in which I hope to discuss the more general question.

It would be impossible properly to realise the magnitude of the unconformity in Forfarshire without a preliminary knowledge of the general succession and tectonic structure of the Lower Old Red series in that locality. Notwithstanding the fact that the series is believed to reach there a greater thickness than anywhere else in Britain, no adequate description exists, and hence I need make no further apology for the brief sketch which forms the first section of this paper.

General Features of the Lower Old Red Sandstone.

The counties of Forfar and Kincardine are sharply divided into highland and lowland sections by the line of the great Highland fault, running south-west from the coast at Stonehaven, and bringing down the Old Red to the south against the schists and granites on the north. The Old Red underlies the whole of the lowland tract. Between the foot of the highlands and the valley of the Tay the low ridge of the Sidlaws intervene, with Strathmore between it and the highlands. These physical features are directly related to the folding of the subjacent rocks. Against the highland fault the sandstones and conglomerates lean almost vertically. After a couple of miles or so the dip rapidly becomes lower, and the synclinal axis is reached, which follows the line of Strathmore. South of the axis the dip in the reverse direction increases to about 25°. It afterwards decreases, and again changes its direction beyond the anticlinal axis which runs along the Sidlaws. On the southern limb of the anticline the dip again rises to about 25°. This pair of folds may be traced right across Scotland, the axes remaining sensibly parallel to the highland fault the whole way, pointing, no doubt, to the simultaneous production of fault and folds. These folds have been familiar for three-quarters of a century, having illustrated the terms 'anticline' and 'syncline' in Lyell's "Elements." There is, however, another, but much less obvious, series of folds affecting these rocks, with axes running north and south. The influence of these is usually slight, but about Stonehaven an anticline of this series brings up rocks much lower than would otherwise be exposed—the lowest, indeed, in the district.

With each of the two series of folds just referred to there is a series of faults associated, some of which are marked on the Survey map. For the most part, however, these are small, and I do not think they need further comment.

Table of the Lower Old Red of Forfarshire.

	Feet.
Edzell Shales	?1000
Arbroath Sandstone	1200
Auchmithie Conglomerate	800
Red Head Series	1500
Cairnconnan Series	2000
Carmyllie Series	1000
Dunnottar Conglomerate	5000
Stonehaven Beds	1500
	14,000

It must be remarked that the subdivisions in the above table are based purely on lithological characters and are only made for convenience of description. No breaks in the series exist to my knowledge, and I am far from supposing that these subdivisions are likely to be traceable for any great distance; rapid lateral variation in the character of the rocks is too obvious a feature of the Old Red Sandstone. The names applied to the subdivisions are taken from the localities where the series may be typically seen. The thickness of the subdivisions are estimated from theoretical sections for the most part, and are therefore to be regarded as only approximately accurate.

The Stonehaven Beds occupy the shore between the harbour of Stonehaven and the south end of Craigeven Bay, where the great fault is exposed. A mass of fault breccia fully a yard in thickness occupies the line of junction, while the rocks on either side of it are shattered for fully four yards. Fine red sandstone, with numerous thin bands of bright red shale, is the first rock seen on the south side, dipping at about 60° to S. 12° W. Further south several beds of the red marly shale, 50 to 100 feet in thickness, separate light red or yellow sandstones and fine grits, with some bands of grey sandstone and grit. Such is the general character of the series, which is distinctly *fine* in character as compared with the mass of the Old Red. About midway between the fault and the town the Lintrathen porphyry dyke cuts across the shore. The dip varies somewhat both in amount and direction, but is always very high, and no important break in this section appears to exist. About the harbour bands of conglomerate appear among the sandstones, marking the passage to

The Dunnottar Group of coarse red and grey sandstones, grits, and conglomerates which form the bold coast the whole way from Stonehaven to Johnshaven. As I have only been able to examine the base and the top of this series, I shall add no more than that it forms by far the most extensive series of conspicuously coarse deposits in the district. In its conglomerates pebbles commonly range up to a foot or more in length, and yet are astonishingly well rounded. They mostly consist of quartzite. South of Johnshaven several thin lavas are interbedded with the top of this series, with sandstones and coarse conglomerates of porphyrite blocks between. Beyond this the coast-section is interrupted by the mass of Upper Old Red which is faulted in, extending from East Mathers to Milton Ness (described below), and which covers the junction between the conglomerate series and the great mass of lavas which forms its natural top. These lavas occupy the coast southward by Montrose to Lunan Bay, being hidden, however, almost the whole way to Montrose by sand and alluvium. From Lunan Bay their outcrop strikes inland along the summit of the anticline by Friockheim and Letham, near which latter place they finally die out. About Friockheim and Leysmill are numerous quarry sections of the

Carmyllie Series, which overlies the lavas. Compact red or grey sandstone is the predominant rock of this series, with subsidiary masses of grey flagstone and blue or red shale, termed 'caulm' by the quarrymen. Together with their interbedded lavas, these rocks form the whole axis of the Sidlaws, all along which they are quarried for building and paving material. The well-known Carmyllie quarries are in the middle of this series. Passing upward, the

Cairnconnan Series is reached, distinguished by its coarser materials, principally dull red or grey grit with bands of conglomerate. The conglomerates are more particularly developed on the north side of the anticline, as at Turin Hill, north of Rescobie Loch. This series should appear on the coast in Lunan Bay, but it is entirely hidden by the sand and alluvium. At the south end of the bay another series of lavas, admirably exposed for study, intervenes between it and the

Red Head Series, which forms the bold cliffs from the promontory of that name southward to Rumness. In its lower part it consists of fine red thin-bedded sandstone with bands of hard bright red shale, while the upper portion is made up of thicker-bedded sandstone. Some six or seven miles to the south-west, at Arbirlot, the lower part of this series, as seen in the banks of the Elliot Burn, consists mainly of blue and grey shales, with partings of sandstone, having so strong a resemblance to some of the rocks of Carmyllie as to have led Hugh Miller to consider them as a repetition of that series. This case illustrates very well the rapid lateral variation to which all the beds of the Old Red Sandstone are liable.

The Auchmithie Conglomerate overlies the previous group in the cliffs just north of the village so named. The series consists of three main masses of conglomerate, with intervening sandstones and conglomerates. The pebbles in the conglomerates are well rounded, fairly large (generally 1 to 6 inches, rarely 12 inches), and, as usual, are mostly quartzite. The thickness of this conglomerate series diminishes along its outcrop to the south-west.

The Arbroath Sandstone is the highest series of the Lower Old Red seen on the Forfarshire coast. Coarse, gritty, sometimes pebbly sandstone is its component rock, always red in colour. Just above the base of the series, by the Signal Tower at Arbroath Harbour, there is a single band of grey grit and marlstone on the shore, containing nodules of limestone from the size of a pea to 1 foot in diameter. This is noteworthy in view of the almost complete absence of lime from the Lower Old Red System. In Strathmore the Geological Survey traced a thin bed of limestone for some miles, and, as far as I can judge, that bed occupies about the same horizon. If they should prove to be the same they would form a valuable datum-line in correlating the beds north and south of the anticline—at present a very difficult matter. In the few old descriptions of the rocks of this district other limestones are referred to (Powrie, 1861), but these are either in the Margie Series (Barrow, 1901) or in the Upper Old Red.

The Edzell Shales lie in the more depressed parts of the synclinal trough of Strathmore, but are not represented, so far as I am able to judge, south of the anticline. They overlie the Arbroath sandstones. They are generally bright red fine sandstones, shales, and marls, either hard or soft, frequently mottled with small circular patches of pale yellow, grey, or green, or more rarely with bands of the same colour. These rocks are admirably displayed in the banks of the North Esk at Edzell, and even better in the South Esk, below its junction with the

Prosen, about Shielhill Bridge. They are the highest beds which, to my knowledge, the system presents in this district.

The volcanic rocks of the district do not call for description here. It may suffice to remark that they are, with very rare exceptions, in the form of contemporaneous interbedded sheets, and are merely a continuation of the series of the Ochil Hills, where they have been described in detail by Geikie and others (A. Geikie, 1900).

Position of the Fossil-bearing Beds.

Attention must now be drawn to a point, the importance of which has not, I believe, been hitherto recognised. All the recorded fossils from this district—and I suspect that the same applies to Perthshire—are from a very limited series of horizons near the middle of the Lower Old Red System, the Upper Old Red being, of course, left out of account. The Carmyllie series is the fossiliferous group *par excellence*, while a few of the worked localities may lie in the Cairnconnan series (e.g. Tilliewhamland quarry, Turin Hill), or the top of the Dunnottar conglomerates. Odd fossils have occasionally been obtained from other horizons, but they are quite a negligible quantity.

The palæontological evidence as to the age of this Lower Old Red System, then, as here developed, can only be affirmed of its middle beds; to apply it to the whole system, as has been implicitly done, is obviously unjustifiable. Geikie has stated that these rocks may reach a maximum thickness of 20,000 feet, which cannot be any great exaggeration. The Orcadian Old Red he estimates at 16,000 feet; then follows a considerable unconformity not represented by any deposits, in Scotland at least, and some 2,000 feet of Upper Old Red above that. Add these up and we obtain the modest sum of 38,000 feet with a great unconformity, or certainly the equivalent of over 40,000 feet of strata to represent the Old Red Sandstone! Small wonder Sir A. Geikie shrank from admitting such a thickness, and turned to Austen's hypothesis of isolated lake-basins to account for the difference of the 'Caledonian' and 'Orcadian' faunas, without having to superpose the latter rocks on the former!

Unfortunately for this solution of the difficulty it is becoming more and more obvious that the hypothesis is untenable. The objections fall into two categories—physical and palæontological. Those of the former class were well stated by Macnair & Reid in 1896 (M. & R., 1896). At Towie, in Aberdeenshire, an outlier of 'Orcadian' Old Red approaches within barely twenty-five miles of the main mass of the Caledonian deposit; and this outlier, like that of Tomintoul a little further west, is actually on the Grampian ridge which must have separated the two Old Red basins, so that it is very improbable that at the time when it was deposited the ridge was in any important degree higher than at present. Bearing in mind this fact, it is only necessary (as pointed out in the paper just referred to) to replace the Caledonian deposits in their original position, as before they were faulted down, to see that all the higher beds must pass over the Highland ridge to join the Orcadian series.

The palæontological evidence was fully appreciated by Murchison (1859) and Salter (Salter, 1863), who based their conclusion that the fossiliferous horizons of Caithness were higher than those of Forfarshire on a comparison with the continental Devonian and Old Red rocks, as is so well known. That conclusion is now greatly strengthened by the patient work of Traquair, who regards the question rather from the biological side. From that view, the evidence may perhaps best be summarised thus: The fishes of the Orcadian Old Red are undoubtedly more nearly allied to those of the Upper Old Red than are those from the Caledonian rocks; while, on the other hand, the Forfarshire fossils bear a much greater similarity to those of the highest Silurian beds than do those of Caithness. These facts, then, fully bear out the conclusion of Murchison and Salter. Goodchild vigorously advocated this view in a paper written shortly before his lamented death (Goodchild, 1904), and, for a fuller analysis of the palæontological data, reference may be made to the exhaustive account by Evans (Evans, 1891). As this latter paper may not be readily accessible, it may be stated that he finds that of the thirty species of fish in the Orcadian Old Red, six occur in the Upper Devonian of Russia. A single species is very doubtfully common to the Forfarshire rocks. Of the eighteen genera, ten occur in the Upper Devonian or Upper Old Red. One genus is common to the Lower Old Red, and two others very doubtfully so. I think it may safely be added that the work done since 1891 has at least fully confirmed this distinctness of the Caledonian and Orcadian faunas (Horne, 1901).

Two points thus seem clear: it is physically impossible that the two areas of Old Red under consideration could have been entirely deposited separately, yet the faunas are entirely distinct, and the nature of the faunal difference is such as to indicate that the Orcadian fossil-beds are higher than the Caledonian. In other words, the fossiliferous deposits of Caithness *must* be superposed on those of Forfarshire. But that is quite a different matter to saying that 16,000 feet of Old Red in the north must be superposed on 20,000 feet in the south. In Caithness the lowest 4,000 feet or so appear to be unfossiliferous, or practically so (lower part of Wick group, below Achanarras, and the lower Sandy and Conglomeratic groups), and hence 12,000 feet will be a liberal estimate for the thickness, which includes all the fossiliferous horizons, even on Geikie's estimate, which Evans, in the paper referred to, considers too great. In Forfarshire I have pointed out that the fossil-bearing strata are confined to the Cairnconnan and Carmyllie series, with a combined thickness of certainly under 4,000 feet. Hence 16,000 feet will be a generous estimate of the united thickness of the fossiliferous beds of the two areas. The 4,000 or 5,000 feet above the highest fossil-bearing zone in Forfarshire and the 4,000 below the lowest in Caithness count for nothing.

It will be remarked that there is still some 6,000 or 7,000 feet of strata below the fossiliferous band in Forfarshire to be dealt with. Regarding these I would say that as they have as yet yielded no fossils it is impossible to say definitely what their age may be, except in relation to the beds above.

Upper Old Red Sandstone.

The main mass of this deposit, in Northern Fife and the Carse of Gowrie, has been several times described, most recently by Sir A. Geikie in his "Geology of Western Fife and Kinross" (A. Geikie, 1900), and therefore needs no further description here. The small outliers, however, along the coast of Forfar and Kincardine have never received attention.

There are four of these patches, which obviously represent the remnants of a once continuous strip along the shores. The most southerly is near Arbroath, the next forms the tiny promontory called Boddin Point, at the north end of Lunan Bay, while the third (which is largely covered with alluvium) and fourth form a broken strip from the north side of the Montrose Basin to near Johnshaven. It is clear, therefore, that this deposit was originally a continuous and almost perfectly horizontal sheet. On the Survey map dips may be seen marked in this deposit up to as much as 15°, but these are quite erratic, and are doubtless due entirely or almost entirely to current-bedding; there is no sign of any such irregular folding in the older series of rocks.

The identification of these outliers as belonging to the Upper Old Red depends on their lithological character and general tectonic relations, no fossils having been found in them.

Tectonic Relations.

These rocks are clearly younger than the folding which has affected the subjacent Lower Old Red, and also later than a good deal of the denudation which followed it. Before the horizontal strata of Montrose and Boddin Point were laid down there must have been not less than 8,000 feet of rock worn from the top of the Lower Old Red anticline. This must, no doubt, be held to imply a great break between those two sets of rocks.

Precisely the same relation, however, holds between the Upper Old Red of the Carse of Gowrie and the rocks below. That mass also lies directly over the Lower Old Red anticlinal axis, and can therefore only have been deposited after a similar amount of denudation. The type-specimen of *Holoptychius nobilissimus* was obtained from those beds, so that their age admits no question.

It will be desirable to illustrate this unconformity more fully when the lithological character of these coast deposits has been described, and its bearing on their age considered. Meanwhile it is clear that their tectonic relations are exactly similar to those of the most undoubted Upper Old Red.

Lithological Characters.

Two distinct types of sedimentation occur in these rocks—the sandy type and cornstone type. The former alone is developed in the mass near Arbroath, where it reaches a thickness of about 200 feet. The materials of this deposit are precisely similar to those of the Lower Old Red on which it lies, and from which it has no doubt been derived. Fairly soft red sandstone, with numerous bands of conglomerate, which are usually thin and irregular, occasionally thicker and more persistent, is a fair description of the whole deposit. In a broad view, the whole mass would be described as a conglomerate. No trace of calcareous material is present, except in the form of veins and patches of calcite (e.g. about Whiting Ness). These veins are of value as indicating that there have formerly been calcareous strata overlying these beds, as would be expected from a comparison with the deposit in other areas.

I have carefully searched through the pebbles in the conglomerates for evidence on the age of these rocks, but with only negative results. There appear to be no pebbles of later age than the Lower Old Red, and this fact so far confirms the Upper Old Red age of these beds.

In the other two exposures of this series of rocks on the coast, viz. at Boddin Point and St. Cyrus, the lower part of the section shows red sandstone, the upper cornstone. At Boddin Point the series is brought down by a strong fault against the porphyrites, the fault being beautifully exposed on the south side of the headland. About 40 to 50 feet of quite soft yellow or white sandstone, mottled with light red, is exposed below the cornstone, while the base of the series is thrown below sea-level. Above this sandstone we have the following beds, No. 1 being the sandstone itself:—

		Feet.
(11)	Hard brecciated very calcareous sandstone	+4
(10)	Mottled purple sandstone	1
(9)	Hard compact calcareous sandstone	2
(8)	Fine soft mottled purple sandstone, with irregular limestone nodules	3
(7)	Mottled purple sandstone	4
(6)	Yellow brecciated sandstone, with dendrites	5
(5)	Mottled yellow and red sandstone...	10
(4)	Brecciated yellow dolomite, with dendrites	$\frac{2}{3}$
(3)	Mottled sandstone	4
(2)	Yellow dolomite, with dendrites	1
(1)	Yellow and mottled sandstone	+40

The terms used in the above table are the best I could find to briefly indicate the nature of the various beds, but accurate description is exceedingly difficult. As to the nature of the materials composing the rocks, every mixture may be found between a pure sandstone and an almost pure limestone, as I have ascertained by actual estimation of the quantity of lime in various specimens. And as to the structure of the rock, there is still further difficulty. All the beds described as 'brecciated' have the appearance of typical breccias on a weathered surface, but on a fresh fracture the same rock frequently appears perfectly compact and even. In such cases I believe the brecciated appearance is entirely due to crystallisation in the limy matrix. In other cases the brecciated character is still evident, though far less prominent, on the broken surface, and in those instances it would seem to be due to the breaking up and re-consolidation of the deposit during its formation. Very seldom is the material a true breccia. Here and there, however, pebbles in one bed have evidently been derived from the break-up of a lower stratum. Irregularity and discontinuity of deposit are further evidenced by strongly developed false-bedding, by local erosion of beds (No. 6, for example, is in places completely removed), and by the fact that the beds are so irregular that they cannot all be traced from one side of the little promontory to the other.

In the more extensive outlier at St. Cyrus essentially the same rock-types occur but in much greater thickness. The 'cornstone' type is there probably 40 to 50 feet in total thickness, and is covered in turn by another 30 feet of sandstone. The cornstones include a beautiful band of flesh-coloured calcareous sandstone, in which the limy matrix forms crystals up to about half an inch in diameter, the quartz grains being included. The sandstones below pass down into red sandstone with conglomerate exactly similar to the rocks at Arbroath. I have not been able to make a sufficiently detailed examination to estimate the thickness, which could only be ascertained by careful mapping.

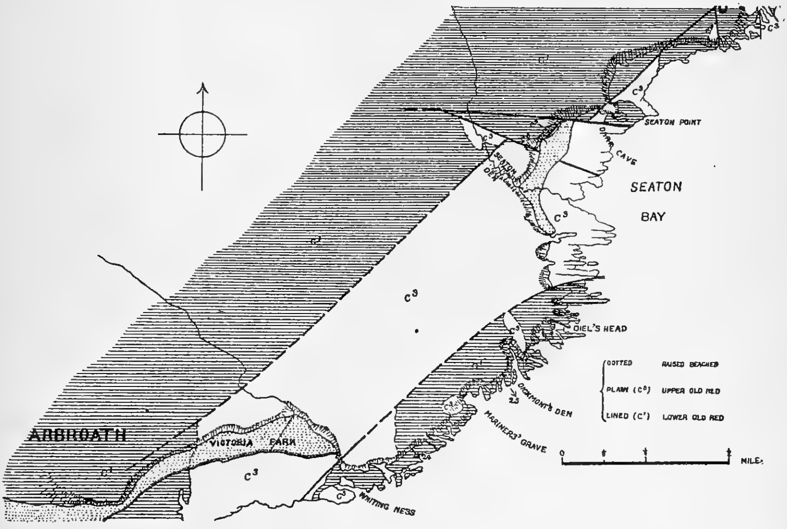

FIG. 2.—Map of the Outlier of Upper Old Red Sandstone near Arbroath.

The base of the series here, again, is unfortunately not exposed. The junction of the outlier with the porphyrites at the south end is a beautiful fault, not a natural boundary as shown on the Survey map. At the north end the junction with the Lower Old Red conglomerates is either a fault or the Upper series is banked up against an old cliff of the Lower.

It is clear from the description which has now been given of these outliers of Upper Old Red that their lithological characters are exactly those of the typical Upper Old Red—red sandstones at the base, passing up into more variegated calcareous sandstones and marls. The upper or cornstone type has long been recognised as indicating peculiar conditions of formation; what the conditions were we are not here concerned with. In view of what has already been said regarding the tectonic and geographical relations of these deposits, it can, I think, scarcely be doubted that the peculiar conditions which led to the formation of this rock-type here were in the main contemporary with the corresponding conditions in Fife and the Carse of Gowrie. It would be foolish to contend that the base of these outliers is on precisely the same horizon as the base of the series in other localities, but I think it must be admitted that these rocks are of Upper Old Red age, which is the only point of importance.

The Unconformity between the Upper and Lower Old Red.

Having now examined the evidence proving that these outliers are of the same age as the typical Upper Old Red of Fife, we may profitably examine more fully the relation of the deposit to the Lower series, where it is so admirably displayed in the cliffs of Arbroath.

The accompanying sketch-map shows, in addition to the main mass of the deposit let in between a pair of faults, numerous small patches which lie undisturbed in depressions in the ancient surface of the Lower Old Red. The actual junctions of the Upper and Lower series are, moreover, exposed in numerous places, and thus a very fair idea of the old surface may be obtained. In the south-west of the map, on the foreshore opposite Victoria Park, the junction may be traced right across the shore, the Upper beds sometimes abutting against a vertical face of the Lower, while in other places they extend horizontally over them. At Whiting Ness, again, the junction may be traced for several hundred yards in the foot of the cliff and on the shore. The surface of contact is nearly horizontal and fairly even until the eastern limit of the Upper beds is reached, where they end off against a high bank of the Lower strata, which is cut in section by the present cliff and rises its whole height (Pl. XX, Fig. 1). In the base of the Upper beds west of the foot of this old bank, angular blocks of the sandstones of the Lower series more than a yard in length are included. Another fine example of the Upper series resting against a steep bank of the Lower is to be seen at Seaton Point, where the main fault forming the north-west boundary of the former is also admirably exposed (Fig. 2), the Dark Cave being drilled through the Point along it. On the east side of Dickmont's Den two troughs cut out in the Lower beds are seen in section in the cliff filled in with the conglomerates of the Upper series. But by far the finest example of a valley cut in the older series is to be seen in an inlet in the cliff in the extreme north-east of the map, and on the west side of Lud Castle (just off the map). There the horizontal Upper beds fill a V-shaped depression over 100 feet in depth.

It appears from these instances — and others might be added — that the old surface on which this mass of Upper Old Red rests is a distinctly irregular one, in every way a typical old land-surface.

This fact is of considerable value in estimating the significance of this unconformity. Those wishing to minimise the importance of this break might suggest that the folding and erosion of the Lower Old Red proceeded *pari passu* with its deposition, and that though the break appears great where the Upper series oversteps on to the lower beds of the Lower series, in the centre of the anticline, yet the

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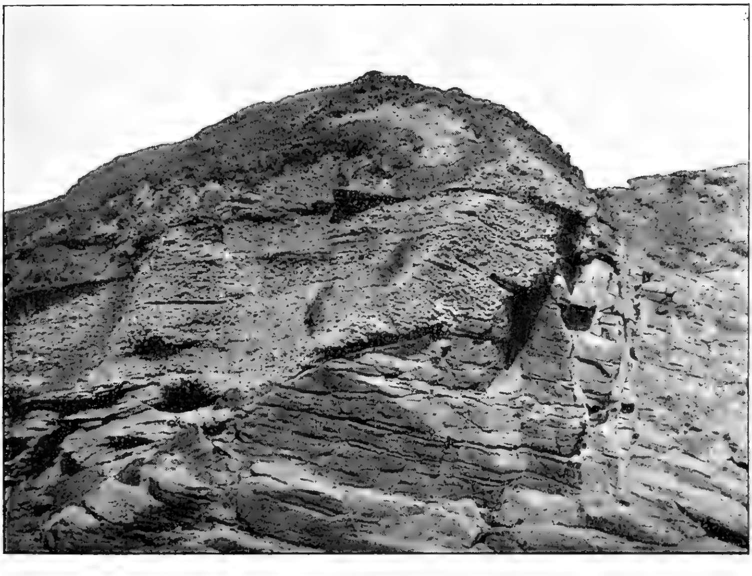

FIG. 1.—Junction of Upper and Lower Old Red Sandstone, Whiting Ness.
FIG. 2.—Upper and Lower Old Red at Seaton Point, fault at the Dark Cave.

discordance might be small or non-existent between the top members of the Lower and the base of the Upper. The sections here described furnish a complete answer to this objection. The beds on which the Upper series here rests are the Arbroath sandstones, near the top of the Lower series. They are dipping at 20° – 25° to the south-east—the maximum inclination shown on this side of the anticline—while the irregular surface on which the Upper series rests is broadly horizontal. Hence it is perfectly clear that—

(1) The folding of the Lower series was subsequent to the deposition of the *whole* of that series.

(2) The extensive denudation by which the anticline was planed off flat was entirely subsequent to the deposition of the whole Lower Old Red.

(3) The deposition of the Upper Old Red was subsequent to the folding and denudation.

There remains the question whether this folding and denudation can be referred, wholly or in part, to the period of the Orcadian Old Red. The only facts which may help to a conclusion on this point are these: The upper beds of the Forfarshire Lower Old Red, to which the folding is certainly subsequent, probably are the equivalents of part or the whole of the Orcadian series; either that, or we must admit the enormous total thickness of the Old Red, which is the difficulty so often felt before. It should be noted, too, that no natural top to the Caledonian series is anywhere seen, so that there is certainly no evidence that sedimentation ceased in that area any sooner than further north. Again, we have the fact that the Upper Old Red of the Moray Firth, some of which has been concluded, on palæontological grounds, to be older than that of Fife (Horne, 1901), is itself generally considered to rest unconformably on the Orcadian series. It would seem, therefore, that though it is just possible that a part of the great interval of time represented by this unconformity in Forfarshire may be accounted for by the Orcadian deposits, a large part of it at least must have been subsequent to the formation of those beds. The magnitude of the unconformity in Forfarshire has been sufficiently demonstrated. Its magnitude elsewhere and its general significance must be discussed in a subsequent communication.

Summary of Conclusions.

The Lower Old Red Sandstone of Forfar and Kincardine is upwards of 14,000 feet in thickness. No indication of a base or natural top is seen in the district. The characteristic fossils of this series have all been obtained from its middle beds within a vertical range of less than 4,000 feet. There is no palæontological evidence of the age of the beds above or below that zone. It is concluded, on physical and palæontological grounds, that the fossiliferous beds of the Orcadian area are really younger than those of Forfarshire, but there is no proof that the higher part of the Forfarshire series was not contemporaneous with the Orcadian deposits.

The folding of the Lower Old Red strata into the syncline and anticline parallel to the Highland boundary fault took place subsequently to the deposition of the *whole* of those strata. This folding, and denudation to the extent of 8,000 feet over the anticlinal axis, were accomplished after the deposition of the Lower and before the beginning of the Upper Old Red. The surface on which the Upper Old Red rests, in Forfarshire, is broadly horizontal, but very uneven—evidently an old land-surface.

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EXPLANATION OF PLATE XX.

Fig. 1.—Photograph showing horizontal Upper Old Red conglomerate resting against inclined surface of Lower Old Red. The full dip of latter beds is not seen. The lower part of the Upper Old Red on the left consists of soft sandstone. Cliff 200 yards east of Whiting Ness. Height of cliff about 50 feet.

Fig. 2.—Upper Old Red (on right) faulted down against Lower (on left) at Dark Cave, Seaton Point. Height of cliff at fault, 140 feet. At the extreme point the inclined beds of the Lower series are seen rising from under the Upper. On the other side of the Point the junction may be seen to be similar to that in Fig. 1.

EXPLANATION OF PLATE XXI.

Fig. 3.—Photograph of Upper Old Red conglomerate at Cove Haven, Seaton Bay. Height of cliff in photo about 10 feet.

Fig. 4.—Cliffs at Cove Haven, Seaton Bay, showing general character of Upper Old Red of this outlier. Height of cliff in foreground about 50 feet.

III.—The Gavarnie Overthrust, and other Problems in Pyrenean Geology.

By E. E. L. Dixon, B.Sc., F.G.S.

(*Concluded from the August Number, p.* 373.)

Of the places where undisturbed limestone rested on older rocks, the most important visited by us was the valley of Hount-Sainte on the Spanish slope. This does not appear to have been considered by Carez, nor to have been hitherto described in detail. The following sequence is clearly exposed, in descending order:—

4. Palæozoic—Devonian and Carboniferous according to Bresson. Shales and limestone in the lowest part, the base evidently a plane of disturbance.

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Fig. 3.—Upper Old Red Conglomerate, Cove Haven, Seaton Bay.
Fig. 4.—Upper Old Red Sandstone Cliff, Cove Haven, Seaton Bay.

3. Cretaceous (Campanian). Rubbly, thick-bedded, partly dolomitic, white limestone with hippurites, etc., the base, which contains many angular quartz-fragments, showing no signs of disturbance.

2. Permo-Trias. Chiefly micaceous shales, red on the whole, but partly changed to buff and green at the top; also some fine-grained sandstones, and, at the base, several feet of quartzitic sandstones and conglomerates of subangular quartz-fragments. Total, about 50 feet.

1. Basement-platform. Granite and mica-schist, worn down to an even surface to which Permo-Trias and Campanian are parallel, both as a whole and in individual beds.

Carez, in discussing the relations of the Campanian to underlying rocks, does not refer to the fact that on the Spanish side it is underlain by Permo-Trias, and consequently does not consider the relations of these two, but it is a necessary consequence of his theory that the former should be regarded as thrust over the latter. But here the rocks immediately beneath the supposed overthrust do not form a rigid platform as in the cases considered by Carez, where their abrupt truncation lent colour to his supposition; on the contrary, they consist of soft beds on which the limestones rest with apparent conformity, and, although the one group would be much less rigid than the other under the influence of lateral pressure, neither shows any sign of differential movement either within itself or relatively to the other. Also, the fact that the basement-platform of crystalline rocks passes beneath the Permo-Trias shows that it has not been planed down by an overthrust, as there is no evidence of such movement of the beds which are there resting on it.

In view of these facts and their bearing on Carez' arguments, we have concluded that the Cretaceous in the neighbourhood of Gavarnie has not been overthrust. The same is probably true of the Cretaceous elsewhere in the same region, for it is on the strength of the evidence already discussed that Carez relies largely when he says, "Le Crétacé supérieur de Gavarnie, du Balaïtous, des Eaux-Bonnes et du pic Bazès n'est pas en place, et ces lambeaux sont les restes d'une immense nappe de charriage venue du Sud et qui se montre . . . depuis Eugui jusqu'au rio Flamisel, sur une largeur de plus de 200 kilomètres." (Eugui and the river Flamisel are, respectively, far to the west and east of Gavarnie.) As Gavarnie lies nearest the roots of this supposed overthrust and at about the middle of its length, the undisturbed state, in places, of the Cretaceous there, appears to us to invalidate Carez' overthrust, and with it Termier's conclusion, based on Carez', that the whole Cretaceous of the Pyrenees has been 'carted' from the south. It appears, therefore, that a very useful service has been performed by Mr. Stuart-Menteath in protesting against the wholesale invocation of *charriages* if they are supported by no better evidence than in this instance.

The third problem we shall discuss relates to the age of the crystalline rocks of the basement-platform below the Cretaceous in the Gavarnie (Pau) and Héas valleys, and is of more than local interest as it raises the old question whether gneisses and schists, to all appearance Archæan, may in reality be Palæozoic or even younger.

The rocks consist of mica- and quartz-schists, containing an abundance of secondary minerals, such as biotite, garnet, cordierite, silliminate, etc., with, here and there, crystalline limestones, the whole injected with a plexus of plutonic rocks; they evidently, as MM. Michel Lévy and Lacroix have already stated,[1] represent a sedimentary series which has been profoundly modified by thermal metamorphism. However, the rocks which crop out over the whole area enclosed by the Cretaceous of the above valleys (Fig. 2) show no general diminution of metamorphism in any direction to guide us to the unaltered originals; they have, in fact, been completely recrystallised throughout, and are so abundantly and intricately veined with gneisses and granites that it is often difficult to say whether the heterogeneous resultant is a mass of granite crowded with enclosures or a mass of sediments crowded with veins.

The resemblance of this sedimentary and igneous complex to the fundamental rocks of other parts of the world led the older writers, Ramond and De Charpentier amongst others, to refer them to the 'primitive' series (our Archæan), at that time regarded as part of the original crust or as crystalline sediments of a primæval sea. Bresson, however, points out that Lévy and Lacroix have adduced evidence of the production of these schists from normal sediments, and goes on (op. cit., pp. 39, 160–163, 167–169, 181–184, 194–197) to give reasons for regarding the age of the sediments in this case as Ordovician, and of the granites which have altered them as Hercynian (post-Carboniferous, but pre-Triassic), though he states at the same time (p. 197) that both groups differ in no respect from Archæan rocks. The evidence he cites is as follows. The rocks in question, though occurring as an inlier in the Cretaceous without visible connection with neighbouring Palæozoic outcrops, lie in the course of a belt of metamorphism which he has traced in a westerly direction to within a short distance of them, through an area composed entirely of Palæozoic rocks (see Fig. 2). This metamorphism is generally characterised by considerable reconstruction of the sediments, e.g., the production of secondary mica, sillimanite, and large chiastolites, and appears to increase in intensity westward towards the Géla, where the rocks (Ordovician slates) become highly micaceous and crowded with chiastolite, and pass into leptynolites. At the same time a great number of veins of quartz, pegmatites, and 'micro-granulites' [quartz-felsites] appear. Hereabouts the sedimentary and igneous rocks form the basement-platform of the Cretaceous, beneath which they disappear westward. At a short distance in that direction the platform reappears in the Héas and Pau valleys, where, however, it is composed of the rocks whose age is in question. The relationship of the latter to the metamorphic rocks of the Géla cannot, therefore, be determined directly, as the change occurs below the Cretaceous, but the relative positions and degrees of metamorphism of the two series of altered rocks has suggested to Bresson that those in the Héas and Gavarnie valleys are continuous beneath the Cretaceous with those to the east, a conclusion which is supported, in his opinion, by observations in the valleys themselves. Thus, in several places, such as the Cirque de

[1] Bresson, op. cit., p. 160.

Troumouse, Silurian slates thrust over the Cretaceous (as shown in Pl. XVIII, Fig. 2) contain abundant chiastolite, and though not in their original position they doubtless, he says (p. 162), come from the deep-seated margin of the schists. But he attaches the greatest weight to the reported occurrence, within the granite-plexus, of masses of unaltered slates and quartzites, as well as the schists, in one of which at la Prade de Saint-Jean, between the village and the cirque of Gavarnie, *Calymene Tristani* is said to have been found (pp. 39 and 162) by the elder Frossard.[1] He further points to the close petrological affinity of the Gavarnie-Héas complex to that of Caillaouas, which, though at some distance to the east, is connected with the other by the belt of metamorphism previously mentioned, and in the neighbourhood of which Devonian rocks themselves have been metamorphosed (p. 163). As this suggests that the Gavarnie-Héas granite itself is post-Devonian, and as throughout the district he finds little evidence of large earth-movements prior to the Hercynian folding, such as elsewhere precede pre-Carboniferous intrusions, but on the other hand can prove that the Hercynian mountain-building was followed hereabouts by the irruption of granite masses into various formations, he concludes that the Gavarnie-Héas and the Caillaouas granites are themselves Hercynian (p. 169).

His evidence does not, however, appear to be conclusive. The increase in intensity of the metamorphic belt westward is not necessarily due to our approaching the Gavarnie complex, but is sufficiently explained by the fact, unknown to Bresson when he published in 1903 the work to which we have been referring, that granite is present in the higher part of the Géla Valley, where, as stated above, the metamorphism of the belt becomes very intense. It is shown on the Luz sheet of the Carte Géol. Dét., published in 1906, and appears to have been found by Bresson himself, as it is included in that part of the sheet surveyed by him. It is represented (see Fig. 2) as a westward continuation of the Bielsa granite, which lies to the south of the belt. The belt itself is due to granite, apparently an offshoot of the Bielsa mass, which just reaches the surface at the Pic de Lustou. We must ascertain, therefore, whether the Gavarnie granite may be regarded as a continuation still further westward of the Bielsa mass, and with that view we shall now compare the rocks of the two places, as their relationship is not directly determinable.

The Bielsa granite appears as a large, uniform, and coherent mass

[1] The original record does not state very clearly the exact source of this specimen, and on that account the conclusion drawn from it has appeared to be of limited value, but fortunately the specimen itself is still in existence, and has been examined by Stuart-Menteath, who has questioned the identification in his "Pyrenean Geology," and, more recently, by Bresson. The former has kindly supplied the following extract from Bresson's remarks in the recently published final part of the Bull. Soc. Géol. France, tome vi, which contains an account of an excursion of the Society to Gavarnie, and which has appeared since these notes were written:—"Mais l'examen de ce fossile a montré qu'il provient, d'après ses caractéres et d'après la composition de la gangue, du Coblenzien du pic de Mourgat, dont les éboulis récouvrent les pentes de la Prade et qu'il appartient au genre Phacops (*Phacops* aff. *Potieri*, Bayle)." In view of these views of Stuart-Menteath and Bresson the fossil evidently has no bearing on the question of the age of the schists.

of ordinary granite on the Carte Géol. Dét. It was examined by us during a traverse from Bielsa to Aragnouet, and was found to be a normal biotite-granite of fine or coarse grain, generally quite massive, but here and there, as at Bielsa itself, foliated as though by differential movement when partly consolidated. Its aureole, both in the Géla valley, as described by Bresson, and in the Pinara valley, as observed during our ascent to the Port de Bielsa, evidently belongs to the second of the two types found by Lacroix in the Pyrenees and characterised respectively by hornstones and mica-schist-like rocks.[1] The actual contact was not seen, but at a short distance mica-schists were observed, so closely resembling the Gavarnie schists, at least in outward appearance, that no specimens were collected for comparison. But it was soon found that such rocks extended for a comparatively short distance from the granite, probably less than 400 m., giving place gradually to spotted phyllites, which in turn shaded away into spotted slates. At the Port de Bielsa, at a distance of 800 m. from the granite boundary as mapped by Bresson, the spotting itself had become so slight as to be negligible, and unaltered Palæozoic slates were reached. In fact, it became obvious that a normal aureole had been crossed. Specimens were collected from the intermediate zone of spotted phyllites (191) and from the outer zone of spotted slates (192), which have been microscopically examined by Mr. George Barrow for comparison with the Gavarnie rocks (see p. 423). The above estimate of the width of the aureole agrees with the width in the Géla valley as shown in the Carte Géol. Dét. by Bresson, and does not appear to be exceptionally narrow.

In the Gavarnie and Héas Valleys the igneous and metamorphic rocks have a completely different relationship, being inextricably mingled to form a complex which shows no progressive change in any direction. This fact has long been recognised, and with the exception of a few igneous veins they are coloured as 'granitised' schists and quartzites, gneiss, and mica-schists on the Carte Géol. Dét. The metamorphism in fact is regional; the rocks it has affected, as exposed in the two valleys with their tributaries, are completely altered throughout, i.e. for a length of 11 kilom. and a breadth of 9 kilom. (Fig. 2).

The complex was examined at various places, and the following notes, though referring primarily to the rocks exposed along the torrent which descends the eastern side of the Héas Valley at Héas, may be regarded as descriptive in general of the whole outcrop. The sedimentary rocks vary from mica- to quartz-schists, according as they were originally argillaceous or arenaceous, their banding, which probably represents the original bedding, being now strongly contorted. A specimen (No. 190) of similarly banded schist from the Gavarnie district, showing both quartzose and micaceous parts, is described by Mr. Barrow on p. 422. In that neighbourhood it was noticed that biotite had developed along both the banding and the foliation of some of the schists, and that crystalline limestones were mingled

[1] Lacroix, "Le Granite des Pyrénées et ses Phénomènes de Contact" (2^{me} mém.): Bull. Carte Géol. Fr., tome xi (1900), No. 71, p. 64.

with them to a slight extent. As seen at Héas gneisses and gneissose pegmatites have been intruded into the schists, and when injected *lit par lit* as in the case of No. 186 (p. 421, from Gavarnie), are often difficult to distinguish from the intervening strips of partly digested sediments on account of the parallel arrangement of their own constituents. When, however, they cross the banding of the schists their igneous origin is obvious; their own foliation is then a continuation of that in the adjacent schist, but is coarse and irregular, being frequently interspersed with 'augen.' A common type is a gneissose biotite-granite, in which the biotite attains a large size (a length of $2\frac{1}{2}$ cms.); less commonly the gneiss contains black schorl along the foliation planes, sometimes as 'augen.'

Both schists and gneisses are seamed by later veins which are distinguished by their unfoliated structure, and are themselves divisible into at least two sets, the one being dark and possibly dioritic, and the other, which in places crosses the former, consisting of white granites and possibly pegmatites. No evidence was obtained of the time-intervals between any of the intrusions, but no chilled margins were observed.

It is obvious, therefore, that there are important differences between the Gavarnie and Bielsa granites. On the one hand, the latter forms a coherent mass or boss of simple outline, almost if not entirely devoid of veins of later granite, and surrounded by an aureole of normal type, in Palæozoic slates, in which the metamorphism, though intense near the contact, diminishes steadily outward and shortly disappears completely; on the other hand, the Gavarnie mass is really a complex in which (1) the commingling of igneous and sedimentary rocks is so intimate that they are frequently difficult to distinguish from one another in the field, and altogether beyond separation on a map; (2) the igneous constituents consist of several granitic injections, including pegmatites, each represented by numerous veins, the later, which are massive, cutting not only the sediments but also the earlier veins, which themselves are foliated; (3) no progressive metamorphism is distinguishable in the sediments, which are, generally at least, represented by crystalline schists and limestones.[1]

These differences are so great as to show that the Gavarnie granite is wholly unconnected with the Bielsa granite. Consequently, as the latter with a probable offshoot accounts for the belt of metamorphosed Palæozoics previously mentioned, there is no reason to regard the proximity of this belt to the Gavarnie granite as other than accidental, and therefore without any bearing on the question of the age of the granite.

The occurrence of chiastolite in the Silurian slates (Fig. 2) thrust over the Cretaceous near Gavarnie is of little importance in view of our ignorance of the original position of the altered rocks and the widespread distribution of Hercynian granites capable of producing them.

Bresson's next statement, however, that the Gavarnie granite encloses not only mica-schists but also masses of unaltered 'schistes' and quartzites, would go far towards proving the Hercynian age

[1] Bresson states that unaltered sediments also are enclosed in the granite.

of that granite. But here I feel compelled to differ from him on a question of fact, for knowing that the age of the schists was said to be Ordovician I carefully examined many exposures in the Gavarnie and Héas Valleys, with the open mind of an enquirer, without discovering any evidence anywhere of unaltered sediments. The shaliest-looking schist (No. 188, p. 422) was found under the microscope to be as thoroughly metamorphosed as any. And in the neighbourhood of the bridge near la Prade de St. Jean, whence Bresson recorded reddish and greenish 'schistes,' almost unaltered, associated with grey quartzites, the whole resembling the Ordovician beds of the Géla (op. cit., pp. 39, 162, 182), every exposure of sedimentary rock showed, as Mr. Stuart-Menteath pointed out, merely mica- and quartz-schists. In fact, so complete had been the metamorphism in the rocks that were seen that the occurrence close by of comparatively unaltered Ordovician sediments, if unquestionable, would point either to extensive faulting or to the metamorphism of the schists being pre-Ordovician. But it is so far from being unquestionable in view of the inference that palæontological confirmation of the Palæozoic age of any part of the schists is lacking, which may be drawn from Bresson's statement about the *Calymene*, previously quoted, that we may say that no conclusions, one way or the other, should be based on it.

Bresson next points with truth to the close resemblance of the Gavarnie granite to the Caillaouas granite as indicative of a genetic connection, but the post-Devonian age of the second is not so certain. It is based on the occurrence of altered fossiliferous Devonian, at no great distance from the granite, but Bresson's most recent work, published on the Luz sheet, shows that the altered rocks form part of the metamorphosed belt previously mentioned, and are much nearer the granite which crops out at the Pic de Lustou in the middle of the belt than the Caillaouas granite, so that their alteration is, at least, as likely to be due to granite connected with the Bielsa mass, which no one doubts is Hercynian, as to the Caillaouas granite.

Finally, although there is a lack of such direct evidence of powerful pre-Carboniferous earth-movements as is found in connexion with pre-Hercynian granite intrusions in other districts, it is certain that the folding of the Gavarnie schists preceded their thermal metamorphism, and that the latter itself was earlier than at least one period of shearing. This period is attested by the crushing, which in places has reduced the rocks, contact-minerals and all, to mylonite. As it is probably Hercynian from the rarity of later disturbances in these schists, the thermal metamorphism and original folding of the schists may well be pre-Hercynian.

Thus we see that Bresson's evidence that the age of the Gavarnie schists is Palæozoic and their metamorphism Hercynian appears to be inadequate and to leave the question open to solution from other considerations, such as those brought forward in the following pages by Mr. Barrow on petrological grounds. But at the same time light may also be thrown on the problem by stratigraphical evidence, on the lines of a comparative study of the neighbouring granitic and metamorphic rocks. Materials for a preliminary comparison are already to hand in the admirable work of Bresson (pp. 139–197), already so extensively referred to. There he enumerates six granite-masses as outcropping in the area of the Luz sheet, viz., those found at (1) Cauterets, (2) Néouvielle, (3) Bordères, (4) Gavarnie, (5) Pic du Midi de Bigorre, (6) Conques. To these will be added the Bielsa and Caillaouas granite-masses, the latter already mentioned, because it lies but a short distance to the east of the Luz sheet and has been carefully described by Lacroix.[1]

The first three masses have been shown by Bresson to form a natural group in that they penetrate various Palæozoic formations, including the Carboniferous, and traverse both anticlines and synclines. It is apparent from his descriptions and those of Lacroix[2] that they are coherent and closely resemble one another and also the Bielsa mass in those very features in which the latter differs from the Gavarnie granite, and that, as he maintains, they are Hercynian. Masses (4), (5), and (6) he places in a second group, because they have not reached the Carboniferous and because they form the cores of anticlines. In their case, the accounts make it clear that they are linked closely together and with the Caillaouas granite by the same characters which have been mentioned as separating one of them, the Gavarnie granite, from that of Bielsa, i.e. from the first group. They each consist of a complex of granite, gneiss, and mica-schist like that of Gavarnie already described.[3]

In spite, however, of the marked differences between the two groups, Bresson regards the second also as Hercynian, chiefly on account of the altered character of Palæozoic rocks adjacent to its members. But that it is by no means certain that the latter have produced the alteration, is apparent from his description and that of Lacroix and the subsequent work published on the official map, especially in view of both the frequency of undoubted Hercynian intrusions in the whole area, some of which barely reach the surface, and also the complications arising from the subsequent Tertiary disturbances.

A point of the greatest importance is the fact that these mixtures of schist and granite form the cores of anticlines in those cases where their relations to Palæozoic formations are known, and in two instances are surrounded by comparatively uniform belts of Silurian rocks. But whereas Bresson explains this fact by supposing the granites to be deep-seated 'roots' of intrusions, in my opinion it points strongly to their really being parts of a widespread complex, in age pre-Silurian at least, on which the contiguous rocks have been deposited and which we now see exposed in a few places in large folds by extensive denudation. This view is greatly strengthened by their marked contrast with the Hercynian granites in the neighbourhood, all of which in their turn resemble one another in essentials. The whole question, however, is a large and important one, worthy of close attention and fraught with difficulties on both sides.

[1] Op. cit., pp. 34 et seq.

[2] Op. cit., pp. 45–61.

[3] It is interesting to note that Lacroix draws attention to the fact that in the inner part of the aureole of the Cauterets mass (Hercynian) the felspathised schists remain distinct from the igneous rock injected into them, whereas in the case of the Caillaouas mass they pass insensibly into it through highly micaceous, gneissose granite (pp. 64–5). The second mass thus resembles that of Gavarnie in what is probably a fundamental character.

IV.—Appendix to the Geology of the Gavarnie District and Pyrenean Geology.

By P. W. Stuart-Menteath, A.R.S.M.

My observations at Gavarnie commenced with the detection of the great fault of the Cirque, sketched in Bull. Soc. Géol. of 1868, and are summarized in my "Pyrenean Geology," pp. 169, Dulau & Co., completed to 1907. The Hippurite limestone having been classed and mapped as typically metamorphosed Cambrian, on the ground that my maps and descriptions are *à priori* inexact, I have recently been concerned with the rectification of the simultaneously asserted Triassic age of the gypseous marls, which I have found to be Tertiary and Cretaceous, from Biarritz to Cardona. Before 1868 the Hippurites of Gavarnie and Heas were already described as anomalous by Leymerie in his Manual and papers, and by Frossard in his "Guide du Géologue." The only specifically determined specimen mentioned by Bresson is from "near the Hourquette d'Alans," a point touching the never-questioned Cretaceous beyond the great fault, and situated at 600 metres above the anomalous sheet in question, as it is figured on Bresson's largest sections. The only fossil of his basal Ordovician I had long previously ascertained to be in a fallen fragment from a peak to the west, outside the rocks in dispute. His 'fundamental section' east of Gedre is a local accident due to a fault, and his section of the Cirque is wildly in contradiction to the real stratification, as well as his section of the Spanish slope of the pass of La Canao and the Hount Sainte. All these errors are corrected on his definitive map of the French Survey, and in the report of the meeting of the Société Géologique in the Pyrenees in 1906. At that meeting the theory founded by M. Carez on the contradiction of my description of Eaux Chaudes, of Bull. Soc. Géol. of 1893, was explicitly acknowledged to be baseless and untenable by that writer himself, as well as by all present.[1]

A course of lectures on the New Geology, delivered by M. Léon Bertrand at the Collége de France, and reported in the "Revue Générale des Sciences" of 29th February, asserts that all geologists are adhering to his tenets as verified in the Pyrenees; and the volume of the Bulletin of the French Survey just published (No. 118) presents nearly 200 pages of gorgeously illustrated compilation to the effect that the interpretation of the Pyrenees proposed by M. Carez and himself is correct, in spite of all observations to the contrary, and especially in spite of the trifling anomalies of Gavarnie and Eaux Chaudes. He explicitly maintains that his first observations at Biarritz are correct, and that he is warranted in extending them

[1] In view of these results, the two papers which I presented at Eaux Chaudes have been suppressed, and I have been refused all rights as a member of the Société Géologique, in spite of a new formal presentation, signed by M. Bresson and M. Fournier, the two survey officers best acquainted with my work. Any novel result of my field observations in the Pyrenees since 1866 will consequently appear dismissible as *à priori* inexact, and any necessary reference to the conditions under which I work will appear to be obviously incredible and deserving of prompt suppression.

to the entire Pyrenees. I have consequently dealt with those observations and their sources in 25 pages of the "Bulletin" of the Biarritz Association, obtainable from Dulau & Co. In the report of M. Bertrand's lectures I find only a reconstruction of a section of Magnan, and in his volume I discover a reconstruction of the 500 sections of M. Roussel. His own additions are what he terms 'coupes perspectives,' to my mind a contradiction in terms, and in my experience the most fruitful source of paradox in geology. Magnan began his work by confounding the Tertiary with the Trias in the Aveyron, and assuming that continuous folds were present where isolated bosses are characteristic. On these convenient errors he added section to section along the entire Pyrenees, and hence finally confounded the Trias with the Tertiary in the Biarritz district. M. Bertrand copied these errors at Biarritz, and has worked back along the whole course of Magnan and his subsequent imitators.

M. Termier, the most expert disciple of the official geology in the Alps, has been called to the rescue, and has already published and elucidated the maps of Biarritz and St. Jean Pied de Port. His conclusion, from the data he is required to justify, is summarized in the Compte Rendu of Soc. Géol. of 2nd December last, and in the text of the maps. He finds that the entire Pyrenees, including all Southern Europe and the north of Africa, consist of rocks shovelled in confusion and reversal from distant and unknown sources. The types of the entire scale of fossils of the south hence demand radical revision. Anomalies in the Paris basin are already referred to mechanical inversion. The scale constructed by William Smith is selected from a comparatively small patch of rocks bordered by the biggest *charriages* described in Suess' latest volume. M. Bertrand states that Suess has informed him that the Pyrenees will be interpreted in his final volume. Since 1883 I have awaited that revision of the scale of fossils which Suess then promised as an essential section of his work. The hints of Neumayr, Walther, and many others have not enabled me to dispense with the *Paléontologie Française.*

It is waste of time to ignore the officially presented aspects of a problem involving the essential structure of the most typical and most accessible of all mountain chains. Alpine geologists habitually quote the abundant literature of the typical Pyrenees. M. Bresson, in applying the Alpine theory to Gavarnie, complains that I had not explained why I referred the facts to illusion. I had found the emergence of the same rocks to the east of Arreau, which M. Bresson has ignored, at fifteen miles to the north of their disappearance on the southern side; and I stated that I was not prepared to believe the entire Pyrenees to be a shovelled mass, as M. Termier has already announced and as M. Bertrand has approximately maintained. For all mining, tunneling, and other industrial work the consequences are of transcendent importance. A theory which destroys the accepted scale of fossils on which its every contention is practically based, suggests hasty mapping rather than a revolution in geology. In presence of the gorgeous maps and sections of the latest volume of the Survey, a practised mining surveyor must remember that his regular proof that a map is worthless is the simple circumstance that paradox is its outcome. The question for every practical geologist is to find how the error comes in. Is the stratigraphy hastily assumed on fragmentary data? Are the sections only 'coupes perspectives'? Does the rest of the Pyrenees warrant another explanation? Are the Hippurites, with their accompanying forms of a similar fauna, decisive of certain age?

On the last question I may remark that I determined the best specimens of these Hippurites at Miegebat in 1885, and was hence denounced for twenty years, and my Upper Cretaceous figured as Cambrian, along over fifty miles of the official map; whereas fossils that do not touch the problem are eagerly quoted since the wind has changed.

The one point certain regarding the Hippurite limestone is its subordination to that "Austrian Flysch or *Wiener Sandstein*" which I detected in 1881, and which is now accepted as a main element of the Pyrenees. All the fossils of this formation, named and classed in the museums of Austria, Italy, and Switzerland, are repeated in the Pyrenees, and have been of notoriously doubtful value for half a century. Hippurites have been scarcely less puzzling, and have been cited by Darwin in the Jurassic and by most authorities as peculiar to the Turonian. At Eaux Chaudes I have proved the base of the anomalous limestone to be Cenomanian by *Ostrea flabellata*, *Janira quinquecostata*, Sciosia, *Ostrea* cf. *carinata*, and various corals; but its base at Gavarnie is Campanien, on the excellent authority of M. Douvillé. Thousands of years should consequently have elapsed between its deposition at these two points of an identical sheet.

The final and most elaborate sections of M. Bresson are those of Eaux Chaudes, in his description of the meeting of the Société Géologique of 1906. The point most contrasting with my section of the same Bulletin of 1893 is his figure of the Arrioutort, represented as an overlying syncline. Numerous visits to that point have assured me that the Hippurite limestone is there the termination of a long wedge running north and south, and descending almost vertically to the bottom of the neighbouring valleys. As in the single case which I showed Mr. Dixon at La Prade, the limestone figured by M. Bresson as a flat platform is in deep and narrow synclinal wedges descending to beneath the valley bottoms. Such wedges are a special feature of the western Pyrenees, and have the very peculiar property of abruptly changing their direction at right angles. MM. Fournier, Termier, and Bresson all attest this fact in their latest mappings. Its effect is to produce an appearance of underlying Cretaceous exposed by valley erosion. I have traced it to the filling of ancient gulfs or valleys, and hence compared the case to that of Gosau. At Camarasa, and much of Catalonia, the gypseous Oligocene runs vertically downwards to the bottom of such valleys. At Salies du Salat, M. Leon Bertrand has maintained that the Trias has glided along the surface of even the Oligocene, and has moulded itself on an ancient valley to a depth of over 1,300 feet, proved by borings that indicate horizontal bedding. Normal deposition in valleys is less complicated. At Gavarnie and Eaux Chaudes the continual formation of hard travertin filled with transported fossils is a common source of error, and, when submarine and followed by dislocation, involves unsuspected sources of illusion.

M. Lacroix has hence abandoned his first impressions of the early age of ophites, but M. Bresson, in obedience to that abandoned theory, figures as necessarily mechanical intrusions the ophites which at Eaux Chaudes I have traced as visibly volcanic injections. As a regular sheet of Permian, he figures the crush-breccia of a ferruginous lode which cuts across beds of any age. The notion that an unlimited number of worthless arguments amount to one good one, is favoured if verification can be limited to telegraphic phrases.

As regards the age of Pyrenean granite, even M. Bertrand, after founding his earliest example of *charriage* entirely on its assumed antiquity, now admits that it can be Cretaceous or Tertiary, and so follows the example of M. Carez and M. Lacroix, after visiting points I have indicated as decisive. In 1881 I gave the results of microscopic and field examination of sixty ophites, and the notion of their Triassic age has since been generally abandoned, while their intimate connection with the granite is unquestionable. So long as independent observation is classed as *à priori* inexact, the picture of official geology in the recent Traité de Géologie of M. Haug is a true reflection of his present experience rather than of a past which I had occasion to know. Of the theory of its first Director he writes: "By a strange irony of fate, this theory, in spite of all attacks, has remained unshaken; the pretended facts of observation, whose interpretation it professed to furnish, have long since vanished as an illusive mirage . . . It has literally hypnotised several generations of geologists, in virtue of the great scientific authority and especially the high official situation of Elie de Beaumont." Under his successor my most decisive facts have been regularly suppressed in both France and England, because they opposed observation to authority in unavoidable contrast. To accept the existing conditions of verification is to encourage paradox as practically safe. Obvious fallacies of fundamental method can alone secure attention, and resulting confusion in all geology may indicate something seriously wrong.

The description of the entire Pyrenees in the latest volume of the French Survey Bulletin is an avowed extension and justification of its author's first observations at Biarritz. My latest papers, obtainable from Dulau & Co., being a comparison of those statements with the local experience of an engineer, are an unavoidable outrage on high authority. They give the decisive facts concerning Biarritz and Gavarnie. Mr. Dixon naturally refers to them as wholly questionable, and as strangely compromised by references to the dominant theory of Palæontology. They show that every fallacy at Biarritz is supported by the excellent palæontologist M. Douvillé, because those fallacies enable him to evolve a plausible succession of Foraminifera. The innovations of M. Termier and M. Bertrand offer a vastly greater convenience. By their method, evolutionary theories of any fossils can be made plausible against all observations whatsoever. The thirty volumes of Dr. Le Bon's series include one, by a skilled palæontologist, which does for fossils what other writers have done for physics. The Academy of Sciences have noticed in their "Comptes Rendus," but consigned to their archives, two papers which state my results regarding Biarritz and Gavarnie. The theory of Elie de

Beaumont had the fatal defect of offering means of verification. The tunnel of Gardanne has proved that no means of verification can affect the theory of his successors. The engineer commissioned to find coal under the supposed Trias of Biarritz and Cardona, or to tunnel across the supposed Cretaceous basis of the Pyrenees, may find in psychology, but not in the rocks, the justification of the task he undertakes.

The very latest section of Gavarnie is presented in M. Bertrand's book. It represents the overlying Palæozoic in the form of a feeding-bottle, rammed into the heart of the Cretaceous mass that rises from Spain to form the Cirque. It is a caricature of the first erroneous section of M. Bresson, combined with a confusion of Carez, who makes the Cretaceous in question overlie the Palæozoic by 1,500 yards, through mistaking the Port de Pinede for the Port Biel. Bresson's latest section recognizes the fact that the Hippurite limestone forms a vast wedge between the Spanish Cretaceous and the Palæozoic; that it abuts on the great fault which Bertrand is pleased to suppress; and that, far from entering the heart of the Cretaceous, it may probably have left outliers on its summit. Perspective illusion has unfortunately made him sketch the fault as dipping at 23° to the south in place of its real dip of 50°. M. Bertrand similarly sketches a perspective illusion wherever a practical geologist has detected a vertical fault, and by selecting the point of view of his 'coupes perspectives' he obtains any overlap he can wish for. He selects districts never visited by tourists, but Biarritz and Gavarnie have amply illustrated his method. His gratuitous conjectures regarding districts he has never seen are directly contrary to the facts which I have mapped in mining surveys where accuracy is required. They serve the purpose of making local observation intolerable and *à priori* inexact. As Suess reforms the geology of Central Asia, so his emulators deal with the Pyrenees. It is the business of official science to solve all problems at the cheapest rate. The simple suppression of verification will irresistibly appeal to the 'good business head.' The detection of self-contradiction is the only effectual check on the new science, which protects plausible conjectures by defaming every proved expert. The new map and Guide to Interlaken, by Baltzer and his pupils, is a protest against the method applied by M. Douvillé and his subordinates to Biarritz, Interlaken, and Gavarnie. The forcible suppression of my papers is a tribute to the views I share with Baltzer and every local expert from Sicily to the Hartz. The interpretation of the Scotch Highlands proceeds on the assumption that such problems are clearly solved elsewhere. Their excellent description proves them to be as obscure as when Ramsay, in the presence of Nicol, explained them to me forty years ago. The current denial that science bristles with such antinomies has attained a somewhat desperate culmination. But the art of manipulating with the amassed wealth of observation is not proved to be the only legitimate content of human reason, although the entire resources of chromolithography are recklessly squandered in the attempt to exterminate direct research.

V.—Notes on some Rocks from the Gavarnie District of the Pyrenees.

By George Barrow, F.G.S.

(PLATE XIX.)

MR. DIXON has handed me a small collection of rock specimens from Gavarnie (Hautes Pyrénées) and the district to the east. Microscopic sections have been made of these, with the object of ascertaining whether the structures and composition of the rocks throw any light on the vexed question of the age of the metamorphism in the two areas specially dealt with in the preceding communication.

The igneous rocks from Gavarnie and Héas, both in their general character and mode of occurrence, show the features specially characteristic of very old intrusions. They tend to infinite subdivision, occurring either as thin sills of granite or as veins of more or less foliated pegmatite (giant granite). It is an additional feature of these thin intrusions that in the majority of cases their foliation is of protoclastic (pre-consolidation) and not of kataclastic (post-consolidation) age.

The two specimens, 186 (near Gavarnie) and 189 (Héas Valley, near the cirque de Troumouse), are typical examples of a sill of granite and a foliated (protoclastic) pegmatite. The first (186) is mainly a typical igneous 'granulite,' in which the grains are of fairly uniform size, and there are no specially large patches of either quartz or felspar, though the junctions of the component grains are essentially the same as those of a normal granite. It is composed of quartz, orthoclase and plagioclase, with a subordinate amount of brown and white mica. The plagioclase is mainly oligoclase, and shows a typical feature of these old rocks, namely, the development within the plagioclase crystals of numerous small flakes of white mica, due probably to their being kept at a high temperature for a long period after they had separated out. The biotite is in irregular shaped patches and often intergrown with muscovite, only a small quantity of the latter being free.

On the margin of the igneous granulite are films or patches rich in felted brown mica, having the reddish-brown tint of the 'contact mica,' developed in altered sediments by heating. They show clearly the presence of original films of sedimentary material, now intensely altered; the bulk of the new quartz and felspar associated with the mica-films merges absolutely into the adjacent igneous material, and no trace of a true junction between the two is visible in the microscopic section. This absence of clear junctions is a characteristic feature of *lit par lit* intrusion in very old rocks.

In the gneissose pegmatite 189, large crystals were formed, which are now more or less rounded, as well as surrounded by a mixture of fine 'granulite' material and slightly larger grains. The latter adhere so closely to the large rounded crystals as to suggest they were broken off from the latter during 'pasty-flow,' the structure being, in fact, a typical 'protoclastic foliation.'

Three specimens of the older altered sediments have been selected for examination. Of these the first, 187 (near Gavarnie), is a hard, tough, crystalline rock showing marked contortion, which had clearly been subjected to great mechanical stresses and deformations before heating. These stresses broke up the original sediment into lenticles or phacoids, the length of which suggests the rock was a gritty shale, possibly a banded shale.

The lenticles are built up of well-crystallized quartz and felspar, the whole thickness of a single lenticle being often filled by one grain of quartz. There are also present patches of irregular-shaped garnet, often bordered by brown mica. These lenticles are separated by films or flaser-ribands of pale fibrous material suggestive of decomposed sillimanite. In this only a few needles of sillimanite can be still recognized; but where the fine mesh comes into contact with quartz the terminal threads of the former penetrate the quartz, and in this case are at once seen to be sillimanite, which has been protected from decomposition by its coating of quartz. This latter phenomenon is a very characteristic feature of these flaser films of sillimanite. The rock is a sillimanite gneiss.

The second (188), also from Gavarnie, is a slightly horny-looking, brownish rock, largely built up of lenticles and films rich in brown mica. The lenticles are of slightly different composition; one set are largely composed of rich red biotite (contact-biotite) associated with a little sillimanite; the other set are composed of sillimanite in long-bladed crystals arranged parallel to the foliation, and associated with brown mica in somewhat smaller crystals. Both types of lenticles are enveloped by films of fibrous sillimanite, much decomposed, and practically identical with those in the rock last described. The rock is a sillimanite gneiss, and was clearly a shale originally and markedly less siliceous than 187.

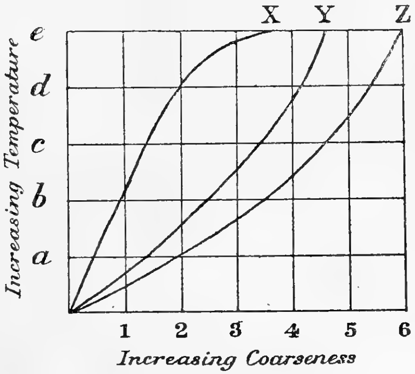
So far as the minerals are concerned, these rocks might be of almost any age; but experience has shown that if of post-Torridon age the sillimanite-bearing rocks would be restricted to the immediate margin of a large mass of coherent granite, a fact well brought out by Dr. Barrois in his descriptions of the great coherent masses of granite in Brittany, which are substantially of the same age as the great coherent masses referred to by Mr. Dixon.

The third type (190, from the east side of the Pau Valley at Gavarnie) was much more siliceous originally and probably a banded very fine sandstone, partly calcareous. It is a banded rock, with a fine gneissose structure, the darker bands being composed of greenish-brown hornblende in irregular-shaped patches, disseminated through a groundmass of plagioclase felspar with which a subordinate amount of quartz is associated. The hornblende suggests the original rock was slightly calcareous. The lighter-coloured bands are more quartzose and there is little or no hornblende present, but decomposed biotite is fairly abundant. The structure of both is essentially that of a 'granulite' produced by the prolonged and intense heating of a somewhat crushed siliceous sediment. In many respects the lighter bands bear a close resemblance to the less common 'plagioclase phases' of the Moine gneiss. (See Photo, Pl. XIX, Fig. 1.)

Of the rocks occurring within the aureole of contact metamorphism surrounding the large coherent granite of Bielsa, two may be referred to. The first (191), collected about half-way between the River Pinara and Port du Bielsa, is a very fine spotted schist or phyllite. Like the specimens from the older series already described, this was subjected to considerable deformation before heating, and is now a very fine schist largely composed of quartz grains and small crystals of white and brown mica. In this, as a matrix, are set a number of large patches of shimmer aggregate material, almost certainly decomposed andalusite. (Photo, Pl. XIX, Fig. 2.)

The second (192), from Port de Bielsa, is a fine phyllite composed of small flakes of biotite, with some muscovite and chlorite, wrapping round lenticles of quartz and chlorite. The latter are reconstructed segregations, formed when the rock was crushed, anterior to the heating. The fine texture of these rocks (190 and 191) at once separates them from the former group; in the Archæan rocks it would be practically impossible to find such large patches of andalusite associated with such a fine groundmass.

Rocks of very fine texture and well foliated do occur on the 'outer margins of crystallization' of the old Archæan areas, but they contain no such minerals as andalusite. It is necessary to go some distance into these areas, in the direction of increasing crystallization, before such minerals are met with, and by this time the texture of the groundmass has invariably become far coarser than that of 191.



The lines X, Y, Z show the coarseness of the texture for a given temperature in—

X[1] = post-Torridon aureoles of thermo-metamorphism.
Y = areas of newer Archæan ,, ,,
Z = areas of older Archæan ,, ,,

The distinctive feature of the two groups is best shown by the size of grain of the quartz-felspar material in the two specimens 190 and 191, which is brought out by the photographs of sections of them (Pl. XIX, Figs. 1 and 2). The texture seen in Fig. 1 may occasionally be met with close to the actual margin of a great coherent mass of

[1] The flattened termination of X is intended to show the rapid increase of texture just at the margin of a big intrusion.

post-Torridon granite, but it is invariably restricted to within a few feet of that margin ; in the older Archæan areas it may cover many hundreds of square miles without a break; it is regional. The mode of occurrence of the rocks in the Gavarnie and Héas Valleys, described by Mr. Dixon, is characteristic of the regional or Archæan type of thermo-metamorphism.

In both types of areas, as we approach the zones of increasing metamorphism, a series of minerals is met with which requires an increasing temperature for their development. The Archæan areas of thermo-metamorphism can be broadly distinguished from those due to post-Torridon intrusions by the far more rapid increase in coarseness of texture of the groundmass of the former, *if well foliated.* The difference may be illustrated diagrammatically by arranging a series of vertical and horizontal co-ordinates. In the diagram (p. 423) the minerals *a*, *b*, *c*, *d*, etc., represent increasing temperature, while 1, 2, 3, 4, etc., represent increasing coarseness of texture. The lines X, Y, Z show the difference in texture produced by the older and newer thermal metamorphism.

EXPLANATION OF PLATE XIX.

Fig. 1 (No. 190).—Rock-section taken from the east side of the Pau Valley at Gavarnie (see text for fuller details).

Fig. 2 (No. 191).—Rock-section from half-way between the River Pinara and Port de Bielsa ; a very fine spotted schist or phyllite.

The two photographs show the difference in size of grain of the quartz-felspar material in (1) the older Archæan rocks, and (2) in any post-Torridonian rocks; the crystalline metamorphism being due in both cases to thermal action.

VI.—The Waterberg Sandstone.

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S. (Rhodes University College, Grahamstown, South Africa).

THE geology of South Africa is once again being brought to the notice of European geologists in the able papers by Dr. Voit in the *Zeitschrift für praktische Geologie.* In the first instalment Dr. Voit follows Drs. Hatch & Corstorphine[1] in correlating the Waterberg Sandstone with the Table Mountain Sandstone, which is a small matter perhaps, but as it would in Europe be equivalent to correlating the Old Red Sandstone with the Torridon Sandstone, it is necessary to state the objections to this correlation and enable geologists to judge for themselves whether it is right or wrong.

To emphasize the difference between the South African older and younger rocks, which are separated by a great unconformity, and the younger series of which begins in the Palæozoic with the top of the Silurian or base of the Devonian, I have used the words Palæo- or Pal-Afric and Neo-Afric as group names. The Table Mountain Sandstone is at the base of the Neo-Afric group, and the Waterberg Sandstone at the top of the Pal-Afric; the former is a blue, false-bedded sandstone weathering grey, and the latter consists of a series of conglomerates and sandstones characteristically coloured red or buff.

[1] "Geology of South Africa" (London, 1905), p. 179.

No. 190.

FIG. 1.

No. 191.

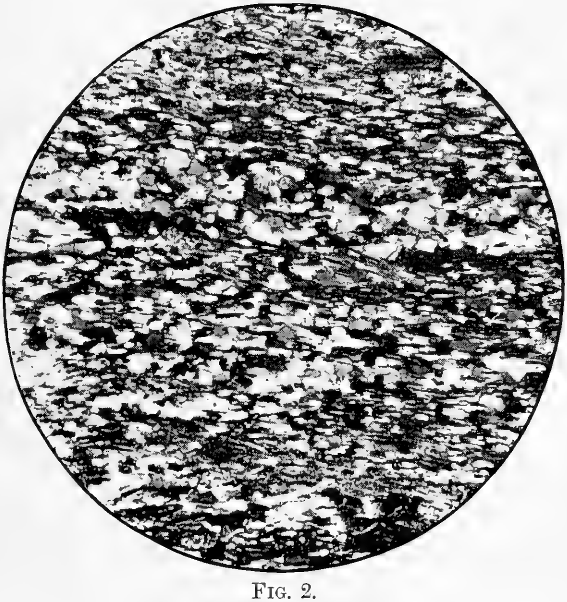
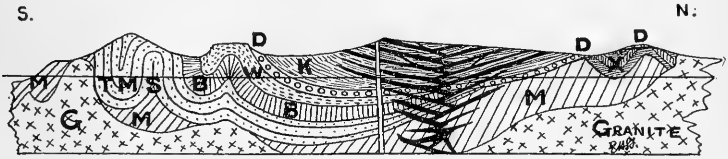


FIG. 2.

Rock-sections from the Gavarnie District of the Pyrenees.

The Table Mountain Sandstone surrounds the sub-continent on the west and south, and is usually marked in on the east as well, but in Natal Mr. Anderson at first refused to consider the sandstones as equivalent to the Table Mountain Sandstones, calling them instead Palæozoic Sandstones. The only place I have seen the Natal Sandstone was near Pinetown, where the rock is a red arkose.

On the west the Table Mountain Sandstone is typically developed on the mainland opposite the Cape Peninsula, where it is some 5,000 feet thick; proceeding northwards the sandstones thin out, and gradually the overlying beds, the Bokkeveld (Devonian) and Witteberg Beds, disappear from beneath the Dwyka (glacial) Conglomerate, so that the last rests on the thinned-out Table Mountain Sandstone; finally at Stinkfontein Poort, north of Van Rhyn's Dorp, the Table Mountain Sandstone itself wedges out. We can to a certain extent examine the rocks below the Karroo by means of volcanic pipes, which act as boreholes, bringing the rocks to the surface, and we know from the ejactamenta of the Sutherland volcanic pipes that the Table Mountain Sandstone must underlie the Karroo in this part of the country, so that in drawing a section through the middle of South Africa we cannot be far wrong in filling in the sub-structure on the lines indicated in the upturned edges of the basin in the west.



M. Malmesbury } Pal-Afric Beds.
X. Matsap }
T.M.S. Table Mountain; B. Bokkeveld; W. Witteberg; D. Dwyka; K. Karroo, with intrusive Dolerite.

Sketch Section through the middle of South Africa from the south to just beyond the Orange River on the north, to show the relationship between the Dwyka Conglomerate and the Table Mountain Sandstone on the one hand, and the Dwyka Conglomerate and the Matsap (Waterberg) Sandstone on the other.

A short way to the north of the Stinkfontein Poort there is a series of remarkable arkoses and grits which Dr. Rogers named the Nieuwerust Beds,[1] which undoubtedly lie unconformably below the Table Mountain Sandstone, and which, therefore, belong to the Pal-Afric group. Further to the north, in Namaqualand, there has been marked on the older geological maps of South Africa a patch of Table Mountain Sandstone. I can give the authority for this from the original notes made on the spot by the late Dr. W. G. Atherstone in 1854: "Schaap River. Granite forms the base of the mountain, gneiss above it, and, covering all, the Table Mountain quartzite. (The latter is) externally of a red colour, and breaks off in vertical cliffs, but (with) apparently horizontal beds precisely like Table Mountain." I think there can be little doubt that this Schaap River Sandstone belongs to the Nieuwerust Beds; certainly it is different

[1] Ninth Annual Rept. Geol. Comm. (Cape Town, 1905), p. 35.

from the Table Mountain Sandstone. If Drs. Hatch & Corstorphine are right in correlating the Waterberg Sandstone with the Natal Palæozoic Sandstone, then it seems likely that these Nieuwerust Beds may turn out to be the western equivalents of the Waterberg Series.

In Prieska we have red sandstones which Stow called the Matsap Beds, and which are undoubtedly the equivalents of the Waterberg Sandstone; all geologists are agreed on this. The Dwyka Conglomerate rests on the upturned edges of the Matsap Beds, and it also rests on the eroded edges of the Table Mountain Sandstone of the south; therefore Drs. Hatch & Corstorphine and Dr. Voit say they must be equivalent. But the Dwyka Conglomerate in the south rests on beds of Table Mountain Sandstone which had been very little disturbed, and the two epochs left out in the unconformity, the Bokkeveld and Witteberg, are of no very great geological extent. On the other hand, the Matsap Beds were buried and metamorphosed, were exposed again by denudation, thrust up into high mountain ranges, and cut into peak and valley before the Dwyka Conglomerate was laid down. The glacial boulder-clay is in Prieska extraordinarily fresh and unaltered, and rests in the valleys cut in the Matsap Hills as if the Ice Age during which it was formed was but a short time past, and we can find in the till boulders of Matsap Sandstone altered and metamorphosed, thus proving the vast lapse of time which must have intervened between the laying down of the Matsap sediments and the Dwyka Conglomerate.

The Waterberg (Matsap) Sandstone, then, is a series of rocks with a prevalent reddish or buff colour like the Torridon Sandstone, the Table Mountain Sandstone a blue quartzite weathering grey. The Dwyka Conglomerate rests on the Table Mountain Sandstone with an unconformity represented elsewhere by a conformable series of beds (Bokkeveld and Witteberg) 4,000 feet thick; it rests on the Waterberg Sandstone with an unconformity representing a lapse of time during which the Waterberg Sandstone was buried, metamorphosed, folded into mountain chains, and denuded. Judged by European standards, the Table Mountain Sandstone-Dwyka unconformity would mean the leaving out of the Devonian and Carboniferous epochs, quite time enough many would say for the changes to have gone on in the Matsap (Waterberg) Beds, but where the series is conformable there was a steady process of sedimentation from Table Mountain Sandstone times to the Dwyka, whereas between the Matsap Beds and the Dwyka there was sedimentation certainly equivalent in extent to the Bokkeveld and Witteberg epochs, in order to procure 'cover' for the folding to take place, then the period of crushing, and finally a prolonged land period ending in the Permian Ice Age, and this lapse of time to my mind must have been immeasurably longer than the other, so much so that I still think the Waterberg (Matsap) Beds should be put into the Pal-Afric group. If the Nieuwerust Beds turn out to be the equivalents of the Waterberg Sandstone, the question will be settled definitely, for the outcrops of the two rock-systems are close enough in Bushmanland to enable one to make sure that there is a great unconformity between them.

NOTICES OF MEMOIRS.

I.—Index Generum et Specierum Animalium.

Report of a Committee consisting of Dr. Henry Woodward (Chairman), Dr. F. A. Bather (Secretary), Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, Hon. Walter Rothschild, and Lord Walsingham.[1]

STEADY progress has been made with the indexing of the literature for the second portion of this Index (1801–1850). Among numerous works dealt with, the compiler, Mr. C. Davies Sherborn, specially mentions the following:—

Boisduval's works on Lepidoptera.
Publications of the Bologna Academy.
Bonaparte's numerous tracts and his "Conspectus Generum Avium."
Publications of the Bonn Natural History Society.
Publications of the Bordeaux Linnean Society.
Roret's edition of the "Suites à Buffon."

The number of index slips increases with great rapidity, and continual effort is needed to keep this mass of material in order for reference. The sheets already arranged constitute a mine of information for monographers and others. They are preserved in the Geological Department of the British Museum (Natural History), where reference is frequently made to them by members of the staff and outside workers, while information derived from them is often asked for by correspondents at a distance. The Committee would, however, be glad to see still more advantage taken of the facilities now offered for the consultation of this valuable aid to systematic work.

A copy of the first volume of the "Index" is being shown in the Science Hall of the Franco-British Exhibition.

The Committee asks for reappointment, and earnestly hopes that the full sum of £100 will be granted towards the continued preparation of the "Index Animalium."

II.—Glacial Drift in Scilly.

OUR attention has been drawn by Mr. W. A. E. Ussher to the following passage in a paper by the late E. A. Wünsch, "On Raised Beaches," read on June 15th, 1894, at the Joint Meeting of the Scientific Societies of Cornwall at Penzance. In that paper he accepts the evidence put forward as to the stranding of erratics on the shores during the formation of the raised beaches, and continues thus:—"We must hence refer the age of our Raised Beaches to the later stages of the Glacial Period, and with this great northern drift with its heavier burden checked by and deposited in front of the Isle of Wight and Portland Bay we must connect the effects of the same drift farther westwards, by means of which, and by ground ice and

[1] Submitted to the Meeting of the British Association, Section D, Zoology; Dublin, September, 1908.

local ice-floes, the dispersion and extensive distribution of flint so conspicuous in all southern beaches, and extending even as far as the Scilly Isles, can alone be accounted for."

III.—On the Viscosity of Ice. (Abstract.) By R. M. Deeley, F.G.S.[1]

THE movement of glaciers has excited a great deal of interest, and the facts recorded concerning their motion have shown that the flow is such as would result if ice obeyed the laws of viscous flow. The viscosity of a liquid is measured by the tangential force per unit area of either of two horizontal planes at unit distance apart, one of which is fixed, while the other moves with unit velocity, the space between the planes being filled with the viscous substance. Taking such figures as are available, and estimating others as nearly as may be, it is possible to calculate roughly the viscosity of several glaciers. Stated in dynes per square centimetre by 10^{12}, the results obtained are roughly as follows:—The Mer de Glace 27, Morteratsch 143, Lower Grindelwald 3, and Great Aletsch 126. It seems probable that these discrepancies arise rather from differences in the actual viscosity of the glacier ice, due to its varying granular structure, than to errors in the data. Further measurements are required, however, before this can be regarded as proved.

It is also shown that the viscous motion of a glacier such as the Great Aletsch must exercise a drag on the floor upon which it rests amounting to two and a half tons per square foot, and that owing to the ability of the ice to transmit thrust, this force may be greatly exceeded at points where much resistance to motion is caused by inequalities in the floor upon which the ice rests.

McConnel made a number of very careful experiments on the shearing motion which can be produced by even very small forces in directions at right angles to the optic axes of ice crystals. A careful consideration of the experimental data shows that the rate at which the motion is produced is proportional, very nearly, to the stress, and that the resistance to shear increases very rapidly with rise of temperature. The flow at right angles to the optic axis is such as would be the case if ice were viscous (liquid) in a direction at right angles to the optic axis, the viscosity at 0° C. being about 3×10^{10} dynes per square centimetre.

McConnel showed that when the load was taken off a bar of ice which had been yielding viscously, there was a slow partial recovery of the original form. Experiments with highly brittle pitch also showed that when the load was taken off a weighted bar there was an immediate elastic recovery, and also an additional slow recovery. When this slow recovery ceased, the pitch bar again began to bend under its own weight.

[1] Royal Society, June 4th, 1908. Communicated by Dr. H. Woodward, F.R.S.

REVIEWS.

Radiolaria from Triassic and other Rocks of the Dutch East Indian Archipelago. By Dr. George J. Hinde, F.R.S. pp. 44, with 6 plates. [From Dr. Rogier D. M. Verbeek's "Report on the Geology of the Moluccas": Jarb. v. h. Mijnwezen in Nederlandsch Oost-Indië, vol. xxxvii (1908).]

THE rocks containing the Radiolaria described in this memoir were obtained, some years since, by Dr. R. D. M. Verbeek from the islands of Timor, Roté (Rotti), Savu, Ceram, Celebes, Buru, and Mangoli. These Radiolarian rocks are very similar in character to those already known from other countries. The greater number are of chert or hornstone, either light grey, reddish, or jaspery, apparently entirely siliceous, and, as seen in microscopic sections, filled with Radiolaria, now, for the most part, in the condition of casts, showing merely the outlines of the organisms. In other cases the rock is siliceo-calcareous, the Radiolaria in these retaining their siliceous character and occasionally their structural details. Radiolaria are also present in other rocks, mainly, if not entirely, composed of limestone, and containing large numbers of *Halobia*, but in these, as a rule, the Radiolaria are very imperfectly preserved and, for the most part, replaced by calcite. Exceptionally, however, some of the tests remain siliceous, with their outlines clearly defined, although their interior structures have disappeared.

Geological Age.—The association of the Radiolarian rocks in Roté and Savu with beds of limestone filled with the shells of characteristic Molluscan genera, *Halobia* (Bronn) and *Daonella* (Mojsisovics), and in one locality in Savu with the Belemnite genus *Asteroconites* (Teller), is satisfactory evidence that the rocks in question belong to the horizon of the Upper Trias. If this conclusion is confirmed, an additional importance will be attached to the Radiolaria from the rocks of these islands as representing forms characteristic of this geological period. Fortunately, many of the Radiolaria in these Upper Triassic beds on Roté and Savu are fairly well preserved, and most of the forms described and figured in the paper have been obtained from them.

With regard to the geological age of the boulders and pebbles of Radiolarian rocks occurring in secondary positions on the islands of Ceram, Mangoli, Buru, and Celebes, very little is known at present. The rocks from Ceram are considered by Dr. Wanner to be probably Triassic, and a similar age is assigned to those from East Celebes. Those from Buru and Mangoli are considered to be younger, probably Jurassic or Lower Cretaceous, but they are of less importance, as the Radiolaria in them are too poorly preserved for specific identification. Detailed descriptions follow of the position and general characters of the Radiolarian rocks from different localities, with a list of the genera recognised in them. To this is added a description of the genera and species, illustrated in the six large octavo plates. A summary shows that the Radiolaria examined belong to five orders, referable to 28 genera and 83 species, viz.—

Name of Order.	No. of genera.	No. of species.
BELOIDEA	1	1
SPHÆROIDEA	5	10
PRUNOIDEA	2	3
DISCOIDEA	4	9
CYRTOIDEA	16	60
	—	—
	28	83

Of the 83 species described 74 are new, and not more than 9 are known already from other areas. A significant feature is the large proportion of species, nearly three-fourths of the whole, belonging to the CYRTOIDEA.

The Radiolarian rocks *in sitû* on the islands of Roté and Savu have yielded the greater number of the species described. From Roté 41 species were recognised altogether; 35 of these are not known elsewhere, and 6 are common to other localities. Most of these forms are from cherty or mainly siliceous rocks, but in the *Halobia* limestone of Baä 10 species of CYRTOIDEA were met with, which appear to be restricted to this rock and locality. From Savu 33 species are described, 24 of which are limited to this island and 9 occur in other islands.

From the rolled and travelled cherty fragments from Ceram 10 species of Radiolaria were found, only 20 of which belong exclusively to that island, and 8 are common to other islands. Also in Celebes, out of 13 species found in pebbles of chert, 8 have not been met with elsewhere, whilst 5 occur in other areas. The number of species in these detached pieces of rocks, which are also present in the Radiolarian deposits of Roté and Savu, gives support to the view that the original rocks on Ceram and Celebes, from which they were derived, are of the same Triassic age as those of Roté and Savu. Only one species of Radiolaria was recognised in the *Halobia* limestone of Timor, whilst those of Baru are so badly preserved that no species could be determined. No Radiolaria were met with in Mangoli.

The 44 pages of descriptive letterpress, accompanied by 6 plates, comprising 80 well-executed figures of the species determined from these East Indian Islands, makes another valuable contribution by Dr. G. J. Hinde to our knowledge of the fossil Radiolarian fauna of the Dutch East Indies, the geology of which has been so ably investigated by Dr. Verbeek and later by Dr. G. A. F. Molengraaff, to which also earlier contributions, in various branches of Palæozoology, will be found in the past volumes of the GEOLOGICAL MAGAZINE.[1]

[1] R. D. Verbeek, "The Geology of Central Sumatra": GEOL. MAG., 1875, pp. 477–86; 1877, p. 443; 1880, p. 286. H. B. Brady: "Fossil Foraminifera from the West-Coast District, Sumatra," 1875, pp. 532–9, Pls. XIII and XIV. Dr. A. Günther: "Fish Fauna of the Tertiary Deposits of Sumatra," 1876, pp. 433–40, Pls. XV–XIX. Henry Woodward: "Fossil Shells, Corals, etc., Sumatra," 1879, pp. 385, 441, 492, 535, Pls. X–XV. Dr. G. A. F. Molengraaff: "Geol. Expl. Central Borneo, 1893–94" (Review): GEOL. MAG., 1903, pp. 167–73, and Appendix by Dr. G. J. Hinde, "Fossil Radiolaria of Central Borneo," 1903, pp. 172, 173.

CORRESPONDENCE.

COCCOSTEUS MINOR, HUGH MILLER, IN THE OLD RED SANDSTONE OF DALCROSS, INVERNESS-SHIRE.

SIR,—Whilst collecting from the Old Red Sandstone of the Hillhead Quarry, near Dalcross in Inverness-shire, Mr. Wm. Taylor, of Lhanbryde, and myself found large numbers of remains of *Coccosteus minor*, H. Miller. The quarry has yielded previously only *Homosteus Milleri*, Traq., and Osteolepid scales.

Coccosteus minor and *Homosteus Milleri* have not yet been found elsewhere in the Moray Firth area, but are fairly abundant at Thurso.

It thus seems probable that the Hillhead Quarry represents a different horizon to that of the ordinary nodules of Cromarty, Lethen Bar, and Tynet Burn. D. M. S. WATSON.

THE GEOLOGICAL DEPARTMENT,
THE UNIVERSITY OF MANCHESTER.

MESSRS. CRAWSHAY AND WORTH ON THE SUBMARINE GEOLOGY OF THE ENGLISH CHANNEL.

SIR,—I have read with much pleasure Professor Cole's appreciative reference to the papers by Messrs. Crawshay and Worth on the "Submarine Geology of the English Channel," as I feared that a geological paper published through the enterprise of a Biological Association might escape the notice of geologists. By the kindness of Mr. Worth I have been kept posted up in the progress of the great work that the Marine Biological Association has been doing. In the subject-matter of the aforesaid inquiry, physics, zoology, and geology are equally concerned, with the natural result that no physical, zoological, or geological society can be expected to afford the space to discuss it. No one could have ventured to hope that a Biological Association would have dealt with the "Rock Remains in the Bed of the English Channel" and the "Geology of the English Channel,"[1] more especially as neither of these subjects can directly interest pure biologists!

Readers of the GEOLOGICAL MAGAZINE have, no doubt, been much amused at my own efforts in this matter. By the year 1889 I had brought the subject before the British Association at Swansea, Southampton, York, Southport, and Birmingham; published seven papers in the Transactions of the Devon Association, one each in the Proceedings of the Royal Society, in the Journal of the Linnean Society, and in the Proceedings of the Royal Dublin Society; had made two tentative approaches to the Geological Society, with assaults on the GEOLOGICAL MAGAZINE and *Nature* unnumbered!

One of the most important problems in this inquiry is the way in which the bed of the English Channel has been kept free from the deposition of sediment. A paper on deposition and denudation, at Birmingham, in 1886, was with difficulty got on the list for reading. I printed it privately, and, though not published, it has within the present year been cited in an engineering book as an authority!

[1] Journal of the Marine Biological Association, vol. viii, No. 2, May, 1908.

When, in 1872, I recorded my first note from information received, and when, in 1878, I secured my first crystalline block, I was working to confirm the geological theory, *mirabile dictu*, that the Devon schists had been metamorphosed by a submarine prolongation of the post-Carboniferous Dartmoor granite. My first half-dozen specimens dispelled that phantasy. Ten years' work went to show that the Channel blocks were local, and had absolutely nothing to do with Dartmoor. Then the question of the Selsea crystalline erratics and the erratics on the Prawle coast presented itself in favour of a foreign origin. Thus some rocks were local, at any rate the Eddystone reef, but some might be foreign. None, however, claimed relation with Dartmoor. That seemed clear at that time. Since then Mr. Worth has absolutely demonstrated Dartmoor shingle in the beaches of Start Bay, and now he has demonstrated, at any rate to my satisfaction, Dartmoor gravel or stones fifteen miles south of the Eddystone. Mark the complication. We have possibly river-drift down the old drowned river-valleys; we have local rocks certainly; we may have foreign ice-borne rocks; and all in the same area. To disentangle the sizes of the rocks and stones, Mr. Crawshay's paper must be read with Mr. Worth's, as Mr. Crawshay publishes the table of size of shingle to which Mr. Worth refers.

Mr. Worth mentions Godwin-Austen's littoral shells at the mouth of the English Channel. Some occurred more than 100 miles west of the Land's End. As shells are liable to decay and to destruction by marine borers, it is difficult to assign any great antiquity to these shells. But, if modern, they must have been swept out of the Channel by currents, generally unsuspected. And, as a matter of fact, bottom currents are often created and occasionally currents are reversed during heavy gales of wind.

Mr. Crawshay convicts the Channel deposits of extreme disorderliness in their defiance of established rules. A. R. HUNT.

August 5th, 1908.

MISCELLANEOUS.

IN MEMORIAM M. JOACHIM BARRANDE,[1] THE GEOLOGIST OF BOHEMIA (1799–1883).

ON June 6th, 1908, Miss Aline Girardeau died at Prague in the 90th year of her age. She was executrix to the will of Joachim Barrande, who devoted forty years to the study of the Bohemian Silurian rocks and bequeathed his great collections to the Prague Museum. She took great interest in the completion of Barrande's work and left 12,000 kroners to the Royal Bohemian Museum for their publication. To honour his memory she bequeathed to Professor Dr. Ant. Fric 50 kroners to place a wreath on the restoration of the Barrande tablet on the Kuchelbaden Rock, Bohemia.

[1] See his life, GEOL. MAG., 1883, p. 529.

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THE GEOLOGIST.

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HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

OCTOBER, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. X.—OCTOBER, 1908.

ORIGINAL ARTICLES.

I.—Sedgwick Museum Notes: New Fossils from the Haverfordwest District. VIII.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XIV.)

Typhloniscus princeps, sp. nov. (Pl. XIV, Figs. 1–3.)

Head-shield broadly semicircular, gently convex; posterior margin nearly straight; middle shield projecting slightly in front of cheeks, and rather bent down. Glabella subquadrate, length slightly greater than width, front truncate, nearly parallel-sided, widening a little anteriorly to maximum across first lateral lobes, moderately convex from side to side, rising gradually in height from back to front, where it is somewhat swollen and slightly overhangs anterior margin of head-shield; sides marked with three pairs of regular, subparallel, subequal, and nearly equidistant, strong lateral furrows; anterior pair nearly straight, directed a little obliquely backwards, and extending inwards for about one-third the width of the glabella, situated far forward at about one-fourth the length of the glabella, and a little in front of the point of junction of the axial and marginal furrows; frontal lobe short, broad; second pair of lateral furrows nearly straight, arising a little in front of middle of glabella, running inwards parallel to first pair, but a little longer; first lateral lobes with parallel sides; third or basal pair of furrows with inner portion curved back, but not reaching occipital furrow; second lateral lobes of same length along axial furrow as first pair; basal lobes subrhomboidal, rather less than one-third the width of the glabella. Occipital furrow strong, arched forward slightly in middle and at sides. Occipital ring rounded, rather narrow, a little wider in middle. Surface of glabella and occipital ring ornamented with rather coarse tubercles, with smaller ones interspersed. Axial furrows strong, straight, meeting marginal furrows at right angles a little behind first lateral furrows of glabella.

Cheeks triangular, rather wider than glabella, moderately and uniformly swollen, without eyes or facial sutures, ornamented with tubercles like the glabella, and, in addition, with coarse circular pittings. Neck-segment convex, rounded, widening slightly towards genal angle, where it markedly broadens and passes into similarly rounded lateral border. Neck-furrow strong, slightly sinuous, bending forward towards genal angle and uniting with marginal furrow in sharp curve. Lateral border of same general width as neck-segment, but widening somewhat at lateral angles of frontal lobe of glabella, where it passes into pre-glabellar border. Genal angle provided with stout, slowly tapering, rounded spine, projecting outwards and backwards at about 135° to posterior margin, and probably half as long as head-shield. Marginal furrow strong, meeting axial furrow at right angles. Narrow rounded border in front of glabella, separated off by strong marginal groove containing small deep pit on each side of lateral angles of frontal lobe. Neck-segment, genal spine, lateral and pre-glabellar borders ornamented with tubercles like glabella. Thorax and pygidium unknown.

Dimensions :—

	mm.
Length of head-shield	18·0
Width of head-shield	47·0
Width of glabella at base	14·0
Width of glabella across first lateral lobes . . .	16·5
Length of axial furrows	13·0
Width of cheek	16·5

Horizon and Locality.—Sholeshook Limestone: Sholeshook railway cutting, Haverfordwest.

Remarks.—The only species of this genus previously described comes from the Bokkeveld (Devonian) Beds of South Africa, and is likewise only known by head-shields, and it is consequently a surprise to find the genus represented in Ordovician rocks. But there can be no doubt that this Sholeshook trilobite is referable to the genus *Typhloniscus*, which Salter recognised belonged to the Cheiruridæ. The Cape species, *T. Baini*,[1] Salter, differs from ours in having the glabella of a trapezoidal shape, and in the less developed and rather differently directed lateral furrows; the genal spines are also much less strong. But the general characters of the head-shield and typical Cheirurid ornamentation of the cheeks, and most particularly the absence of eyes and facial sutures, indicate their affinities. The blindness of this genus must be regarded as significant of special adaptation, and is not a primitive feature, as the author has previously pointed out.[2] Another blind member of the Cheiruridæ is found in the Ordovician of the Himalayas, and was described by Salter[3] as *Prosopiscus mimus*, but our Sholeshook form cannot be referred to the same genus.

Zygospira Haswelli, sp. nov. (Pl. XIV, Figs. 4–9.)

Shell transversely elliptical to subcircular, biconvex. Pedicle-valve slightly more convex than brachial valve, usually with a shallow, indefinite, broad median sinus near anterior margin; umbo moderately

[1] Salter, Trans. Geol. Soc., ser. II, vol. vii (1856), p. 221, pl. xxv, fig. 14; Lake, Ann. S. African Museum, vol. iv, pt. 4, No. 9, 1904, p. 213, pl. xxv, figs. 8, 9.

[2] Reed, Geol. Mag., Dec. IV, Vol. V (1898), pp. 502–505.

[3] Salter & Blanford, "Palæontology of Niti" (Calcutta, 1865), pp. 7, 8, pl. i, figs. 19, 20 (?).

high, incurved, rising well over that of opposite valve, with small triangular delthyrium below it. Hinge-line gently arched; cardinal extremities rounded; no distinct false cardinal area. Teeth large, stout, short; no dental lamellæ. Posterior and umbonal part of valve much thickened internally with deeply impressed trilobed muscle-scar, composed of short, broad, median, double groove in beak, bifurcating anteriorly into two elongated, narrow, pointed diductor scars diverging at 90°–120°, extending about one-third the length of the valve, dying out towards extremities, with a somewhat elevated crescentic area in the fork between them.

Brachial valve less convex than opposite valve, rarely with traces of weak median fold near anterior margin; umbo small, inconspicuous. Hinge-plate prominent, stout, divided medianly by narrow slit into two large subtriangular rounded lobes with vertical flattened faces, each bearing a submedian, small, sharp, crural process on a level with or slightly behind the dental sockets, and projecting obliquely forwards and downwards. Dental sockets deep. Median septum present, extending about half length of valve, thick at base, decreasing in height and thickness anteriorly. Muscle-scars weakly impressed, elongated, narrow, lying alongside of septum. Surface of valves marked by 150–200 narrow, low, rounded, closely-set, regular, simple ribs, of equal size, and not increasing by division or interpolation near margins; crossed by very fine concentric lines and a few rare growth-striæ.

Dimensions.—Average length 9–10 mm., width 11–12 mm.

Horizon and Locality.—Llandovery Beds, The Frolic, Haverfordwest.

Remarks.—The specimens occur in places in crowds, closely massed together, and are found as internal casts and external impressions of the shell. The external and internal characters of this Brachiopod much resemble the form described by Davidson[1] as *Rhynchonella* (?) *pentlandica* (Haswell), from the Ludlow of the Pentland Hills, and they are probably congeneric. The muscle-scars and teeth of the pedicle-valve and the medium septum and hinge-plate of the brachial valve seem modelled on the same plan, but the division of the hinge-plate and the presence of crural points are well marked in the Haverfordwest species, and the latter also lacks the longitudinal groove of the pedicle valve, and the ribs do not increase by interpolation near the margins. The shell also has normally a more transverse shape. The similarity of the muscle-scars in the pedicle valve to those in *Dayia navicula* (Sow.) is noteworthy. In external characters and ornamentation *Zygospira* (*Catazyga*) *Headi* (Billings)[2] may be compared, but the internal features more resemble typical members of the genus *Zygospira*, and to this genus it may be provisionally referred. It is distinguished from *Z. Hicksi*, Reed,[3] of the Slade Beds of Cuckoo Grove Lane, and Upper Slade, Haverfordwest, by its fine ribbing, and the different character of the muscular impressions in the pedicle-valve.

[1] Davidson, Mon. Brit. Brach., iii, p. 187, pl. xxii, figs. 9–18*a* (? figs. 19*a*, *b*).
[2] Hall & Clarke, Palæont N.Y., viii, Brach. ii, p. 157, pl. liv, figs. 24–34.
[3] Reed, Geol. Mag., Dec. V, Vol. II (1905), p. 452, Pl. XXIII, Figs. 17–19.

EXPLANATION OF PLATE XIV.

FIG. 1.—*Typhloniscus princeps*, sp. nov. Head-shield. × 2.[1] Sholeshook Limestone: Sholeshook railway cutting, Haverfordwest.
,, 2.—Ditto. Side view of same specimen, showing projection of anterior end of glabella. × 2.
,, 3.—Ditto. Portion of surface of cheek. × 4.
,, 4.—*Zygospira Haswelli*, sp. nov. Internal cast of shell, pedicle-valve. × 2½. Llandovery Beds: The Frolic, Haverfordwest.
,, 5.—Ditto. Another specimen. × 2½.
,, 5*a*.—Ditto. Brachial valve of same specimen. × 2½.
,, 6.—Ditto. Internal cast of shell, brachial valve. × 2½.
,, 7.—Ditto. Posterior view of internal cast of another specimen. × 2½.
,, 8.—Ditto. Impression of exterior, umbonal region, showing delthyrium in pedicle-valve. × 2½.
,, 9.—Ditto. Impression of surface of valve, showing ribbing and concentric striation. × 2½.

II.—On two new Gasteropods (*Hipponyx blackmorei* and *H. dibleyi*) from the White Chalk.

By C. Davies Sherborn, F.G.S., F.Z.S.

SOME years ago Dr. H. P. Blackmore called my attention to some fragmentary remains of shell on Echinoids which he had found in the Salisbury district. These he regarded as belonging to *Hipponyx*. The true relationship of these fragments could not, however, be considered certain until Mr. Dibley found the almost perfect example seen in Fig. 1. Dr. Blackmore's finds are recorded in the list of fossils in the "Cretaceous Rocks of England" (Mem. Geol. Survey), iii, p. 473, as "Salisbury," but I have not discovered what form is there referred to under the localities of "East Kent" and "Margate."

Hipponyx blackmorei, n.sp.

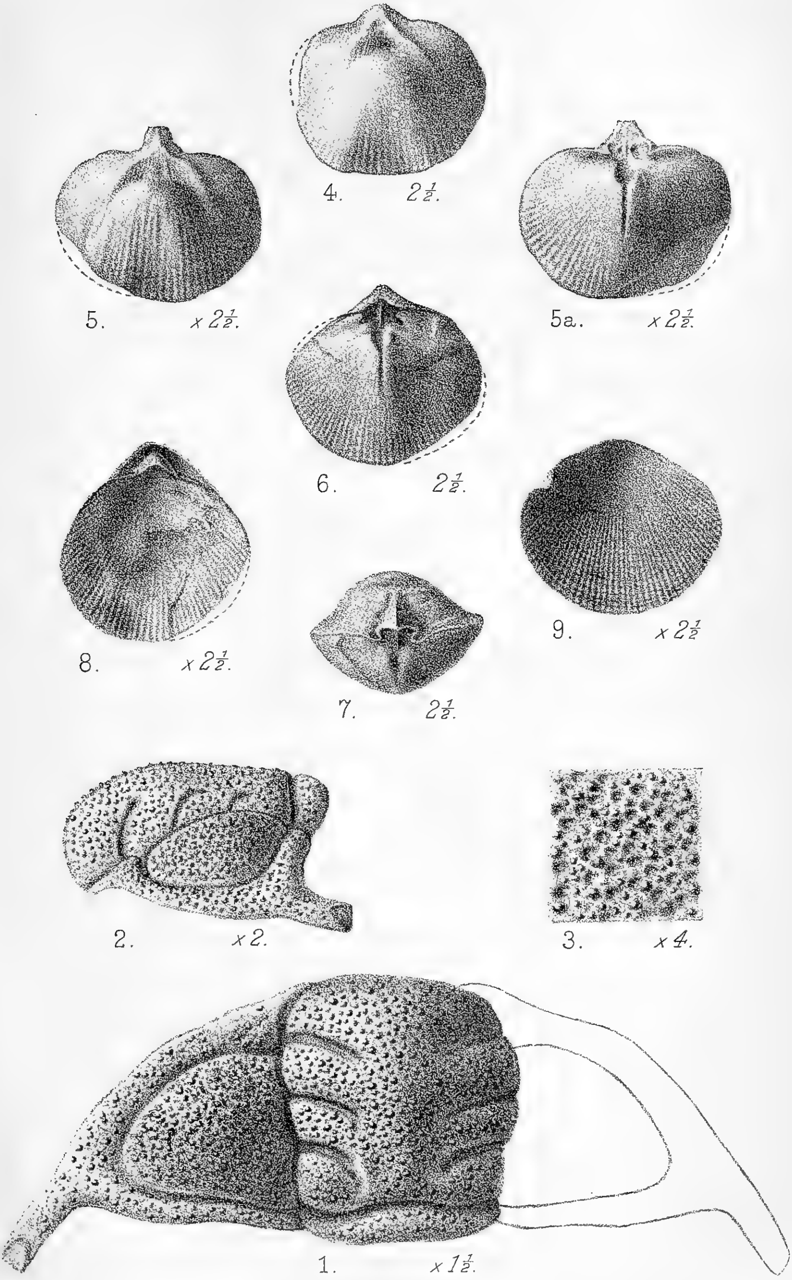
Shell thin, bearing numerous close but coarse radiating ribs, which are ornamented by swellings, becoming at the margin definite and like rows of beads. Apex unknown. Base thin, fairly regular, perfectly smooth, occupying three parts of the area.

Type.—Blackmore Collection, on an *Echinocorys* from the *Actinocamax quadratus* Chalk, East Harnham, near Salisbury. Partly overgrown by a *Spondylus*. Fig. 2, × 2. Another specimen, Blackmore Collection, on a *Micraster* from the *Micraster cor-anguinum* Chalk from Quidhampton. This specimen is in much the same condition as the last, but shows a little more margin of shell. As it does not show any base, it may not be in its original position.

Hipponyx dibleyi, n.sp.

Shell thin, with numerous close, radiating, fine ribs ornamented by irregular swellings, which persist to the margin of the test and do not appear to become bead-like. A few concentric lines of growth. Apex

[1] Marked in error on plate as magnified 1½ times.



A. H. Searle del. et lith. West, Newman imp

Typhloniscus and Zygospira.

and base unknown. Irregularly covered with tubercles, the growing margin of the shell having taken up the natural markings of the Echinoid to which it had attached itself.

Type.—G. E. Dibley Collection, on a large *Micraster cor-bovis* from the *Terebratulina* zone of Cuxton, Kent. This specimen has two delicate tubes running across it, probably foraminiferal. Fig. 1, × 2 and Fig. 3, × 4, the latter showing the ornament. Apparently another specimen of this form is in Dr. Blackmore's collection, and comes from the *mucronata* Chalk of Clarendon, near Salisbury, but it is too crushed to allow of any definite description by me.

There is also evidence of a third species in which the ornament on the ribs is imbricate, but the fragment (in Dr. Blackmore's collection, from the *mucronata* Chalk of Alderbury) is not sufficient for descriptive purposes.

Dr. Blackmore's specimens are all too delicate to take casts from, but Mr. Dibley's specimen (*H. dibleyi*) is so well supported by chalk inside, and so firmly attached to the shell that Mr. F. O. Barlow, the skilful formatore of the British Museum (Nat. Hist.), has been able to take an exact cast for the National Collection by means of wax squeezes.

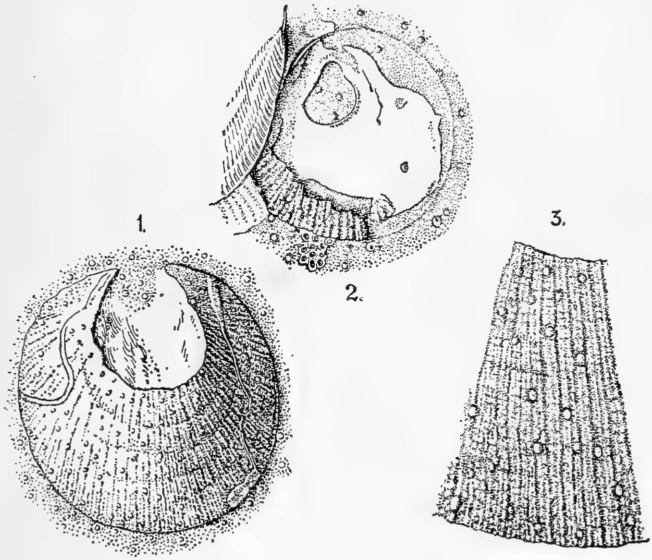


FIG. 1.—*Hipponyx dibleyi*, n.sp.; × 2; from the *Terebratulina* zone of Cuxton, Kent.

,, 2.—*Hipponyx blackmorei*, n.sp.; × 2; from the *Actinocamax quadratus* zone of East Harnham, Salisbury.

,, 3.—Part of Fig. 1 (*H. dibleyi*); × 4.

III.—On the Occurrence of *Haliserites* in the Upper Silurian and Upper Devonian Rocks of Victoria, Australia.

By Fredk. Chapman, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

(PLATE XXII.)

Preliminary Observations.

During the last few years there have passed through my hands for determination many specimens of a twig-like fossil-plant from the highest Silurian flaggy-sandstones of Victoria. These were usually too fragmentary to afford any very decided evidence as to their affinity, although their surfaces showed a close-textured and well-defined structure, referable to that of prosenchymatous wood-cells, and the stem had a definite central vascular axis, such as was first noticed by Hugh Miller in similar fossil remains from the Old Red Sandstone of Scotland.

Quite recently, however, the collectors of the Victorian Geological Survey have secured some better examples, chiefly from the Matlock district in Gippsland, which show not only the stem-like fragments well preserved, but also occasional imbrications or spiny bract-like leaves attached to the stems, together with short ovate (?) leaves and sporangia, and inrolled terminations to the branches. A good comparative series of *Haliserites Dechenianus*, Göppert, from the Devonian of Lethen, Nairnshire, Scotland, as well as from Wassenach, Laacher See, in the National Museum collection, afforded ample evidence as to the common identity of these and the Silurian fossils from Gippsland.

Remarks on the Genus.

Carruthers has already shown[1] that the genera *Haliserites*, Sternberg, and *Psilophyton*, Dawson,[2] are identical; but he has retained the latter generic name for the plant, notwithstanding that Göppert's species, *H. Dechenianus*,[3] was fully established by descriptions and drawings in 1852 as a form of *Haliserites*, whilst Dawson's description of *Psilophyton robustius* did not appear until 1859.[4] Kidston, whose synonymy of the species above quoted should be consulted, follows Carruthers in selecting *Psilophyton* in the place of the earlier described genus.[5]

In all probability the generic term *Haliserites* was discarded by the above-mentioned authors on account of the more perfect preservation of Dawson's specimens, which consequently lent themselves to the framing of a better diagnosis of the genus than was possible with Göppert's specimens; but the fact that the two genera were shown to be identical renders it clear that the earlier name, in accordance with the rule of priority, should be retained for this plant-form.

[1] Journ. Bot., n.s., vol. ii (Nov. 1873), No. 131, pp. 321–7, pl. 137.
[2] Quart. Journ. Geol. Soc., vol. xv (1859), p. 478.
[3] "Foss. Flora d. Ubergangs," 1852, p. 88, pl. ii.
[4] Quart. Journ. Geol. Soc., vol. xv, p. 481, figs. 2*a*, *b*.
[5] "Cat. Palæozoic Plants, Brit. Mus.," 1886, p. 232.

Possibly the misleading sound of the term *Haliserites*, named from its original comparison with the seaweed *Haliseris*, had some influence in determining the adoption of the later generic name. Nevertheless, in scientific nomenclature names are but names, and should never be regarded as accurate indices to the relationship of the organisms thus designated.

In a fully descriptive paper published in 1894 by Professor Penhallow,[1] who, by the way, does not notice Carruthers' previous work, both *Haliserites* and *Psilophyton* are retained, and a third genus, *Dictyotites*, is proposed. It seems evident, however, that the characters there used in attempting to establish these genera may be found in one and the same plant, according to its growth and preservation. For instance, the dichotomous terminations of *Dictyotites*, the apparently membranous fronds of that genus and *Haliserites*, and the spirally arranged scaly leaves, together with the circinate terminations of the branches in *Psilophyton*, may all be found associated, so as to suggest their common reference to a single plant-genus.

Occurrence in Victoria.

The Victorian Silurian specimens occur in a series of fine-grained brown and grey sandstones and indurated shales, which lies above the Yeringian strata comprising the fossiliferous conglomerates and limestones, and attains a thickness, according to the geological surveyors, of 10,000 feet in the Walhalla area. There is another series, known as the "*Monograptus dubius* beds,"[2] said to be below the Yeringian coral limestones, which also contains the remains of *Haliserites*, and this is of undoubted Silurian age. On the other hand, the extensive beds of sandstones containing *Haliserites*, first referred to, may represent a great development of a passage series linking the Silurian with the Lower Devonian in this area of Eastern Victoria.

Certain of our specimens from the newest Silurian rocks are in every way comparable with the well-known examples from the Caithness flagstones, figured by Hugh Miller;[3] and the spinose and spirally arranged leaflets and circinate terminals of the branches help to confirm Miller's and Carruthers' conclusions as to their Lycopod affinities. With regard to this relationship, Carruthers says (op. cit., p. 324): "From the various drawings and descriptions published by Miller, one can see that this plant had stigmarioid roots, a slender Lycopod-like stem, with the lower branches short, simple, or compound, and with numerous short acuminate leaves, and with the upper branches regularly dichotomising, with sharp edges produced by the absence of distinct leaves, the ultimate divisions being short and slender, and sometimes rolled up in a circinate manner at the tips. He also noticed the slender vascular axis running along the centre of the upper branches."

[1] "Notes on Erian (Devonian) Plants from New York and Pennsylvania": Proc. U.S. Nat. Mus., vol. xvi (1893), pp. 105–14, pls. ix–xiv.

[2] This graptolite, determined for the Survey by Dr. T. S. Hall, M.A., is typical of the Wenlock in England, but also ranges upwards into the Ludlows.

[3] "Testimony of the Rocks," 1857, pp. 428, 429, figs. 118, 119. Also Carruthers in Journ. of Botany, vol. ii (1873), pl. 137; especially fig. 4, specimen from the Isle of Stroma, off Caithness.

The genus *Haliserites* is also represented in our Victorian Upper Devonian micaceous shaly rocks, where it is associated with *Sphenopteris* (*Eremopteris*) *iguanensis*, McCoy, *Archæopteris Howitti*, McCoy, and *Cordaites australis*, McCoy. The examples there met with are, however, too fragmentary to admit of a closer determination than that of the genus.

EXPLANATION OF PLATE XXII.

Fig. 1.—*Haliserites Dechenianus*, Göppert. A specimen showing ovate (?) leaves. Near north boundary, Thomson River. × 2.

,, 2.—*H. Dechenianus*. Portion of a circinate termination. Same locality. × 2.

,, 3.—*H. Dechenianus*. Part of a stem with (?) sporangiophore and leaves. Centennial Mine. × 2.

,, 4.—*H. Dechenianus*. Cast of the mould of a stem, showing the outer woody layer of cells and conspicuous vascular axis. West of Thomson River. × 3.

,, 5.—*H. Dechenianus*. End view of a stem-fragment, showing vascular axis and flattened character of the once cylindrical stem. Centennial Mine. × 4.

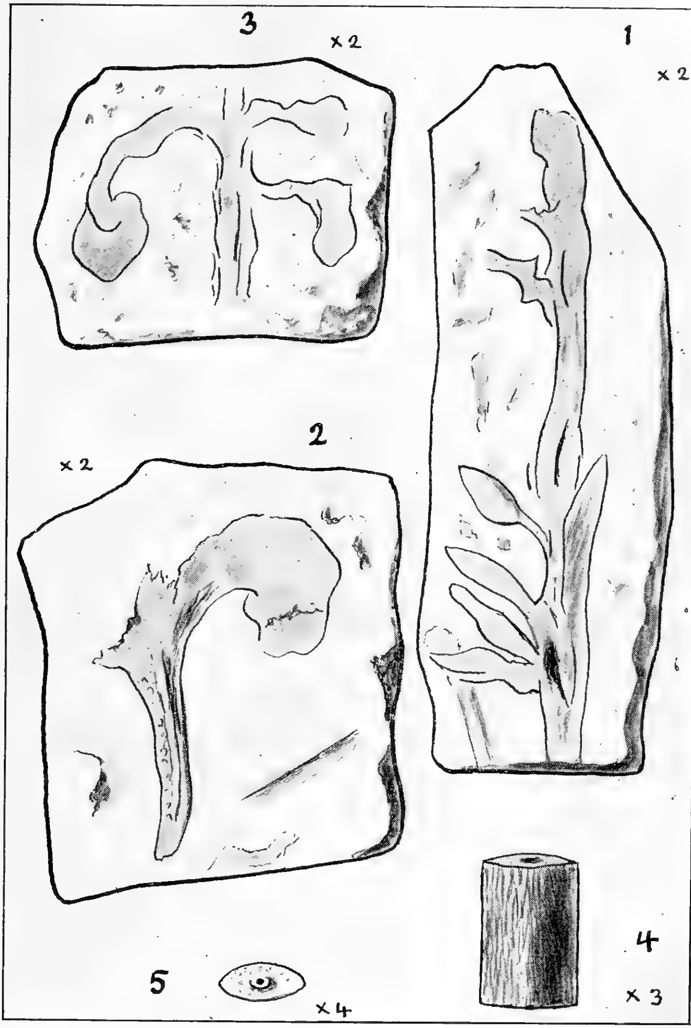
IV.—Note on the Discovery of a Bone of a Monkey in the Norfolk 'Forest-Bed.'

By Martin A. C. Hinton.

(PLATE XXIII, Figs. 1–3.)

THE Upper Freshwater division of the Norfolk Forest-Bed Series at West Runton contains two distinct horizons, viz., a lower, consisting of a rather thick deposit of clay and peat, and an upper, containing a thin seam of gravelly sand, crowded with land and freshwater shells, on which reposes the pebble-bed found at the base of the '*Leda-myalis*' series. My friend Mr. G. White and I have lately collected extensively from the West Runton deposits, and have been rewarded with the discovery of several hitherto unknown voles, etc., which I hope to describe ere long. On comparing the voles from the lower series with those from the upper part of the Upper Freshwater bed one finds considerable differences between them, and I believe that similar differences are shown by the mollusca from the two horizons. These faunistic differences are of course not so great as those which have been shown by Dr. Forsyth Major to exist between the East Runton deposit and the West Runton series taken as a whole, but still they are similar in kind.

Mr. White has been so fortunate as to obtain, from the thin bed of gravelly sand at West Runton above mentioned, a most interesting bone, which he has kindly permitted me to study and describe in this note. The specimen is the distal end of a left humerus, and in the drawings which I have made (Pl. XXIII, Figs. 1–3) it is represented as seen in three positions. Viewed from the front (Fig. 1) the trochlea is prominent, and the capitulum for the radius is rather boldly convex. Between the two is seen a little rounded ridge, which, passing backwards and obliquely outwards round the articulation (Fig. 2), dies out before reaching the posterior surface (Fig. 3). This little ridge appears to be very characteristic of the humerus in Primates, and its function is to play externally into a groove on the inner side of the head of the



F. C. del.

Haliserites Dechenianus, Göppert, from the Silurian of Gippsland, Victoria, Australia.

radius, and internally against a longitudinal ridge developed towards the outer side of the sigmoid articulation of the ulna. Although very little remains of the shaft, there is sufficient to show that the fossil bone belonged to an at least nearly adult animal, all traces of the epiphysial suture being obliterated, and also to determine what is more important, viz. that there is no supratrochlear foramen. The epitrochlear process is mutilated, but enough remains to show that it, as well as the epicondylar process, are comparatively slightly developed for a monkey; and these features, together with the rather great convexity of the capitulum—suggestive of a slight degree of flexion of the fore-limb—indicate a species little given to climbing. The groove for the ulnar nerve is very clearly defined (Figs. 2 and 3), and the articulation is rather stout from before backwards (Fig. 2).

A careful comparison with the humeri of recent monkeys preserved in the British Museum and in the College of Surgeons shows that in all the characters above mentioned the fossil agrees with the larger members of the genus *Macacus*, and that it disagrees in one or other feature with every other genus.

The appended table of measurements will afford an idea of the relations subsisting between the fossil and the recent humeri as regards size. In comparing the humeri of the recent species of *Macacus* with each other, one sees great variations in the form of the articulation and of the epitrochlear and epicondylar processes, no two species, judging from the limited material before me, having these parts precisely alike. The comparison further shows that the fossil humerus has characters of its own, which will be best appreciated from the figures. It will suffice to state here that, judging from the variations seen in the recent species of *Macacus*, our fossil is by no means an extreme form, that it makes a nearer approach to *M. inuus* in some respects and to *M. rhesus* in others perhaps than it does to any of the other species, and that it differs from them far less than, for example, *M. sinicus* does.

Measurements of the Humerus in various species of *Macacus*.	Fossil, West Runton.	*M. inuus.* B.M. 32*d*.	*M. nemestrinus.* B.M. 29*r*.	*M. speciosus.* B.M. 1083*b*.	*M. rhesus.* B.M. 30*g*.	*M. cyclopis* ♂. B.M. 1486*a*.	*M. cyclopis* ♀. B.M. 1486*b*.	*M. brunneus.* B.M. 73. 9. 32.	*M. cynomologus.* B.M. 29*g*.	*M. pileatus.* B.M. 1103*g*	*M. fuscatus.* B.M. 1083*a*.	*M. assamensis.* B.M. 532*a*.	*M. sinicus.* B.M. 962*a*.
1. Transverse width of articulation.	19·5	24·5	22·5	22·5	18·8	18·2	17·5	20 3	16·4	21·3	19·0	18·0	18·4
2. Least antero-posterior diameter of articulation.	10·0	12·5	11·2	11·2	9·8	9·5	8·2	10·2	9·0	9·6	9·0	8 7	8·3

Pomel has described under the name of *Macacus trarensis* [1] (and later as *M. proinuus* [2]) a species known from the limb skeleton alone, obtained from a Pleistocene phosphoritic breccia at Traras, near Aïn

[1] Pomel: Comptes Rendus, cxv, p. 157.
[2] Pomel: Carte Géol. Algérie, Monog. Pal., 1897, pl. iii.

Mefta, in Algeria. From the figures and description it is clear that *M. trarensis* had larger and stouter limbs than either *M. inuus* or the species represented by the West Runton fossil. With regard to the form of the distal articulation of the humerus, the West Runton fossil agrees more closely with *M. inuus* than with *M. trarensis*. Pomel states[1] that in young humeri of *M. trarensis* there is a supratrochlear foramen which is obliterated as age advances, and his observations lead him to believe that such a foramen is normally present in the young humeri of *Macacus*. I have failed to notice any trace of it in the humeri examined by me.

Dolichopithecus, an ape from the Astian or Middle Pliocene beds of Rousillon and Perpignan, had limbs very much like those of *Macacus* in structure, and the humeri figured by Depéret[2] are similar in form to the fossil before me. All the known species of *Dolichopithecus* are considerably larger than that to which the West Runton bone belongs, and while on the one hand *Dolichopithecus* belongs to the Middle Pliocene, *Macacus* on the other undoubtedly occurs in various continental deposits corresponding in age to our Forest-Bed series. I therefore prefer to regard this English monkey as referable to the genus *Macacus*, although it is possible that it belongs to a late and small species of *Dolichopithecus*. I do not doubt that the fossil indicates a species distinct from any of those recent forms with which I have compared it and from *M. trarensis*, but whether or no it be referable to any of the other fossil forms previously described must remain an open question, since there is no material known at present with which it can be compared.

Previous Records of Fossil Remains of Monkeys in Britain.

In 1839 Owen[3] referred a fragment of a lower jaw with the last molar and a detached molar, which had been obtained from the Eocene of Kyson in Suffolk, to a monkey, and in the "British Fossil Mammals"[4] he gave the name of *Macacus eocænus* to these remains. Later on Owen[5] founded a new genus of monkey for their reception—*Eopithecus*—and at a still later date, with further evidence at his disposal, he stated his belief that the fossils in question were really the previously unknown lower teeth of *Hyracotherium*,[6] a view which Kowalevsky[7] subsequently confirmed.

In 1845 Owen[8] described under the name of *Macacus pliocænus* a fragment of a right maxilla with the penultimate molar in place, which had been found by Ball in the brickearth series at Grays Thurrock in Essex, and a little later Owen published[9] a figure of the

[1] Pomel: Comptes Rendus, cxv, p. 158.
[2] Depéret: Mém. Soc. Géol. France, Pal. Mém. No. 3, p. 15, pl. i, fig. 4, and p. 125, pl. xii, fig. 6.
[3] Owen: Magazine of Natural History, September, 1839, p. 446.
[4] Owen: "British Fossil Mammals," 1846, p. 3.
[5] Owen: Palæontology, 1860, p. 341.
[6] Owen: Ann. Mag. Nat. Hist., 1862, ser. iii, vol. x, p. 240.
[7] Kowalevsky, "*Anthracotherium*," pt. i: Palæontographica, Bd. xxii, p. 211.
[8] Owen: Comptes Rendus, xxi, p. 573.
[9] Owen: "British Fossil Mammals," 1846, p. xlvi.

specimen. Lydekker,[1] referring to this specimen, stated that it undoubtedly does belong to a monkey, but that the tooth is so worn that it is not possible to determine the genus. However, in a later work Lydekker[2] refers to it as "a species of *Macacus* from the Pleistocene brickearths of Essex," and in another place Flower & Lydekker[3] allude to it as a species of *Macacus*, very interesting as showing the existence of an ape at this late period in Western Europe. Beyrich[4] thought the reference to *Macacus* arbitrary, but Forsyth Major[5] was inclined to accept Owen's determination, saying: "Cependant cette dent possédant la forme générale et le mode d'usure qui caractérisent le *Macacus* et le distinguent du *Semnopithecus*," etc.

Certain doubts have been expressed to me as to whether the specimen in question, which is now in the British Museum, really came from the Grays brickearth, and I notice that neither in the Introduction to the Pleistocene Mammalia[6] nor in the lists given elsewhere[7] does Boyd Dawkins refer to the Grays monkey.

The reasons for this scepticism appear to be twofold, and with regard to each I should like to make a few remarks. The first and most general ground of suspicion is that, although the deposit at Grays was searched for fossil bones for many years, the fragment of jaw found in 1845 remains the unique specimen from that locality referable to an ape. But there are other animals known from the Grays brickearth whose remains are almost as rare, viz. *Felis catus*, the Hyæna and the Pig, and with regard to the remains of many small vertebrates which are now known to have occurred in extreme abundance in this deposit, it was not until 1899 that their existence in the Grays brickearth was suspected.[8] And even were there no likelihood of the remains of so small an animal as a monkey being overlooked, there would still remain the fact that the habits of the monkey are all against the chance of his remains being entombed in an ordinary fluviatile deposit.[9] It is a noteworthy fact that almost without exception such fossil remains of monkeys as we do meet with in fluviatile deposits are referable to *Macacus*, the least agile genus of the whole order.

The second reason appears to be that *Macacus* looks out of place in occurring at Grays, the Grays brickearth belonging to the Middle Terrace of the Thames Valley, and the deposits of this horizon yielding remains of such animals as *Ovibos* and *Dicrostonyx*. The

[1] Lydekker: Cat. Foss. Mamm. Brit. Mus., 1885, pt. i, p. 4.
[2] Lydekker: "A Geographical History of Mammals," 1896, p. 180.
[3] Flower & Lydekker: "Mammals Living and Extinct," 1891, p. 723.
[4] Beyrich: Abhand. d. Akad. d. Wiss. z. Berlin aus d. Jahre 1860, p. 23, 1861.
[5] Forsyth Major: Atti del Soc. Ital., 1872, xv, p. 86.
[6] Dawkins & Sanford: Monographs of the Palæontographical Society, 1872, pp. xix and l.
[7] Dawkins: Quart. Journ. Geol. Soc., vol. xxiii, p. 101; ibid., vol. xxv, p. 199; ibid., vol. xxxvi, p. 398.
[8] Hinton & Kennard: Essex Naturalist, vol. xi, pp. 347–53.
[9] Falconer & Cautley: Trans. Geol. Soc. of London, 1837, vol. v, p. 499, and reprinted in "Palæontological Memoirs," 1868, vol. i, p. 292. The opening paragraph of this classical paper puts this view in the most striking manner possible.

Middle Terrace stage in the Thames Valley doubtless represents a very long period of time, and although stratigraphically the brick-earths of Grays, Ilford, and Crayford and Erith are inseparable, the palæontological evidence is strong to the effect that they were not deposited at one time. I regard the Grays deposit as intermediate in actual age between the High Terrace drift of Greenhithe and the brickearth of Ilford, and I further regard the Crayford and Erith deposits as later than those of either Essex locality. This is not the place to discuss this question at any length, but, briefly, my reason for such views is that the Grays deposit yields only the older southern fauna, and it has consequently more palæontological affinity with the High Terrace[1] than it has with its stratigraphical equivalent at Crayford and Erith. On these grounds, and on the fact that the actual mineral condition of the fragmentary jaw agrees with the other fossil bones from Grays, I am disposed to regard the only known specimen of *Macacus pliocænus* as a genuine Grays fossil.

As Lartet[2] has stated, monkeys are intolerant of cold, and the occurrence of their remains in a deposit is a proof that at the time of their existence the climate of the region in which they lived must have been a genial one. Remains of *Macacus* are known from the Pliocene beds of the Val d'Arno[3] (two species), Montpellier,[4] and the Sewalik Hills,[5] and from the Pleistocene of Algeria,[6] from the Cave of Montsaumés (Haute-Garonne)[7] and the Heppenloch Cave in Wurtemberg.[8] The latter cave deposit was regarded by Hedinger and Nehring as of Pliocene age. Although at the present time *M. inuus* inhabits Gibraltar, it is a curious fact that no trace of its former existence there was found among the numerous fossil mammalian remains obtained from the Pleistocene cave deposits of the rock.[9]

In conclusion, I have to express my best thanks to Mr. G. White for the loan of the specimen; to Mr. E. T. Newton, F.R.S., Dr. C. W. Andrews, F.R.S., Dr. C. I. Forsyth Major, F.R.S., Mr. Oldfield Thomas, F.R.S., and Professor Keith for much kind help.

[1] Hinton: Proc. Geol. Assoc., vol. xx, p. 52. This question is more fully discussed in my account of the High Terrace Mammalia, which I hope will shortly appear, and in an account of the British Fossil Voles and Lemmings which I am preparing.

[2] Lartet: Ann. d. Sci. Nat., serie v, tome viii.

[3] Cocchi, "Su di due scimie fossili italiane," 1872; and Forsyth Major, Atti del Soc. Ital., xv, p. 89; Ristori, Boll. Comit. Geol., 1890.

[4] Gervais: Zool. et Pal. Français, 1859, p. 11, figs. 4, 5, *M. priscus.*

[5] Lydekker: Rec. Geol. Surv. India, xi, p. 66, and xii, p. 41, pl. i, *M. sivalensis.*

[6] Pomel: Comptes Rendus, vol. cxv, p. 157, and Carte Géol. Algérie, Mon. Pal., 1897, pl. iii.

[7] Harlè: Mém. Soc. d'histoire nat. de Toulouse, 1892, p. 2, and Cat. Palæon. Quatern., 1899, p. 27. I have not seen the latter work.

[8] Hedinger: Neues Jahrbuch f. Min., 1891, Bd. i, p. 169, Taf. 10.

[9] Busk: Trans. Zool. Soc., vol. x, p. 129. Trouessart (Cat. Mamm., vol. i, p. 26) mentions *Macacus fossilis*, Gibraltar, a record based on the following reference by Calderon (Q.J.G.S., vol. xxxiii, p. 128): "Quadrumana: Peñon of Gibraltar? *Imrie*," but I believe Busk's statement to be accurate.

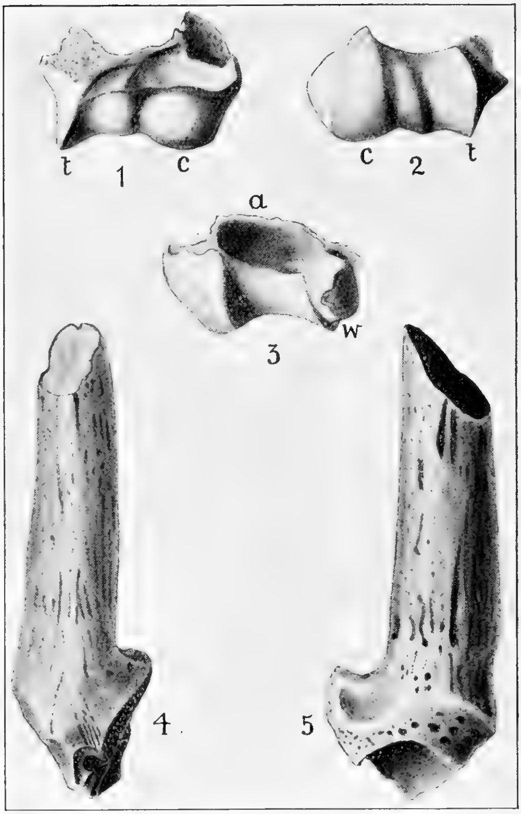


FIG. 1.—Distal end of left humerus, *Macacus* sp., from the "Upper Fresh-water Bed" of West Runton. t = trochlea, c = capitulum; seen from the front.
,, 2.—The same, seen from below.
,, 3.—The same, hinder surface. w = groove for ulnar nerve, a = anconal fossa.
,, 4.—Right frontal and horn-core of *Gazella Daviesii*, Hinton; Norwich Crag, Bramerton. Anterior view.
,, 5.—The same, seen from the outer side.

(All the figures are drawn of the natural size.)

V.—Note on *Gazella Daviesii*, Hinton, an Antelope from the Norwich Crag.

By Martin A. C. Hinton.

(PLATE XXIII, Figs. 4, 5.)

IN 1906 I described[1] a horn-core of a small antelope which had been obtained long ago from the Norwich Crag of Bramerton, and which is now in the collection of Mr. A. S. Kennard. This specimen formerly formed part of the Bayfield collection, and Mr. William Davies had determined it as a horn-core of *Capra* or Antelope. A comparison showed that it was referable to the genus *Gazella*, but that it differed from *Gazella anglica*, a species from the Norwich Crag described by Mr. E. T. Newton,[2] as well as from all the other living and fossil Gazelles respecting which I could obtain information. I therefore ventured to found a new species, *G. Daviesii*, for the reception of Mr. Kennard's specimen.

Unfortunately it was not in my power to give a figure of this horn-core, and the bare description could be of little value. Thanks to the kindness of Dr. Henry Woodward, an opportunity has been given to remedy this defect, and in the accompanying Plate (Pl. XXIII, Figs. 4, 5) the specimen, a right frontal and horn-core, is shown from the front and from the outer side. Compared with *G. anglica*, the principal differences presented by the fossil here figured are the much smaller size, the relatively and absolutely longer pedicle, and the rounder and less compressed horn-core, which has a slight outward curvature instead of being perfectly straight. The pit behind the pedicle on the outer side, so far as it is preserved, appears to have been much shallower than in *G. anglica.*

In my earlier paper mention is made of a much rolled and damaged horn-core obtained by Mr. H. B. Woodward from the Norwich Crag of Thorpe and now in the Geological Survey collection, and I stated that[3] "it certainly is not referable to *G. anglica*, and in my opinion represents a species distinct from that which I have here named *G. Daviesii.*" By some chance I had overlooked Mr. Newton's reference to this specimen.[4] He had already stated that it was distinct from *G. anglica*, and suggested that it might belong to some other genus of Antelope and not to *Gazella*.

VI.—On the Low-Water Channels in Rivers and Estuaries.

By T. S. Ellis.

A CRITIC of my paper on "The Winding of Rivers"[5] writes to me that I and others "do not take into account the nature of the soil traversed by a stream," which "must materially affect its course." Let me call attention to the two figures (117 and 118) on p. 499,

[1] Hinton: Proc. Geol. Assoc., vol. xix, pp. 247–51.
[2] Newton: Quart. Journ. Geol. Soc., 1884, vol. xl, pp. 280–93, pl. xiv.
[3] Hinton: op. cit., p. 251.
[4] Newton: op. cit., p. 280.
[5] Geol. Mag., March, 1908, p. 108.

vol. i, of Sir A. Geikie's Text Book of Geology, ed. 1903.[1] The one is entitled "Meandering course of a Brook," and resembles that which is often seen in meadows. The other represents the "Winding of the Gorge of the Mozelle above Cochem." There is no essential difference between them. Without knowledge of the scale I could not say that either had been formed in alluvium and not in hard rock. Both are based on the same principle; each is an adaptation, evolved from a more extended network of streams, formed to meet the requirements of the area to be drained. Lateral streams, even though they do not now exist—the growth of turf or of timber may have rendered them unnecessary—have united with that line in the network best adapted both for the longitudinal and the lateral drainage. In detail this may differ; in principle it is always the same.

A great geographer, E. Reclus, wrote that "most streams, however winding their course may have been, straighten as they approach the sea and descend towards the shore by the shortest line possible, so as to form a right angle with the coast."[2] The difference is more apparent than real. Estuaries are regarded and shown on maps as they are seen at high water; rivers in their ordinary channels, not as they are at flood-time, when they extend to the sides of the valley, which may be as straight as the margin of the estuary. A river winding in a meadow really corresponds to a low-water channel winding between banks of sand and mud. The purpose of this paper is to show that the course of the low-water channel in the bed of a river, and that of the low-water channels in an estuary, are decided on the same principle.

I have found that a firm faith in the soundness of these views, extended from, but in principle the same as, those recorded more than a quarter of a century ago,[3] sometimes enables me to predict that conditions would, on enquiry, be found to exist although not represented on a map. In a discussion on a paper by the late Mr. Vernon-Harcourt, read before the Institution of Civil Engineers and entitled "The River Hooghly," he states, in his reply to written comments, that "Mr. Ellis had to assume the existence of tributaries which did not appear on the charts."[4] I had assumed this, and large-scale maps of the Hooghly district, afterwards consulted, have justified the assumption. An Admiralty chart, since published,[5] is partly shown in Figs. 1 and 2. On this I rely to support my case. I may remark that the draughtsmen were simply directed to copy the tributaries shown on the chart. The names of streams, when not given there, are indicated by letters; they have been obtained from the large-scale maps.

Fig. 1 commences just below the Botanical Gardens, opposite the docks at Kidderpur, about three miles below Calcutta. At first it shows the river taking a straight course in a narrow but well-defined channel, and, as may be noted, no side-stream enters. Then, opposite

[1] pp. 108, 109 in edition of 1882.
[2] "The Earth," p. 287.
[3] "On some features in the Formation of the Severn Valley"; Gloucester, 1882.
[4] Proc. Inst. Civil Engineers, vol. clx (1904–5), pt. 2, pp. 168, 202.
[5] John Smith, The Minories, London.

Hangman Point, the large Sursuthee Khall (*a*) enters on the convexity, and there is a well-defined channel on this side only. Lower down three Khalls (*b*, *c*, *d*) appear at the convexity on the opposite side, and there is a well-defined channel there. Then in the Koffri Reach, on the right side, three streams appear, not, however, named, and the channel is on this side. Then at the inlet of the Cherrial Khall (*e*) the channel is on the left side, and remains so until it passes round Achipur Point, where the drainage from a large area comes in at the convexity on the opposite side. Here the channel remains until it has received the Champee Khall; then, with tributaries on both sides, there is a 'bar' in mid-stream. Then the large Royapur Khall (*i*) comes in at a convexity on the opposite, left, side. There it remains until, with the Royapur Bar intervening, it is transferred to the right side, where the important Hog River is received.

Close to the left bank, opposite Hiraguni Point, an extension of the deep-water channel is seen pointing upwards. Such features are common in tidal rivers and estuaries; they are formed by the tide, unable to cut a passage *through*, before it has risen to such a height that it flows *over* the shoal, and a passage through it is unnecessary. As they are tongue-shaped and tell of the direction of the tide in its first onset, I call them *tongues of the early* tide. A similar feature less frequently seen is caused by the stream. There is one on the opposite, right, side, where the tongue points downwards. These may be called tongues of the low-water stream. A little lower on this side is seen a double tongue, manifestly due to the tide. Here I may add that these tongues generally extend a little beyond the entrance of a side-stream, as if the tide or stream found an easy course along a channel kept open by the side-stream, but could get only a little beyond it. This is seen on the map in each case. These features seem to indicate the great importance, in the management of a tidal river, of securing, as far as possible, harmony between the direction of the stream and that of the tide.

Fig. 2, continuing the river downwards, shows features corresponding to those above. The Hog River is, clearly, the influence which keeps open the main channel on the right side until the influence of a large stream (*k*), coming in on the left, brings it over to Fisherman's anchorage. The direction of the tide, directly up the channel, is well shown by a *tongue* in the shoal just below Brul Point; similar features are seen just below the mouth of the Damuda River. Here the channel is still on the left side, which the large Fulta Creek may explain; the Damuda River, which is said to have driven the stream over to the left, does not really seem to have current enough to keep quite clear any part of its own outlet. Now we come to the region of the James and Mary Shoal, which Sir F. Treves[1] mentions as "the most villanous of all shoals in this evil river." If a ship touches it she sinks in the soft mud and disappears. All the engineers seem to be agreed that a single, permanent channel should be on the right side. I ventured to express an opinion, without knowing the fact, that tributaries did come in on the left side and kept open

[1] "Inner Side of the Lantern."

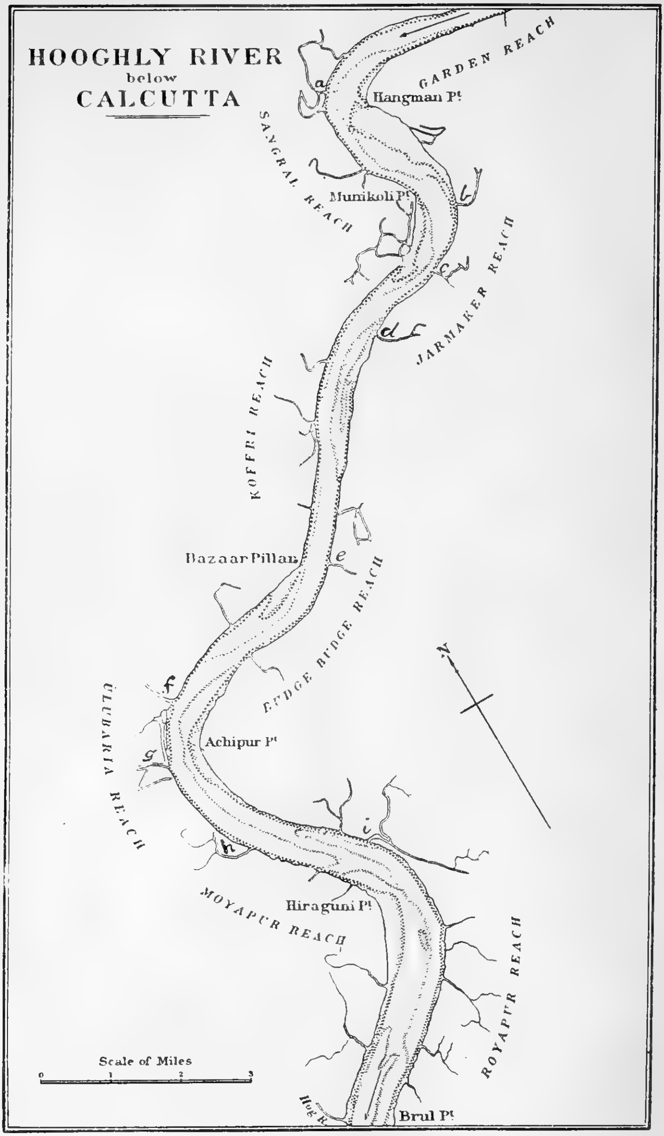


Fig. 1.

a. Sursuthee Khall. *d*. Goom Khall. *g*. Bahirtuffa Khall.
b. Murmekhalle K. *e*. Cherrial Khall. *h*. Champee K.
c. Meerpur K. *f*. Canal from Rajapur Jheel. *i*. Royapur K.

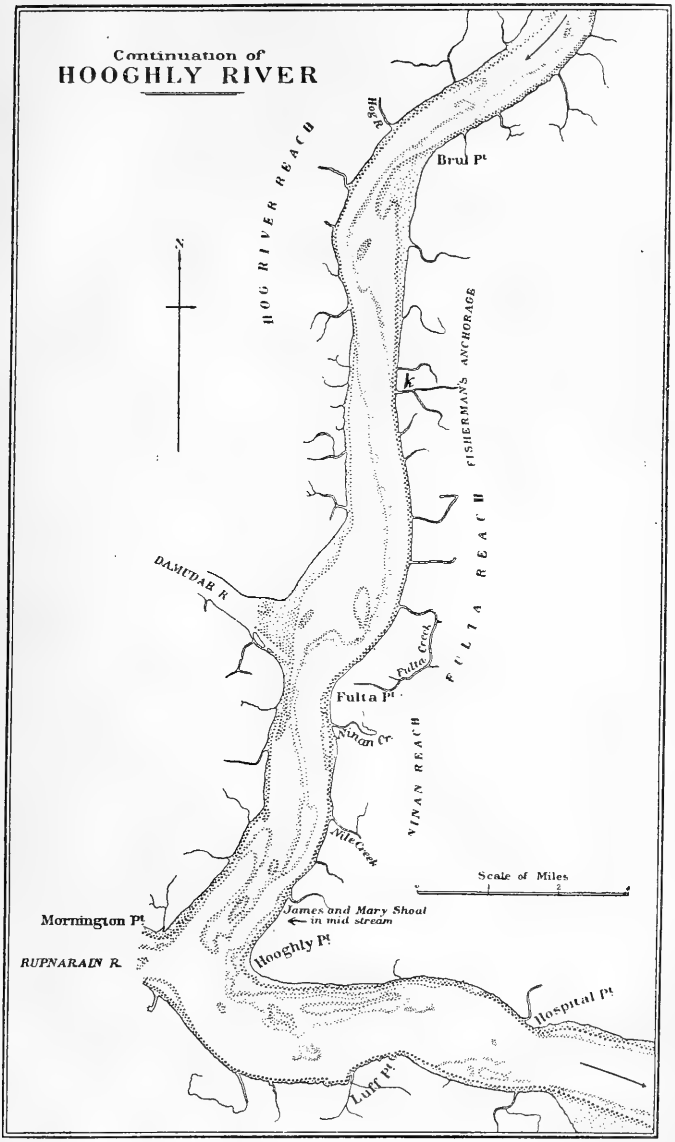


FIG. 2.
k. Chowgarra Khall.

the channel there. My reasoning was that the persistence of a shoal in the mid-stream of a river constantly depositing and removing mud indicated some need for a channel on both sides; and having regard to the line of the tide coming round Hooghly Point and going over to the other side, where, as shown by the tongues in the shoal, it is directed towards Ninan Creek; having regard also to the main stream which from Fulta Creek is directed downwards to the right side, tributary streams seemed to be necessary to account for the persistent channel on the left or eastern side of the shoal. Moreover, it appears that the eastern gut, as it is called, does in the dry season, that is, when there is no local water, partially close, when ships pass on the western side. Thus, in suggesting that the supposed tributaries should be intercepted and united in one channel brought out towards Hospital Point, I did but suggest the perpetuation of conditions under which this undesirable channel does tend to close. Every stream below Ninan Creek should, as I suggested, be so diverted, and the eastern gut be rendered unnecessary as a first step towards its extinction. Then, in my view, the stream would pass from Ninan Creek over to the right side, which is in the line of the tide as indicated by the tongues in the shoal, and a single, continuous channel would be assured.

Mr. Vernon-Harcourt's proposal is to put a long training-wall, extending from Fulta Point, into the shoal; he ignored the tributaries on the left side; he did not in his printed plan indicate their existence. Yet, being there, the creek between the proposed training-wall and the shore could not possibly close.

Fulta Point seems to illustrate a principle which I have long tried to impress on friends concerned in the management of estates. The margin of a river should be drained in a direction away from the stream, and the drainage be brought into the river only at fixed points as far apart as possible. Here the head of the stream is near the margin of the river, and a permanent promontory has formed. The formation of natural, raised banks, or levées as they are called on the Mississippi, seems to be promoted by a division of the flood-water as it recedes, part flowing into the river and part into the lateral drainage, thus leaving a line comparatively free from current.

Neither the map of a survey in 1851–5, to a scale of 1 inch to a mile, nor a later one to a scale of 4 inches, show the tributaries plainly. I am, however, satisfied that a complete map, taken with the chart, would show that every part of the river might be classed under one of these headings.

A. No stream coming in on either side—a straight, well-defined channel.

B. Streams coming in on one side only—a well-defined channel on that side only.

C. Streams coming in on both sides—an ill-defined channel and a disposition to form a shoal in mid-stream.

I may add that of twenty-five engineers who took part in discussing Mr. Vernon-Harcourt's paper, many of them writing at great length, not one seemed to recognize tributary streams as having any influence at all in diverting the river-channel towards their outlets.

Want of space forbids comment on many other points of interest in the paper and in the discussion upon it.

In a wide estuary, where the swing from side to side of a single channel is not possible, there will be appearances of a struggle between the disposition of the river-stream to go in a median line and the influence of tributary streams in keeping open channels on either side which the river-stream may, wholly or partially, adopt. Certainly, while these influences exist, the formation of a single, continuous channel is impossible. What would happen in the case of the Hooghly estuary if all streams coming in on the eastern side were diverted into the channel behind Saugor Island is an interesting speculation. My belief is that the channel on the western side to which the River Haldia gives its name would become the principal one.

Estuary conditions are well seen in the wide, crescent-shaped expansion of the Mersey above Liverpool. Here, in the low-water channels one can see the influence of the tide, of the main stream, and of the tributaries on either side. I can imagine all of these latter on the northern shore, east and west of Hale Cliff, diverted and brought in at Widnes and at Garston, so giving an unbroken front of more than 8 miles. Then, with no need for a channel there, the main stream would follow a great curve on the southern shore, adopting the channel kept open by the Weaver and other streams, which would accord with the line of the tide coming up to Eastham, directed there by the quay walls of Liverpool and of Birkenhead.

Fig. 3 shows the estuary of the Exe with the low-water channel on the left side at Topsham, 4 miles below Exeter. There is no apparent obstruction to prevent a straight course to the sea; the channel is, however, directed towards the right side, but not in a straight line; the upper part is inclined somewhat eastward towards a similar inclination, westward, of the channel continuous with the River Clyst. The two elbows, pointed towards each other, suggest a former union and a comparison with similar features to be seen in rivers and brooks, as mentioned in the previous paper.[1] The channel of the Exe crosses to the right side, where it receives streams coming in near the entrance to the canal. Being here, there is no apparent reason why the channel should not be continued on the same side and unite with Powderham Pool, lower down. It does go over towards the left side and unites with the channel of the Clyst. Again, with no apparent reason why the united channel should not go direct, it crosses over to the right side and receives the Kenn. Again, with a direct course freely open, it goes over and unites with the Lympstone Lake, which comes from the left side. Finally, the channel in its progress towards Exmouth again inclines to the right and receives several streams coming from this side. The influence of the tide in maintaining channels is overrated. Here, the bar thrown up by the current in the sea, running from west to east, would close the estuary if a channel were not kept open by the stream.

The course which the low-water channel in the estuary would take if it were decided by the direction of the tide is clearly indicated by

[1] Geol. Mag., March, 1908, p. 111.

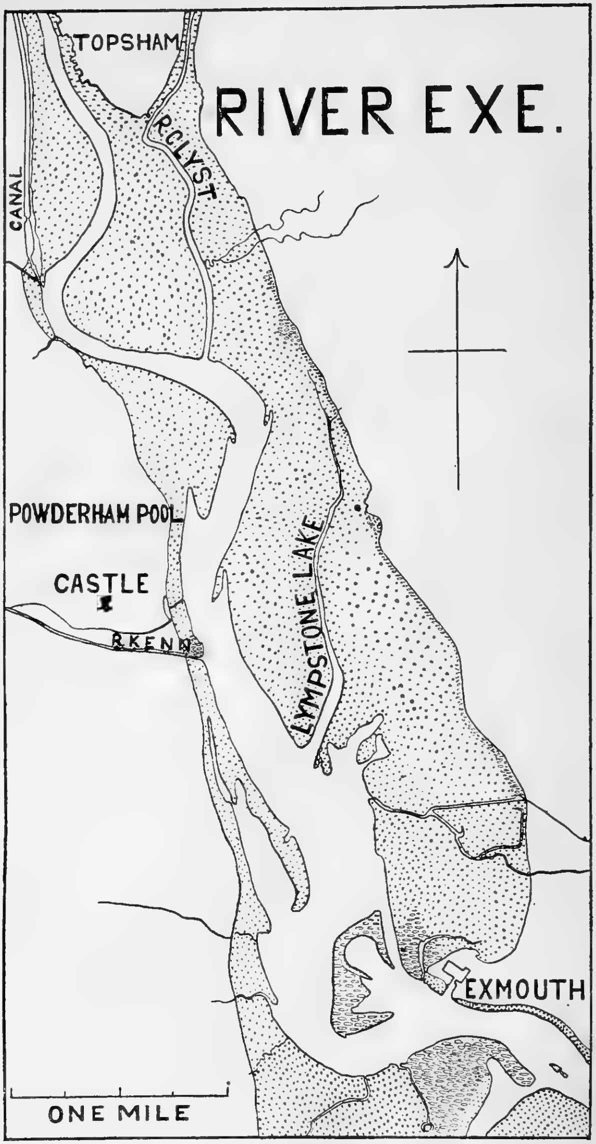

TOPSHAM
RIVER EXE.
R CLYST
CANAL
POWDERHAM POOL
CASTLE
R KENN
LYMPSTONE LAKE
EXMOUTH
ONE MILE

FIG. 3.

Powderham Pool, a *tongue of the early tide* and a permanent feature as indicated by the fact that it has a name. Twice a day the tide attempts to force a passage directly up the river, but succeeds only in removing the mud left at high-water by the previous tide. Not only is the tide unable to cut a way through the shoal; it has been powerless to prevent the formation of it. Permanent features in estuaries are much more interesting than changes; they serve to indicate conditions which conduce to stability. On examination of the map, one of these tongues is seen opposite the mouth of the Kenn, where the early tide has been deflected by a breakwater. Other tongues are seen farther up the low-water channel, the course of which, evidently, is decided by the stream.

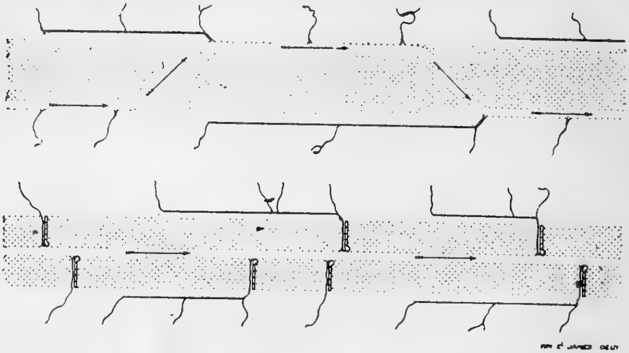
While, in the Exe, the low-water channel passes, through mud, obliquely across the river from the mouth of one tributary to that of another, in the Severn we can see the same thing where the channel is cut in hard rock. The Wye, and a smaller stream just below, are on the right side of the Severn, and the channel is on this side; then it passes obliquely across to the mouth of the Avon, along The Shoots, a cutting in hard rock. We have evidence that it was really cut by material moved by water; when the foundations for the Portskewet Pier (for the ferry) were excavated, the holes were filled at each tide, "sand, gravel, and stones double the size of a man's fist being often found." The line of the early as of the higher tide would not be along this channel if free to take its own course. A *tongue of the early tide*, the Whorl's End, just above, a precisely similar feature to Powderham Pool, has its point directed up the line of the Severn, and is of the same shape as every map has shown it to be for the last hundred years. The tide has, of course, been an active agent in cutting The Shoots; the line of this channel was decided by the stream.

The tide may serve to keep open or to close a channel, to prevent or to cause the formation of new land, according to the presence or the absence of a stream. Throughout a long line from Crossens, on the Ribble, by Southport, no stream falls into the sea, and there is a great accretion of land until, at the mouth of the Alt, the line of the new land recedes. I have often thought that the Nene and all the smaller streams between the Ouse and the Welland might be diverted, right and left, into these rivers so as to give an unbroken front of eight miles. Then a very large area of new land would quickly form in the Wash between the two rivers as they extended their course towards the sea along the coast of Norfolk and of Lincolnshire.

To control the course of a river at high tide or at time of land-water flood may be difficult, but the low-water channel, which, after all, means the deep-water line, would, generally speaking, be easy. If tributary streams fall in on one side only of the river, the channel will be on this side only. A change may be made from one side to the other if, at the point of crossing, no tributary come in on either. So, too, in the case of either a river or an estuary of moderate width, a channel may be fixed in mid-stream if the tributaries, singly or united, be carried out by training-walls to fixed points on either side of the intended channel, not necessarily a straight one if it afford a fairly good flowing line and be sufficiently in accord with the direction of the tide. I assume that the training-walls are up to the level of low water only, so that the tide or flood-stream can pass freely over them. Let either of these conditions, expressed in Figs. 4 and 5,[1] be fulfilled and the low-water channel will be permanent. If the contrary can be shown, I shall have to admit that I am wrong.

4

5



DIAGRAMS OF RIVERS WITH STABLE CHANNELS.

FIG. 4.—Tributary streams coming in on one side only; none at the crossing of the channel.

,, 5.—Tributary streams directed by training-walls to fixed points on either side of the intended channel.

VII.—NATHORST'S METHODS OF STUDYING CUTINISED PORTIONS OF FOSSIL PLANTS.

By F. A. BATHER, D.Sc., M.A., F.G.S., etc.

BOTANISTS who study the tissues of living plants, or those palæobotanists who deal with actual petrifactions, have scarcely any idea of the difficulties that meet the worker on carbonised plant-remains, especially when the material is so limited that the research cannot be repeated in the event of damage to a single preparation. Moreover, the research can be conducted only on those portions of the tissue that are cutinised, since all the rest have been carbonised or destroyed in the course of fossilisation, and no longer appear after the preparations have been bleached. The student of Mesozoic plants is in the further unhappy position that, with a few notable exceptions, he rarely finds portions of the plant that show any structure; he in particular must direct his attention to the cutinised membranes, and above all to the cuticle of the leaves and stems and, in the case of Pteridophyta, to the spores.

So long ago as 1856, J. G. Bornemann, in his memoir "Ueber organische Reste der Lettenkohle Thüringens," described some cuticles, which, thanks to the maceration of the leaves in the course of fossilisation, had been preserved in such a way that they

[1] For these two diagrams and for valuable assistance I am indebted to a young engineer, Mr. W. E. James.

could be studied under the microscope without more ado. "The whole process," he writes, "of obtaining these natural microscope-preparations of the epidermis of fossil plants consists in loosening them from the clay under water with a spatula, mechanically washing the adherent clay from the membrane, and then enclosing the latter in hot, fluid Canada balsam between two glass plates." As a rule, however, more elaborate methods are needed both to obtain the cuticle and to render it fit for study.

August Schenk, in his memoir on "Die fossile Flora der Grenzschichten des Keupers und Lias Frankens" (Wiesbaden, 1867), was probably the first to make any considerable series of such preparations, as well as of the spores of various ferns. Similar researches have been made by R. Zeiller, who, in his "Observations sur quelques cuticules fossiles" (1882, Ann. Sci. Nat., ser. vi, Botan., vol. xiii, pp. 217–38), explained certain methods of treating the cuticle chemically. The cuticle of most plants, though insoluble in cold concentrated sulphuric acid, is dissolved in hot nitric acid, being changed by oxidation into suberic acid; it is also saponified and dissolved by boiling in potash. Fossil cuticles resist concentrated sulphuric acid even when boiling, and are dissolved in nitric acid only by prolonged boiling, the residue giving the usual reaction for suberic acid; they are not acted on by potash. As first observed in the Papierkohle, the carbonaceous matter separating the membranes is not carbon but ulmic acid, and this is soluble in slightly warmed ammonia or potash. Truly carbonised matter may be attacked by chlorine water ('eau de chlore') or by nitric acid, which oxidises it into ulmic acid soluble in alkalis.

Methods based on the foregoing facts have been employed by Zeiller and subsequent authors in this country and elsewhere, but have recently been improved by Dr. Hjalmar Möller, working under the direction of Professor A. G. Nathorst. A full account of them, with examples of their use, is given in some valuable memoirs recently published by Professor Nathorst,[1] and the interest taken in his collodium-method[2] suggests that some abstract of his present remarks may also prove welcome.

In studying carbonised leaves, the usual method has been to bleach them with chlorate of potash and nitric acid[3]; now it is found preferable generally to use the aqueous solution of potassium hypochlorite known as Eau de Javelle. This, being slower and gentler in its action, enables one to obtain larger portions of the leaf-cuticle unharmed. Sometimes, it is true, the material is not appreciably attacked by the Eau de Javelle, and recourse must then be had to the older method.

[1] A. G. Nathorst, 1908, "Paläobotanische Mitteilungen, Nos. 3–6": K. Svenska Vet.-Akad. Handl., xliii, 3 and 6. No. 3, "*Lycostrobus Scotti*, eine grosse Sporophyllähre aus den rätischen Ablagerungen Schonens"; No. 4, "Ueber die Untersuchung kutinisierter fossiler Pflanzenteile"; No. 5, "Ueber *Nathorstia* Heer"; No. 6, "*Antholithus Zeilleri*, n.sp., mit noch erhaltenen Pollenkörnern aus den rhätischen Ablagerungen Schonens." In all, 46 pages, 6 plates.

[2] See Geol. Mag., Oct., 1907, pp. 437–40.

[3] See, for instance, A. C. Seward, "Fossil Plants," 1898, p. 75, at bottom.

There is considerable difference in this respect between different classes of material, and it is not always easy to say beforehand whether the remains of a leaf will yield serviceable preparations of cuticle or not. Leaves with a well-developed cuticle, probably as a rule derived from xerophytes, are generally of a brownish colour, and so elastic that they can be more or less completely freed from the stone. Such leaves are frequently presented by the ginkgophytes and by some conifers, e.g. *Thinnfeldia*, *Ptilozamites*, and *Lepidopteris*. Leaves with a relatively thin cuticle may, however, in certain circumstances have been so preserved that they can be treated in a similar manner, e.g. *Dictyozamites*, *Otozamites*, and *Pterophyllum*. All such leaves yield good and fairly large preparations. On the other hand, leaves that are brittle and exceptionally carbonised fall to powder and yield no preparations of value. Between these extremes are all gradations, and even such leaves as resemble a homogeneous mass of coal may furnish good preparations if only large enough fragments of the leaf can be obtained. All these respond differently to the reagents. While leaves of *Dictyozamites* are completely bleached by Eau de Javelle in a few hours, others take as many days or weeks, or even a longer period, to become sufficiently transparent. The action of the reagents may, however, be hastened by warming.

When the leaf has become transparent it still consists of the cuticle of the two sides, and these have to be separated with dissecting needles. If a part of the leaf-margin is preserved, it is advisable to bend the cuticle of the under side round the margin so as to lay it flat alongside the cuticle of the upper side while retaining its connection therewith. Thus comparison of the two sides is facilitated. For mounting preparations of cuticle, glycerine-jelly is better adapted than Canada balsam.[1]

Although the use of the microscopic study of the cuticle has been generally recognised since the publication of Schenk's work, still it has scarcely been taken advantage of to the extent that is desirable. In every case the systematic determination of a leaf should be checked, when possible, by the study of its cuticle, since the outer form is so deceptive that one can rarely depend on it alone. A notable instance of this is furnished by the leaves from Greenland which were regarded as *Cycas* leaves by Heer and all other botanists, and served as basis for many conclusions of importance to climatology and plant-distribution. Eventually study of the cuticle enabled Professor Nathorst to prove that these leaves did not belong to *Cycas*, but to a new genus, which he named *Pseudocycas* from its remarkable resemblance to *Cycas* in outer form.[2] None the less, the examination of the cuticle should always be combined with as complete a study as possible of the leaf itself. To make and describe preparations of cuticle is easy enough, but is of small value unless one can give some account of the form and structure of the leaves to which they belong.

To turn to the Spores. Whereas those of the Palæozoic Lycopodiales

[1] A. G. Nathorst, 1907, "Paläobotanische Mitteilungen, No. 2, Die Kutikula der Blätter von *Dictyozamites Johnstrupi*, Nath.": op. cit., xlii, No. 5.

[2] A. G. Nathorst, 1907, "Paläobot. Mitt. No. 1, *Pseudocycas*, u.s.w.": ibid.

are fairly well known, especially the megaspores, this is not so with the spores of other fossil pteridophytes, except in the case of those species that occur as actual petrifactions. Spores in themselves are of no great interest, but when found in connection with the mother-plant they should always be studied, if only to complete our knowledge of the plant itself. Good results may often be obtained from unpromising material.

When the sporangia of Mesozoic or Cainozoic ferns are preserved in a carbonised state, they are freed from the matrix and treated with Eau de Javelle or with chlorate of potash and nitric acid. By these reagents the wall of the sporangium is quickly destroyed. To remove the ulmic acid produced by this treatment, it is advantageous, though not always necessary, to follow it by treatment with ammonia; this renders the spores more transparent. After the destruction of the sporangium-wall the spores often continue clinging together so that they can be studied in their original position. Examples of this are given in Professor Nathorst's communication No. 5, "Ueber *Nathorstia* Heer." If the treatment with ammonia is continued long enough, the spores usually become separated from one another; but the same result may be obtained by breaking up the group with a dissecting-needle or simply by pressing on the cover-glass. Such isolation of the spores is of course necessary for their further study.

After successful experiments with Triassic ferns, Professor Nathorst proceeded to apply his method to Palæozoic species. Two specimens were taken at random, one of *Pecopteris Miltoni*, the other labelled "*Cladophlebis Nestleriana* B[rongn.] fructif." Carbonised portions corresponding to the position of the sorus were freed from the matrix and treated with chlorate of potash and nitric acid. The small brownish-yellow fragments that remained were then subjected to the action of ammonia while on the microscope-slide, and the ulmic acid thus removed; this action was accelerated by warming. It was very interesting to follow under the microscope the gradual emergence of the spores from the apparently homogeneous mass, till at last they were completely exposed.

In many cases the spores long remain united, the simple reason being that they were not ripe when fossilised. Had they been so, the sporangia would have opened and scattered them, and it is of course in the unopened sporangia that spores are detected by these researches. It is, however, peculiar that these unripe spores should already have possessed so strongly cutinised a wall.

The success of Professor Nathorst's researches on specimens taken at random suggests that almost any fossil fern of which the fertile soriferous leaves are carbonised might yield preparations of spores. Just now, too, when it has been recognised that many supposed Palæozoic ferns really belong to the pteridosperms, the method might be of exceptional value, even though it be not always easy to distinguish an isospore from a microspore. The seeds of pteridosperms also are often small and liable to be confused with sori or synangia, but this method affords a ready means of distinguishing them. For example, the supposed seeds of *Carpolithus Nathorsti*, Arber, prove to be elongate collections of minute egg-shaped spores: whether fern-spores or microspores cannot be decided, but at any rate the species is not a *Carpolithus*.

The structure of the sporangium itself can to some extent be made out by following the gradual action of the reagents under the lens or microscope. Besides the shape of the spore-sacs, one can see whether the sporangium tissue consists of one or many layers. An illustration of the method is provided by *Nathorstia*. Here the whole sorus forms a firm, closed capsule. When bleached with chlorate of potash and nitric acid, it has at first the appearance of a quite homogeneous, light-brown, discoid mass. When the action has proceeded further, strong illumination under the microscope enables one to detect the carbonised and still black septa between the groups of semi-transparent brownish spores. These septa coalesce in the centre and taper outwards, so that they form a star. On the addition of ammonia the sorus splits into wedge-shaped spore-groups. By pressing the cover-glass on these, the spores are loosened. All these stages are shown by microphotographs, of which the last represents most distinctly the tetrahedral form of the spores under a magnification of 260 diameters.

Not only ferns but other pteridophytes lend themselves to such researches on the spores. The spores of *Equisetites*, for instance, have just been discovered in this way by Mr. Th. G. Halle (Sv. Vet.-Akad. Handl., xliii, No. 1, 1908), and Professor Nathorst thus describes his own discovery of two kinds of spores in *Lepidostrobus Scotti* :—Here the sporangia are easily seen, and their thin wall is removed by Eau de Javelle, which thus exposes the megaspores. This first treatment further results in the recognition of their spore-nature, i.e. the unicellular nature of the dark-brown objects can be determined, while in some specimens one can also observe three ridges meeting at an angle of 120°, as well as a peculiar appendage. One specimen showed that this appendage was placed close upon the ridges, but this was seen more clearly in another preparation which, after the first bleaching with Eau de Javelle, was treated with alcohol and then bleached further. These preparations are remarkably transparent and allow the structure of the megaspores to be observed very exactly. Once clear as to this structure, the next step was to find the microspores, should such be present. The quest did not seem likely to succeed, for very little carbonised matter remained, and none of this was above the assemblage of megaspores. The only part suitable for examination was further down, on the left side of the upper part of the uncovered flower-axis, and seemed to correspond to three sporophyll fragments with sporangia. This part, therefore, was cautiously removed from the stone slab and treated with fuming nitric acid. Since this, however, seemed too violent in its action, the treatment was soon interrupted and Eau de Javelle substituted for the acid. At the end of the bleaching, three closely compressed elongate parts could be distinguished. One of them displayed a collection of megaspores; another resembled it; both therefore corresponded to two megasporangia. The third part, however, showed no megaspores, but a perfectly homogeneous mass, on which there appeared here and there circular spots of about 0·28 mm. diameter. Small isolated fragments of the light brownish-yellow ground-mass were translucent at the margins, and were surrounded by microspores that had separated from them. On teasing the ground-mass with the dissecting-needle, microspores appeared in countless numbers: the ground-mass was entirely composed of them, and the addition of ammonia broke it up into these constituents. These microspores are so thin that they can scarcely be seen if preserved in glycerine-jelly or Canada balsam, especially when they have been rendered more transparent by ammonia. Fortunately they can be stained with erythrosin, and this renders their outline very sharp and clear, so that it has been possible to reproduce microphotographs up to an enlargement of 750 diameters.

The pollen-grains of fossil gymnosperms also may be obtained by this method, and Professor Nathorst has studied the pollen-sacs of a fossil hitherto supposed to represent the male flowers of *Baiera Muensteriana*, but now described by him as *Antholithus*[1] *Zeilleri*, n.sp. The two very small specimens, contained in a soft fissile shale of Rhætic age, were first treated with nitric acid alone, afterwards with the addition of chlorate of potash, and it was soon seen that other fragments were present. On isolating these their form appeared quite different from that of *Baiera*, a fact that could not possibly have been distinguished otherwise. An unopened pollen-sac was treated in the same way as the sporangia mentioned above, and showed itself to be quite full of pollen-grains of oval shape and from 36 to 48 μ in length.

The indestructibility of spores and pollen-grains rendered it probable that they could be washed out of Mesozoic clay deposits, in the same way as plant-remains are washed out of Quaternary clays and sands (see Nathorst, Bihang Sv. Vet.-Akad. Handl., xvii, Afd. iii, No. 5, 1892; and G. Andersson, Geol. Fören. i Stockholm Förhandl., xiv, 1892). An experiment was therefore made with a certain Lias clay, found at Hör in Scania, and full of plants preserved as they grew, among which may be specially mentioned *Clathropteris meniscioides*, *Dictyophyllum Nilssoni*, and *Marattia hörensis*. A piece of this clay was taken and washed after treatment with nitric acid. Though of only some four or five cubic centimetres, it yielded an enormous quantity of different plant-remains. Besides the larger fragments, about fifty preparations of the finest mud were obtained, all containing hundreds of spores or pollen-grains, and yet not half the mud was used up. Obviously the clay was crammed full of such remains, and among them the tiny spores of Marattiaceæ predominated. Other forms could be referred with much probability to *Dictyophyllum* and *Clathropteris*. The most interesting occurrence, perhaps, was that of winged pollen-grains closely resembling those of *Pinus* (sensu lato), a genus previously unknown in rocks older than the Upper Rhætic of Scania.

There seems no reason to doubt that fruitful results would accrue from the extension of this research to other plant-bearing clays, no matter what their age.

[1] The name *Antholithus*, originally used by Linné in Syst. Nat., ed. xii, as a designation for '*Phytolithus floris*,' is here adopted by Professor Nathorst as a general term for all fossil flowers. It implies that the systematic position of the species cannot yet be determined. Compare the use of the words *Radiolus*, *Entrochus*, and *Cystis* in Echinology.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. List of Titles of Papers read in Section C, and in other Sections bearing upon Geology, September 3rd to 9th, 1908.

Presidential Address by Professor John Joly, M.A., D.Sc., F.R.S.

Professor G. A. J. Cole.—The Geology of the Dublin District. (Lantern.)

R. J. Ussher, H. J. Seymour, E. T. Newton, F.R.S., & Dr. Scharff.—On the Cave of Castlepook, near Doneraile.

Professor G. A. J. Cole.—On Probable Cretaceous Outliers off the Coast of Kerry.

R. Carruthers & H. G. Muff.—The Geology of the Leenane District, Co. Galway.

H. Bolton.—On a Section of the Lower Coal-measures at the Emerald Pit, Dungannon.

G. H. Kinahan.—On the Raised Beaches of the Liffey Valley.

Professor J. Joly, F.R.S. — On the Igneous Rocks of the Outer Blasket Islands.

Professor G. A. J. Cole.—The Laterite and Bauxite Zone of North-East Ireland.

Professor S. H. Reynolds & Mr. C. I. Gardiner.—The Igneous and associated Sedimentary Rocks of the Tourmakeady District, Co. Mayo.

Dr. W. F. Hume.—Notes on the Petrography of Egypt. (Lantern.)

Dr. A. Hutchinson.—Dolomites from Algeria.

Dr. A. Hutchinson.—On a new method of drawing Stereographic Projections of Crystals.

Dr. H. A. Bemrose.— Notes on the Microstructure of Derbyshire Limestone. (Lantern.)

Professor J. Joly, F.R.S.—On the occurrence of Native Iron in the Deccan Basalt.

W. G. Fearnsides.—The Tourmaline Rocks of Cwm Dwthwc.

H. Brodrick.—Notes on the Formation of Cave Pearls.

Professor W. Boyd Dawkins, F.R.S.—The Derivation of Sand and Clay from Granite.

Dr. T. T. Groom.—Report on Charnwood Rocks.

Professor W. M. Davis.—Glacial Erosion in North Wales.

Dr. J. Milne, F.R.S.—The Duration and Direction of Large Earthquakes.

Professor C. Lapworth, F.R.S.—Report on Excavations through critical Sections in Shropshire and North Wales.

Dr. Tempest Anderson. — Changes in Soufrière of St. Vincent. (Lantern.)

Professor W. H. Hobbs.—Recent Changes in Level within the Basin of the Laurentian Lakes.

Professor W. W. Watts, F.R.S.—Report of Geological Photographs Committee.

Dr. Dwerryhouse.—Reports on Erratic Blocks.

Professor J. W. Gregory, F.R.S.—Report of South African Correlation Committee.

Dr. F. H. Hatch.—Report on South African Topographical and Geological Terms.
W. G. Fearnsides.—Report on Place-names.
Discussion on Mountain Building. Opened by Professor Joly, followed by Sir A. Geikie, Professor Lapworth, Professor Sollas, Professor Cole, Dr. Teall, etc.
E. Greenly.—Report of Committee on Anglesey Rocks.
W. Whitaker, B.A. Lond., F.R.S.—On the finding of Silurian Beds in Kent.
Dr. Woolacott.—On a case of Thrust and Crush Brecciation in the Magnesian Limestone, Co. Durham.
Dr. G. W. Grabham.—Well-water Supply of the N.E. Sudan.
H. Bolton.—Contemporaneous Erosion in the Lower Series of Coal-measures of the Bristol Coalfield.
Professor S. H. Reynolds.—Report on Pre-Devonian Rocks of Mendips and Bristol area.
J. W. Stather.—Report on Kirmington Deposits.
Professor H. G. Seeley, F.R.S.—On a Fossil Reptile with a Trunk from the Upper Karroo of Cape Colony.
Professor H. G. Seeley, F.R.S.—On the distinctions between the dentition of the fossil Reptilia classed as Cynodontia and Gomphodontia.
H. Brodrick.—Reptilian Footprints from the Inferior Oolite of Whitby.
J. Lomas.—Report of Trias Committee. (Lantern.)
Dr. A. Vaughan.—Report on Carboniferous Succession.
R. Welch.—On Dopplerite from Sloggan Bog, Co. Antrim.

Titles of Papers read in other Sections bearing upon Geology:—

Section B.—Chemistry.

Professor W. N. Hartley, F.R.S.—Lithium in Radio-active Minerals.
Discussion on Peat, in which Dr. Woltereck, Captain Sankey, Professors Ryan, Johnson, and Lyon, Dr. Adeney, Mr. K. B. Elles, and others took part.

Section D.—Zoology.

Presidential Address by Dr. S. F. Harmer, F.R.S.
Discussion on "The abuses resulting from the strict application of the rule of priority in zoological nomenclature, and on the means of protecting well-established names." Opened by Mr. G. A. Boulenger, F.R.S.
Professor Cossar Ewart, F.R.S.—Wild Ancestors of the Domestic Horse.
Lantern Lecture by Dr. A. Smith Woodward, F.R.S.—The Evolution of Fishes.

Section E.—Geography.

Presidential Address by Major E. H. Hills, C.M.G., R.E.
Professor W. M. Davis.—The Physiographic Subdivisions of the Appalachian Mountain System.

Rev. W. Spotswood Green.—Ireland: her Coasts and Rivers.
Dr. W. S. Bruce.—Scientific Results of the Voyage of the "Scotia."
Captain H. G. Lyons.—The Longitudinal Section of the Nile.
Rev. G. Furlong.—Unique Experiences at the Birth of a Volcano.
H. Brodrick.—The Marble Arch Caves, Co. Fermanagh.
Dr. C. A. Hill.—Mitchelstown Cave.

Section H.—Anthropology.

Presidential Address by Professor William Ridgeway, M.A., LL.D., Litt. D., F.B.A.
C. T. Currelly.—A Sequence of Egyptian Flint Implements.
Professor G. Elliot Smith, F.R.S.—Anthropological Work in Egypt.
Rev. Dr. Bryce.—The Mound Builders of North America.
Rev. W. A. Adams.—Some Ancient Stone Implement Sites in South Africa.
Dr. N. Gordon Munro.—Prehistoric Archæology in Japan.
Dr. R. F. Scharff.—Some Remarks on the Irish Horse and its early History in Ireland.

Subsection.—Physical Anthropology.

J. Gray.—Who Built the British Stone Circles?
Miss Nina F. Layard.—An ancient Land Surface in a River Terrace at Ipswich and a Palæolithic Site in the Valley of the Lark.
Report of the Committee to conduct Explorations with the object of ascertaining the Age of Stone Circles.
Report of the Committee on the best means of Registering and Classifying systematically Megalithic Remains in the British Isles.
G. Clinch.—On the Classification of the Megalithic and analogous Prehistoric Remains of Great Britain and Ireland.
Report of the Committee to Investigate the Lake Village at Glastonbury.
W. J. Knowles.—Perforated Stone Hammers and Axes.

II.—On the Cave of Castlepook, near Doneraile, Co. Cork.[1] By R. J. Ussher, H. J. Seymour, E. T. Newton, and R. F. Scharff.

Castlepook Cave, north of Doneraile, leads into an extensive series of deep parallel galleries in limestone. Most of them are narrow, with vertical sides up to a certain level, where the walls recede with a wide sweep, forming an arched tunnel. Near the top of this the galleries are still spanned in places by an ancient stalagmite floor. Some of the sand on which the latter was formed is still adhering to it underneath. Beds of sand filled the lower parts of many galleries. This sand contained, sometimes down to 12 feet, numerous remains, chiefly of reindeer.

The geological evidence as to the age of the cave is unsatisfactory. Only rolled and unstriated pebbles have yet been discovered in the cave and no foreign erratic. This would seem to indicate that the material now in the cave, and hence the cave itself, is pre-Glacial in age, for otherwise a pebble of the granite known to be widely

[1] Read before the British Association, Section C (Geology), Dublin, September, 1908.

distributed throughout the overlying boulder-clay might reasonably have been expected to occur amongst the large number of boulders found in the various passages. No such pebble has, however, been found. The inference, therefore, on more or less negative evidence, is that the cave was formed in pre-Glacial times.

The bird remains found in the cave call for no special remarks. More than half are referable to the domestic fowl, turkey, and duck, though some of the latter may belong to the wild form. Like the bones of the rook, which are also numerous, they may have been brought in recently by foxes. The remainder all belong to such species as are now found in the neighbourhood.

The mammalian remains are of a very different character. It is true that the bones of the rabbit, sheep, ox, horse, pig, fox, cat, and rat seem mostly of comparatively recent origin. By far the greatest number of the bones found belong to the reindeer and bear. The exceedingly numerous bone splinters, the gnawed bones of reindeer, and the presence of many bones of old and young hyænas seem to indicate coexistence in Ireland of the latter and the typically Arctic species. The hyæna, which had not previously been known to have ever inhabited Ireland, is closely related to that now living in South Africa. Other animals, whose remains were probably dragged into the cave by hyænas, are the mammoth, Gigantic Irish deer, red deer, and wolf. Among the smaller mammals the bones and teeth of the Arctic Lemming (*Dicrostonyx torquatus*) and of the Scandinavian Lemming (*Lemmus lemmus*) are very abundant. They may have been brought in by the Arctic fox.

No human remains or implements were found except parts of modern iron tools and charred wood, indicating the presence of man only within quite recent times.

In so far as Ireland is not generally believed to have been joined to England by land in Glacial or post-Glacial times, the presence in the country of the mammoth, Gigantic Irish deer, and hyæna apparently confirms the opinion, arrived at from geological evidence, that Castlepook Cave must be a pre-Glacial one. This view is supported by the absence of many animals from Ireland which seem to have made their first appearance in England during the Glacial period.

III.—Probable Cretaceous and Cainozoic Outliers off the Coast of Co. Kerry.[1] By Professor Grenville A. J. Cole, F.G.S.

THE dredgings made since 1901 by the Fisheries Branch of the Department of Agriculture and Technical Instruction for Ireland have amply supported the conclusions then put forward,[2] to the effect that the geological structure of the sea-floor off western Ireland can be deduced from a study of the stones lying on it from point to point. The most interesting recent results are the discovery of abundant flints, chalk, glauconitic chalk, and two specimens of Milioline limestone in dredgings off the coast of Kerry. Mr. Worth's observations in 1908 on similar materials in the English Channel thus receive

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.
[2] Cole and Crook, Report on Fisheries of Ireland for 1901.

confirmation from areas much further west, and it is clear that both the Cretaceous and Eocene seas extended to an unknown distance in that direction, though we can trace their boundaries fairly on the north-west. Many of the flints of southern Ireland may have been derived from local strata rather than from ice-borne drift.

IV.—On a Section of the Lower Coal-measures at Emerald Pit, Dungannon.[1] By H. Bolton, F.R.S.E., F.G.S.

A SHAFT was sunk in 1894–5 some little distance to the north of the old Drumglass colliery, and was carried to a depth of 197 yards, penetrating five coal-seams before reaching the Main Coal, which was known to the miners as the 'Congo' seam. During the course of the sinking a measured section was obtained of the strata passed through, and a collection of fossils brought together. After work had commenced on the deeper coal-seams, water broke into the colliery on two occasions, causing its abandonment. A generalised section of the measures passed through is as follows:—

		ft.	in.	yds.	ft.	in.
	Strata			46	2	7
1.	Coal (inferior)				1	10
	Strata			3	2	2½
2.	Coal					½
	Strata			65	2	3
3.	Coal (in thin partings with shale)			2	0	5
	Strata			44	0	11
4.	Coal					3
	Strata			25	0	5
5.	Coal: Top Coal	1	0	1	0	10
	Brown Shale		7			
	Coal	1	3			
	Inferior Coal		3			
	Coal		9			
	Strata			5	0	6
6.	Coal				3	3

Down to the level of the fourth coal, the strata consisted mainly of red, yellow, and grey sandstones, with grey bind partings. Below the fourth coal, black and grey shales predominated. At a depth of 133 yards from the surface occurred a black shale containing a typical Lower Coal-measures marine fauna.

The following species have been determined:—

Brachiopoda.
- *Discina nitida.*
- *Lingula squamiformis.*
- *Spirifera trigonalis.*
- *Camarophoria isorhyncha?*
- *Chonetes* sp.

Pelecypoda.
- *Sanguinolites plicatus*, Portlock.
- *Nucula gibbosa.*
- *Nuculana attenuata.*
- *Protoschizodus axiniformis.*
- *Parallelodon* cf. *Verneuillianus*, de Kon.

Gasteropoda.
- *Pleurotomaria* cf. *gemmulifera.*

Cephalopoda.
- *Orthoceras Koninckianum* ? d'Orb.

Vermes.
- *Serpulites membranaceus.*

Fishes.
- Palæoniscid scale and tooth.

[1] Abstract of paper read before British Association in Section C (Geology) Dublin, September, 1908.

V.—Notes on the Petrography of Egypt.[1] By W. F. Hume, D.Sc.

1. The ancient core of the North-East African Continent consists of the Cataract and Sudan Banded Gneisses, which may represent a very ancient igneous magma. They are usually much veined by granitic dykes.

2. In certain places in the Arabian Desert, Cataracts, etc., these underlie highly metamorphosed Schists (the Mica-Schists of Sikait, the Calcareous Schists of Um Garaiart and Haimar and of the Amara Cataracts, also the Dolomites of the latter region), which are sharply separated from the Banded Gneisses, and are possibly the oldest sedimentary representatives in Egypt.

3. The greater part of the mountainous regions of the Eastern Desert and Sinai is occupied by two types of rock, (*a*) a schistose constituent overlying or surrounded by (*b*) an acid member. The first-named (*a*), the Dokhan Volcanic Rocks and Schists, are partly volcanic in origin and partly sedimentary, the former being represented by lavas of various types, while the latter are clearly altered sedimentary strata (grits, conglomerates, etc.). No fossils have yet been found, but they have their nearest analogues in the latest Pre-Cambrian and Cambrian series. Here are included some of the most interesting rocks of Egypt, such as the Imperial Porphyry and the Breccia Verde Antico.

(*b*) The igneous member intruded into these ancient sediments, etc., includes a great diversity of igneous rocks, varying from highly basic to acid types. Contact phenomena of complex nature occur at the junctions of *a* and *b*.

4. Red Granite and Dyke Rocks, whose parallelism and extent of distribution present one of the most conspicuous features of the Eastern Desert of Egypt, mark the final eruptive action before Carboniferous times.

5. Three periods of volcanic activity have been subsequently noted.
- (*a*) In Western Sinai in late Carboniferous times.
- (*b*) An undated series of eruptions interbedded with the base of the Nubian Sandstone or intrusive into it with marked contact alterations.
- (*c*) The Basic intrusions near Cairo and the Fayum, etc., which are intimately associated with the Oligocene Continental Period in Egypt.

VI.—The Tourmaline Rocks of Cwm Dwythwc, near Llanberis (North Wales).[1] By W. G. Fearnsides, M.A., F.G.S.

Some years ago, when examining sands from the neighbourhood of Caernarfon, I found that both the river sands of the Seiont and the beach sands of the Menai contain tourmaline. In order to trace the mineral to its source I have since examined the heavy mineral residues of the sands of nearly all the tributaries of the Seiont, and find that all those which flow across the Cambrian Slate Belt contain either needles or broken grains of brown tourmaline. The sand from

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.

the Afon Arddu (whose delta parts the two lakes of Llanberis) is exceptional, and is very rich in well-formed trigonal prisms of blue tourmaline. The sand from the Afon Hwch, its tributary from between Moel Eilio and Moel Goch, is even more surprising, and in the sand from the spits along the flatter reaches of this burn tourmaline can generally be distinguished with a pocket lens.

I have therefore mapped the Cwm Dwythwc on the 6 inch scale, and in mapping have found the tourmaline rocks *in situ*. They are mostly coarse grits, grits, flags, and slaty flags, and occur along the horizon of the unconformity between Cambrian and Ordovician rocks. The tourmaline is not clastic, but has been formed *in situ* from the felspathic ground-paste of the grits or flags, and clustered new-formed needles enter and pierce the quartz pebbles of the grit or the chloritoid ground-mass of the slate in a most fascinating manner. There has been thrust-faulting along the unconformity, but no large intrusive mass of igneous rock has been observed within five miles of the locality. Tourmaline new-formed in the slate and the remains of tuning-fork graptolites can be found within 3 or 4 inches of each other. The tourmaline is a soda-bearing variety.

VII.—The Derivation of Sand and Clay from Granite.[1] By Professor W. Boyd Dawkins, D.Sc., F.R.S.

THE decomposition of granite by the attack of carbonic acid in the rain-water on the soluble crystalline constituents of the granite results in the formation of a surface covering more or less complete over the solid rock which can only be studied in non-glaciated regions. It is conspicuous by its absence from the ice-swept granite areas of the Lake country, of Scotland, and of Ireland, and of Middle and Northern Europe.

The quartz in the granite has resisted decomposition, and where the finer products of decomposition have been swept away it forms a coarse sand, each grain presenting an irregular surface indented by the felspars and micas as they cooled from the heated magma. These are traceable more or less through a large number of sandstones, and more especially through those of the Millstone Grits and Coal-measures of Middle and Northern England.

The attack of the rain-water containing carbonic acid on the micas results in the decomposition of the biotite and to a lesser degree of the muscovite, while the soluble felspars, such as orthoclase, are completely dissolved, constituting hydrated silicates of alumina and new minerals such as kaolinite and secondary minutely crystalline muscovite. All these occur in the china clay of Cornwall and Devon, and are invariably associated with grains of quartz, primary mica, and tourmaline present in the unaltered granite. These constituents occur in all the samples ranging from the purest china clay through the whole series which have as yet been examined, with the addition of others of local derivation.

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.

These facts indicate that granite has been one of the chief sources, not merely of the arenaceous, but also of the argillaceous rocks. It is not improbable that both may ultimately be proved to have been derived from the siliceous acid layer believed by Durocher and Haughton to have been the first to become solid in the cooling globe.

VIII.—Glacial Erosion in North Wales.[1] By Professor W. M. Davis.

THE mountains of the Snowdon district are believed to represent a group of monadnocks which surmounted the peneplain to which a large part of the region was reduced in Tertiary time. The valleys between the monadnocks were somewhat deepened by normal erosive processes, in consequence of a general elevation of the region in late Tertiary time. As a result, the topography of the Snowdon district in immediately pre-Glacial time may be described as exhibiting a group of well-subdued mountains, drained through valleys of somewhat sharpened form. The difference between the forms thus described and the forms seen to-day in the Snowdon district is very great, both in amount and in kind, and cannot be accounted for by normal erosion during Glacial and post-Glacial time. But the difference is, in amount and kind, just what might result from glacial action, if it be postulated that glaciers are effective eroding agencies. The depth of glacial erosion in certain cwms and valleys is believed to have been 400, 600, or 800 feet; the breadth of glacial erosion must have been of even greater measure.

IX.—The Duration and Direction of Large Earthquakes.[1] By Dr. John Milne, F.R.S.

SMALL earthquakes, as for example those which occur in this country, have a duration of a few seconds near to their origin. At places 50 or 100 miles distant they may not be recordable. The duration, therefore, has varied between a few seconds and zero. With many large earthquakes, however, this decay during transmission is not appreciable, and duration near to their antipodes may be as great as it is near to their origin. Duration as one of these disturbances travel, rather than decreasing, at times appears to increase. The greatest duration is at about 90° distance from an origin. That which occurs may be compared with what we observe after a flask of water has been tilted. The contents oscillate like a pendulum, and any one part of the fluid comes to rest about the same time as any other part.

Another observation in connection with recent seismological observations is that large earthquakes travel farthest in particular directions. I have taken seventy-nine large disturbances with fairly well-known origins south of the Caucasus, north of India, and to the east or south of Japan. These earthquakes have travelled farther to the west than to the east, and there has only been a small percentage of them that have found their way across the equator to observatories in the southern hemisphere.

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.

X.—The Soufrière of St. Vincent: The Changes subsequent to the Eruption of 1902.[1] By Tempest Anderson, D.Sc., F.G.S.

In 1902 the author visited St. Vincent, along with Dr. Flett, after the then recent eruption. In 1907 he revisited the island and examined the changes that had taken place in the new deposits.

In 1902 an incandescent avalanche descended into the valleys which occupy the great transverse depression across the island to the south of the Soufrière, and in particular the Wallibu Valley was filled for a great part of its course to a depth of at least 100 feet, but less near its mouth. In this deposit of red-hot material the secondary phenomena of re-excavation of the valley by the river, the falls of hot ash, the steam explosions, and the flows of boiling mud took place, and are described in the Report, Part I.[2] In 1907 almost the whole of this ash had been washed away, but a fragment remained in the shape of a terrace, 60 to 80 feet high, situated on the north side of the valley. The ash of which it is formed is unstratified, and contains very few ejected blocks or fragments of any kind. The floor of the valley is all composed of water-sorted material, chiefly gravel and coarse sand, but with a good many blocks as big as a man's head. They represent ejected blocks and fragments of lava derived partly from the ash of 1902 and partly from older beds, the fine ash in each case having been washed away. The surface of the gravel-bed showed marks of quite recent running water, and during the last Winter (1906–7) the river ran along the foot of the north bank of the valley. When examined in March, 1907, it ran along the south side of the valley, and had already in those few months excavated a new channel about 30 feet in depth. The stratification, as exposed in this new valley, is very distinct, and the sorting by water, mentioned above, is very evident. Further up the mountain the remains of the avalanche became more abundant in the valley bottoms, and here they were also better preserved, so that traces of the feather-pattern erosion, so noticeable in 1902, were still visible on the surface. This was mainly due to the surface of these ash deposits, like those to be presently mentioned on the plateaux and on the ridges, having consolidated into a crust, almost like a cement pavement, which resists the action of the rain.

Another interesting point was observed with regard to these massive beds of recent material. Instead of one stream re-establishing itself along the centre of the deposit, the tendency is for a new stream to form on each side at or near the junction of the new ash with the old valley slopes; and as these streams deepen their beds two new valleys are formed where only one previously existed, and the walls of each are composed on the one side of the new ash and on the other of older tuff, with occasional terraces.[3]

An account was also given of a visit to Montagne Pelée, in

[1] Abstract of paper read at the British Association in Dublin before Section C (Geology), September, 1908.

[2] Anderson & Flett, Phil. Trans., 1903, Series A, vol. 200; Anderson, Geographical Journal, March, 1903.

[3] See, further, Anderson, Report, Part II, Phil. Trans., Series A, vol. 208, pp. 275–300; Flett, Petrology, ibid., pp. 304–33.

Martinique, with a discussion of the phenomena of the extrusion of and subsequent destruction of the spine which have been described by Lacroix and others, and a comparison of the eruptions of the two islands.

XI.—On the Finding of Silurian Beds in Kent.[1] By W. Whitaker, B.A. (Lond.), F.R.S.

A BORING has lately been made, to a great depth, at Messrs. Curtis & Harvey's works, on the Thames Marshes at Cliffe, for the purpose of getting a supply of water, firstly from the Chalk and then from the Lower Greensand. It has failed in this, the water from both formations being too salt to be of any use; but it has succeeded in adding a geologic formation to the Kentish list, and that the oldest yet found in the county.

Details of the section will be given in a forthcoming Geological Survey Memoir on the Water-supply of Kent. It should be noted that the division between some of the formations is doubtful, but any error from this cause is immaterial in the following abstract:—

	Feet.	
Alluvium and River Gravel	77	1,074 feet.
Upper, Middle, and Lower Chalk	656 (or more)	
Gault	208 (or less)	
Lower Greensand	96 (or less)	
Dark-grey clayey rock	37 (or more)	

Nearly the whole of the Chalk has been pierced, the topmost part only being absent. The thickness given to the Gault is a little more than in the borings at Chatham, Frindsbury, and Strood eastward, and still more than at Erith (Crossness) westward. The thickness given to the Lower Greensand is also more than at Chatham, whilst at Erith there is none of this formation.

The chief interest of the boring, however, lies in the facts that the floor of the older rocks, which has been proved in many places in Kent, was reached at a level of about 1,030 feet below Ordnance Datum, and that the Palæozoic formation found is of Silurian age, nothing older than Devonian having been hitherto recorded from the deep borings of the county, and that only at Brabourne, unless the red rocks at Crossness should turn out to be of like age.

The proof of the Silurian age of the lowest beds is given by the occurrence of fossils at the depth of 1,063 feet, *Atrypa reticularis* and *Plectambonites* having been determined at the Palæontological Department of the Geological Survey by Mr. H. A. Allen, from samples of the cores sent by Mr. Baldwin Latham. There are traces of other fossils.

The practical value of the boring is that it puts a northern limit to the Kent coalfield in its neighbourhood.

XII.—On a case of Thrust and Crush-brecciation in the Magnesian Limestone, Co. Durham.[1] By David Woolacott, D.Sc., F.G.S.

ALONG the two miles of cliff between South Shields and Marsden the breccias that formed so marked a peculiarity of the Magnesian Limestone of North-East England are best exposed. The rocks seen are

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.

the yellow sands, marl slate, and Magnesian Limestone, but the effect of the thrust on the first two cannot be observed. The limestone, although much disturbed, has a general low dip to the south. It consists of a series of rocks of different flexibility, rigidity, brittleness, and compressive strength, and the uniqueness of the section is due to the action of a thrust from the north, which has caused some of the beds to move laterally upon the others, with an associated production of folding, minor-thrusting, and fissuring, and a consequent development of dynamic brecciation.

In Frenchman's Bay the lower limestone (40 feet thick) is a brownish-yellow, regularly bedded rock of relatively high compressive strength and rigidity. Its lower layers are gently folded, but its top layers are considerably disturbed, being fractured, tilted up, and laterally displaced. Resting on this is about 50 feet of brecciated limestone, consisting almost entirely of a cemented mass of broken fragment, which have here and there been dissolved out from the cementing matrix, the rock becoming cellular. In places the bedding, unfolded but fractured, is still preserved. It was originally a finely laminated granular limestone, and is of low rigidity and compressive strength. Experiments performed by Dr. Morrow give the following results:—Compressive strengths (tons per square inch to break rock), lower limestone, 5·7 tons; brecciated bed (lower middle), 1 ton.

The junction of the brecciated beds with the lower limestone is a thrust-plane, which does not always coincide with the line of demarcation between the two strata; and the disturbance of the upper layers of the latter rock, together with the smashing up of the former, is due to the thrust movement.

The brecciated beds occupy the top of the cliff for over a mile. Their upper surface, which is seen at the north end of Marsden Bay, is very irregular and hummocky, the breccia having been forced up into the base of the beds above. These consist of about 200 feet of rock differing much in flexibility and compressive strength (specimens tested vary from 1 ton to 37 tons per square inch). They have been thrust against a 'Horst,'[1] and consequently folding, thrusting, and dynamic brecciation have taken place. The flexible beds have been deformed without being much broken, while a harder, more brittle, wedge-shaped limestone has been highly brecciated. The latter has also had a coarse cleavage structure impressed on it, and part of it has been torn off and thrust into the beds above. Breccia gashes and vertical fissures filled with breccia, which has fallen into them, occur on both sides of this folded and broken area. The amount of lateral displacement at this point has probably been about 100 yards, and the experiments indicate that the magnitude of the thrust was about 300 tons per square foot.

[1] 'Horst,' see Suess, "Antlitz der Erde," 1st ed. (1885), vol. i, p. 167, and also Maria Ogilvie, Quart. Journ. Geol. Soc., 1893, vol. xlix, p. 77, for explanation of term.

XIII.—The Laterite and Bauxite Zone of North-East Ireland.[1] By Professor Grenville A. J. Cole, F.G.S.

THIS paper was merely explanatory of an exhibit of the types of rock formed during the interval between the basaltic eruptions in the north of Ireland in Eocene times. It was urged, in agreement with the views of Richardson and Tate and Holden, that the red lateritic zone represents basalt altered *in sitû* even down to depths of 40 feet, the so-called 'volcanic bombs' in the layer being residual lumps of less altered basalt. Such a type of alteration is clearly connected with the climatic conditions of Eocene times. Some of the pisolitic iron-ore may have accumulated on the surface of the laterite in pools formed during the rainy seasons. The pale bauxites are derived from sporadic eruptions of rhyolite, and the bi-pyramidal crystals of quartz in them prove this over a wide area. The thin bauxitic layer, occurring as it does above the pisolitic iron-ore, may be in part formed by wind-borne material.

XIV.—On some Fossil Shells from Comparo Road, Trinidad.[2] By R. J. Lechmere Guppy.

AMONG the fossils submitted to me for determination at different times by Mr. E. H. Cunningham-Craig, F.G.S., lately Government Geologist, was one collection of peculiar interest consisting of fresh-water shells of genera and species not now found in Trinidad, and forming a fauna completely distinct from any now existing here. The locality given me was Comparo Road. I furnished Mr. Craig with the names of the shells and notes on them, but I think it as well to put on record the names of these fossils.

1. *Hemisinus sulcatus*, Conrad.
Amer. Journ. Conch., 1870.

Conrad considers *H. tenellus* to be a near ally of this shell. It is, however, very closely akin to *H. bicinctus*, Reeve, an existing species of South American rivers. *Melania cingulata*, Moricand (Journal de Conch., 1860, pl. xii, fig. 6), and *M.* (*Melanopsis*) *brasiliensis*, Mor. (ibid., pl. xii, fig. 7), are also very near.

2. *Leptoxis crenocarina*, Moricand.

An inhabitant of Brazilian rivers. A remarkable and aberrant form of *Melania*.

3. *Anodon batesii*, H. Woodward.
Ann. Mag. Nat. Hist., 1871–4 ser., vol. vii, p. 103, pl. v, fig. 10.

There is no need to go to Asia for the nearest analogue of this bivalve, which is related to the *Anodon leotaudi* of our rivers and equally so to *A. sirionos*, Orb., and *A. puelchana*, Orb., of South America. The African shell figured under the name of *Margaritana pfeifferiana* by Bernardi (Journal de Conch., 1860, pl. xii, figs. 1, 2) bears much likeness to the species named, which are all closely related.

[1] Read before the British Association, Section C (Geology), Dublin, Sept. 1908.
[2] Bulletin Botanical Department, Trinidad, July, 1908, Article No. 1005.

4. *Cyrena semistriata*, Desh.

I had attached the manuscript name of *craigiana* to this shell, but a closer comparison of the numerous specimens contained in a slab presented by Mr. Craig to the Victoria Museum caused me to feel doubtful whether it ought to be accounted distinct from the *C. semistriata* of the European Tertiaries (Pictet, Paléontologie, pl. lxxvi, fig. 10; and Forbes, Isle of Wight, pl. iii, fig. 2). It is akin to *C. solida*, Phil., of Central American rivers.

5. There is also a very remarkable bivalve whose fragmentary condition prevents determination.

The collection indicates fluviatile or estuarine conditions, and has resemblances to the Tertiary deposits of the Amazons valley, whose fauna has been described by Conrad (Amer. Journ. Conch., 1870) and H. Woodward (Ann. Mag. Nat. Hist., 1871). I am of opinion that a Pliocene age is denoted.

Note.—In addition to the papers referred to by H. Woodward in the place above cited, there is a paper by Etheridge in the Quarterly Journal of the Geological Society of London, 1879, vol. xxxv, pp. 82–8, on fossils collected by Barington Brown in the Amazons valley.

XV.—On the Cement-producing Materials of Naparima, Trinidad.[1]

By R. J. Lechmere Guppy.

When I retired from office under Government at the beginning of 1891, I undertook an examination of the rocks of Naparima in Trinidad. These formations had occupied my attention at intervals ever since 1859, when I first studied them. The discovery of the wonderful series of Foraminifera, of which I had previously gained only a glimpse in 1872, was the first reward of that examination; but as a collateral result I found that we had here a very extensive series of deposits apparently suitable as material for the manufacture of cement. I inquired of the Public Works Department if this information would be of any use to them, more especially as the beds passed through and were developed on Government lands. The reply I got was that all the cement wanted could be furnished by the Crown Agents for the Colonies and there was no need of any local supply.

The results of my examination of the Naparima rocks were embodied in a paper read to the Geological Society of London and published in their Journal, November, 1892, p. 519.[2] In that paper I casually mentioned the occurrence of cement materials in these rocks in these words (p. 530): "I think it highly probable that in some of the marls we have a material suitable for the manufacture of cement." It was not until this paper was before the Geological Society that I was aware that Messrs. Harrison and Jukes-Browne had been working at the geology of Barbados and had read a paper thereon before the Society. These gentlemen were good enough to forward to

[1] Bulletin Botanical Department, Trinidad, July, 1908, Article No. 1006.
[2] See Geol. Mag., 1892, p. 331, and a further paper in Geol. Mag., 1900, pp. 322–5.

me a copy of their highly interesting and elaborate paper (Journal Geological Society, London, 1891, p. 198, and 1892, p. 170), which showed that there was a remarkable similarity between the rocks of Barbados and those of Naparima. But it was not even then, but a couple of years later, that I became aware of the existence of cement-producing materials in the oceanic rocks of Barbados similar to those of Naparima. Professor Harrison had the kindness to send me, what I had not seen before, a copy of the report prepared by him in conjunction with Mr. Jukes-Browne on the geology of Barbados for the Government of that island. In this they say:—

"The lowest chalky beds of the oceanic series possess a value which is derived partly from their chemical composition and partly from the fact of their lying immediately upon the dark clays. In these deposits we have the materials for the manufacture of cement. We believe the cement-making will be, if the suggestion is followed up with energy, one of the most promising of the industries of the island. We may mention that there are other beds of chalky earth which would be equally suitable for the manufacture of cement, and, further, that there are beds of dark-grey earth consisting partly of chalky earth and partly of fine mud, which have a chemical composition that seems to indicate their suitability for making cement without any admixture of clay."

Beds of the identical composition of those referred to in the foregoing extract occur in the Naparima district. It is matter for trial and experiment merely which of them is best for the manufacture of cement. My own opinion is that the softer beds will be the best, but some of them may require to be mixed with more argillaceous material, which can easily be obtained from the other beds in the neighbourhood. It is probable, however, that a material will be found which will give the right proportions without any admixture.

During my investigation of the Naparima rocks, particularly in 1891, I was struck by the remarkable resemblance in composition between these rocks and those from which cement was manufactured as described by various authorities. I have not at present by me all the works I have consulted on the subject, but it will suffice to refer to the United States Geological Reports, namely, the 20th Annual Report (1898–9), the 21st Annual Report (1899–1900), p. 402, and the 22nd Annual Report (1900–1), p. 728. According to these the average composition of the material for the best quality of cement is practically the same as found in the Naparima deposits.

REVIEWS.

I.—Catalogue of Minerals in the Technological Museum of the South Australian School of Mines and Industries. Compiled by Herbert Basedow, Honorary Curator. pp. 200. Adelaide: C. E. Bristow, 1907.

It is evident from the Catalogue which has been carefully prepared by Mr. Basedow that the South Australian School of Mines possesses a collection of minerals well adapted to the purposes of teaching. Numbering about 25,000 specimens, it includes all the important mineral species, South Australian minerals being, of course, well represented. The species are classified according to the arrangement adopted by Dana in the sixth edition of the "System of Mineralogy," and the information contained in the Catalogue comprises the registered number of each specimen, its locality when known, the source through which it was obtained, and occasional remarks of general interest.

II.—A Pocket Handbook of Minerals. By G. Montague Butler. pp. ix + 298, with 89 figures in the text. New York: John Wiley & Sons, 1908. Price 12*s.* 6*d.* net.

TO those who have to arrive at a rapid determination of mineral specimens—for instance, prospectors and other workers in the field—the convenient handbook prepared by Professor Butler will prove welcome. In it he gives for each species the physical characters, such as the colour, lustre, hardness, and streak, that are observable almost by mere handling of the specimen, and the reactions that may be determined by means of the ordinary blowpipe and simple reagents included in any prospector's outfit, the more important and decisive tests being emphasized by a judicious use of heavy type. The various characters are summarised in tables printed at the end of the book on folding sheets of paper, an inconvenient arrangement that would probably not stand the wear and tear of constant use. Ample space is left for the addition of notes that experience may suggest, and the book is well illustrated with sketches of characteristic crystals and pictures of typical specimens. The additional chapters dealing respectively with the commercially important ores of the various metals and with the average retail prices of gem-stones and minerals will be valuable to the prospector, and the ample glossary will be useful to those not conversant with the technical terms in vogue among mineralogists. The arrangement of the mineral species follows closely Dana's well-known treatise, from which, indeed, the information given has been mainly culled.

The value of the book would have been greatly increased by the addition of numerical data, such as the specific gravity, which is given only in cases where it is an obviously distinctive character, and the refractive constants. Methylene iodide has been so much reduced in price of late years that an ounce or so is no serious addition to the expense of an outfit; even without a dilutant it may after a little experience be employed to give valuable information. Now that portable refractometers are available it is possible to determine in the case of most transparent substances the refractive indices, often a satisfactorily decisive test.

III.—Brief Notices.

1. Plumbago.—It is singular to find how little one knows about the most ordinary things, and Dr. J. W. Evans must be congratulated in having, at the instance of Dr. Murray, cleared up the history of the

word Plumbago. But it has required 47 pages of the Philological Society's Transactions for 1908 to tell the story. The earliest use of the word seems to occur in Pliny (Hist. Nat., v, 95), where, quoting from Dioscorides, he says, "quidam limatum plumbum sic terunt, quidam et plumbaginem admiscent." 'Plombagine' occurs in Cotgrave, French and English Dictionary, 1611, but the first English use of 'plumbago' is believed to be seen in John Woodall's "Surgion's Mate," 1617, p. 113, where the word is explained as "Plumbago, or red leade, hath the force of binding, mollifying, filling up hollow ulcers with flesh." The paper is of extreme interest, not only from the care with which it has been prepared, but from the light it throws on the early history of mineralogy, for the history of Plumbago may be taken as a type of that of any other mineral.

2. Local Societies.—Mr. W. G. Clarke has a paper on the "Distribution of Flint and Bronze Implements in Norfolk," and Mr. Frank Leney writes on "Some Additions to the Norwich Castle Museum in 1906," in the Trans. Norfolk and Norwich Nat. Soc., vol. viii, pt. 3. None of these accessions are of geological interest. Mr. Clarke's paper is most useful, as it gives information as to the present resting-place of the specimens and where they were described. The Trans. Edinburgh Geological Society, vol. x, pts. 1 and 2, includes papers "On the Mineralogy of the Faeröes, arranged topographically," by James Currie; "Volcanic Tuffs on Ben Nevis," by Wm. Mackie; "Fossils and Conditions of Deposit, a theory of Coal formation," by C. B. Crampton; "Contemporaneous Volcanic Action in the Banffshire Schists," by Wm. Mackie; "New Localities for Oil-bearing Shale near Edinburgh," by Crampton & Tait; "Recent Progress in Seismology," by C. G. Knott; "Geology of Malcolm," by R. Campbell & A. G. Stenhouse; and "Egg-shaped Stones dredged from Wick Harbour," by D. Tait. These curious egg-shaped stones are considered by Mr. Tait to be rolled concretionary nodules of Jurassic age.

3. Museums.—We call the attention of our readers to an able article on the present position at the British Museum (Natural History), which appears in the August number of the *Museums Journal*, *à propos* of the letter signed "Wilfred Mark Webb" which appeared in the *Times*, 10th July last.

The Report of the Borough of Colchester Corporation Museum, 1908, shows a good deal of activity chiefly in an archæological direction. Many important local finds are listed, and some of the more interesting have been photographed and sold as postcards. This photography of all objects of interest cannot be too greatly persevered in, as the pictures are valuable to others who cannot obtain the real thing. When, moreover, they are utilized as postcards, there is every chance of their paying for themselves, and thus confounding one of the chief difficulties of local authorities.

The Report of the Ruskin Museum for 1908 lists as an accession to the mineral collection a "specimen of laminated talc containing arborescent pyrolusite." Beyond that all additions have been artistic or literary.

The Manchester Museum has arranged the "Mark Stirrup" collection, a series of Coal-measure plants from the Radstock series, and is now taking in hand the Cretaceous collection, which was sadly in want of attention. Among noteworthy accessions is the Thomas Parker collection of Carboniferous fishes and Brachiopods, containing types figured by Mr. J. W. Davis and Dr. Thos. Davidson. The geological library has been enriched by Mr. Stirrup's books, and a large collection of stone implements presented by Mr. R. D. Darbishire.

The Museum of the Yorkshire Philosophical Society has appointed the Rev. W. Johnson as curator in the place of the late J. F. Walker. The Tertiary fossils have been re-labelled, but we hope the original labels have in every case been kept. The geological department did not receive a single accession during 1907–8. The "Report" is mainly archæological, save Dr. T. Anderson's paper on the Volcanoes of Guatemala, which has been reprinted from the Geographical Journal.

Rugby School Museum has acquired, through the generosity of the Hon. E. C. Fraser, a collection of bones of the Dodo and the Solitaire.

We learn from the *Naturalist* that Beverley in Yorkshire will soon have a local museum.

4. Ice.—Mr. J. G. Buchanan's lecture on Ice to the Royal Institution of Great Britain in May last has now reached us. Full of suggestive and interesting matter and well illustrated, we can only find room to call attention to the chief headings dealt with. These are the nature of the ice formed by freezing saline solutions; the distinction between the melting-point of a substance and the temperature at which it melts under given conditions; the influence of salt in inducing the melting-point of ice; cryoscopic equivalence between pressure and salinity; influence of impurity on the apparent latent heat of ice; glacier grains; their size; sun-weathering of granular ice produces white surface of glacier; snow nevé and glacier; lake ice; its grain; characteristics of an advancing glacier; grooving of ice by rock; and external work of a glacier. The author concludes his printed lecture with an explanation of "the real region of mechanical erosion and attrition is the seashore," with a note on the advantage of study of tropical lands, and refers to the 'Crumble' formation. He lays down the law that "the chemical action of atmospherical moisture and the tendency of every part of a mountain or rock to yield to gravity when not adequately supported, suffice to account for all the degradation of rock which we observe." Excellent photographs of granular ice, of a stream-bed after three rainless years and on the same day but after a violent rainstorm, and of the chemical and gravitational degradation of the mountain slopes at the back of Antofagasta, Chili, where the landscape consists of a succession of taluses in a rainless district, are given.

5. Geological Survey of New Jersey.

Annual Report of the State Geologist for the Year 1907. 8vo; pp. 192. Trenton, N.J., 1908.

The bulk of this volume is occupied with J. V. Lewis' Petrography of the Newark Igneous Rocks, illustrated by many plates of field occurrences and their sections. The other portion of the volume consists of reports on an Inland Waterway from Cape May to Bay Head, by H. B. Kümmel, with estimates by Vermeule and Haupt. Detailed maps are also given.

6. CEYLON.

CEYLON, A HANDBOOK FOR THE RESIDENT AND THE TRAVELLER. By J. C. WILLIS. 8vo; pp. 246, map, and many illustrations. Colombo, Colombo Apothecaries' Co.; London, Dulau & Co., 1907.

This book provides information on the Geology, Geography, Climate, Zoology, Botany, Forests, and Irrigation, besides the History, People, and Archæology of the Island. The scientific matter is sketchy, and the zoology needs expansion. Several pages are filled with notes on the mineral products, and among the illustrations is an excellent picture of a graphite mine taken by Mr. Coomaraswamy. To anyone visiting this delightful island the book should be indispensable.

7. MARYLAND.

MARYLAND GEOLOGICAL SURVEY: Vol. VI. 8vo. Baltimore: John Hopkins Press, 1906.

This volume deals with the physical features of the State by W. Bullock Clark and E. B. Matthews, and gives a general summary of the geology under formations, the mineral resources, etc., with special references to economics, rainfall, hydrography, and forestry. Plates are given of the characteristic fossils and maps of the clays and other minerals. Mr. A. N. Johnson gives his fourth report on the highways of Maryland, with details of road-construction and other matters, as cost and maintenance, of value to local bodies. Mr. E. B. Matthews defines the counties of Maryland, their origin, boundaries, and election districts, and his paper is illustrated by a series of coloured maps. An 8 miles to 1 inch map of the whole State, geologically coloured, is included in an envelope, and on this is also indicated the agricultural soils.

8. CORAL REEFS.—In a paper on "Coral Reefs of the Great Barrier,"[1] Queensland, Messrs. C. Hedley and T. G. Taylor remark—"Unhappily for its subject, the controversy upon Coral Reefs has been mainly conducted in cities distant the world's breadth from the scene of investigation. Data compiled for other purposes are pressed into service, and opportunities of verifying facts are denied to authors. Some who discourse learnedly on coral geology have perhaps never touched a living coral." They then proceed to describe in detail three traverses of the Great Barrier Reef, and give the following summary of zones as typical of East Hope Isle:—

	Feet.
1. Living coral rampart	10
2. Living coral (inner zone)	30
3. *Alcyonaria*, etc.	300
Algæ (*Halimeda*, etc.)	600
Islet—Coral sand beach	60
Tree-clad Island	600
Beach and coral rock	60

[1] Adelaide Meeting of Australian Association, held January, 1907.

		Feet.
1. *Chama* beds		300
2. Pseudo-lagoon—	(*a*) Sponges	300
	(*b*) Mussels, etc.	900
	(*c*) *Heliopora*	1500
3. Clinker embankment (broken corals)		30
4. Rock pools		90
5. Outer zone, massive living corals		30

A map and diagrams are given. The authors summarize as follows:—The growth of an individual reef is shown to proceed in a regular cycle. If the reef reaches the surface with its axis along the wind, then its shape endures; but if across the wind, then its extremities are produced backwards, forming first a crescent, later a horseshoe, and lastly an oval, thus enclosing a lagoon. Descent at this stage arrests development or rejuvenates the reef. In quiescence the lagoon walls broaden, the lagoon is obliterated with sediment, a vegetated sandbank spreads on the summit, and the atoll, grown to a cay, has arrived at maturity. 'Negro-heads' are not, as has been advanced, relics of former raised reefs, but masses of coral tossed up by hurricanes, and no great antiquity can be ascribed to them. They find for Darwin's view that this portion of the Great Barrier has been formed during subsidence.

CORRESPONDENCE.

SUMMARY OF PROGRESS.

Sir,—In the review of the Summary of Progress of the Geological Survey for 1907 (August number, p. 379), two rather misleading statements have been inadvertently made which it is desirable to correct. It is stated that the Appendix contains articles "on the Mugearites, one of the Tertiary igneous rocks of the Inner Hebrides," and "on the marine beds near the base of the Upper Carboniferous in Scotland."

The article on the Mugearites was written to describe rocks of this type occurring in the Carboniferous volcanic series in Midlothian and East Lothian. The Tertiary Mugearites, previously recognised and named by Mr. Harker, were only introduced for the sake of comparison. The marine beds referred to occur, not near the base of the Upper Carboniferous in Scotland, but near the base of the Upper Carboniferous red barren measures, which in Scotland overlie all the worked coal-seams of the Coal-measures.

J. Horne.

DESOR'S "SYNOPSIS DES ÉCHINIDES FOSSILES."

Sir,—The "Synopsis des Échinides Fossiles," by E. Desor, is a work still in constant use by every worker on the Echinoidea. Its use, however, is rendered difficult, first, by the lack of an index—a want particularly felt in these days when so many names have been altered; secondly, by the fact that it was published in *livraisons* issued at different dates, and that certain sheets were cancelled, others being substituted at a later date.

I propose, therefore, to publish a double Index to the generic and specific names in the "Synopsis," the names in the first part being arranged alphabetically under the trivial names, while the second part will be an index to generic names, each followed by a list of the species referred to it by Desor. This index will be preceded by a "Note sur les dates de publication," drawn up by Mr. Jules Lambert, who has spent many years in ascertaining all the bibliographic details with regard to this work.

The Index will be printed on paper of the same size as the "Synopsis."

Should there be as many as eighty subscribers, the price may be as low as five shillings.

I shall be glad if intending subscribers will communicate with me at the Natural History Museum, S.W., at an early date, as after publication the price will probably be raised.

F. A. Bather.

THE TYGERBERG ANTICLINE.

Sir,—I regret to have again to refer to this subject, not that I wish to insist that my explanation of the cause for this fold is the correct one, but that I cannot let a fold described by me as an anticline, and shown to be an anticline even in Dr. C. Sandberg's photograph in the Geological Magazine for July, p. 311, be referred to as a syncline. Dr. Sandberg's photograph is taken on the opposite side of the poort to that from which the photograph in Mr. Rogers' "Geology of Cape Colony" is taken, and the real difference is that the south limb of the anticline is cut away and only appears in the background. In the original communication in the Trans. Geol. Soc. S.A., 1906, vol. ix, Dr. Sandberg records that his study of this fold was pursued during a "stay of a few hours off and on" (p. 82), and geologising in a new and unfamiliar country under such conditions is the only excuse Dr. Sandberg can offer for seeing things upside down.

Ernest H. L. Schwarz.

Albany Museum,
Box 13, Grahamstown, Cape Colony.
August 16, 1908.

THE TERM 'CREVASSE.'

Sir,—In several American books on Physiography the term 'crevasse' is employed to designate the gap that is occasionally made in natural or artificial levees. Surely such an employment of the term is to be deprecated, seeing that it has for long been used in another connexion. I have also a faint recollection of having seen it used synonymously with the term 'grike.' There are already too many terms in circulation that are used technically in more than one science. In many cases their usage in the several sciences has obtained such general recognition that it is undesirable to suggest any change, but in such a branch of science as river-development this can scarcely yet be argued. In Holland, where incursions of the sea are not infrequent owing to the breaking down of the artificial levees, the term 'eenbroek' is employed to describe the 'breaking in.' The term is a convenient one to pronounce, and may be suggested as an alternative for 'crevasse,' which is preoccupied.

L. RICHARDSON.

CHELTENHAM.
September 14, 1908.

OBITUARY.

JOAQUIM FELIPE NERY DELGADO,
FOR. MEMB. GEOL. SOC. LOND.

BORN 1844. DIED AUGUST 3, 1908.

WE regret to learn from Monsieur A. Torres, the Secretary to the Service Géologique du Portugal, Rua do Arco a Jesus, 113, Lisbon, of the death of Monsieur J. F. Nery Delgado, Director of the Geological Survey of Portugal, which occurred at Figueira-da-Foz on the 3rd August. Mr. Delgado was elected a Foreign Correspondent of the Geological Society of London in 1887 and a Foreign Member in 1899. He was a retired General of Division, Inspector General of Mines, and Member of the Royal Academy of Sciences of Lisbon. Under his directorship the Geological Survey of Portugal has published a long and valuable series of maps and memoirs, illustrated by some very excellent plates, beginning in quarto form as far back as 1865, and also in octavo form since 1885.

Mr. Delgado's first important work was the exploration of the caves in the Jurassic limestone of Cesareda, Portugal, of which he published an account in 1862 (abstract in Quart. Journ. Geol. Soc., vol. xxiv, 1868, pt. ii, p. 9). He afterwards devoted special attention to the Palæozoic rocks of Portugal, and prepared an important memoir on the Silurian for the Geological Survey in 1876. In the course of this research he became interested in the remarkable tracks and markings found in grits, supposed to be of Arenig age, in Central and Northern Portugal. He accordingly published his well-known memoir on the so-called *Bilobites* or *Cruziana,* with a fine series of illustrative plates, in 1886. He formed the opinion that these problematical fossils were the impressions of algæ. In 1892 M. Delgado described a new Silurian trilobite, *Lichas* (*Uralichas*) *Ribeiroi,* of very remarkable size, and some years later he published some notes on the minerals and rocks of the Portuguese African possession of Angola. In 1888 M. Delgado attended the International Geological Congress in London, and became personally known to many British geologists. His manner was that of the true scholar, quiet and unassuming, and he endeared himself to a large circle of friends who mourn his loss.

MISCELLANEOUS.

SIR THOMAS HENRY HOLLAND, K.C.S.I., F.R.S., Assoc. R.C.S., DIRECTOR GEOLOGICAL SURVEY OF INDIA.

We are pleased to record that among the recipients of Birthday Honours, Thomas Henry Holland, F.R.S., Director of the Geological Survey of India, has been created a Knight Commander of the Order of the Indian Empire.

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ASSISTED BY

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NOVEMBER, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. XI.—NOVEMBER, 1908.

ORIGINAL ARTICLES.

I.—Van Hise on the Division of the Pre-Cambrian.

By Alfred C. Lane, State Geologist of Michigan, U.S.A.

WHEN President Van Hise finished his address before the Geological Society of America last winter, which the Society has just issued, he leaned over benignly and glanced at Dr. Coleman, Professor Lawson, and myself, and said that while it was not customary to discuss the President's address he hoped in this case the custom would be waived, as he knew a number of members disagreed with him, and he felt they would have criticism of value to contribute. Whereupon ensued a most friendly but lively discussion, in which many took part. It has not been the custom of the Society to report such discussions, but I am sure that Van Hise will not object to see some of the points raised by the writer in print, as well as his Address.

The writer believes that the Keweenawan is Cambrian, and stands in somewhat the same relation to the Georgian and Acadian as does the Old Red Sandstone to the Devonian of the Eifel, or the Permian and Trias, with their lavas, to the Alpine facies of the same beds. This belief is shared with Professor Seaman, of the Michigan College of Mines, and N. H. Winchell, and we are as conversant with the facts as any.

It is true no fossils have been found, and that the extreme Upper Cambrian where it abuts against the Lower Keweenawan series overlaps it unconformably. But if, as Leith suggests, it is a land formation, that is exactly what would be expected. It is, however, a moot question of fact, upon which probabilities must be balanced, and I believe that in the forthcoming monograph by Van Hise and Leith on the Lake Superior region both sides of the question will be fairly put forth, and they will doubtless agree with the writer in saying that it would be dangerous, in making estimates of the age of the earth, to assign to this series of lavas and conglomerates a thickness of 50,000 feet or anything like the age-value of a series of limestones and shales. This was recently and quite pardonably done by a writer in the Geological Magazine, who was not acquainted with the local facts. It will be much wiser in such estimates to count it as part of the Cambrian. There are, however, some other questions of word usage not requiring local knowledge, but rather matters of English style, upon which one may rightly appeal to an English audience for a fair and intelligent judgment, in regard to which the writer differs from Van Hise.

In the first place, while Van Hise no longer absolutely restricts the Archæan to non-klastics, he does restrict it to pre-Huronian.[1] But, as he clearly states, the term Archæan was introduced by Dana to avoid the implication as to life of the term Azoic (and Eozoic) for all the pre-Cambrian rocks, and was divided by Dana into two groups, the Huronian and Laurentian. The excuse of Van Hise for thus modifying the definition and denotation of the term and its connotation is that to include "both pre-Cambrian groups under one name would result in making two groups of rock to appear to be alike when, as a matter of fact, they are radically different"—the same objection that some feel against using the term Algonkian to include Keweenawan and Huronian.

While he thinks that in so doing he carries out the "essential intent" of Dana, the writer cannot agree with him. Nor did Dana himself. In view of the fact that Van Hise has to use the synonym pre-Cambrian fifty-three times in twenty-six pages, there would appear some justification for those geologists who prefer to employ the term in the original sense. It is not so bad if one does not mind capitals in the midst of a word to write pre-Cambrian, but if one needs to refer to time since, it is certainly clumsier to say post-pre-Cambrian than post-Archæan.[2]

But are they really so "radically different"? Van Hise has shifted his definition. It is no longer the distinction between klastic or not. He makes it very clear that it is not 'zoic,' and a lack of clarity exists, which, as it is absent from the style of this clear and forceful writer, seems rather imaginary. An extra widespread and important unconformity between them, a greater proportion of normal sediments in the later division or Huronian, and very great difficulty in applying ordinary stratigraphic methods to the earlier pre-Cambrian—these appear to be the bases of division. But it is clear, it is indeed emphasized by Van Hise, that division on such lines is essentially local, unless one could show some reason why all over the earth at the same time there should be a great unconformity, as when the moon went off.

It would seem to the writer on *such grounds* impossible to be sure, for instance, that the Kona Dolomite of the lowest Huronian might not be the equivalent of the Grenville Limestone of the Upper Laurentian.

It is unfortunate that in a paper devoted to discussing the division of the pre-Cambrian, by an oversight Van Hise should forget to mention the early thesis of the eminent geologist Credner on this subject,[3] while he pays so cordial a tribute to Pumpelly and Marvine,

[1] If we remove the Keweenawan to the Cambrian, the Algonkian becomes a synonym, around Lake Superior at least, for Huronian.

[2] Cf. Becker in the same Bull. Geol. Soc. Amer., 19, p. 128.

[3] "Die Gliederung der eozoischen (vorsilurischen) Formationsgruppe Nord Amerikas": Zeitsch. für die Ges. Wiss., 1868, xxxii, pp. 353–405.

with whom Credner was associated. This rather rare paper was probably not at his hand. Credner was one of the earliest writers to advocate substantially the dual division of Van Hise, though with other nomenclature, thus:—

Eozoic { Huronian.
Laurentian.

It strikes the author as a pretty good nomenclature, well worthy a few moments discussion by Van Hise.

It seems to him, however, and he does not wish this paper to be purely critical, that there will be such a dual division, on a sound philosophic and 'zoic' basis, though not exactly on the line laid down by Van Hise.

There has been much discussion of late of desert sedimentation, by Walther, W. M. Davis, Barrell, Huntington, and others. It seems to the writer that many of the peculiarities of the desert are due, not to the arid climate *per se*, but to the fact that it is devoid of vegetation. This we now find practically only in arid lands, but before the earth was clothed with verdure, or moss or lichen existed, the land must have been bare, and even though the climate were wet the sedimentation must have been very different. In particular, without the organic acids there must have been little chemical denudation by organic acids and carbon dioxide. This had an effect in two ways. In the first place, the streams contained little carbonates and yielded little to the ocean. In the second place, the sediments formed by disintegration of the rocks, which mechanically is much more active when not protected by vegetation, must have been much richer in the soluble bases, which would otherwise have been removed by the organic acids. In this way were produced the ancestors of the arkoses, greywackes, and sedimentary gneisses and schists. Thus the peculiar character of the early sediments upon which Van Hise comments may have a direct 'zoic' meaning. Nor is this the whole story. The subtraction of organic additions and disintegration leaves the other kind of chemical activity more important—the volcanic exhalations, in which there is reason to believe chlorine and sulphur emanations were prominent, would still exist, and in fact there was volcanic activity and agglomerates on a large scale. These acid radicals would, however, tend to carry off the iron to the sea and not precipitate it as the carbonate radical does. We should, therefore, have had in the Azoic ocean at the end an accumulation of chlorides of calcium, iron, and other bases, and its sediments composed of volcanic agglomerates and conglomerates, and mechanical sediments, like arkoses and gneisses and mica-schists, differing but slightly from the associated igneous rocks. Now this is the character of the oldest rocks, the Keewatin series, and analyses indicate that the early ocean was relatively a solution of calcium chloride, while Quinton's very plausible theory, especially with the modifications suggested by the writer,[1] implies a relatively fresh ocean. Such, then, would be the Azoic, the early part of the pre-Cambrian.

[1] "The Early Surroundings of Life," Science, 1907, vol. xxvi, p. 129; "The Chemical Evolution of the Ocean," Journal of Geology, 1906, vol. xiv, p. 205; Bull. Geol. Soc. Amer., 1907, vol. xvii, p. 691.

When life came, perhaps waiting until enough carbon for its existence had accumulated in the ocean from volcanic sources, there would be a gradual development of more ordinary sediments, and river waters, with sodium carbonate and silicate in solution, such as now drain granite areas, would begin the precipitation of calcium chloride as calcium carbonate and accumulation of sodium chloride, which has been the dominant factor in oceanic chemical evolution. Very promptly, however (this theory is due to Leith), the sodium silicate would react upon the chloride of iron, precipitating the silica and iron as iron oxide and chert, mixed perhaps with carbonates. I have recently seen an ideal specimen of such a rock from a 2,000 feet drill-hole in the deep continuation of the Mesabi range. Thus we have the cherty iron members, which are so universal a feature of the various Huronian series, and we also have sodium chloride left in solution.

During the period of the dawn of life there would then be as characteristic the chemical precipitation of the carbonates of calcium, iron, magnesium, etc., and of chert and iron oxides, from chloride or sulphate solutions.[1] Decaying organic matter would also produce the black muds from which come the graphitic slates. The other sediments would approach gradually the customary types.

Chamberlin and Salisbury have touched upon the abnormal character of the pre-Cambrian sediments, though not using it as a basis of subdivision.

During all this time, however, the ocean remained relatively fresh and unfavourable to the secretion of shells, and the rapid evolution of life into various branches of the animal kingdom went on without hard parts, and without a body-cavity closed from the oceanic vital medium. But with the steady accumulation of salts in the ocean, its waters reached and passed the physiological optimum of eight parts per thousand. Numerous different branches responded to this change of environment for the worse by secreting calcium carbonate or phosphate, which were already present to saturation, at first as a pure physiological or pathological necessity like renal calculi. But it at once was found to be of immense value as a skeletal support and protection. Only in some such way does it appear to the writer that we can account for the appearance of hard parts in numerous branches of the animal kingdom at about the same time. It must be due to a general reaction to some general change of environment, and this particular change, supported as it is by analyses of connate waters and the general drift of chemical evolution of the ocean, as well as by the physiological evidence so acutely marshalled by Quinton, is by far the most plausible. This event marks practically the beginning of the Cambrian. The classification which the writer would suggest as probably that of the future is tabulated below. The connotation is very different from that of Van Hise, but in denotation of application the only changes needed will be to remove perhaps a small portion of that generally referred to as Keewatin, as well as the Grenville Limestone and associated beds, from the Azoic.

[1] Judging from the results of analyses of connate waters, the writer leans to chlorides.

SUGGESTED SUBDIVISION OF THE PRE-CAMBRIAN.

Life Eras.	Life.	Ocean.	Land.	Formations.
Palæozoic.	Animals with hard parts and body-cavity closed; land animals begin.	Growing salter, with Na Cl increasing.	Ordinary sediments and fossils.	Cambrian (Keweenawan).
		Total solids 8 per thousand. / Na Cl = 1 : 12 +		
Eozoic or Proterozoic.	Life important, abundant, rapidly increasing, and differentiating, vegetable life on land. Sea animals without hard parts and probably without a closed body-cavity.	Fresh, perhaps slightly acid with volcanic emanations, unfavourable to lime secretion, but precipitating it with iron and magnesia by reaction of chlorides (or sulphates) with sodium carbonate or silicate, and perhaps by vegetation like *Chara*.	Land clothed with low vegetation, chemical composition of streams like those of the Laurentian Highlands to-day; mechanical erosion becomes less, chemical more, important. Sediments: chert, iron oxides, volcanic agglomerates, greywackes, precipitated dolomites, also the ordinary mechanical sediments and black slates. Fossils only preserved as imprints.	Neo-Huronian (Animikie). Mio-Huronian. Eo-Huronian. Logan's Upper Laurentian.
	Animal life begins.	Total solids very low. / Na Cl = 1 : 60 +		
Azoic.	Life absent or local and insignificant, probably a good part of the time conditions such as would make its wide distribution impossible.	Fresh, unfavourable to life, acid with volcanic emanations; chlorides accumulate. Sulphates reduced to sulphides by ferrous iron (?) from basic rocks, hydrocarbons accumulate. Resultant sediments mechanical, not unlike in chemical composition to the rocks from which they were derived, no organic rocks (like black slates), no leached or chemically deposited iron ore, no true massive stratified dolomites, volcanic rocks abundant.	River-water fresh, nearly free from carbonates, with little tendency to leach out the alkalies exclusively. Surface uncovered, exposed to very rapid mechanical action.	(Most of the) Keewatin, Greenstone schists, gneisses (Coutchiching, if it exists, as the writer does not think).

Archæozoic or Proterozoic. Dana's Archæan Pre-Cambrian.

The question naturally arises with regard to the above table, which of the above characteristics shall be taken as determinative in drawing the lines? The writer may be prejudiced by his studies of connate waters, but he feels very strongly that a marked point in the chemical evolution of the ocean, which must be practically nearly universal and coeval, makes the best of dividing lines. So he would put the beginning of the Cambrian at the time the concentration of the ocean passed the physiological optimum (somewhere between six and eight parts per thousand), and the secretion of hard parts by living organisms began, and he would put the beginning of the age previous when the water supplied to the ocean became alkaline, and hence the accumulation of chlorides of lime, magnesia, and iron was checked, and he believes that was due to the first great extension of living vegetation over the surface of the land. He does not believe it purely accidental that massive beds of dolomite, of chert and iron, i.e. jaspilite, and of black slate appear in about the same series.

II.—On the Dentition of the Palate in the South African Fossil Reptile Genus *Cynognathus*.

By Prof. H. G. Seeley, F.R.S., F.G.S., King's College, London.

(PLATE XXIV.)

The Cynodont reptilia from the Lower Karroo rocks of South Africa, characterized by relatively large incisors and relatively small, sharp-pointed, molar teeth, were grouped under the type genus *Lycosaurus* as Lycosauria. The removal of matrix from the palate of *Ælurosaurus* showed that in one member of the group at least the palate carries patches of teeth, each of which has the form of a small blunt flattened cone. From the fact that no Cynodont skull is available in which the mandible is free from the head, the nature of the palatal dentition is imperfectly known.

Of the new Cynodont reptilia obtained by myself from the Upper Karroo rocks in 1889, the most complete were species of *Cynognathus* (Phil. Trans. Royal Soc., B, 1895, p. 59). But these specimens, with relatively large denticulated molar teeth, all have the mandible closed upon the skull, so that the anterior part of the palate is not displayed.

In *Cynognathus crateronotus* (op. cit., fig. 9, p. 83) the palatine bones arch over the palato-nares, but as they extend backward laterally each appears to be twisted over, with a lateral bulge, to make the walls of the palato-nares behind the hard palate. The mandibular symphysis obscures the front of the palate, but it only extends posteriorly as far as the maxillary canines. No teeth were exposed upon the maxillary plates of the palate. The matrix is so intractable and the bones so friable in the figured species *C. Berryi* that no attempt can be made to expose the palate with the chisel. In this species the extremity of the snout is lost. But the weathered nasal chamber shows a vertical median plate of bone (op. cit., fig. 24, p. 124) which appears to enter into the palate, rising for some distance into the nasal chamber, where it is flanked by thin, curved plates which may represent turbinal bones. It is less than $\frac{2}{10}$ inch wide, separated from the flat maxillary bones of the palate by vertical sutures. It appears to afford evidence that the premaxillary bones enter into the front of the hard palate, and are free from palatal teeth. The skull of *C. platyceps* (op. cit., fig. 30, p. 139) adds nothing to our knowledge of the anterior part of the palate. Only the posterior part of the median suture is exposed, dividing the concave channel of the hard palate. There are no indications of palatal teeth; but this is no evidence that such teeth did not exist, for such structures are not likely to be found unless there is reason to look for them, and they would be easily removed by the chisel without detection.

I am indebted to the generous co-operation and enthusiasm of Dr. D. R. Kannemeyer for a fragment of a right maxillary bone from Wonderboom, which has almost exactly the size, form, and aspect of the corresponding region of the jaw of *Cynognathus crateronotus*. I have removed the matrix in the Geological Laboratory of King's College, London; and the bone (Plate XXIV) shows both externally (Fig. 2) and on the palate (Fig. 1) characteristics seen in no other figured example, but confirmed by other evidence in my hands.

The maxillary bone is separated by sutures of a squamose type from the nasal bones above and the premaxillary bones in front. The vertical premaxillary sutural surface is $1\frac{2}{10}$ inch deep, flattened, $\frac{4}{10}$ inch wide, and is limited posteriorly by the large cavity for the mandibular canine, which is excavated in the skull for $1\frac{1}{4}$ inch, and made partly by the maxillary, partly by the premaxillary bone.

Above the premaxillary suture in front is a small, smooth, rounded notch, which appears to be the hinder angle of the anterior narine, between the premaxillary and nasal bones.

The maxillary bone is limited at the upper border by the strong, vertical, squamous suture with the nasal bone. This sutural surface seen on the inner aspect of the specimen is half an inch deep in front, with the depth increasing as it extends backward. The curved contour-line of junction is indicated by the maxillary bone being 2 inches deep in front and about $3\frac{1}{2}$ inches in depth at the vertical fracture behind.

Externally (Pl. XXIV, Fig. 2) the anterior and larger part of the bone is convex, both from front to back and from above downward. This convexity is only modified by a slight, shallow, wide, longitudinal concavity, extending backward from below the nasal suture towards the direction of the prefrontal bone. But inferiorly the bone contracts in width behind the canine tooth, defining the bulbous snout, so that the lower and hinder external surface is concave.

The alveolar border behind the canine tooth, seen from the side, is straight or concave in length, while in front it recedes laterally upward towards the premaxillary suture, being convex above the maxillary canine and concave in front of the mandibular canine.

The posterior fracture passes through a conspicuous, circular, pre-orbital pit in the middle depth of the bone, situated above the fourth or fifth molar tooth. It corresponds in position exactly with the sub-orbital or middle foramen seen in the maxillary bone of the type-specimen of *Cynognathus crateronotus* (op. cit., p. 72, fig. 5). Now that the matrix is removed (Pl. XXIV, Fig. 2), the fossil shows externally at $\frac{9}{10}$ inch above the alveolar border a linear succession of four foramina corresponding in position with the bases of the roots of molar teeth. There are also three or four smaller foramina further forward, nearer the alveolar border, which have no obvious relation to dental nutrition. There are several small, scattered, vascular foramina above the diastema in advance of the maxillary canine tooth.

In the original description the external surface of the anterior bulbous part of the maxillary bone of *C. crateronotus* is only referred to as being irregular with undulating depressions and convexities. In *C. Berryi* the bone shows a finely pitted ornament of a radiating sub-crocodilian type, in advance of the sub-orbital foramen.

In this maxillary bone the ornament (Pl. XXIV, Fig. 2) consists of close-set, small bosses with concave summit-surfaces, surrounded by depressions, which are divided into groups by sub-parallel winding longitudinal canals, with vertical connecting branches. Two or three of these sinuous, vascular channels close together are below the sub-orbital foramen, one is level with it, two are above and wider apart. Some short oblique canals descend upon the convexity of the root of the canine tooth, giving that part of the bone a fluted or folded aspect. The pitted ornament is most dense in the central area above the imbedded root of the canine tooth, and is less distinct downward, forward, and upward to the nasal suture.

The maxillary bone is exceptionally strong, averaging $\frac{8}{10}$ of an inch thick at the posterior fracture, and thinning away in front and above to the squamous premaxillary and nasal edges. Its transverse width on the palate at the canine tooth is $1\frac{8}{10}$ inch, giving the snout a width of about $3\frac{1}{2}$ inches by allowing for the left maxillary.

The internal surface of the bone above the palate and below the wrinkled sutural surface for the nasal bone is smooth, convex over the oblique root of the canine tooth, and excavated concavely below and behind it, owing to the inward extension of the maxillary plate which forms the palate.

The palatal surface of the maxillary bone contracts in width behind the canine (Pl. XXIV, Fig. 1). It is $1\frac{1}{2}$ inch wide over the first molar tooth, and about $1\frac{8}{10}$ wide at the posterior fracture. Anteriorly the palatal width decreases towards the premaxillary suture.

The crowns of all the teeth, canine and molars, are broken off level with the alveolar margin of the jaw, so that no trace is preserved of the characteristic forms of the molars of *Cynognathus*. The base of the crown of the canine is slightly ovate, compressed on the inner hinder side, implanted obliquely, directed forward, downward, and outward. It is 1 inch from front to back and $\frac{7}{10}$ inch transversely. The fracture shows a small pulp cavity.

Behind the canine is the triangular area which indicates the remnant of the base of the milk or first canine, which was removed by absorption (Pl. XXIV, Fig. 1). That tooth-fragment is obscure, but may have been fractured during the life of the animal. The absence of a tooth in this position gives the jaw laterally the aspect of having a small false diastema.

The molar teeth extend backward in a line with the inner border of the canine tooth. They vary in size, but the oval roots of the first five are contained in a length of $1\frac{8}{10}$ inch. The first has a sharp

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EXTERNAL SURFACE.

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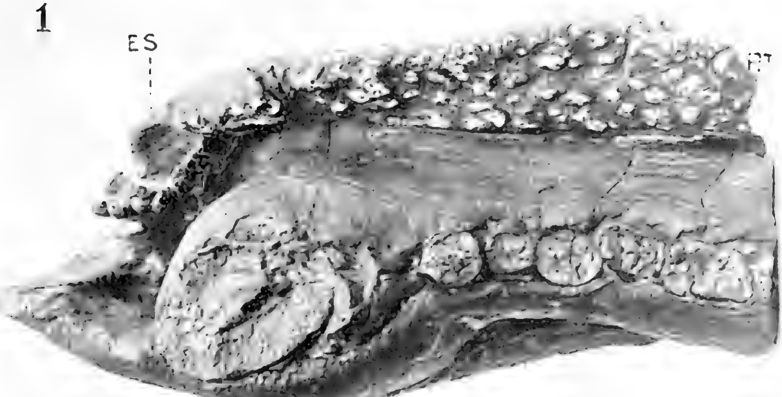


PALATE.

Maxillary dentition and snout-sculpture, *Cynognathus crateronotus.*

cutting-edge in front, and is rather larger than the second. The third is longitudinally oval, and the fourth and fifth are more elongated, with a laterally compressed aspect. All are crowded into close contact.

The fracture passes through the root of the sixth tooth, which is an inch deep in the jaw, and shows the anterior border of a pulp cavity, which appears to be narrow, but is closed at the base. The root is $\frac{3}{10}$ inch wide, slightly curved inward, and its termination shows a slight notch, too slight to suggest root tubercles.

The palatal surface (Pl. XXIV, Fig. 1) comprises three areas: first, the external dentigerous border described; secondly, a middle smooth longitudinal channel; and thirdly, an inner longitudinal dental armature.

The middle concavity is wide and inclined on the outer part, narrow and steep towards the inner teeth. The more flattened part is marked towards the alveolar border with a fine, impressed, longitudinal, vascular line almost like a suture, but there is no trace of sutural separation on the posterior fracture. This smooth area ascends in front of the canine tooth into the pit for the mandibular canine, by a continuous rounded surface. The mandibular canine pit is apparently triangular, $1\frac{1}{2}$ inch deep, convex over the inner side of the canine, concave on the external lateral border, and internally it is obscured a little towards the palatal armature by crushing, but was probably concave.

The smooth palatal surface is about $\frac{3}{4}$ inch wide behind the canine tooth where widest, and extends backward with a uniform width of about half an inch. Opposite the fourth and fifth molars it develops a small longitudinal ridge, and on the inner side, next the palatal armature, there is a deep narrow groove, which is prolonged upward as a cleft or canal as though the palatal plate of the maxillary had originally been a distinct ossification from the dentary plate.

The internal portion of the palate, which carries a dental armature adapted for crushing food, is wedge-shaped in form, narrow in front between the canine teeth, widening posteriorly to fully half an inch at the posterior fracture. On the inner margin it forms a strong dental ridge, but the rest of the plate is inclined outward, so that its thickness diminishes towards the smooth channel already referred to. This armature has a certain resemblance to the tooth-plates of *Hyperodapedon* carried upon the maxillary bones and upon the parallel palatine bones. But these tooth-plates are supported upon the maxillary bone only, like the separate teeth of Endothiodonts and Lycosaurians. This triangular dental wedge is a little injured by transverse fractures, made during movements of the rock, which have bent it slightly outward at both the anterior and posterior ends. The tooth-plates are supported upon a very thin palatal expansion of the maxillary bone. With this the crushing toothed armature unites without visible suture. But a small dental plate anterior to the others was not anchylosed, and is lost. Its empty socket (Pl. XXIV, Fig. 1, E.S.) next the vacuity for the mandibular canine tooth shows that it had a basal and internal support, and rested against the dental plate behind. The premaxillary bones may have extended between and above this region of the armature, but there is no evidence of those bones preserved, unless it be in the anterior internal thickening of the maxillary bone as a wedge which thins as it extends backward supporting the palatal armature. There is no doubt that the tooth-plates met each other in the median line of the palate without any sutural union or connection between the contiguous maxillary bones other than the premaxillary bones may have given.

The inner median surface of the dental plate shows no indication of sutural separation from the opposite maxillary bone, except in the smooth base of the empty anterior socket.

This inner surface of the plate is even, flat, with a straight base-line, prominent above the contiguous maxillary bone, curving upward as it extends forward. It is sub-parallel to the palatal dental crest; the depth of the dental plate is half an inch behind and $\frac{7}{20}$ inch in front. This internal surface shines as though covered with a film of enamel. It is finely pitted along its extent. It is roughened with the contours of constituent denticles, of which there are more than a dozen in a length of 2 inches, all welded together. Some are triangular, and their points do not reach the palatal surface, while the denticles between them, with exposed crowns, have ovate surface contours on the summit-ridge of the palate. The appearance is that of a mass of teeth densely packed in osseous union or cement.

The fractured posterior surface is less clear than might have been expected. It shows that the denticles are parallel to the inner surface and to each other. They are vertical and form about six rows, so that the individual teeth of the successive rows become shorter as they extend outward from the median line in harmony with the incline of the dental plate. The obscure sections appear to be narrow and cylindrical, but the teeth are probably of a flattened ovate form in section, like the low crowns on the palate.

On the palatal surface the denticles are arranged in parallel rows (Pl. XXIV, Fig. 1, P.T.), rising inward in successive tiers one behind another. The short, low crowns have an ill-defined appearance of being also arranged in rows which extend obliquely outward and backward. Each crown is longitudinally ovate. They vary in size and elevation and distance apart. Generally the convex surface carries one or two raised lines and a few granules which show no definite plan of arrangement. The rows of denticles become fewer as they extend forward, and at the front of the principal plate are reduced to three rows. At this point a fracture occurs, which appears to mark a second dental plate, in which all the rows are gathered up into one compressed elevated tooth-mass, about half an inch long. Its constituent denticles appear to be worn with use; they are close set, small, ovate, oblique, and comprise two parallel rows. The narrow missing tooth was shorter and may have had a similar structure.

Having this remarkable armature on the maxillary bones, it was important to re-examine the skull of *Cynognathus crateronotus* in the Natural History Museum, and Mr. Richard Hall has so far removed the matrix from the symphysial region of the mandible, with the approval of Dr. A. Smith Woodward, as to demonstrate the presence of teeth of a similar kind upon the maxillary plate of the palate, and prove that this dental armature is one of the generic characters of *Cynognathus*.

The mammalian aspect of the alveolar dentition in *Cynognathus* may have drawn attention away from the obvious resemblances between the Lycosauria with prehensile molars and the Cynognathia with cutting molar teeth. But the teeth upon the maxillary plate not only emphasise a close affinity between these divisions of the Cynodontia, but appear to indicate wider affinities of the Cynodontia with other Anomodont reptilia. Thus in *Pareiasaurus* the palate carries parallel rows of slender prehensile teeth as well as the alveolar teeth. And in the Endothiodontia the palatal dentition is fully developed though the alveolar teeth are absent. In all these types the palatal teeth preserve their individual separation from each other, and it is only in *Hyperodapedon* that any parallel is found to the way in which the palatal plate is formed in *Cynognathus*.

The posterior widening of the palatal armature by which the crowns of the denticles become separated from each other I regard as a specific character only, for in the badly preserved and crushed skull of another species the posterior expansion of the dental plate appears to be absent. If that specimen should eventually have the matrix removed sufficiently to be figured, it will show that the posterior nares were margined in this genus by broad, flattened, dental bands upon the palatine bones which have the aspect of crushing teeth, wrinkled transversely in front and somewhat tuberculate behind, but quite unworn, as might have been anticipated. The palatine dental plates can only be uncovered with the needle, and would be lost under the chisel.

EXPLANATION OF PLATE XXIV.

Maxillary dentition and snout-sculpture of *Cynognathus crăteronotus.*

Fig. 1.—Palatal aspect of the right maxillary bone, showing A.T., the line of alveolar teeth, and the large canine tooth, all broken off in their sockets, also the pit for the mandibular canine tooth in front. Internal to these teeth is the smooth concave tract of the palate. P.T. indicates the long wedge of consolidated palatal teeth, narrowing in front. The crowns of these teeth have been touched with white to throw them into more distinct relief in the photograph. E.S. is the empty socket from which a tooth appears to have been lost.

Fig. 2.—External surface of the anterior half of the maxillary bone, showing the pitted and vascular sculpture. The notch in front indicates the back of the narine. Above is the line of suture with the nasal bone. The base of the canine tooth is visible on the convex middle part of the alveolar border.

The figures are of natural size.

III.—On a large Cirripede belonging to the genus *Loricula*, from the Middle Chalk (Turonian), Cuxton, near Rochester, Kent.

By Henry Woodward, LL.D., F.R.S., F.G.S., V.P.Z.S.

More than sixty years ago Mr. G. B. Sowerby, jun., described and figured a unique specimen of a remarkable fossil Cirripede from the Chalk of Kent which he named *Loricula pulchella.*[1] It was obtained by Mr. N. T. Wetherell, F.G.S., of Highgate, and was subsequently acquired with that gentleman's collection by the British Museum (Natural History). Mr. Wetherell's *Loricula* was again

[1] G. B. Sowerby, jun.: Ann. Nat. Hist., 1843, vol. xii, p. 260.

described and figured by Charles Darwin in his "Monograph on the Fossil Lepadidæ or Pedunculated Cirripedes of Great Britain."[1]

About thirty years ago I found a second specimen of *Loricula pulchella*, or, I ought rather to say, the *intaglio* or hollow impression left by the upper surface of its valves, upon the shell of an *Ostræa* from the Chalk, which had evidently grown upon the *Loricula*, and thus preserved on the outside of its attached valves a perfect facsimile of the upper surface of the Cirripede. At that time I made a cast in *relievo* from this natural mould and placed the two side by side in the British Museum case next to Mr. Wetherell's type-specimen. (See Gallery viii, Geology, Invertebrata, T. Case 22.)

Professor K. A. von Zittel[2] has described a *Loricula* (*L. lævissima*) from the Senonian (Upper Chalk) of Dülmen, Westphalia, and Professor W. Dames[3] *Loricula Syriaca* from the Cenomanian (Lower Chalk) of the Lebanon.

In 1887 Professor Dr. Anton Fritsch[4] described and figured a number of *Loriculæ* from the Turonian (Middle Chalk) of Weissenberg, Bohemia, which he referred to Sowerby's *L. pulchella*, making two varieties, *L. pulchella*, var. *gigas*, and *L. pulchella*, var. *minor*, both of which were found attached to specimens of *Ammonites peramplus* and *Ammonites Woolgari*.

Dr. J. F. Whiteaves, in 1889, described a species of *Loricula* under the name of *L. canadensis*, Whit., from the Cretaceous, Fort Benton group, south of Duck River, Township 34, Range 23 W. (See Cret. Foss. British Columbia, North-West Territory and Manitoba: Contrib. Canadian Palæontology, 1889, vol. i, pl. xxvi, figs. 4, 4*a*.)

In 1907 Mr. George E. Dibley, F.G.S., who has for some years carefully collected the fossils of the Chalk formation of Kent, etc., was so fortunate as to obtain from the Turonian (Middle Chalk, in the zone of *Rhynchonella Cuvieri*) at Cuxton, near Rochester, three specimens of *Loriculæ* attached to the shell of an Ammonite, *Pachydiscus peramplus* (Mantell). These beautiful specimens are now preserved, like the type itself, in the Geological Department of the British Museum (Natural History).

Saving some small distinctions to be presently pointed out, and some additional details not preserved in Mr. Wetherell's original specimen, those now obtained agree generally with the type, but are more perfect and much larger in size. One point of very great interest lies in the fact that Mr. Wetherell's type-specimen, and those since discovered by Mr. Dibley, were all obtained from the same locality, and in each instance were found attached, parasitically, by the side

[1] Charles Darwin, Fossil Lepadidæ, 1851, pp. 81–6, Tab. v, figs. 1–4: Mon. Pal. Soc., 1851, vol. v.

[2] K. A. von Zittel, "*Loricula lævissima*, Zittel, Ob. Kreide, Dülmen, Westfalea": Sitz. der Math.-phys. Classe vom 8 Novr., 1884, pp. 586, 587, fig. 4, *Loricula lævissima*. "*Loricula Syriaca*, Dames, Cenomanian": op. cit., p. 589, fig. 5.

[3] W. Dames, "Ueber eine Art Cirripeden Gattung *Loricula* aus den Kreideablagerungen des Libanon (*L. Syriaca*)": Berlin Naturf. Freunde Sitzber., 1878, pp. 70–4.

[4] Dr. Anton Fritsch and Jos Kafka: "Die Crustaceen der Böhmischen Kreideformation Prag," 1887, pp. 1–3, Taf. i, 4to.

of the peduncle to the shells of Ammonites. This was also the case with all the examples of *Loricula* discovered and described by Dr. Fritsch from the Chalk of Bohemia (see *ante*).

Specimens of the still earlier *Pollicipes concinnus*, J. Morris (Annals N.H., 1845), from the Oxford Clay were also found in a group attached to the shell of an Ammonite, *Amm.* (*Cosmoceras*) *Elizabethæ*, from that formation, but in *P. concinnus* the peduncle was free and movable, not attached by one side to the Ammonite shell, only fixed by its base.

Fig. 1. The most perfect of the three specimens attached to the newly discovered Ammonite (*Pachydiscus peramplus*) from Cuxton, near Rochester, measures 45 mm. in length and 25 mm. in extreme breadth (the breadth being greatest across the peduncle at about the ninth row of scales, below the capitulum). Measured obliquely along the base of the capitulum where it unites with the peduncle, it is only 20 mm. in breadth, the height of the capitulum being 15 mm. and the length of the peduncle 30 mm.

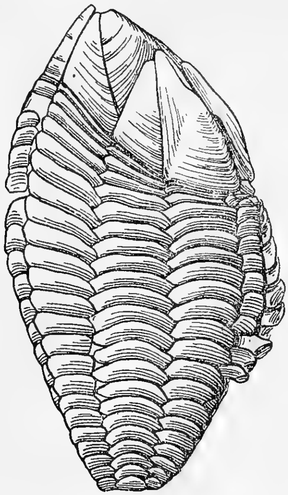


Fig. 1.—*Loricula Darwini*, H. Woodw., sp. nov., one of three specimens found attached to an Ammonite from the Middle Chalk, Cuxton, near Rochester, Kent, now in the British Museum, Geological Department. Drawn twice natural size. [Registered No. I. 9130.]

The *Capitulum.*—In an ordinary pedunculated Cirripede this would consist of 10 valves (4 being paired lateral valves and 2 marginal single ones), namely, 2 terga, 2 scuta, 2 carinal latera, 2 middle or upper latera, and, lastly, a carina and a rostrum.

In the original specimen of *Loricula* figured and described by Darwin, only 3 valves are preserved, namely, a scutum, a carinal latus, and a middle or upper latus; he assumes, however, that a tergum, a carina, and a rostrum must have been present when it was perfect, and that in order to complete the specimen a corresponding set of paired valves originally existed on the lower side of the capitulum.

In the newly obtained specimens the upper exposed surface (Fig. 1) of the capitulum shows the carina, see lettered Diagram-outline figure (Fig. 2, *c*); the second or carinal latus (*l*); the first, middle, or upper latus[1] (*l′*); the tergum (*t*); the right scutum (*sct*); and one sees the inner occludent margin of the left scutum (*sct′*) exposed beneath the right one.

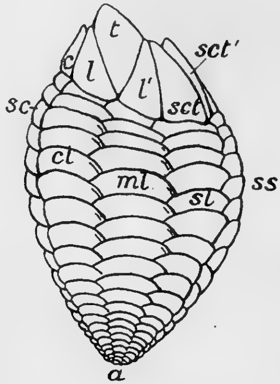


Fig. 2.—Diagram-outline of *Loricula pulchella*, G. B. Sowerby, var. *minor*. (After Fritsch.) From the Chalk of Bohemia.

Valves of *Capitulum*.—*c*, carina; *l*, carino-latus[2]; *t*, tergum; *l′*, upper latus or middle latus[2]; *sct*, scutum; *sct′*, edge of the pair-valve of scutum seen from the inside. (The small rostrum is not seen in any of the specimens, and was lost, or probably aborted.)

Peduncle.—*sc*, series of carinal scales; *cl*, carino-lateral series of scales; *ml*, medio-lateral series; *sl*, series of scutal scales; *ss*, sub-scutal (or sub-rostral) series of scales.

a, initial point of attachment of the young animal in the earliest stage of its becoming fixed and ceasing to be a free-swimming nauplius.

In all the specimens at present known and examined, however, the rostrum (usually a very small single valve lying at the base of the paired scuta) appears to have been absent,[3] but, arguing from the lines of scales seen in the peduncle, Darwin believes that a rostrum most probably existed. With this exception the capitulum may be said to be complete.

The small size of the capitulum, and its narrowness compared with the breadth of the peduncle, led Darwin "to believe that the greater

[1] In his monograph on the Fossil Lepadidæ (Pal. Soc., 1851) Darwin writes, p. 85: "In the imaginary restored figure [Tab. v, fig. 4, op. cit.] the tergum has its normal shape and manner of growth. The first latus now answers to the *upper* latus in *Scalpellum*, but it is interposed to a quite unprecedented extent between the scutum and tergum [see Fig. 2, *l′*]; the second latus [see Fig. 2, *l*] is on this view the carinal latus; and the rostral latus, always smaller than the carinal latus, and in *Scalpellum quadratum* and *S. Peronii* reduced to a very small size, is here quite aborted."

[2] *l′* is spoken of by Darwin also as the first latus; *l* is referred to by Darwin also as the second latus.

[3] It seems not improbable that in *Loricula* the rostrum may have been aborted in this curious parasitic form.

part of the animal's body was lodged in the peduncle, as in the recent genera *Lithotrya* and *Ibla*" (op. cit., p. 82).

We are, fortunately, able to record the complete series of the valves of the capitulum in *Loricula* as seen upon the exposed upper right side of the specimen recently acquired for the British Museum, with the exception of the rostrum, which may or may not have been present, but in any case it has not been preserved in any of the examples so far discovered.

Carina.—The carina is 5 mm. in height by 2 mm. in greatest breadth at its base, and tapers to a point at its summit; it is marked by fine transverse lines of growth. The 'carinal latus' (also called the 'second latus') is obliquely triangular; it is 5 mm. in height upon the carinal border, which is nearly straight, the apex only being slightly curved towards the tergum; the tergal border is slightly concave and is 10 mm. in length, the lower point being covered by the base of the middle or scutal latus (also called the 'first latus'); the base, which is somewhat curved, is 7 mm. broad.

The middle or first latus is 6 mm. in height on the tergal border and 8 mm. on the scutal margin (its apex is slightly abraded); its base 4 mm. broad. Resting between these is the tergum, which measures 7 mm. along its carinal-lateral border, 5 mm. upon its upper free occludent border, and 7 mm. on its latero-scutal border; both the upper points of the middle latus and scutum slightly overlap the tergum.

The scutum is the largest paired plate in the capitulum, being 8½ mm. in height along its lateral margin and 11 mm. along its occludent margin, the ascending wing being much prolonged upwards beyond the umbo, and very attenuated and narrow like the valve of a mollusc, such as *Neæra*, the base being 5 mm. broad; the lines of growth in the lower part of the valve are parallel to the tergo-lateral and basal margins; the umbo of the valve, which is largely developed and very prominent, is 5 mm. below the apex, in fact about midway on its occludent margin. Mr. Darwin writes (op. cit., p. 82): "In this important respect [the scutum of] *Loricula* resembles that of *Scalpellum magnum*, *S. tuberculatum*, and *S. cretæ*."

In evidence of the presence of both upper and under side of the paired plates to the capitulum in *Loricula*, the new specimen (Fig. 1) shows clearly, and Dr. Fritsch's specimen (Fig. 2) also, the inner margin of the second valve of the scutum (*sct'*) exposed beneath the occludent margin of the upper valve. It is along the occludent borders of the paired tergal and scutal plates that the cirri of the Cirripede are extruded in search of food, or again withdrawn within the capitulum when the animal is alarmed or at rest.

Peduncle.—This has a most singular, elegant, loricated structure; it is wider than the capitulum and twice as long. It is entirely covered, at least upon its exposed surface, by three nearly equal rows of smooth, calcareous scales, much elongated transversely, the ends of the scales in each row intersecting those in the adjacent rows[1] and

[1] The beautiful imbricated arrangement of the rows of transversely elongated calcareous plates, protecting the peduncle in *Loricula*, suggests at once comparison with the test of that anomalous Cretaceous Echinoderm *Echinothuria floris*,

corresponding in longitudinal order with the valves above each row in the capitulum, the left-hand long row (see Fig. 2, *cl*) being immediately below the carinal latus (*l*); the middle row (*ml*) below the median or upper latus (*l′*); the scutal row (*sl*) below the scutum (*sct*). Outside these are two very narrow rows of scales, that on the left-hand margin of the peduncle, named the carinal series (*sc*), being immediately below the carina (*c*), that on the right-hand (*ss*) being the sub-rostral (?) or sub-scutal row. On the same margin may be seen a portion of yet another series of narrow scales showing their *inner surfaces* (see Fig. 1, right-hand side of peduncle), which are no doubt the second row of sub-rostral or sub-scutal scales, forming the *attached* margin of the peduncle, but slightly displaced like the inner border of the left scutum (*sct′*) seen immediately above them.

Taking the rows in order, from left to right, in the peduncle, the first carinal row is only about 1½ mm. in breadth at the base of the carina, and the scales are almost rectangular oblong in shape and are not imbricated as in the three central series; they are 17 in number and diminish gradually downwards to about 25 mm. from the capitulum, when the series disappears, only the three central transversely elongated lines of scales being persistent to the extremity of the peduncle. Although visible in other specimens, as well as in Darwin's type-specimen, the small initial extremity of the peduncle in the large new specimen is imperfect (see Fig. 1). This tiny point may represent the loss of five or even six rows of very minute scales, so that in counting the number in these three central series five lost scales may very safely be added to each. The carino-lateral row is 5 mm. broad just beneath the latus; there are 23 scales in the longitudinal series (+ 5 missing = 28), which is one more than in the median row. These scales are not imbricated with the carinal row, being only united by a straight, simple line of suture, but on the inner border the end of each scale is pointed where it interlocks with two rows of the median series, so that the scales in each series alternate with the row adjoining it. The scales are slightly arched along their upper margins, and after the ninth scale, counting from the capitulum, they diminish rapidly in breadth to the apex. The median lateral scales are the most symmetrical series; they are slightly wider (near the middle of the peduncle) than those on either side, and each scale is pointed at both ends, their upper margins being flatly arched near the capitulum, and more strongly arched in the lower part of the peduncle. They have one less scale (22 rows) than in the preceding series, and they diminish less rapidly in breadth downwards than the lateral series of scales.

The scutal series of scales are 4 to 5 mm. broad at their upper and

S. P. Woodward, described and figured in the *Geologist* for 1863, vol. vi, pp. 327–30, pl. xviii, in which the test of the Echinoid is rendered flexible by ten segments, or a double series of imbricating calcareous plates. See also Wyville Thomson's account of the living genus *Calveria* (*Asthenosoma*) *hystrix*, in "Depths of the Sea," 1873, pp. 155–9, and Phil. Trans. Roy. Soc., 1874, vol. clxiv, pp. 730–7; and Professor J. W. Gregory on Echinothuridæ, etc., Quart. Journ. Geol. Soc., 1897, vol. liii, pp. 112–22.

widest part; there are 21 rows, not counting the lost small extremity; the scales in each row are pointed at their inner end where they unite with the alternate rows of the median lateral series, but they unite by a nearly straight suture with the sub-scutal or sub-rostral series. This outer (rostral?) row (like the carinal row on the opposite side of the peduncle) is only $1\frac{1}{2}$ mm. broad; the scales are almost rectangular in form and are evidently incomplete at their lower end, only 8 being preserved. Beyond this row is seen yet another series, 10 in number, evidently a second rostral series, belonging to the margin of the lower side of the peduncle, attached to the shell of the Ammonite, as they show the inner surface of the scales slightly displaced, having only a straight suture-line to unite them with the overlying narrow series.

Writing of the peduncle (p. 82, op. cit.) Darwin says: "The base is sharply pointed, down to which the full complement of scales extends. In each row there are about 21 scales, their number obviously depending on the age and size of the individual" (p. 83).

We have already pointed out the difference in the number of scales in the three principal series, viz., 23 rows in the carino-lateral, 22 in the median, and 21 rows in the scutal series, causing the very oblique arrangement of the capitulum, which slopes downwards from the carina towards the scutum. Darwin also refers to this: "There is one more scale under the second latus than under the first [or middle] latus, and one more under this than under the scutum; hence the summit of the peduncle is obliquely truncated, being lowest at the rostral end. In this respect there is some resemblance to the genus *Lithotrya*."

Growth.—Under the subject of growth Darwin says (p. 84): "New scales for the peduncle are formed round its upper edge at the bases of the valves of the capitulum, the chief growth of which is downwards: hence we here have, as in other pedunculated Cirripedia, a principal line of growth round the summit of the peduncle. It can be seen that a new scale is first formed under the second latus, at the carinal end of the peduncle, and this agrees with the fact that there is one more scale in this row than in that next to it, and one more in the latter than in the row under the scutum. I may mention, as in conformity with this fact, that in the development of the young of *Scalpellum vulgare* from the larval condition the calcareous scales on the peduncle first appear under the carina."

In Darwin's description of *Loricula pulchella* (op. cit., p. 81) he describes the peduncle as having "*ten rows* of smooth calcareous scales, five rows upon the *upper* and five rows on the *under* surface of the peduncle, of which the six lateral rows are much elongated transversely, and the four end rows narrow; and that along the rostral and carinal margins of the peduncle there is a straight medial suture, with the scales not intersecting each other."

Having carefully removed the Chalk from beneath one of Mr. Dibley's specimens (now in the British Museum, No. I. 9130), I find that the three principal rows (Fig. 1, *cl*, *ml*, and *sl*) of much elongated calcareous scales are absent, and I therefore venture to suggest that they were *not developed upon the underside* of the peduncle, which was attached to the shell of the Ammonite along the margins (Fig. 2, *sc* and *ss*), the mode of growth of *Loricula* being *always prone*, from the time it first abandoned its free-swimming larval existence and became fixed at the initial point (*a*), only the capitulum retaining its valves complete on both surfaces, so as to enable it to open and close its body-cavity and allow the cirri to be freely protruded and retracted at pleasure. Darwin has himself stated that "in *Loricula* the attachment was probably by one lateral face of the lower part of the peduncle, for it is by no means unusual for the cement-stuff (even when proceeding only from the two original central orifices, where the prehensile antennæ of the larvæ may still be found) to encroach largely on the peduncle, and thus fix it down. The calcareous scales of *Pollicipes* and the horny spines of *Ibla* may often be found thus embedded and firmly fixed to the supporting rock; it is, moreover, possible that in *Loricula* the cement was poured out of orifices specially situated on one side of the peduncle, as takes place along the rostral margin in *Scalpellum vulgare* and high up on both sides of the peduncle in *Lepas fascicularis*" (Darwin, op. cit., p. 84).

Mr. Darwin states that Mr. Wetherell's original type-specimen which he so carefully described was found "embedded outside the cast of an Ammonite" (op. cit., p. 82), from which it appears he did not quite realize that it was adhering to the shell and parasitic upon the Ammonite, as *Coronula balænaris* attaches itself to the skin of the whale, and *Chelonobia testudinaria* and *C. caretta* affix themselves to the carapace of the turtle to-day.

The abundant evidence now obtained from the Chalk of Bohemia and the Chalk of Kent as to the habit of *Loricula* to live attached to the shells of Ammonites is conclusive that it was always firmly fixed by one side of its peduncle, and that in all probability the calcareous scales were only developed upon the upper exposed surface.

In connection with this remarkable loricated form of Cirripede *Loricula* it may not be uninteresting to quote the observations of Monsieur A. Gruvel, who has devoted so many years to this group:—[1]

"It is impossible for us to arrive at an exact idea of the form under which the first ancestor of the Cirripedia showed itself after the initial *Cypris*-state. In the present condition of our palæontological knowledge of these animals, the first traces which remain to us are met with in the Silurian and Devonian strata of Europe and North America by those calcareous scales, very similar in appearance, which were considered by Professor de Koninck as the plates of Chitons (*Chiton Wrightianus*), by H. Woodward as peduncular scales, and by Barrande as part of the capitulum of a Cirripede.

"Our opinion is that they are the remains of the *complete imbricated covering* of a primitive Cirripede, first correctly designated by H. Woodward under the name of *Turrilepas*. The real animal may be said to have been enclosed in this species of scaly cylinder, which afforded only a poor protection to its appendages and soft parts. To furnish a more efficient shelter, the plates of the upper row were

[1] "Monographie des Cirrhipèdes ou Thécostracés," par A. Gruvel, Université de Bordeaux. Roy. 8vo, pp. x + 472 = 482, avec 427 figures in text. Paris: Masson & Cie., 1905.

much more specially developed than the others, and the hard external covering was more completely divided into two series; the upper series being more developed to form the plates of the *capitulum*, whilst the remaining rows, nearly all alike in form, constituted the scales of the *peduncle*. It is here that we have observed a modification in a form belonging to the Cenomanian (*Loricula Syriaca*, Dames) and in another form from the Upper Chalk (*Loricula pulchella*, Sow.). The evolution beginning in this way becomes more and more apparent, in such a manner as to constitute finally the forms with which we are familiar in both a fossil and recent state, as *Pollicipes* for example, in which two very distinct general regions exist, one above forming the capitularian plates, which are well developed and most thoroughly protect the soft parts of the animal, and another lower region, serving solely as a support and covered by the peduncular scales, nearly all alike and much smaller in size than those of the capitulum.

"The above deductions are supported clearly, not only by palæontological proofs which we shall specify, but also facts of embryology and anatomical details.

"Therefore, if, for example, one studies the post-larval development of *Pollicipes polymerus*, Sow., one sees that in very young specimens it is impossible to define the capitulary region because the lower plates of the capitulum nearly resemble the upper scales of the peduncle.

"Again, Koehler was the first to point out an organ in the centre of the scales of *Pollicipes*, which we have described after him as being an organ of sensation. One finds this again, modified it is true, quite in the inferior plates. It only disappears in those in which the scales have arrived at a much higher stage of development.

"We see, on studying each of the sections of this sub-class, how the different forms are derived from the primitive type and how they are connected again one with another." (Gruvel, Introduction, pp. 5, 6.)

This large *Loricula*, both on account of its much greater size and more remarkable capitulum, merits recognition as a new species, rather than to be placed with *Loricula pulchella* or only treated as a variety. If such distinctive points as the form of the scutum and the latera deserve specific recognition,[1] I desire to name it after the illustrious author of the monograph on the Cirripedia [published by the Ray Society, 1854], and of the fossil Lepadidæ and Balanidæ [by the Palæontographical Society, 1851 and 1854], *Loricula Darwini*,—whose great work on "The Origin of Species by Natural Selection" has just been celebrated by the Linnean Society of London.

I am much indebted to my friend and former colleague for so many years, the present Keeper of the Department of Geology, Dr. Arthur Smith Woodward, F.R.S., for giving me the pleasure of describing this fine, newly discovered *Loricula* from the English Chalk, which has now been added to the National Collection.

[1] A comparison of *Loricula Darwini* (Fig. 1, *supra*, p. 493) with that of *L. pulchella*, var. *minor* (Fig. 2, p. 494) will emphasize the specific differences between the former and the latter. Fig. 2 agrees closely with Darwin's original figure of *L. pulchella* (Mon. Pal. Soc., 1851, T. 5), especially in the outline of the valves of the capitulum, and both differ markedly from the capitulum of *L. Darwini*, as drawn in our Fig. 1.

IV.—Notes on the Petrography of Egypt.[1]

By W. F. Hume, D.Sc., A.R.S.M., F.G.S., Superintendent, Geological Survey of Egypt.

(WITH A PAGE MAP.)

PRIOR to the foundation of the Geological Survey of Egypt in 1896, the general relations of the sedimentary strata had already been established on a firm basis by the labours of numerous observers, but the characters and affinities of the igneous and metamorphic rocks had been but little investigated. Such studies as had been made were more or less isolated in character, those that had been carried out including a description of rock-specimens from the First and Second Cataracts by Newbold,[2] Delesse,[3] Dawson,[4] Bonney,[5] and Miss Raisin,[6] of the Abu Zabel basalts by Arzruni, of some Eastern Desert rocks by Liebisch (Zeitschr. d. Deutsch. Geol. Gesellschaft, 1877, xxix, p. 712), and, in addition, the principal ornamental rock of Egypt, the Imperial Porphyry, had received special attention (see references in Barron & Hume, "Eastern Desert of Egypt," p. 236, etc.),[7] but a general picture of the petrographical history of Egypt as a whole has not yet been delineated. Pending a more detailed description of the Egyptian igneous and metamorphic rocks, the following epitome of the results already obtained may be of interest, the region under consideration embracing Egypt and the Sudan, the peninsula of Sinai, and the countries immediately adjacent.

The subject may be most conveniently considered under the following six divisions:—

I.—Gneisses: (*a*) Cataract gneisses, (*b*) Arabian Desert gneisses.
II.—(*c*) Pre-Carboniferous plutonic rocks, (*d*) red granite, (*e*) igneous dykes.
III.—Pre-Carboniferous volcanic and sedimentary series.
IV.—Ancient metamorphics of schistose character.
V.—Carboniferous and post-Carboniferous volcanic activity.
VI.—Early Tertiary volcanic occurrences.

I.—Gneisses.

(*a*) There is little doubt that the ancient continental core of this vast area is represented by the *Cataract* and *Sudan* gneisses and schists, which often display banding of marked character, both the more closely foliated schists and highly crystalline gneisses being

[1] A brief abstract of this paper appeared in the Geological Magazine for October, p. 465. Read at British Association, September 4, 1908. Given by permission of Director-General, Survey Department.

[2] "On the Geology of Egypt": Q.J.G.S., 1848, vol. iv, pp. 324–49.

[3] "On the Rose-Coloured Syenite of Egypt": Q.J.G.S., 1851, vol. vii, pp. 9–13.

[4] "Geology of Egypt": Geol. Mag., 1884, pp. 289–92, 385–92, 439–42.

[5] "Note on the Microscopic Structure of some Rocks from the neighbourhood of Aswan": Geol. Mag., 1886, pp. 103–7.

[6] Geol. Mag., 1893, pp. 436–40, and Q.J.G.S., 1897, vol. liii, pp. 364–73 (on rocks collected by Captain Lyons).

[7] There are also some notes on the rocks from the Sinai Peninsula by Professor Bonney in Palmer's "Desert of the Exodus" (1871, p. 556), and by Mr. Rudler in Appendix B of Professor Hull's Memoir on the Geology, etc., of Arabia Petræa.

represented. In general the latter consist of highly acid and hornblendic or mica-bearing varieties, as granitoid gneiss forming the main rock in Uganda and the Southern Sudan. They extend from Kordofan to the base of the Abyssinian hills (where the volcanic series overlies this ancient formation), and once more reappear as prominent members in the various cataract regions. The banded gneisses have also been proved to be the fundamental member north of the Shabluka rapids (Sixth Cataract), between Abu Hamed and Shirri Island in the Fourth Cataract, forming the base-rock of the Third Cataract region, of Semna, and of Ambugol, between Dongola and Wady Halfa, and are again present in the outskirts of Aswan. Nor are they absent in the great deserts east and west of the Nile, for the writer has met with them near the Arbain Road far south of Kharga Oasis, and west of the Nile between Ibrim and Dungul, while in the Eastern Desert they form the bold peaks of Meeteq, of Sebahi, and the Abu Tiur, familiar to all travellers down the Red Sea, and are of the widest extension both near the emerald mines of Sikait and in the desert south-east of Aswan. This ancient series still requires most careful and exhaustive study, and may in part at least represent an intrusive magma anterior to the great post-Archæan sedimentary series, which will be described later. Dawson has remarked on their great resemblance to the Laurentian series of North America, and the Cataract gneisses also appear to agree closely with the Bengal gneisses of India (see Vredenburg, Summary Geol. India, p. 5).

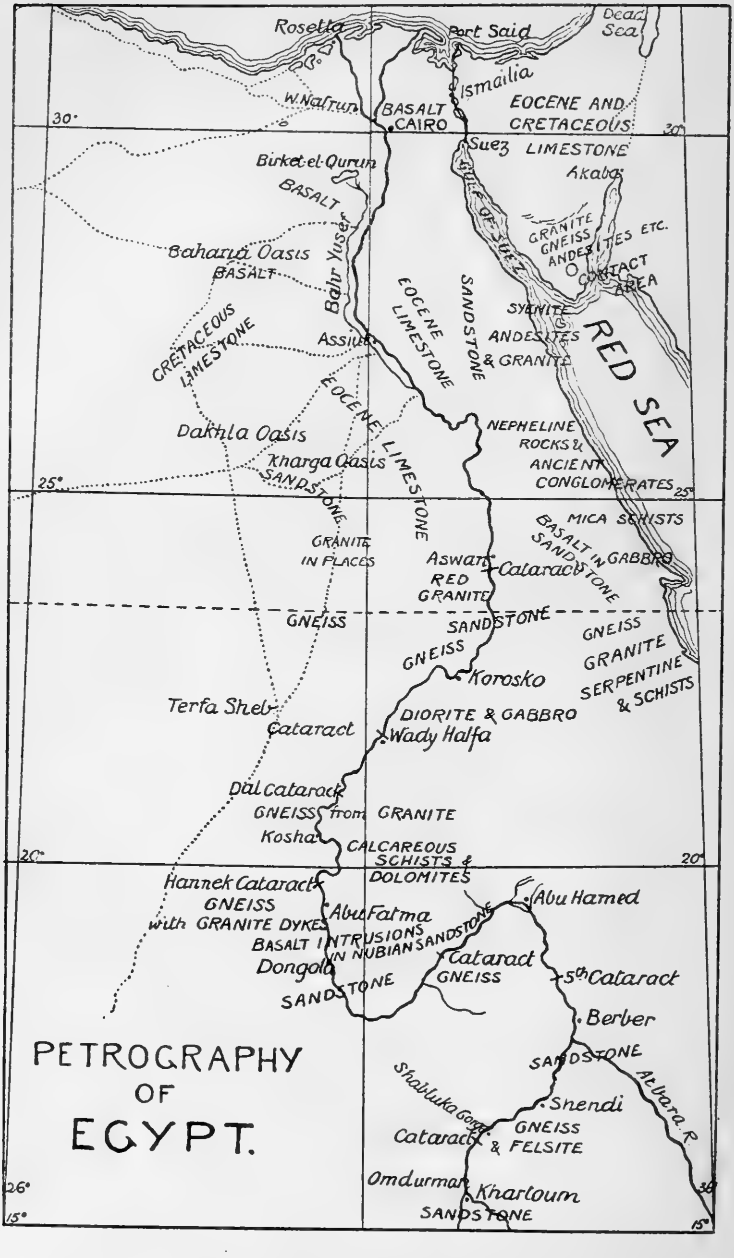
Although the main banding or foliation of these rocks appears to be an original structure, or, if the result of earth-movements, of very ancient date, a pseudo-foliation has in some cases been produced, due to the intrusion of thin granitic veins between the foliated gneiss, giving rise to a very coarsely banded variety, such as is present at Nab Island, in the Third Cataract area, north of Dongola.

The gneiss of the Dal Cataract region, south of Wady Halfa, can also be distinctly traced back to a granite with large porphyritic felspar crystals, but it is open to question whether this rock is of as great an age as the more highly foliated members, rich in mica or hornblende, which form the principal constituent of this division.

(*b*) A second type of gneiss, that of the Arabian Desert, has a very wide extension in the Eastern Desert and Sinai, but has no marked foliation except in isolated instances. It agrees with the Bundelkhand gneiss of India in having the general characters of a fairly coarse pink granite, though many varieties have been observed. The evidence available indicates that this series represents a granitic magma which has played a most important part in the structure of the Eastern Desert and Sinai.

These great acid intrusions appear to have been of two dates, one preceding the deposition of the pre-Carboniferous sedimentaries, as these contain fragments of granitic rocks (both hornblendic and more acid types) among the boulders and pebbles of their conglomerates. A younger granite invasion has subsequently produced marked contact changes, especially in Eastern Sinai.

It is difficult at present to indicate definitely the origin of the banded gneisses, though the writer after examination of these rocks


PETROGRAPHY
OF
EGYPT.
Rosetta
Port Said
Dead Sea
Ismailia
W. Natrun
BASALT
CAIRO
EOCENE AND
CRETACEOUS
LIMESTONE
Suez
Akaba
Birket-el-Qurun
BASALT
GULF OF SUEZ
GRANITE
GNEISS
ANDESITES ETC.
CONTACT AREA
Baharia Oasis
BASALT
Bahr Yuser
EOCENE LIMESTONE
SANDSTONE
SYENITE
ANDESITES
& GRANITE
RED SEA
CRETACEOUS LIMESTONE
Assiut
EOCENE LIMESTONE
Dakhla Oasis
Kharga Oasis
SANDSTONE
NEPHELINE
ROCKS &
ANCIENT
CONGLOMERATES
MICA SCHISTS
BASALT IN SANDSTONE
GABBRO
GRANITE
IN PLACES
Aswan
Cataract
RED
GRANITE
GNEISS
SANDSTONE
GNEISS
Korosko
GNEISS
GRANITE
SERPENTINE
& SCHISTS
Terfa Sheb
Cataract
DIORITE & GABBRO
Wady Halfa
Dal Cataract
GNEISS from GRANITE
Kosha
CALCAREOUS
SCHISTS &
DOLOMITES
Hannek Cataract
GNEISS
with GRANITE DYKES
Abu Fatma
BASALT INTRUSIONS
IN NUBIAN SANDSTONE
Dongola
SANDSTONE
Abu Hamed
Cataract
GNEISS
5th Cataract
Berber
SANDSTONE
Atbara R.
Shabluka Gorge
Shendi
Cataract
GNEISS
& FELSITE
Omdurman
Khartoum
SANDSTONE
30°
25°
20°
15°

over wide areas leans to the view that these represent the earliest igneous intrusions observed in Egypt, and that the magma was more readily plastic than in the later intrusions.

No such difficulty exists with regard to the Arabian Desert gneiss, which in a large number of cases reveals its granitic or igneous origin by the effects produced where it is in contact with the ancient sedimentaries subsequently described, and is thus directly connected with

II.—The Pre-Carboniferous Plutonic Rocks.

(*c*) The rocks of this series vary from the most highly acid granites to ultra-basic varieties. Of these undoubtedly the most interesting is the *Red Granite* of Aswan, which has recently been described by Ball ("Aswan Cataract," p. 70) in some detail. This rock is characterized by the large idiomorphic crystals of orthoclase, associated with quartz, biotite, and hornblende. The latter is very variable in quantity.

Ball has further shown that the granite has undergone intense crushing, the orthoclase having been completely changed to *microcline*,[1] while round the large crystals is a 'mortar' of small granules resulting from the attrition consequent on the sliding produced by the act of crushing.

During the course of the Survey much interesting material has been collected bearing on the results of contact-metamorphism near the junction of the plutonic rocks and the schistose (ancient sedimentary) rocks into which they have been intruded. The plutonic rocks in numerous instances have been found to undergo a change from acid to more basic varieties. In Sinai, near Dahab, the gneissic fringes are well marked, hornblende or mica increase in quantity near the junction, and *sphene* may become an important constituent.

Syenites in general are rare, though well developed at Aswan and Jebel Zeit, but *diorites* are of the widest extension throughout the Arabian Desert. The dark rocks constituting the principal member of the Second Cataract at Wady Halfa is also of this nature, the hornblende being present in large quantity. *Quartz diorites* are especially present in the neighbourhood of the Imperial Porphyry region of Dokhan.

In some areas *basic rocks* attain unusual development, especially in the neighbourhood of the Qena-Qosseir Road, about lat. 26° N., between the Nile and the Red Sea. These usually are in the form of coarse *gabbros*, which are composed of plagioclase and augite, but the latter readily changes to hornblende. Locally the rock may be almost purely composed of diallage, and under such conditions is sometimes highly magnetic, while at El Ranga, near the old Berenice, hæmatite has been produced by concentration from a gabbro rich in a ferruginous constituent. A very hard gabbro is also present in the

[1] The formation of microcline appears to be associated with the crushing in this case, but that it always originates in this way is not implied in the above remarks. Professor Bonney (in a letter) mentions the 'Laurentian gneisses' as a case where no such evidence is forthcoming.

Second Cataract, forming the sides of the Bab-el-Kebir rapid, whose presence is due to the wearing away of a porphyrite dyke intrusive in the massive basic rock.

Norites, etc., have been observed locally in the Eastern Desert, but their general relations are still obscure, and massive beds of dolerite form an important constituent between Qena and Qosseir.

The rarity of felspathoid rocks in Egypt renders occurrences of this nature of special interest. In 1896 Mr. Barron brought back a rock from the Wadi Zeidun which in section showed hexagonal and rectangular sections strongly recalling *nepheline* in appearance, though internal strains had rendered the hexagonal sections nonisotropic. The position of the specimen was not precisely fixed, but last year the writer brought back a variety from Jebel Hadarba which attracted M. Couyat's attention. Having made a section from the specimen, he has privately informed the writer that we are here dealing with a representative of the *nepheline-syenites*, so that the central region of the Arabian Desert between lats. 25° and 26° N. will probably yield felspathoid-bearing varieties over an extended area.

II (*d*).—A much younger group of acid intrusions is of the greatest geographical importance, it being the most notable mountain-former in Eastern Egypt and Sinai. This is the *red granite* (mainly composed of quartz and felspar, with occasional nests and films of muscovite mica), which is widely distributed in its range. Some of the finest mountain masses are composed of this rock (Um Shomer and Ed Deir in Sinai, El Shaib and the Gattar range, etc., in the Eastern Desert), while in the Cataract regions it gives rise to the rugged hills of Akasha, south of Semna, and the boulder-strewn region of Shirri, in the Fourth Cataract. Possibly in part contemporaneous with it are—

II (*e*).—The dykes of varied composition (granites, felsites, dolerites, etc.) which seam the greater part of the Egyptian igneous and metamorphic rocks, and themselves have complicated inter-relationships, as mentioned in the Egyptian Geological Survey Memoirs.

1. *Acid types.*—Of these the most conspicuous and common are the close and often coarse intergrowth of quartz and orthoclase felspar, frequently known under the name of *pegmatite granite.* It is probable that every region in Egypt provides examples of this type. Ball ("Aswan Cataract," p. 84) states that it is the most frequent rock at the Cataract, though actual graphic structure is uncommon. It is also well developed in the Eastern Desert north of Qosseir and near the Sikait emerald mines, while a beautiful graphic form was obtained by Stewart at Gebel Ribdab in the south, near the Sudan frontier.

2. In the second rank are a group of *microgranites* (notably in West Sinai) occasionally containing porphyritic crystals of orthoclase and plagioclase, while locally a beautiful granophyric structure is developed.

3. *The quartz porphyries*, or felsites with microcrystalline base, are not so prominent as those of micrograniti type, but typical examples were obtained by Barron at Ain-el-Akhdar, in West Sinai, and from Jebel Zeit, in the Eastern Desert.

4. *Felsitic types*, showing well-marked *spherulitic* structures, have

also been obtained from Wadi Barud (Eastern Desert of Egypt north of Qosseir) and at several localities in East Sinai.

5. *Intermediate types.*—Ball has recorded the presence of a boss of highly-altered *syenitic porphyry* between Aswan and Shellal, characterized by the presence of abundant lath-shaped orthoclase felspars.[1] This type is, however, rare in the Eastern Desert and Sinai, rocks which from hand-specimens had been regarded as such being mainly very fine-grained granites with quartz in fairly large proportions.

Well-marked dykes of *diorite* have been observed in West Sinai, and further study will probably show these to be of considerable importance elsewhere.

Very noticeable in every part of the igneous region from Sinai to the Fourth Cataract are a series of chocolate-brown or light-yellow rocks (often with satiny lustre) which are referable to the *porphyrites.* Ball has described some interesting examples from near Aswan, including a variety rich in enstatite from near Sehel Island, and another from East Sinai, near Dahab, was closely related to a Bostonite, but was more coarsely crystalline (see Hume, "Eastern Sinai," p. 163).

6. *Basic types.*—These are extremely numerous, and often as much as thirty metres wide, showing cannon-ball weathering. The dense black types are usually dolerites, the easily decomposed varieties diabases.

All these intrusive and crystalline rocks are pre-Carboniferous in age, and were formed *anterior to the deposition of the Nubian Sandstone.*

The researches of the Survey have brought into view the importance of a further group of rocks, which, though geographically closely connected with the intrusive granites and gneisses, are of totally different origin and character.

III.—The Pre-Carboniferous Volcanic and Sedimentary Series.

At a very early stage in the work of the Survey it was found that volcanic rocks closely connected with sedimentary formations played a most important part in the history of the Eastern Desert and Sinai. Rhyolites of typical character were obtained from near Qosseir, in the Ferani Hills of East Sinai, and were also well developed in the Shabluka (Sixth Cataract region) north of Khartoum. To this series also belongs the well-known manganese-bearing andesites and porphyrites of Jebel Dokhan (the Imperial Porphyry), the andesites of Jebel Katherina and many other summits in Sinai and the South-Eastern Desert, and the dolerites or basalts developed on a large scale between Qena and Qosseir. Serpentines also are of the widest distribution, and near Sikait are exceptionally developed, while Dr. Ball has now reported them to attain an unusual importance in the region he has recently studied in the South-Eastern Desert near the frontier-line of the Sudan and Egypt, he having proved that the mountains of Abu Dahar, Gerf, Korabkansi, etc., are entirely composed of this type of rock.

[1] The identification is based on the predominance of simple twinning.

Closely associated with these evidences of intense volcanic activity are the metamorphosed sedimentary strata which, once grits and conglomerates, are now changed to slates and crushed conglomeratic beds. Isolated occurrences of these rocks, and especially the conglomerates, had been recorded, for instance, by Professor Hull in Sinai, and by Captain Lyons on the road between Korosko and Abu Hamed, while the Breccia Verde Antico of Hammamat was well known to all archæological students. These rocks are now known to be developed throughout the desert from East Sinai to the confines of the Sudan. Occurring to the north in isolated areas, they play a most important part in the Eastern Desert of Egypt in lat. 26° N.

This ancient series often presents the most interesting metamorphism where it comes into contact with or overlies the granitic rock. M. Couyat, who had the advantage of studying under M. Lacroix, has pointed out to me that the remarkable basic-looking fringes surrounding some of the granitic masses agree in all particulars with the 'roches cornéennes,' and thus represent contact alterations of the sedimentary rocks by the granite with which they are in immediate contact. In East Sinai, in a district north-west of Nebk, a palm-grove on the Gulf of Aqaba, the contact-phenomena are very striking. Veins from the granitic intrusive mass have in some parts penetrated between the laminæ of the sedimentary slates, giving rise to a rock having the appearance of a mica-gneiss, the well-known *lit par lit* structure. Elsewhere the sediments, probably in part volcanic in origin, have been altered to hornblende-schists[1] near the point of contact, and gradual stages can be traced from this marked alteration at the boundary to garnetiferous mica-schists and spotted slates in the central portions of the areas. The sedimentary strata show every variation from fine-grained slates to conglomerates made up of the most varied materials, among which granites and porphyries are conspicuous. In places they contain quartz-pebbles which have been fractured and recemented, and their detailed study will undoubtedly throw much light on their origin and derivation. The absence of any fossil evidence renders the determination of their age a matter of comparison only. It may be stated broadly that they are pre-Carboniferous and post-Archæan, and appear to have close lithological resemblances to the Pebidian beds of Wales.

IV.—Ancient Metamorphics of Schistose Character.

In addition to the coarse gneisses of the Cataracts and the metamorphosed ancient sedimentaries, there is a series of rocks which may in part be connected with the first-named, and in part represent the remnants of an older period of sedimentation and vulcanicity. This includes the highly-foliated, dark, emerald-bearing mica-schists of Sikait, with which are associated beds rich in talc and tourmaline. These rocks immediately overlie a highly banded gneiss, and in Sikait

[1] The writer has stated the opinion to which he was led by the field relations in dogmatic form, but fully recognizes that the conditions are exceptional. The ordinary explanations of the origin of these schists failed to satisfy the conditions observed.

separate this coarse metamorphic rock from a highly complicated grouping of schists and serpentines.

In the Cataract districts are schists of very complex structure and origin, judging from the preliminary studies already made. One of these from the neighbourhood of Amara (between Wady Halfa and Dongola), which was examined by the writer with the kind co-operation of Dr. J. W. Evans, proved to be a labradorite-wollastonite-zoisite rock. In close connection with this series were some calcareous-looking bands which did not respond to the action of dilute acid, but in microscopic section proved to be *dolomites* whose origin must for the time being remain doubtful, though it is probable that they are derived from the alteration of early Palæozoic or even pre-Cambrian limestones. Another line of change is indicated by the presence of true *marble* bands intercalated between the schistose and gneissose members.

Taking the distribution of the metamorphic and sedimentary rocks as a whole, the writer is inclined to the view that sedimentation and intrusion have succeeded each other at least twice in the pre-Carboniferous periods in Egypt, foliation being most marked in the archaic epochs represented by the Cataract gneisses. Up to the present time no fossil records have been obtained which would supply a date for the ancient sedimentary strata, though there is always a possibility that such materials may yet be forthcoming. Such evidence as is available shows conclusively that all these ancient strata are pre-Carboniferous, the first fossiliferous sandstones containing a late Carboniferous fauna lying unconformably upon them.

V.—Carboniferous and Post-Carboniferous Volcanic Activity.

There have been at least two periods of volcanic activity in Egypt since the Nubian Sandstone was first laid down. The earliest occurrences of this nature at present known are the basic eruptions recorded in Western Sinai by Mr. Barron, the most interesting rock-type being a uralite-diabase from the summit of Sawasia.

During the Survey operations of 1905 a series of volcanic rocks of varied composition (rhyolites, andesites, and basalts) were noted in lat. 25° N., about midway between the Nile and the Red Sea, and immediately underlying the Nubian Sandstone, while in the same neighbourhood were conspicuous summits (Jebel Sufra,[1] the Nahuds, etc.) which are either volcanic rocks or lava-flows still showing a distinct columnar structure. Mr. Ferrar studied the Nahud necks and found them to be trachytic in nature, while Charteris Stewart brought andesitic rocks from the summit of Sufra. At El Ranga, on the Red Sea, in about lat. 24° 50′, an andesite (once a lava-flow) is now intercalated between the beds of sandstone, thus fixing the age of these lavas as not being greater than that of the Nubian Sandstone itself.

In the Northern Sudan south of Wady Halfa is a series of basic rocks of basaltic character, which is evidently younger than the associated Nubian Sandstone, the latter having undergone marked change to

[1] Mr. Wells had previously brought the writer an instructive photograph of Jebel Sufra, and had remarked on the marked evidence of volcanic action at that locality.

columnar structure where in direct contact with the intrusive material. One of the most conspicuous occurrences is on a low hill at the east end of the Kaibar Cataract, and other striking examples are seen at Delgo, at Jebel Alarambia, near Kerma, at Jebel Alibersi, and at El Lagia, in the El Kab Oasis near Dongola. The contact alterations are distinctly marked not only by the formation of the columnar sandstones, but by highly crystallized quartzites. As the intrusive rock has the altered sandstone both above and below it in the Alarambia district, its age is probably of the same period as those previously mentioned.

VI.—Early Tertiary Volcanic Occurrences.

The basaltic rocks in the north of Egypt and Sinai appear to belong to a later period of eruption, being closely connected with the Oligocene Continental Period. In the Fayum and near Cairo they overlie limestones of Upper Eocene age, and are overlaid by the Miocene and Oligocene strata where the latter are present, in the former case giving rise to the well-known precipitous shelf above the Birket-el-Qurun Lake, while at Abu Zabel, north of Cairo, they are of considerable economic importance. The rock is classed as a basalt on account of its ophitic structure, but in its typical development olivine is markedly absent. A rock of the same type has also a wide extension both to west and east, having been recorded from Baharia Oasis, from Gara Soda and Gebel Gebail in the Nile Valley, and from Western Sinai. These resemble the Cairo basalts in all essential particulars.

In addition to these occurrences in the north of Egypt, some interesting intrusions of andesitic and trachytic masses into Eocene limestones have been recorded by various members of the Survey. This is notably the case in an area east of Assiut examined by Beadnell, and from Jebel Abuhad, near Qena, examined by Barron and the writer.

Summary.

1. The ancient core of the North-East African Continent consists of the Cataract and Sudan banded gneisses, which may represent a very ancient igneous magma. They are usually much veined by granitic dykes.

2. In certain places in the Arabian Desert, Cataracts, etc., these underlie highly metamorphosed schists (the mica-schists of Sikait, the calcareous schists of Um Garaiart and Haimar and of the Amara Cataracts, also the dolomites of the latter region) which are sharply separated from the banded gneisses and are possibly the oldest sedimentary representatives in Egypt.

3. The greater part of the mountainous regions of the Eastern Desert and Sinai are occupied by two types of rocks, a schistose constituent overlying or being surrounded by the acid member. (*a*) The first-named, the *Dokhan volcanic rocks* and *schists*, are partly volcanic in origin and partly sedimentary, the former being represented by lavas of various types, while the latter are clearly altered sedimentary strata (grits, conglomerates, etc.). No fossils have yet

been found, but they have their nearest lithological analogues in the latest pre-Cambrian and Cambrian series. Here are included some of the most interesting rocks of Egypt, such as the Imperial Porphyry and the Breccia Verde Antico. (*b*) The igneous member intruded into these ancient sediments, etc., includes a great diversity of igneous rocks, varying from highly basic to acid types.

Contact-phenomena of complex nature occur at the junctions of (*a*) and (*b*).

4. *Red granite* and dyke rocks, whose parallelism and extent of distribution present one of the most conspicuous features of the Eastern Desert of Egypt, mark the final eruptive action before Carboniferous times.

5. Three periods of volcanic activity have been subsequently noted—

(*a*) In Western Sinai in late Carboniferous times.
(*b*) An undated series of eruptions interbedded with the base of the Nubian Sandstone or intrusive into it with marked contact alterations.
(*c*) The basic intrusions near Cairo and the Fayum, etc., which are intimately associated with the Oligocene Continental Period in Egypt.

V.—On the Phyllis Collection of Inferior-Oolite Fossils from Doulting.

By L. Richardson, F.R.S.E.

The Inferior Oolite and contiguous deposits of the neighbourhood of Doulting have been described in detail in my paper on "The Inferior Oolite and Contiguous Deposits of the Bath-Doulting District";[1] but since that paper appeared, through the courtesy of the Urban District Council, I have had the loan of the John-Phyllis Collection of Inferior-Oolite fossils that are housed in the Shepton-Mallet Museum.

This collection is probably only a portion of that made by Phyllis, and although deficient in a number of specimens that are still to be found in the neighbourhood, is a useful one, and contains a considerable number that were not included in my lists.

John Phyllis, of course, knew the localities whence his specimens came, but—as is, unfortunately, so often the case—does not appear to have been sufficiently particular about labelling them with their localities. In a number of cases "near" Doulting must be understood. At the time the collection was submitted for revision the legends, in the majority of cases, read simply "L[ower] O[olite], Doulting." In a number of cases also it was certain that even this information was erroneous. For example, a *Schlotheimia* of the *S.-angulata*-Group, from the Lower Lias, was similarly stratigraphically allocated and localized. However, a knowledge of the

[1] Quart. Journ. Geol. Soc., 1907, vol. lxiii, pp. 383–444.

neighbourhood and matrices has enabled me to indicate with little possibility of error both approximate horizons and localities; but in studying the following lists it must be remembered that they are only approximations. Where the evidence was insufficient for more precise stratigraphical allocation the subdivision-columns are left blank and the more-embracing name of "Doulting Beds" entered in the column headed "Remarks."

Considerable accuracy may be claimed for the lists of fossils given. Mr. S. S. Buckman, F.G.S., identified the Ammonites; Mr. W. H. Hudleston, F.R.S., most of the Gasteropods; Mr. W. D. Lang the Corals and Bryozoa; and Mr. E. T. Paris the Echinoids.

To the north-east of Doulting the Inferior Oolite is in many places in actual contact with the Palæozoic rocks of the Mendip Hills. But traced away from those hills Liassic beds are seen to come in below them, and there is very soon the normal formational sequence of, Inferior Oolite, Upper, Middle, and Lower Lias, with the Rhætic and Keuper below.

The Marlstone or rock-bed of the Middle Lias is very well exposed in an abandoned quarry on Mays (or probably more correctly "Maes") Down, a mile and a half to the south of Doulting. Above are seen the basement-beds of the Upper Lias—clays and thin limestone-bands—which are also exposed on the slope of Small Down, below the "ancient entrenchment." Deposits of *falciferi* and *bifrontis* hemeræ are in evidence; then comes clay. How thick this clay is it is difficult to say, but there appear to be "Sands" also present in the hillsides. In the railway-cutting at Doulting Bridge a clay-bed comes immediately below the Inferior Oolite. Probably it overlies some sand, and—if it could be traced further east—might be seen to be succeeded by sand. Its date, however, is difficult to determine, but it is probably either *striatuli* or *Struckmanni*.[1]

Above the Upper Lias exposed in the railway-cutting comes the Inferior Oolite. In this neighbourhood it is divisible as follows:—

	Subdivisions.	*Approximate thicknesses in feet.*	
Doulting Beds.	i.—Rubbly-Beds; *Terebratula globata*, auctt., *non* Sowerby, common, etc.	8	= *Clypeus*-Grit.
	ii.—*Anabacia*-Limestones	$8\frac{1}{2}$	
	iii.—Doulting Stone; massive Freestone ...	44	
	[Upper Coral-Bed and Dundry Freestone wanting.]		
	vi.—"Conglomerate-Bed" [Upper *Trigonia*-Grit].	$1\frac{1}{3}$	= Upper *Trigonia*-Grit.

There can be no doubt that the Conglomerate-Bed finds its equivalent in the similarly-designated deposit at Maes Knoll, Dundry Hill, near Bristol, where there is evidence that it is succeeded by the Dundry

[1] At first I thought the clay-bed might come below the *Striatulum*-Bed, making it pre-*striatuli*, but then an alternative explanation suggested itself, which was graphically represented on p. 392 of my main paper. Unfortunately, however, the statement of the earlier view (lines 15–17 from bottom of p. 391) escaped the necessary qualification.

Freestone.[1] The Upper Coral-Beds succeed the latter at the quarry near the Church, and then—as is known from the evidence of many sections—follows the Doulting Stone. But in the neighbourhood of Doulting the Doulting Stone succeeds the Conglomerate-Bed at once, without the intervention of any Dundry Freestone or Upper Coral-Bed: there is a non-sequence. The Doulting Stone includes the celebrated Doulting Freestone—a stone well-known in building-circles. On the whole the limestones of the Doulting-Stone subdivision are of fairly uniform aspect and not conspicuously fossiliferous. Fossils can, however, be obtained by diligent search, and it is worthy of record that near the top is a circular variety of *Pecten demissus*, Phillips, which occurs on precisely the same stratigraphical horizon in the local *Clypeus*-Grit of the Horton-Rectory Quarry in the South Cotteswolds, to which the Doulting Stone is the equivalent. The *Anabacia*-Limestones are typically very distinct from the underlying Doulting Stone and overlying Rubbly-Beds. The Rubbly-Beds are the most fossiliferous of the Inferior-Oolite strata in the neighbourhood. Sometimes they are not so definitely marked off from the *Anabacia*-Limestones, and when such is the case it is rather difficult, if a fossil is not found *in sitû*, to say from which it came. If there is any matrix adhering it will generally be found that on fossils from the *Anabacia*-Limestones the matrix is of a white colour, while on those from the Rubbly-Beds it is distinctly browner, and there are few oolite-granules.

During a number of visits to Doulting, made since my main paper was published, particular attention was paid to the occurrence of ammonites in the upper portion of the Doulting Beds and Fullers' Earth, with a view to the more precise dating of these deposits.

There are now about 12 feet of Fullers' Earth exposed at the Farmcombe Quarry, and the little oyster identified with *Ostrea Knorri*, Voltz, occurs in the lowest portion immediately above the "limestone, rubbly, white, mixed with clay; variable, say 1 foot" (Quart. Journ. Geol. Soc., 1907, vol. lxiii, p. 395). From this bed has been obtained a fragment of an ammonite that is probably *Zigzagiceras clausiprocerum* (S. S. Buckman); and either from the same bed or the top of the Rubbly-Beds a fragment of "? *Parkinsonia lævis* (Quenstedt)." So the basement-portion of the Fullers' Earth may be of *zigzag* hemera, and the *Knorri*-Clays of approximately the same date.

The *Aulacothyris doultingensis*, Richardson, MS., is closely allied to the form from the "Marl-Bed" (*Garantianæ*) of Stoford, Somerset, which has been recorded as *Aulacothyris* "*Meriani*, var."[2] It does not appear desirable to describe either this or the new *Velopecten* in this paper, but to await one devoted entirely to the description of some new Inferior-Oolite fossils.

[1] The statement in my main paper (p. 420)—"but how thick it was, or whether it rests directly upon the 'grit,' or was separated therefrom by the Upper Coral-Bed . . . "—was inadvertently transcribed from notes made before I had satisfied myself about the correct position of the Upper Coral-Bed and should be erased.

[2] Quart. Journ. Geol. Soc., 1893, vol. xlix, p. 484.

LIST OF INFERIOR-OOLITE FOSSILS IN THE JOHN-PHYLLIS COLLECTION FROM DOULTING, SOMERSET.

SPECIES.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	REMARKS.
II. CŒLENTERATA.						
ii. CNIDARIA.						
1. ANTHOZOA.						
Anabacia complanata (Defrance)	–	*	*	*	–	Common.
Dimorphoræa sp.	–	–	–	–	–	Doulting Beds. Numerous pieces said to be from Doulting.
? *Isastræa limitata*, Lamouroux	–	*	–	–	–	
? — *microphylla*, Tomes	–	*	–	–	–	
Montlivaltia delabechei (Edwards & Haime).	*	–	–	–	–	
— *lens*, Edwards & Haime	–	–	–	–	–	Doulting Beds.
— *numismalis* (d'Orbigny)	–	–	–	*	–	
— cf. *trochoides*, Edwards & Haime	–	–	–	–	–	Said to be from Doulting.
— sp.	–	–	–	*	–	
— sp.	–	–	–	–	*	Common at Farmcombe Quarry.
— sp.	–	–	–	–	?	
Thecosmilia ? sp.	–	–	–	?	–	
2. HYDROZOA.						
Acanthopora spinosa (Lamouroux)	–	–	–	–	–	Doulting Beds. Common.
III. ECHINODERMATA.						
iii. ECHINOZOA.						
1. ECHINOIDEA.						
Acrosalenia spinosa, Agassiz	–	*	–	*	–	Common.
Clypeus Hugi, Agassiz	–	–	–	*	–	Doulting-Bridge Quarry.
Collyrites ovalis (Leske)	–	*	–	–	–	Typical form.
— aff. *ovalis* (Leske)	–	–	–	–	*	Not so oval as the typical form.
Echinobrissus clunicularis (Lhwyd)	–	*	–	–	–	
Holectypus depressus (Leske)	–	–	–	*	–	Common.
— *hemisphæricus*, Agassiz	–	–	–	*	–	
Stomechinus ? *bigranularis* (Lamarck)	–	–	–	*	–	One immature specimen.
IV. VERMES.						
5. ANNELIDA.						
Serpula convoluta, Goldfuss	–	–	–	–	–	Doulting Beds.
— *deplexa*, Bean	–	–	–	?	–	Large variety similar to that occurring in the Pea-Grit, Lower *Trigonia*-, and *Buckmani*-Grits of the Cotteswold Hills and the Millepore Limestone of Yorkshire.
— *deplexa*, Bean	*	–	–	–	–	Small variety similar to that in the "Marl-Bed" (*Garantianæ*) of Bradford Abbas.

Species.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	Remarks.
Serpula cf. *trochleata*, Goldfuss	*	–	–	–	–	Same form occurs in the "Marl-Bed" of Bradford Abbas, and the Upper *Trigonia*-Grit of the Cotteswold Hills.
— spp.	–	*	–	*	–	Including forms 1 and 2.
Vermilia quinquangularis (Goldfuss)	–	–	–	*	*	
MOLLUSCOIDEA.						
1. Bryozoa.						
Ceriopora sp.	–	–	–	–	–	Doulting Beds.
Diastopora Michelini (Blainville)	–	–	–	*	–	
Heteropora conifera (Lamouroux)	–	–	–	–	–	Doulting Beds. Common.
Spiropora annulosa, Michelin	–	–	–	–	–	,, ,,
2. Brachiopoda.						
Acanthothyris doultingensis, Richardson & Walker.	–	–	–	–	*	
— *midfordensis*, Richardson & Walker.	–	–	–	–	*	
— *spinosa* (Schlotheim)	–	?	–	*	–	
Aulacothyris carinata (Lamarck)	–	–	–	–	*	
— *Mandelslohi* (Oppel)	–	–	–	–	*	
— *doultingensis*, Richardson, MS.	–	–	–	–	–	
Dictyothyris Morieri (Davidson)	?	–	–	–	–	Precise horizon doubtful, but probably it came from the Conglomerate-Bed. This specimen, found by Phyllis, is in the British Museum.
Ornithella cadomensis (E. Deslongchamps).	–	–	–	–	*	Fullers'-Earth Rock, (? near) Doulting.
— *ornithocephala* (Sowerby)	–	–	–	–	*	Fullers'-Earth Rock, (? near) Doulting.
Rhynchonella plateia, Richardson & Walker.	–	–	–	–	*	Rare.
— *Smithi*, Walker	–	–	–	–	*	
— aff. *subdecorata*, Davidson	?	–	–	–	–	? *Scissi*: remanié in the Conglomerate-Bed.
— *subtetrahedra*, Davidson	–	–	–	*	–	
— 3 spp.	–	–	–	–	–	Doulting Beds. [Forms 1, 2, and 3, L. R.]
Eudesia cf. *cardium* (Lamarck)	–	?	–	–	–	Doulting Beds. Rare.
Terebratula globata, Sowerby, *non* auctt.	–	–	–	–	*	Fullers'-Earth Rock, (? near) Doulting.
— *globata*, auctt., *non* Sowerby	–	–	–	*	*	Common.
— *doultingensis*, Richardson & Walker.	–	–	–	–	*	
— *sphæroidalis*, Sowerby	–	–	–	–	*	Immature.
— (nearest to) *sphæroidalis*, Sowerby.	–	–	–	–	*	Umbo of dorsal valve not sufficiently flat.
Zeilleria emarginata (Sowerby)	–	–	–	–	*	Very rare.

Species.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	Remarks.
VI. MOLLUSCA.						
1. Pelecypoda.						
Alectryonia gregaria, auctt.	–	–	–	*	–	
? *Cardium citrinoideum*, Phillips	–	–	–	*	–	
Ceromya plicata, Agassiz	–	–	–	?	–	Same size as specimen figured in Monogr. Great Oolite Mollusca, Pal. Soc., pt. 2 (1853–4), pl. x, figs. 1*a* and *b*.
Corbis (*Corbicella*) *complanata*, Lycett	–	–	–	*	–	
Cypricardia ? *cordiformis*, Deshayes	–	*	–	–	–	
— aff. *rostrata* (Sowerby)	–	–	–	*	–	The casts of the umbones are more slender and prominent than the *Phillipsiana*-*Bourguetia*-Bed fossils figured by Morris & Lycett, Monogr. Great Oolite Mollusca, pl. vii, fig. 9.
Goniomya anguilifera (Sowerby)	–	–	–	–	*	Fullers'-Earth Rock, (? near) Doulting.
Gresslya abducta (Phillips)	–	–	–	*	–	
Homomya gibbosa (Sowerby)	–	–	–	*	–	Typical form.
Isocardia minima, Sowerby	–	–	–	*	–	
Limatula gibbosa (Sowerby)	–	–	–	*	–	Typical form.
Limea duplicata (Sowerby)	–	*	–	–	–	Same form as in the Cotteswold Hills.
Lithophagus inclusus (Phillips)	–	*	*	*	–	
Lucina rotundata (Römer)	–	–	–	?	–	
— ? *crassa*, Sowerby	–	–	–	*	–	Internal cast.
Myoconcha implana, Whidborne	–	?	–	–	–	
Ostrea acuminata, Sowerby	–	–	–	–	?	Several specimens apparently from the Fullers' Earth.
— cf. *acuminata*, Sowerby	–	–	–	*	–	More convex than the above.
— *costata*, auctt.	–	–	–	*	–	Common.
— *gregaria*, auctt.	–	–	–	*	–	
— *Knorri*, Voltz	–	–	–	–	*	Common.
— *sandalina*, Goldfuss	–	–	–	*	–	
— spp.	–	–	–	*	*	Several species not yet identified.
Pecten (*Chlamys*) *articulatus*, Schlotheim.	–	–	–	–	?	Near to base of Fullers' Earth or top of Rubbly-Beds.
— (*Camptonectes*) *arcuatus*, Sowerby.	–	–	–	*	–	
— (*Syncyclonema*) *demissus*, Phillips	–	–	–	*	*	Nearest to this form.
— of the *Pecten-vagans*-group	–	–	–	*	–	
Pholadomya aff. *Heraulti*, Agassiz	–	–	–	–	*	
— aff. *fidicula*, Sowerby	–	–	–	?	–	The same species as occurs in the *Clypeus*-Grit of the Cotteswold Hills.
— ? *spatiosa*, Whidborne	–	–	–	*	–	
Pinna aff. *cuneata*, Phillips	–	–	–	*	–	Not quite so flat as the form from the Lower *Trigonia*-Grit.

Species.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	Remarks.
Pleuromya decurtata (Goldfuss, *non* Phillips).	–	–	–	*	–	*Vide* Chapuis & Dewalque, "Description des Fossiles des Terrains Secondaires de la Province de Luxembourg," pl. xxi, fig. 8.
— *Goldfussi* (Lycett)	–	–	–	*	–	
Pseudomonotis echinata (Sowerby) .	–	–	–	–	–	Doulting Beds.
Posidonomya opalina, Quenstedt . .	–	–	–	*	–	Rare.
? *Protocardia clypeata* (Witchell) . .	–	*	–	*	–	Internal casts.
Pteria (*Oxytoma*) *costata* (Sowerby) .	–	–	–	*	–	
— cf. *inæquivalvis* (Sowerby) . .	–	–	–	–	–	Doulting Beds.
— *digitata* (Deslongchamps) . .	–	–	–	–	–	,,
— *Münsteri* (Goldfuss)	–	–	–	–	*	,,
Trigonia costata, Sowerby	–	–	–	?	–	*Vide* "British Fossil *Trigoniæ*," Pal. Soc., 1872–9.
— *costata*, Sowerby	–	–	–	?	–	Similar to the specimen figured in pl. xxix, fig. 5.
— cf. *pullus*, Lycett, *non* Sowerby	–	–	–	–	–	Similar to the specimen figured in pl. xxxiv, fig. 9. Doulting Beds.
— 2 spp.	–	*	–	–	–	Internal casts.
Velopecten doultingensis, Richardson, MS.	–	–	*	–	–	
Volsella cuneata (Sowerby) . . .	–	–	–	–	–	Doulting Beds.
— *gibbosa* (Sowerby)	–	–	–	*	–	Typical form.
4. Gasteropoda.						
Actæonina antiqua, Lycett . . .	–	–	–	*	–	Same as at Rodborough Hill, Stroud.
— *gigantea* (Deslongchamps) . .	–	–	–	*	–	Same as at Rodborough Hill, Stroud.
— aff. *gigantea* (Deslongchamps) .	–	–	–	*	–	Cf. fig. 3, pl. xliii, of W. H. Hudleston's "Gasteropoda of the Inferior Oolite," Mon. Pal. Soc.
— aff. *gigantea* (Deslongchamps) .	–	–	–	*	–	Cf. fig. 2, pl. xliii, and fig. 3. Less truncated base than the specimen depicted in the former figure, and less acute spire than that in the latter.
— aff. *gigantea* (Deslongchamps) .	–	–	–	*	–	Short variety; more abbreviated than that figured by Hudleston, fig. 2, pl. xlii, measuring 10 mm. across the widest part and only 10·5 in length along the body-whorl.
Alaria sp.	–	?	–	–	–	
Amberleya Orbignyana, Hudleston .	–	–	–	*	–	
— sp. indet.	–	–	–	*	–	
Ataphrus Labadyei (d'Archiac) . .	–	–	–	*	–	

Species.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	Remarks.
Ataphrus lævigata (Sowerby)	–	–	–	*	–	
Bourguetia striata (Sowerby)	–	–	–	*	–	Indistinguishable from the small forms from the *Bourguetia*-Beds of Cleeve Hill, near Cheltenham.
Cerithinella sp.	–	–	–	–	–	Doulting Beds.
? *Cerithium* sp. indet.	–	–	*	–	–	Internal cast.
Euspira cf. *canaliculata*, Morris & Lycett.	–	–	–	–	–	A megalomorph. Too high a spire for the true *E. canaliculata*. Doulting Beds.
Natica bajociensis, d'Orbigny	–	–	–	*	–	Common.
— *Hulliana*, Lycett	–	–	–	*	–	
— *Zelima*, d'Orbigny	–	*	–	*	–	? = *N. dundriensis*, Tawney.
— spp.	–	–	–	–	–	Immature. Doulting Beds.
— sp.	–	–	–	–	*	
Pleurotomaria armata, Munster	–	–	* or	*	–	
— ? *elongata* (Sowerby)	–	–	–	–	–	Doulting Beds.
— ? *granulata* (Sowerby)	–	–	–	–	–	″
— ? *fasciata* (Sowerby)	–	–	* or	*	–	2 spp. of the *P.-fasciata*-Group.
— ? *ornata-depressa*, Hudleston	–	–	–	*	–	Closely allied to a form from the Upper Coral-Bed of Worgan's Quarry, near Stroud.
— sp.	–	–	* or	*	–	
— sp.	–	–	–	*	–	
Pseudomelania cf. *astonensis*, Hudleston.	–	–	–	–	–	Doulting Beds.
— *lineata* (Sowerby)	–	–	–	*	–	Or *P. lineata* (Sowerby).
— *procera* (Deslongchamps)	–	–	* or	*	–	Doulting Beds.
Solarium subvaricosum, Hudleston	–	–	–	–	–	″
— sp. indet	–	–	–	–	–	
Straparollus sp. indet.	–	–	–	*	–	
Trochus duplicatus, Sowerby	–	–	–	–	–	"Inferior Oolite, Doulting."
5. Cephalopoda.						
Nautilus cf. *burtonensis*, Foord & Crick.	–	–	–	–	–	Doulting Beds. Worn specimens.
Cadomites aff. *Deslongchampsi* (d'Orbigny).	?	–	–	–	–	*Niortensis* hemera. Very rare indeed. Said to be from Doulting. ? remanié in the Conglomerate-Bed.
Morphoceras aff. *polymorphum* (d'Orbigny).	–	–	–	–	–	"Inferior Oolite, Doulting."
Oppelia aff. *subradiata* (Sowerby)	*	–	–	–	–	*Niortensis*: remanié.
Otoites Sauzei (d'Orbigny)	–	–	–	–	–	*Sauzei*, (? near) Doulting.
Parkinsonia ? *lævis* (Quenstedt)	–	–	–	–	*	
Perisphinctes aff. *Davidsoni*, S. Buckman.	*	–	–	–	–	*Niortensis* or *Garantianæ*.
— aff. *funatus* (Oppel) and — *pseudofrequens* (Siemiradzki)	*	–	–	–	–	*Garantianæ*.

Species.	Conglomerate-Bed.	Doulting Stone.	*Anabacia*-Limestones.	Rubbly-Beds.	Fullers' Earth.	Remarks.
Stepheoceras cf. *macrum* (Quenstedt) and *bayleanum* (Oppel).	–	–	–	–	–	*Sauzei*, "Inferior Oolite, Doulting."
— aff. *pyritum* (Quenstedt) . . .	*	–	–	–	–	Remanié from *Blagdeni*.
— aff. *umbilicus* (Quenstedt) . .	*	–	–	–	–	,, ,,
Belemnites (*Belemnopsis*) *aripistillum*, Lhwyd.	–	–	–	–	*	
— (*B.*) *bessinus*, d'Orbigny . . .	–	–	–	–	*	
VI. ARTHROPODA.						
i. BRANCHIATA.						
1. Crustacea.						
Eryma sp.	–	[* D. B.]			–	19 pieces: mostly the fixed ultimate joints. D. B. = Doulting Beds.
VIII. VERTEBRATA.						
1. Pisces.						
Hybodus sp.	–	[?* D. B.]			–	1. Tooth.
Lepidotus sp.	–	–	–	[*]	–	1. Scale. Ident. Dr. A. Smith Woodward.
Strophodus magnus, Agassiz . . .	–	[* D. B.]			–	Common.
3. Reptilia.						
Ichthyosaurus sp.	–	[?* D. B.]			–	1. Vertebra from the tail. Said to be from the Inferior Oolite of Doulting.

It is hoped that the specimens listed above, now that they have been subjected to a careful revision, will be useful to students of the Inferior Oolite and Fullers' Earth of the neighbourhood of Doulting. Of course there are gaps, but before long it is probable that many of them will be made good. The examination of the collection has emphasized the correctness of the correlation of the Doulting Beds with the *Clypeus*-Grit of the Mid-Cotteswolds, the majority of the fossils being identical in form and appearance.

Among the ammonites are specimens indicative of *Sauzei*, *Blagdeni*, and *niortensis* hemeræ, as well as *Garantianæ*. The Conglomerate-Bed, of course, is of *Garantianæ* hemera, and there is little doubt—judging by the matrices of some of the specimens—that some of the ammonites indicative of *Blagdeni* and *niortensis* hemeræ were remanié in it—those indicative of *niortensis* in particular. But the same cannot be said about the *Otoites Sauzei*. Leaving this out of consideration, what the ammonites seem to indicate is the destruction of at least deposits of *Blagdeni* and *niortensis* dates during the "Bajocian Denudation."

VI.—The Mechanics of Overthrusts.

By T. Mellard Reade, C.E., F.G.S.

In attempts to unravel some of the weightier problems of geology it has lately been assumed that certain discordances of stratification are due to the thrusting of old rocks over those of a later geological age. Without in any way suggesting that the geology has in any particular instance been misread, I should like to point out the difficulties in accepting the explanation looked at from a dynamical point of view when applied on a scale that seems to ignore mechanical probabilities. Some of the enormous overthrusts postulated are estimated at figures approaching 100 miles. Have the authors considered that this means the movement of a solid block of rock or rocks of unknown length and thickness 100 miles over the underlying complex of newer rocks? If such a movement has ever taken place, would it not require an incalculable force to thrust the upper block over the lower, even with a clean fractured bed to move upon? Assuming that the block to be moved is the same length as the overthrust, the fracture-plane would in area be $100 \times 100 = 10{,}000$ miles. I venture to think that no force applied in any of the mechanical ways known to us in Nature would move such a mass, be it ever so adjusted in thickness to the purpose, even if supplemented with a lubricant generously applied to the thrust-plane. These are the thoughts that naturally occur to me, but as my mind is quite open to receive new ideas I shall be glad to know in what way the reasoning can be met by other thinkers.

REVIEWS.

I.—Memoirs of the Geological Survey of England and Wales.

The Coals of South Wales, with special reference to the Origin and Distribution of Anthracite. By Aubrey Strahan, M.A., Sc.D., F.R.S., F.G.S., and W. Pollard, M.A., D.Sc., F.G.S.; assisted by E. G. Radley. pp. v, 74, with 10 folding plates. London: printed for H.M. Stationery Office, 1908. Price 1*s.* 6*d.*

This memoir includes a chapter entitled "Historical and Introductory," which deals with previous knowledge of the occurrence and distribution of anthracite in South Wales, and states certain facts as to the distribution of anthracite and its passage into other forms of coal. "The changes undergone by the coal present certain stages . . . from House Coal, or the most bituminous, the change is gradual into Steam Coal, and from Steam Coal into Anthracite."

We are told that the "Anthracitic regions lie in the north-western corner of the Carmarthenshire, Brecknock, and Glamorganshire field and in Pembrokeshire," and "Lines of equal anthracitisation circle round an area which extends from Kidwelly to Glyn Neath. In Pembrokeshire all the coal is anthracitic."

The second generalization states that "the seams all show the change on approaching the anthracitic region, but the higher seams show it later than the lower," and a third that "the loss of bituminous matter takes place at a more rapid rate in a south to north direction than in an east to west direction."

A very complete and carefully carried out series of analyses have been made of coal methodically collected for that purpose, the results of which, with details of the methods employed, occupy a large part of the memoir.

Chapter ii, on the sequence of the seams, is short and unsatisfying. No reasons are given for the individual correlation of seams, and palæontological methods might have been unknown. The idea of an appeal to fossils, either plants or shells, does not seem to have occurred to the author, although in other coalfields excellent results have been obtained.

Chapters iii–viii deal with statistics and the explanation of the plates, and the memoir closes with a chapter on the "Origin of Anthracite." Here previous views are discussed, and the theory is adopted that "the differences between anthracitic and bituminous coals of South Wales are mainly due to original differences in deposition," for the following reasons:—

1. The seams are not all similarly anthracitic; though each seam is generally more anthracitic than the one above it, there are many exceptions to this rule.
2. The anthracitic character was not due to faults, but existed before the faults were formed.
3. The anthracite existed as such before the coalfield was reduced by denudation to its present dimensions.
4. The percentage of ash diminishes *pari passu* with the decrease of bituminous matter.

It must be confessed that the conclusion leaves the question in an unsatisfactory condition, and no details of what may have been the difference in deposition are suggested; therefore the *vera causa* of anthracitization is still to be discovered. The question in the present volume has been attacked only from the chemical side, and it would be interesting to know whether the microscope would have revealed any structural or biological changes in the seams of coal. A good and adequate index completes the volume.

W. H.

II.—The Rhodesian Miner's Handbook. By F. P. Mennell, F.G.S. pp. x + 143. Bulawayo: Ellis Allen, 1908. Price 5*s*.

THIS valuable handbook forms publication No. 4 issued by the Rhodesia Museum, of which institution the author has been for the past six years the curator. Of its extreme usefulness to the prospector in Rhodesia there can be no question, and he will save himself much waste of time, and possibly bitter disappointment, if he takes care to include it in his outfit. The book teems with invaluable information relating to the ores of commercial importance, the type of rock in which they may most probably be found, the identification of the principal mineral species, the testing of the quality of a lode, the steps to be taken to establish a title to a mine, the proper method of working one, and so on. It, however, by no means consists of a series of working notes briefly and badly set down, but opens with a short, yet sufficiently general, account of geological formation and the origin of ore which will enable the miner who has had no previous geological training to appreciate the disposition of lodes and the natural processes that have brought them about. The general reader, moreover, will be interested in the statistical accounts of the mineral resources of the country which are incidentally given; there seems no doubt that, despite a somewhat chequered career in the past, the mineral industry of Rhodesia has a great future to be realised when the country has been opened up and the railway facilities fully developed.

After the general discussion referred to, chapters follow which deal with the metals, precious and base, and the minerals containing them, precious stones, and coal. It may surprise many to find that Rhodesia already ranks as one of the great gold-producing countries of the world, and may in the near future challenge the position held by the Transvaal. The account of the methods used by the natives in ancient times for crushing and concentrating the ores shows how little in principle the system of working has altered. The section dealing with zinc includes a description of the remarkable mineral occurrence at the new Broken Hill mines which has attracted so much attention among mineralogists. The Somabula gem-district appears to be prolific in all kinds of precious stones, especially diamond, chrysoberyl, and topaz,. the last of a peculiar pale-blue colour. Rhodesia is fortunate in possessing an ample coal supply, which will be of increasing importance as time goes by and local manufacturies spring up.

The book is well printed and enriched by a large number of excellent illustrations, mostly reproduced from photographs.

III.—Rocks and Rock Minerals. A Manual of the Elements of Petrology without the use of the Microscope. By Louis V. Pirsson. pp. 414 + vi, with 74 figures in the text and 36 plates. New York, John Wiley & Sons; London, Chapman & Hall, 1908.

So great was the impetus imparted to the development of petrological science by the introduction of the use of the polarising microscope that all modern textbooks dealing with the study of rocks consider the subject from the microscopical point of view. Yet there has long been felt the need for a book that should enable an observer by the aid of a pocket-lens and the application of a few simple tests, which can readily be carried out even in the field, to identify with sufficient accuracy for practical purposes any rock that may be met with. Thus the engineer and the architect are anxious to learn whether some particular rock is characterised by strength and durability, and are not concerned with the minutiæ of petrology. There can be little doubt that Professor Pirsson's manual will be in great demand; of the excellence of the work his name alone is sufficient guarantee, and he has had the teaching experience requisite for gauging the type of book wanted.

The author divides the book into three principal parts. In the first he gives useful hints as to the most suitable course of study, and includes a description of the simple apparatus and reagents required. A brief discussion follows on the nature of the interior of the Earth and the character of its crust, and some of the differing hypotheses that have been put forward. The second part is occupied with the minerals that are of importance in the formation of rocks. The author commences by rehearsing the physical and chemical properties which admit of ready determination, and proceeds to describe concisely the characters of the important species, grouped together as silicates and oxides, hydrous silicates, carbonates, and sulphates. In the next chapter he gives some simple chemical tests, such as need no elaborate apparatus, and the part ends with two valuable tables for the identification of minerals: the first, which is based upon the most obvious physical characters, such as cleavage, streak, transparency, and hardness, and comprises about thirty species, is intended for use in the field; while the second, which is based in addition upon the ordinary blow-pipe reactions, and includes about fifty species, should preferably be employed whenever the additional tests can be made. The third and last is the main part of the book, and, indeed, fills two-thirds of the total number of pages. It is occupied with a full description of the various kinds of rocks, divided into the three great groups, igneous, stratified, and metamorphic rocks, and with a discussion of their classification. For each rock the author gives the composition, properties, occurrence, uses, and relation to other rocks, and at the end adds a useful table for the determination of rocks from their most obvious characters. A copious index, in which the names of rocks are italicised, brings the book to a close.

Mention must not be omitted of the numerous admirable illustrations which add so much to the value of the book. The reproductions from photographs have been printed as plates, and are exceptionally clear and distinct.

G. F. H. S.

IV.—Egypt.

The Topography and Geology of the District between Cairo and Suez. By Thomas Barron. 8vo; pp. 133; maps and plates. Cairo (Survey Department), 1907.

THIS fine memoir has been printed just as it left the hands of its lamented author. Opening with a chapter on the topography of the region, full of interesting matter on meteorology and water supply, vegetation and zoology, botany and inhabitants, the author describes the Pleistocene, Miocene, Oligocene, Eocene, and Cretaceous beds, their fossils, etc. The basaltic flows, necks, and sheets are dealt with in chapter vii, and are recognised as Oligocene and of the same age as those seen south-west of the Giza Pyramids. The faults and folds of the area are fully described in chapter ix, one of 55 metres and another of 165 metres being especially mentioned. The final chapter (x) deals with the relief of the ground, and discusses at length the denudation, agents of sculpture, sand action, sand-blast, three-angled stones, and other matters of interest. Dr. Barron considers that the direction of the wind, *not* the prevailing wind, causes the erosion, and agrees with Dr. Vaughan Cornish, but differs from the majority of writers on the subject. He compares this locality with the Libyan Desert, and finds that in both areas the sand-carrying wind comes from the south-west, while the prevailing wind comes from the N.N.W. And this is shown by the orientation of the sand-dunes, the planed-down surfaces of the rocks, and the direction of the long slope of the dunes. An excellent index has been provided by those who have so carefully seen our lamented friend's manuscript through the press.

V.—Granite and Gneiss.

Sederholm (J. J.): On Granite and Gneiss, their Origin, Relations, and Occurrence in the Pre-Cambrian Complex of Fenno-Scandia. Bull. Comm. géol. Finlande, No. 23, Helsingfors, 1907.

THIS is a long summary in English of a paper in Swedish in which the author shows, through the investigation of the schists of Finland, that rocks occur in these masses showing every sign of having been formed by the same slow processes of sedimentation as younger strata, or by true volcanic action, but differing as to its intensity, or the conditions under which the magma solidified, from that of later times. These pre-Cambrian sediments have been traced throughout the whole eastern portion of Fenno-Scandia, and analogous rocks have been found in the western area of the region. Finnish geologists have also traced these pre-Cambrian beds progressively downwards in a geological sense, and backward in time until they have apparently reached the bed-rocks of this ancient area. Ascertaining the probable origin of any rock-mass in the region, their relative ages have been determined by studying the contact-relations to each other, especially with regard to those granitic masses which have the widest extension. The relations of the different rocks to the great orogenetic movements which have affected the region, and have impressed upon the rocks their widely differing secondary characters, have also been observed. From all this the author has evolved a classification which seems to him to hold good for a great part of Fenno-Scandia. Descriptions and illustrations of all these rocks are given, as well as a geological map of 1 : 8,000,000 showing their distribution.

VI.—Geological Literature for 1907.

ONCE more it is our pleasing duty to call the attention of geologists to the "Geological Literature added to the Geological Society's Library during the year ended December 31st." This remarkable work, compiled entirely by Mr. William Rupert Jones, and edited by Mr. L. L. Belinfante, has now reached its fourteenth year. It consists of 120 pages of author titles, thus listing about 3,000 items, and an index to their contents of 90 pages, which index includes a number of maps not placed among the author titles. It is compiled by one who is thoroughly conversant with his subject in all its varied branches. Whether geologist, palæontologist, mineralogist, petrologist, or mining expert, no one who pretends to do any work can afford to be without this publication, which, despite the faults of omission or commission usual in any work of the kind, is far and away the most valuable of any geological bibliography offered to the public.

The singular thing is that it should still remain unknown to many at home and abroad, for its low price (2*s.*) places it within reach of all. But as no attempt is made by the Society to advertise its existence, perhaps this is not to be wondered at. Some people seem to think that it is limited in its scope to those items received by the Geological Society; so it is, but the Society receives over 80 per cent. of the publications on the sciences it includes. The extraordinary value of the book lies in its index. Take one entry—" C. Reid, on the Geology of the country round Newquay, Mem. Geol. Survey, 1907." This is indexed under no less than fourteen heads, so that practically the whole contents of the memoir can be picked up under any special item. The same minuteness of indexing applies to the foreign literature.

It is undoubtedly the most valuable publication issued by the Geological Society of London, and will remain a standard work of reference as long as any geologist worthy the name interests himself in the subject.

CORRESPONDENCE.

THE GAVARNIE PROBLEM.

Sir,—Having only now seen Mr. Dixon's sections and conclusions, I can supplement them from observations repeated during the present year.

On Mr. Dixon's map the essentially continuous sheet of Hippurite limestone is figured as absent over two spaces each a kilometre in extent, and definable as the most easily accessible from Gavarnie. One of these is concealed by talus, but that at the mouth of the Ossoue valley gave me, in 1894, the following results of field and microscopic observation, repeatedly verified since that date. The supposed break is merely an extremely metamorphosed portion of the visibly continuous Cretaceous. It is penetrated throughout by numerous veins and bosses of microgranulite, undeniably proceeding from the underlying granitic basis. M. Bresson first admitted it to be pinched Cretaceous, but is now compelled to describe it as Palæozoic " by analogy of facies and by the established data of the age of granite." This analogy and these data led the last Director of the French Survey to map the Hippurite limestone as Cambrian over half the Pyrenees, and to denounce my maps and observations as "*a priori* inexact." Even M. Carez, M. Lacroix, and M. L. Bertrand admit them to be baseless. But M. Bresson is similarly compelled to figure the Caprina Cenomanien as Aptien at Sarrencolin and the Ordovician at Bagneres de Bigorre as Permian, and to describe the Cambrian of Jacquot as a masterly definition of the Devonian, although it was defined as *beneath* the Silurian and although its types were selected from the heart of the Cretaceous. As at the valley of Ossoue, so at every point where limestone occurs in the Archæan basis of Mr. Dixon, there is a visible synclinal descent of the Cretaceous into the said basis. At Eaux Chaudes the same Hippurite limestone descends into the granite basis at the valley of Bitet, and is similarly penetrated by microgranulite; being especially metamorphosed at contact with intrusions of Porphyry, termed Andesite and Labradorite on the map, which porphyry traverses the main granitic mass, and is itself traversed by a white granulite common at Gavarnie beside the synclines of Cretaceous. To Mr. Dixon's classification of the Gavarnie basis as Archæan I have no objection, provided that, with many geologists, I may interpret such Archæan as an imperfectly cooked example of a magma that is frankly eruptive at other points. Certainly around Gavarnie this magma was so plastic as to permit the descent of thin sheets of Cretaceous to three hundred yards in depth, and to exhibit, at visible points of contact, the most distinctive features of irruptive intrusion. Around Eaux Chaudes vast portions of the Hippurite limestone are converted into white crystalline marble, irregularly mixed with ferruginous and dolomitic segregations. Their irregularity forbids their attribution to those dynamic influences which Sauer and others have controverted in the Alps of Glarus, where *augen gneiss* is as irruptive as at Gavarnie. Finally, at the Ossoue valley and elsewhere around Gavarnie, I have traced the constant presence of the 'Permian' of Pinede, passing insensibly into a peculiar gneiss crammed with ferruginous concretions. M. Bresson admits its presence in his latest papers. In the Pinede valley it is eaten into by the homogeneous granite, and reduced in places to a conglomerate of granitic basis.

One other point may be recommended, without offence, to future observers. South of Gavarnie the Spanish plateau is composed, for many miles, of that Flysch which I introduced and defined in 1881 as that of the Vienna basin. Over a thickness exceeding 2,000 feet it exhibits the Helminthoids, composition, and very peculiar structure of that formation. Between Torla and Faulo it overlies the Danien as regularly as throughout the Spanish Pyrenees. The denial of the possibility of its post-Danien age, and the denial of its association with gypsum and salt, form the basis of the 200 pages of the latest French Survey Bulletin by M. Leon Bertrand. Yet in Spain, as in France, it presents characteristic Nummulites, which are ignored as deliberately as my Hippurites of Eaux Chaudes in 1885. In three papers of the Biarritz Association I have invited verification of the facts. The peculiarity of this formation is its alternation of tranquil and violently contorted portions, and its abundant evidence of local volcanic action. Some of these have been recently verified by Professor Fournier. But the formula "*a priori* inexact" has been more popular than observation, and is confirmed in Mr. Dixon's conviction that my references to current Palæontology have no connection with matters wholly decided thereby. On Mr. Dixon's own map the extent of the supposed 'thrust-plane' can be measured as 8 kilometres, yet he adds 2 kilometres in favour of his theory and resorts to microscopic evidence in its difficulties. The popularity of this method of settling problems which concern the roots of all geological reasoning is assured, if only the exclusive discussion of authors whose decisive sections are totally erroneous by their own testimony can be persistently maintained.

P. W. STUART-MENTEATH.

ST. JEAN DE LUZ.
September 15, 1908.

GLACIER GRAINS.

SIR,—I have pointed out[1] that in caves cut in the ice of glaciers, and also on the surfaces of glacier ice at high altitudes in places protected from the sun, the glacier grains are finely striated, the striations on different grains running in various directions. As each glacier grain is a distinct more or less strained crystal, it seemed advisable to determine whether the surface striations produced by evaporation bear any relationship to the crystalline structure of the ice grains.

Tyndall has pointed out that when, by means of a burning glass, the sun's rays are focussed in ice, liquid discs or flowers appear in the interior. These discs or flowers would, of course, be at right angles to the optic axis. I, therefore, last August, from the upper cave of the Rhone Glacier, cut samples of ice which showed these striations, and then by means of a burning glass produced the liquid discs within. In all cases these discs proved to be parallel with the external striations. One crystal in particular showed this very clearly. It was cut from a prism of ice and was striated on three sides. Not only were the striations on these faces in agreement, but the liquid discs produced by the sun's rays throughout the interior of the ice were in all cases in the same plane as the striations on the surfaces.

R. M. DEELEY.

THE OCCURRENCE OF FLINTS IN AN OLD GRAVEL-BED NEAR NEWBIGGIN-BY-THE-SEA (NORTHUMBERLAND COAST).

SIR, — Some years ago I first found flints in this deposit. Previously their presence had been unknown, and, so far as I am aware, nothing has since been published concerning them. The gravel-bed is of pre-Glacial age and lies upon sandstone of the Coal-measures, the only available section being that exposed in the cliffs between Newbiggin and the mouth of the River Wansbeck. Here it may be traced for a distance of 480 feet. At its northern boundary it is seen to rest against an ancient cliff running in a direction normal to the present sea-front, and at this point the gravel is over 18 feet thick, the total height of the cliff being 22 feet.

[1] GEOL. MAG., 1907, p. 529.

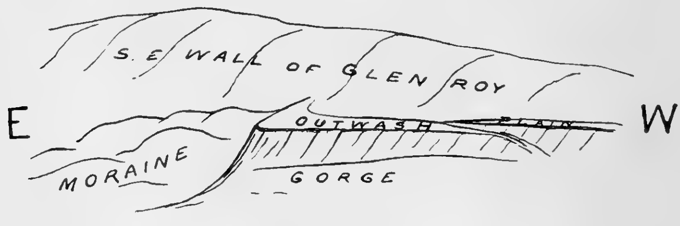
Southward the gravel thins out, until at a distance of 470 feet from the old cliff the section is only 1 foot thick. The bed consists of pebbles for the greater part, sandstones, porphyry, etc., of the neighbourhood. They are all well-rounded and water-worn. The flints are old chalk flints, usually broken and angular in form, occasionally flaked as if broken by impact with other stones, and sometimes red in colour. Their presence here seems to indicate the existence, somewhere in the bed of the North Sea, of Cretaceous deposits, probably derived from the Chalk formation which appears to have at one time existed in the North of Scotland, and of which the rounded, water-worn flints of Aberdeen are remains.[1]

R. G. A. Bullerwell, B.Sc.

Balgonie House,
Maddison Street, Blyth.
September 18, 1908.

A RECENT VISIT TO GLEN ROY, BY AN AMERICAN GEOLOGIST.

Sir,—In June last it was the writer's good fortune to visit Glen Roy with the excellent paper by Jamieson in his hand (Quart. Journ. Geol. Soc., 1892, vol. xlviii, pp. 5–37). It is a pleasure to confirm from observation the correctness of the conclusions reached by the author. It seems to the writer, however, that there are indications in the valley of a later chapter of glacial history, which, from enquiries, it is inferred has not yet been worked out, if it has indeed been noted. The object of this communication is to draw attention to the more clearly revealed facts in order that others who are nearer the locality may search for additional indications of this glacial episode.



The great glacial dam at the south base of Bohuntine Hill is clearly a terminal moraine laid down at the margin of the ice which proceeded from the Ben Nevis centre and impounded the drainage of the glen to produce one of the local lakes. There is, however, another heavy morainal obstruction in Glen Roy, situated just above the entrance to Glen Glaster, which affords the clearest evidence that the glacier

[1] [See the following:—(1) "On the Cretaceous Fossils from the Drift of Moreseat, Aberdeen," by G. Sharman & E. T. Newton, Geol. Mag., 1896, pp. 247–54, giving a list of fifty-three species belonging to the Lower Greensand, Gault, Upper Greensand, and to the Upper and Lower Chalk. (2) A second paper also in this Magazine for 1898, pp. 21–32, by A. J. Jukes-Browne & John Milne, giving a list of fifty-nine species, all from the Speeton Clay, Lower Greensand, Gault, and Upper Greensand, but none from the Chalk.—Ed. Geol. Mag.]

which deposited it entered the valley from a centre of dispersion to the eastward, and subsequent to the Lake period, the history of which Jamieson has so well cleared up.

The topography of this obstruction and its material are typical of terminal moraines, and what is most conclusive regarding its western frontage, there is an outwash apron which starts from its western margin and slopes gently away into the lower valley. This outwash plain has been cut away in a gorge subsequently eroded by the River Roy. The plain is, however, perfectly preserved on both sides of the valley, and seen from above was a conspicuous feature in the landscape at the time visited, because of a carpet of green, which contrasted sharply with the brown hue of the less fertile moraine and the valley walls.

It thus seems probable that the waning of the ice in the western mass around Ben Nevis was succeeded by an augmentation of the ice in the more eastern of the near-lying centres of dispersion.

WM. H. HOBBS,
Professor of General and Dynamical Geology.

DEPARTMENT OF GEOLOGY,
UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICHIGAN, U.S.A.
September 26, 1908.

OBITUARY.

CHARLES FREDERICK COCKBURN.

BORN 1830. DIED OCTOBER 6, 1908.

MAJOR-GENERAL C. F. COCKBURN, R.A., joined the Army on December 19, 1849. He served in Canada, the Crimea (including the siege and fall of Sebastopol), Gibraltar, and Halifax (Nova Scotia). He was at the Royal Small Arms Factory, Solinger, Prussia, from 1859 to 1862, and was Assistant Superintendent at the Birmingham Factory for five years. He was the fifth generation of his family in the Army and the fourth in the Royal Artillery.

General Cockburn was an enthusiastic collector of fossils, especially from the Chalk, and immediately after the fall of Sebastopol employed any spare time he had in making a collection of Danian and other fossils from that region. His collection was described by W. H. Baily in the Quarterly Journal of the Geological Society, vol. xiv, 1858, and the types formerly in the Museum of Practical Geology are now in the British Museum. As this was one of the pioneer collections, its importance was such as to necessitate a visit from Dr. Karakasch only this year, and this geologist had the pleasure of meeting General Cockburn at Dover during his visit. Baily's paper was supplemented by a few pages of stratigraphical notes from the General's pen. During the years he collected, General Cockburn supplied many workers with valuable material from the Chalk, and among these we may mention Edward Forbes and Thomas Wright, who described several of his specimens in the decades of the Geological Survey. Echinoidea were his greatest love, and those who knew him can well remember the keen pleasure it gave him to handle and describe his treasures, most of which came from Dover. Until the last year or two, when increasing infirmity forbade it, he was constantly under the cliffs patiently collecting material during the summer to be worked at during the winter, and might often be encountered with his pockets bulging with fossils and in a state of chalkiness, at once his pride and the astonishment of his friends. Even after his 75th year he eagerly traced the *Uintacrinus* band along the high ground between Dover and Walmer, visiting every pit and carefully recording on map and notebook his lines and fossils. To know General Cockburn was to love him, and a very great loss has been sustained by all his friends, and especially by those who pen these few words as a tribute to his memory.

A. W. R. & C. D. S.

MISCELLANEOUS.

Thrust and Crush-brecciation in the Magnesian Limestone, Co. Durham.

Dr. David Woolacott desires to correct an unfortunate error made in a notice of his paper; see Geol. Mag., October, pp. 469, 470. On line 12 from foot, p. 470, "from 1 ton to 37 tons per square inch" should read "1 ton to 3·7 tons per square inch."—Edit. Geol. Mag.

Professor W. Boyd Dawkins, D.Sc., F.R.S., F.G.S.

The resignation of Professor William Boyd Dawkins, M.A., D.Sc., F.R.S., etc., from the Chair of Geology and Palæontology in the Victoria University of Manchester was announced to take effect in September last, but we now learn that the Chair will not be vacated until September, 1909.

It was in 1870, after serving for a period of eight years on the Geological Survey of Great Britain, that Mr. Dawkins was appointed Curator of the Manchester Museum and Lecturer in Owens College. Four years later he became Professor.

In accepting the resignation the Council expressed the great regret its members felt at Professor Dawkins's retirement from a Chair which he has held with such distinction and with such benefit to the College and the University. It was further stated that Professor Dawkins would retain his association with the Manchester Museum, where he had done such valuable work, and would also continue the popular lectures and special courses of lectures which have become so widely known.

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ASSISTED BY

WILFRID H. HUDLESTON, F.R.S., &c., DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

DECEMBER, 1908.

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With this Number is presented an Extra Sheet, containing Index and Title for Decade V, Vol. V, 1908.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. V.

No. XII.—DECEMBER, 1908.

ORIGINAL ARTICLES.

I.—The Rôle of Solution in Valley-making.

By A. J. Jukes-Browne, B.A., F.G.S.

(WITH A PAGE MAP.)

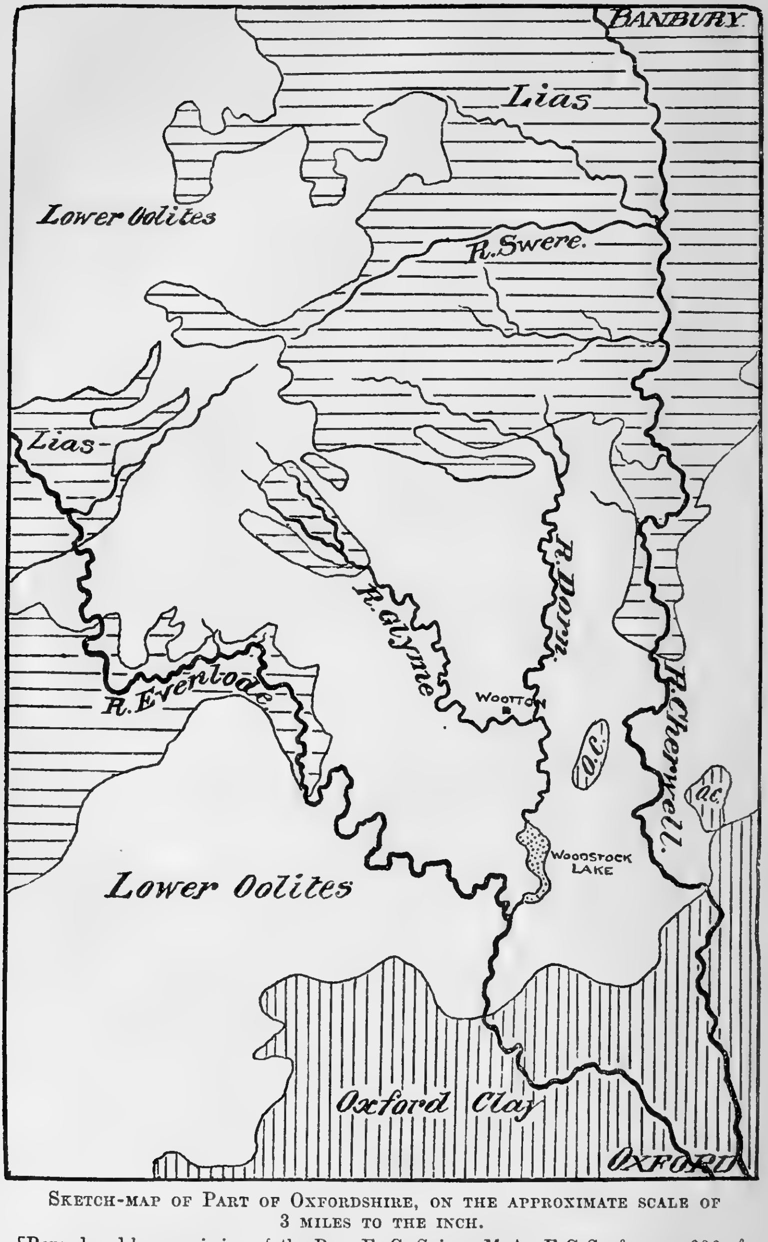
IT has recently been suggested that many of the dry valleys which are found in limestone districts owe their formation to subterranean solution, and not to surface-erosion; in other words, that they are the work of subterranean watercourses which, by dissolving the rock substance, have caused subsidence of the surfaces overlying the lines of such watercourses.

This theory has been put forward as a complete explanation of a whole system of valleys to the entire exclusion of the current view that the chief agent in the excavation of all valleys is the mechanical action of surface water-flow. The new theory assumes that in certain districts there were no surface streams, that their drainage was entirely subterranean, and that the existing valleys have been formed by the gradual subsidence of the surface above the courses of the underground streams.

It has always been acknowledged that solution plays an important part in the enlargement and deepening of the valleys in limestone districts, but the idea of such solution has been chiefly connected with the chemical action of the surface stream-water, and not with the action of such water as sinks beneath the river bottom. It may perhaps be admitted that we needed a reminder that a dry valley may also be deepened by solution, but I very much doubt if the solution is carried on in the manner imagined by the Rev. E. C. Spicer.[1] I think he pushes his theory much too far, and that he credits underground waters with much more concentrated power in the way of solution and valley-making than can possibly be attributed to them.

We are asked to believe that a definite system of underground streams can be formed, without any surface-system, in such districts as the Great Oolite plateau of Oxfordshire and the Chalk area of the Chiltern Hills. We are told that the valley-system of the Glyme and

[1] See "Solution Valleys in the Glyme Area (Oxfordshire)," by the Rev. E. C. Spicer, M.A., F.G.S.: Quart. Journ. Geol. Soc., 1908, vol. lxiv, pt. 3, pp. 335–44, pls. xxxviii, xxxix.



Sketch-map of Part of Oxfordshire, on the approximate scale of 3 miles to the inch.

[Reproduced by permission of the Rev. E. C. Spicer, M.A., F.G.S., from p. 336 of his paper "Solution Valleys in the Glyme Area (Oxfordshire)," Quart. Journ. Geol. Soc., 1908, vol. lxiv, pp. 335–44.]

Evenlode has been determined by a double set of joints; "percolating water," he says, "will reach a master-joint or a series of master-joints and dissolve out a winding course underground. The water from the neighbouring joints will gradually tend to leak into the master-joint line, and thus a winding area of weakness will be established which tends continually to widen. The ground above this weakened line will slowly subside, and at length the weakened material will be entirely removed, exposing the stream" (op. cit., p. 341).

This proposition assumes that the rocks of the district are traversed by a double set of joints which coincide approximately with the windings of the streams, but no evidence is adduced to prove that this is actually the case, and his own map shows that the windings of the Glyme and the Evenlode are so irregular that they cannot be reduced to the intersection of two sets of lines. This map is reproduced on the opposite page, so that the reader can judge for himself.

Again, it is assumed that a fairly equal amount of subsidence will take place along the whole course of the supposed underground stream, the result being that a surface-valley is produced which exhibits such an extraordinary resemblance to a graded valley of erosion that no one has hitherto suspected it to be anything else. I should have expected the subsidence to have been very unequal.

Mr. Spicer appears to have been afflicted with ghosts, and to have suffered from some form of *erosion-nightmare* as badly as Sir Henry Howorth suffered from his 'Glacial nightmare,' for the former writes, evidently with a sigh of relief, "the spectre of erosion which appears to haunt almost every valley upon the earth's surface must, I think, be banished from the Great Oolite plateau." If Mr. Spicer will examine his 'spectre' a little more closely I think he will find it to be a very real and effective power, and not by any means a mere deceptive phantom.

Mr. Spicer thinks that "the valleys under consideration have no single confirmatory mark of erosion," and that "there is no sign of the past existence of any surrounding heights sufficiently great to have produced streams strong enough to carve out the valleys by mechanical erosion. The whole region appears to have been never anything but a gently-tilted plateau."

Does he, therefore, imagine that the rain falling on the surface of this plateau has never gathered into surface-streams, even during the great Glacial era of frost, snow, and rain, and that running water has never accomplished any erosion in this particular district? Does he imagine that this plateau was the same in Miocene and Pliocene times as it is now, that it never extended further west, and that the Oxford Clay never spread over the area through which the Glyme and the Dorn now run? Has he not completely ignored the significant testimony of that outlier of Oxford Clay near Tackley, which he has nevertheless been careful to insert on his map; and the other outliers of the same clay to the west of Evenlode, which are omitted from his map?

Three of the omitted outliers occur in the area where the words "Lower Oolites" are engraved on the map, and there is another large one to the west of Woodstock Lake. These outlying tracts enable us to look back to the time when the present basset-surface of the Lower Oolites was entirely covered by Oxford Clay, and when the outcrop of the underlying limestones lay further north across the Banbury district; doubtless also forming higher ground than the plain of Oxford Clay. Such must certainly have been one phase in the gradual development of scarp and valley during Tertiary time.

Surely it is more reasonable to regard these courses of the Glyme and the Evenlode as valleys which originated on a clay-cover in the usual manner, and have been incised into the underlying limestones. I feel sure that in this new theory the cart has been put before the horse, and that the whole valley-system of the Oolitic plateau was formed in the ordinary way by the mechanical action of rain and running water long before the plateau was reduced to its present condition; but there can be little doubt that some of the features which the valleys now exhibit are attributable to the chemical action of the water which runs into the waterways and sinks underground.

In brief, my conviction is that the valleys have swallowed the ancient watercourses, and that it was the latter which determined the courses of the subterranean streams, and not any hypothetical system of joint-planes. It is quite possible that under present conditions more material may be annually removed by chemical solution than by mechanical erosion, but I do not think that solution would be specially active along the valleys unless they had been previously formed by surface-erosion. On this view it is easy to understand why there is only one valley-system, but if Mr. Spicer's theory were correct we ought to find traces of an ancient system of mechanically-formed valleys which did not coincide with the subsequently-formed 'solution-valleys.'

In another paper [1] Mr. Spicer has applied his theory to the valleys of the Chiltern Hills, and Mr. F. J. Bennett has independently evolved a similar theory in explanation of certain interrupted valleys which traverse the Hythe Beds of Kent.[2]

Mr. Spicer remarks that "the strongly marked Chiltern valleys run in various directions, but they are in the main joint-valleys. There are no heights sufficient to produce them by superficial denudation, there are no alluvial fans showing the results of underground action . . . They are too varied in trend and too marked in character to be due to any possible cause that can be logically suggested, except one, but they display universally the characters and results that would naturally arise from the percolation of acidulated water through rock so easily soluble . . ."

This seems to me an extraordinary series of statements. How can valleys which run in various directions be "in the main joint-valleys"? In my opinion their arrangement is that of a natural system of surface rainfall drainage, and Mr. Spicer quite ignores what I have written about the former extent of a clay-cover (i.e. the Clay-with-flints) all over this region. Why he should expect to find 'alluvial fans' I do not understand, nor why (if present) they can

[1] Geographical Magazine for September, 1908, p. 288.
[2] Op. cit., p. 277.

show underground action. As regards the 'marked character' of these Chiltern valleys, I suppose he means their depth and the manner in which they have been cut back into the escarpment-ridge, and sometimes even through it. I cannot see anything in these characters incompatible with the view that these valleys are the modified relics of an ancient system of drainage superimposed upon and finally transferred to the Chalk.

The high-level gaps in the escarpment are surely the truncated portions of valleys which date from a time when its frontal face lay much further west. The deeply-sunk terminations of the valleys inside the escarpment-ridge are due partly to the solution of the chalk along the previously established waterways, and partly to the frequency of landslips when the rainfall was greater than it is at present.

In this connection I would observe that the part taken by landslips in the formation of these valleys has not been sufficiently considered, and I must plead guilty to having omitted any mention of landslips or of solution when describing the formation of valleys in Chalk districts in a recent memoir,[1] though they were duly credited with a share of the work in my paper on the 'Clay-with-flints.'[2]

I believe that small landslips are more frequent in the dry valleys of Chalk districts than is commonly supposed. I have seen many such landslips on slopes of solid chalk where there were no permanent springs and no impervious substratum. The valleys I have in mind are the upper parts of those on the dip-slopes of the Chalk escarpment in Wilts and Dorset; these have very steep sides, the angle of incline being often between 25° and 28°, and small slips from these slopes often take place after heavy rains, leaving bare faces of chalk with a ruckle of soil, rubble, and turf below, the whole forming a conspicuous scar on the prevailing green turf slope. These slips seldom exceed 5 or 6 yards in width, but they illustrate one of the processes which have operated both in widening the valley and in causing the recession of the valley-head. If such slips occur at the present day, how much more frequent must they have been in earlier Pleistocene time, when the precipitation of rain and snow was so much greater than it is now?

Chemical solution must also have been operative in deepening these valleys, but I think it acts from above downward and not from below upward. After a heavy rainfall a part of the water falling on the escarpment and on the ridges between the valleys is directed into the valley-ways, where it soon sinks beneath the surface, and having acquired some carbonic acid and some humic acids in its descent of the valley-slopes, it cannot fail to exercise a solvent action on the chalk below the valley-floor, and thus to deepen the valley by the removal of chalk in solution.

But this solution process is confined to the depth of a few feet from the surface, and is not the process imagined by Mr. Spicer. He expressly says that the subterranean water-flow "will always tend to produce a master-joint, which will carry an underground stream in

[1] "The Cretaceous Rocks of Britain": Mem. Geol. Survey, 1904, vol. iii, p. 418.
[2] Quart. Journ. Geol. Soc., 1906, vol. lxii, p. 158.

hard limestone, but in chalk will tend to produce by solution a constantly widening and deepening area of weakness, above which the superincumbent strata will sag and produce at length a deeply sunk valley."

In the discussion on the papers read at the Geographical Society Dr. A. Strahan mentioned that "in Dorset where dry valleys are dissected by the cliffs it may be seen that the underlying chalk is rotten and undergoing solution." This is perfectly true, but the observation does not support Mr. Spicer's theory, as Dr. Strahan seemed to suppose. The chalk under such valley-floors is decomposed and disintegrated into a loose mass of chalky paste and rounded pellets of chalk, which is evidently due to the solvent action of water percolating down from the surface; whereas on Mr. Spicer's solution-theory the cliff-section of such a valley ought to show an underground channel or fissure widened by the passage of water, and all the chalk above this widened fissure should show signs of the disruption, sagging, and subsidence which he postulates.

The facts and arguments brought forward by Mr. Spicer and Mr. Bennett afford ample proof that chemical solution by percolating water has played an important part in the deepening of certain valleys, but I cannot see any good basis for their view that these valleys were initiated by solution, nor for Mr. Bennett's theory of the "upward hydrostatic action of underground water." It should be mentioned, however, that Mr. Bennett fully admits the former existence of clay-covers and the co-operation of mechanical erosion in the process of valley-making, so that his view is much more rational and scientific than that of Mr. Spicer.

To sum up, therefore, I think that the actual initiation of valleys in Chalk districts must be ascribed to the influence of surface conditions which have long since ceased to exist; and that the special features which they now present can be explained by the action of surface-causes which are still visibly in operation, namely, landslips and solution of the valley-floors. I cannot see that there is any difficulty in accounting for the dry valleys of limestone districts, or any reason for inventing a special theory of 'solution-valleys' to account for them.

I do not know the area described by Mr. Bennett, and consequently I cannot discuss the origin and formation of its valleys, but I should have thought that the phenomena which he describes were as easily explained on the old theory of the valleys having swallowed the surface-streams as on his new theory of the swallow-holes having initiated the valleys.

II.—On the Occurrence and Origin of Laterite and Bauxite in the Vogelsberg.

By J. R. Kilroe, A.R.C.S.I., H.M. Geological Survey of Ireland.

A RECENT visit to Central Germany afforded the writer an opportunity of studying the conditions under which the Vogelsberg iron-ore and bauxite have been formed, and a brief account of what was observed may assist in broadening the basis upon which a sufficiently comprehensive view of the origin of those substances may ultimately stand. On this account my visit to the region was approved by the Department of Agriculture in Ireland, in connection with the work now in progress on the iron-ore and bauxites of co. Antrim. In my traverses I enjoyed the very agreeable companionship of Dr. Schottler, of the Grossherzoglich Hessischen Geologischen Landestaldt, and the advantage of his guidance. His elaborate description of the basalts in the vicinity of Giessen [1] has since been issued, and is referred to in this paper. The admirable and exhaustive accounts of the bauxite by Professor Adolf Liebrich,[2] and of the iron-ore by H. Münster,[3] are also appealed to frequently. Among other important papers consulted regarding the chemical processes involved may be mentioned those of M. H. Coquand,[4] Professor G. A. Cole, F.G.S., M.R.I.A.,[5] Max Bauer,[6] Sir T. H. Holland, A.R.C.S., F.R.S.,[7] H. Warth, D.Sc.,[8] & F. J. Warth, B.Sc.,[8] Malcolm Maclaren, B.Sc., F.G.S.,[9] H. Brantwood Muff, B.A.,[10] and the summaries by F. Wigglesworth Clarke [11] and Dr. C. Doelter.[12]

The principal points which came under my observation may be briefly summarized as follows :—

(*a*) In the Vogelsberg the ores do not lie in a common zone, or in a zone or zones geologically distinct, and are not associated with lignite.

(*b*) Laterite with iron-ore is developed in irregular tracts on each side of a post-basalt dislocation.

(*c*) The best iron-ore (limonite and non-pisolitic earthy ore) has accumulated below a thick more or less ferruginous layer of completely weathered basalt, clay with pseudo-stratified arrangement.

(*d*) This ore is formed chiefly, if not wholly, from lavas of the lowest stage, while the bauxite is chiefly derived from those of the succeeding stage.

(*e*) The ore-bearing clays carry only a thin covering, if any, of Post-Pliocene date, and are of superficial origin.

(*f*) The date of their origin, therefore, probably late Pliocene.

Taking these points *seriatim* we find—

[1] Abhandlung der Grossherz. Hessisch. Geol. Landes. zu Darmstadt, Band iv, Heft iii, Wm. Schottler.

[2] 28th Bericht der Oberhessischen Gesell. für Natur- und Heilkunde.

[3] "Die Brauneisenerzlagerstätten des Seen- und Ohmtals am Nordrand des Vogelsgebirges": Zeitsch. für Prak. Geol., 1905, p. 242.

[4] "Sur les Bauxites de la Chaine des Alp.": Bull. Soc. Géol. de France, tome xxviii (1871), p. 111.

[5] "The Rhyolites of the County of Antrim": Sci. Trans. Roy. Dub. Soc., 1896, ser. II, vol. vi.

[6] "Beiträge zur Geologie der Seyschellen": Neues Jahr. für Min. Geol. und Palæontologie, 1898, p. 163.

[7] "On the Constitution of Laterite": Geol. Mag., 1903, Vol. X, p. 59.

[8] "The Composition of Indian Laterite": Geol. Mag., 1903, p. 154.

[9] "On the Origin of certain Laterites": Geol. Mag., 1906, Dec. V, Vol. III, p. 536.

[10] "East Africa Protectorate."

[11] "Data of Geochemistry": Bulletin No. 330, U.S. Geol. Survey, 1908.

[12] "Petrogenesis," 1906.

(*a*) The volcanic series near Giessen is divisible into two groups according to Schottler,[1] viz.:

a. Basische Basalte, with 40·6 to 46·7 per cent. of silica, subdivided into basalts with porphyritic and granular structures respectively. The lavas of this stage attain a thickness of about 20 metres.

β. Trappgesteine (anamesites), containing 45·4 to 53·8 per cent. of silica, and reaching some 30 to 40 metres in thickness, perhaps more.

γ. A third group is added—jüngere basische Strombasalte—to be seen near Kloster Arnsburg, etc., referred to by Münster[2] after Schottler.

These members of the series are well defined and traceable in the field with precision. Yet at no point has it been found that the junctions are marked by a definite zone of either bauxite or laterite. In my traverses I passed from the Lower Basalt to the Traps, east of Watzenborn, where the rock is well exposed, without perceiving indications of any such zone. Near Kloster Arnsburg also, where the Upper Basalt rests on the Traps, in the river bank of the Wetter, only a little bole, tuff, and a very thin seam of white indurated clay marked the junction of the two groups.

(*b*) The area is traversed by several post-basalt faults, dislocating the members of this otherwise undisturbed series. One of these, an important 'fossa,' runs southward by Mücka, along the Ohm- and Seen Valley, on each side of which, as shown by Münster,[3] laterites (including ferruginous and aluminous clays with iron-ore and some bauxite) have accumulated to a considerable depth, and to irregular distances up to some 2,500 metres from the fault-line. This observer has shown that the peculiar alteration of the basalt has proceeded from the boundary plains of the component masses—pieces of breccia, exfoliating balls, etc.—towards the centre of each mass, in some cases leaving cores of undecomposed basalt; that the Brauneisenerz —'Stückerz' of the miners—accumulates in the boundary joints, and is removed from the adjoining clay by washing; and that a considerable accumulation of this ore exists beneath the yellow, red, and brown lateritic clay, and in the basalt, some 16 to 18 metres from the surface.

The clay is studded here and there with exfoliating lumps of aluminous material, grey and yellow coats alternating around central cores of undecomposed basalt, precisely comparable to those seen in the Antrim lithomarge. Sketches which I have made of these roundish masses in the Grube 'Hoffnung,' near Stockhausen, might serve as illustrations of those to be seen at the Giant's Causeway,[4] and near Parkmore and Carnlough in Antrim.

(*c*) The yellow and red clay resulting from the disintegration of the basalt is often strongly aluminous, and, as at rothen Hang, to be afterwards referred to, contains lumps of bauxite with basalt structure. At Grube 'Luse,' east of Mücka, these lumps are so numerous as to

[1] Abhandlung der Grossherz. Hessisch. Geol. Landes. zu Darmstadt, Band iv, Heft iii, pp. 331, 451–67.

[2] Op. cit., p. 244. [3] p. 243.

[4] See paper by Tate & Holden, Quart. Journ. Geol. Soc., 1870, p. 155.

form a conglomerate over the iron-ore layer, as mentioned by Münster.[1] The bauxite occurs in comparatively insignificant quantity in the Mücka region; the chief mining industry there is that of iron-ore, which is for the most part dug out of open pits. A good section is to be observed at the Grube 'Hoffnung,' where at the time of my visit a large systematically worked pit had reached the approximate dimensions of 150 by 200 yards and 40 to 50 feet in depth. The section seen was somewhat as follows:—

	Feet.
'Diluvial' matter with stones of basalt	0 to 2
Other superficial material, chiefly sandy clay, termed Löss by Münster .	5 to 8
Yellow and grey clay with dendritic manganese oxide	3
Yellow, grey, red, and brown clay with 'Stückerz,' exfoliating basalt lumps, and nests of pyrolusite	25 to 30
Layer of weathering basalt	12
Limonite (Stückerz or Braunerz), sometimes concretionary and stalactitic, with clay	6

(*d*) The basalt from which the laterite just described has been formed is believed by Dr. Schottler to be entirely that of his first stage, though Münster thought it consists, in part, of the 'Trap' or Anamesite. The difference is immaterial, but the point is mentioned because when we pass to the chief area of bauxite, this ore, and the aluminous clay containing it, at rothen Hang, east of Garbenteich, are derived entirely from the Trappgesteine of Schottler.

The road from Lich, westward to Garbenteich, leaves a somewhat elevated area on the right, known as hohen Stein, opposite which on the south side stretches undulating ground covered with red clay containing pieces of bauxite, which may be picked out of the soil. Westward of hohen Stein the road runs between Auf der Haide and rothen Hang, on both of which the bauxitic clay also forms the soil. That on rothen Hang is the chief source of bauxite, and the area covered with the peculiar clay amounts in the aggregate to about a square kilometre; it reaches a depth or thickness of about $1\frac{1}{2}$ to 2 metres. The layer has all the appearance of having been formed in place by peculiar weathering and disintegration of the anamesite, to be seen *in sitû* throughout the elevated tract of hohen Stein.

Describing the bauxite, Liebrich writes as follows:—"The bauxite of the rothen Hang shows unmistakeably its origin . . . . the yellowish grey bauxite showed clearly a medium-ground anamesite."[2] And again: "The bauxite of this region is very nearly related in structure to the anamesite of hohen Stein. The small pieces of bauxite which occur at the foot of the hohen Stein, in the weathered products of the anamesite, have exactly the same structure as this. The size and number of the transformed plagioclases correspond completely."[3] Pieces of bauxite up to half a metre in diameter have been met with in pits, and, as Liebrich notes, in no case has a core of unweathered basalt been found in the bauxite lumps. Notwithstanding

[1] "Die Brauneisenerzlagerstätten des Seen- und Ohmtals am Nordrand des Vogelsgebirges": Zeitsch. für Prak. Geol., 1905, p. 251. [2] Op. cit., p. 72.

[3] p. 75. Some beautiful points are indicated by Liebrich in this connection, viz., that the basalt-ironstone pieces, also met with in the bauxitic clay, have the same structure as the anamesite, and that the proportions of Fe_2O_3 and Al_2O_3 in the ironstone, and Al_2O_3 and Fe_2O_3 in the bauxite, correspond atomically—they alternate.

this, there can be little doubt that the clay and contained ore are the result of peculiar weathering in place which the basalt has locally undergone.

(*e*) It is a very striking fact that the ores and containing clays, both at Mücka and east of Garbenteich, have little or no superficial covering. In the latter place I was unable to notice any. To sustain some comparison with the conditions in Antrim I hoped to find the red clay, etc., at rothen Hang passing, in indurated form, under the columnar anamesites of hohen Stein; but Dr. Schottler assured me that in a well-boring put down 30 or 40 metres at the Abdeckerei des Kreises, near the Lich-Garbenteich road, nothing of the kind was met with. The clay with bauxite on the rothen Hang is therefore absolutely superficial, and the laterites at Mücka, when not so, bear no covering earlier than the Loess.

(*f*) The volcanic history of the Western Vogelsberg commences with tuffs in the Giessen Sands, which correspond to those at Münzenburg, to the south-east, and at Marburg on the north. These follow the Oligocene of Mainz, and are therefore believed to be of Miocene age. The interbedding of tuffs, basalt, and sands ceases at Giessen before the stage of the 'Traps' is reached, so that the series as a whole is considerably younger than the basalts, etc., of Antrim.

Moreover, the region, as stated previously, is traversed by post-basalt faults, i.e. later than the third stage of volcanic outpourings; and it must have undergone considerable denudation since the faulting, to produce the present surface features. Münzenburg Hill, which is a neck from which lava streamed forth, is now isolated from the group. The pretty feature of Schiffenberg retains only a thin cap of glassy Trap, while it overlooks sedimentary strata which must have been perhaps thickly covered with both Traps and some Lower Basalt. The Frankfurt $\frac{A}{M}$ Section 18, of the geologische Karte by Lepsius (1 : 150,000), shows Pliocene strata in some of the Vogelsberg valleys, e.g. those of Allendorf and Zell and one near Weitershain. It seems quite just, therefore, to infer that the present contours are of Pliocene age, and that the surfaces, in relation to which the ores have been developed, are the result of late Pliocene sculpturing; and even if we take the palms of the Münzenburg Sandstone as indicative of a warm climate, we must come much nearer to a Post-Pliocene date and glacial conditions, for the origination of the Vogelsberg laterite and bauxite, than the Miocene or Eocene, with the climatic conditions which then prevailed in our latitude.[1]

Origin of Laterite and Bauxite in the Vogelsberg.

It is noteworthy that these substances originate for the most part under tropical conditions.[2] These conditions are stated as essential by

[1] It interests me to find that Münster questions whether a tropical climate has been a factor in the formation of the Vogelsberg iron-ores and bauxites. Op. cit., p. 257.

[2] Whether in Ireland or in Southern France in earlier geological times; or in India, the Deccan, Malabar, etc., to-day; Georgia, Alabama, Arkansas; Brazil, Surinam; the Congo, East Africa; the Seychelles, Java, Sumatra, and the Hawaiian Islands—all have their aluminous clays and ores; and so natural has it become to assume a hot climate that Bauer assumes it (Neues Jahrbuch, 1898, p. 219), a view mentioned without comment by Doelter ("Petrogenesis," 1906, p. 235).

Maclaren: "Lateritic deposits require for their formation (*a*) tropical heat and rain with concomitant abundant vegetation; (*b*) alternating wet and dry seasons."[1] Holland, too, assumed the necessity for tropical conditions when relying upon the intervention of bacteria for the production of laterite. Whatever value may be attached to this suggestion, it is freely admissible that the chemical processes involved, organically, in the abundant growth and rapid decay of vegetation, or in the inorganic reactions proceeding in the earth's crust, are greatly stimulated by heat; but are tropical or sub-tropical conditions requisite? The laterite (red clay) described by Muff occurs at such an elevation[2] in East Africa that heat could scarcely be claimed as an essential condition for the peculiar alterations in question; he holds that the decay of forest vegetation—acids resulting therefrom—is a chief factor in the transformations.[3]

The usual impressions regarding the necessity for tropical or sub-tropical heat were in one's mind in going to Germany; with this, however, was my conviction that atmospheric carbonic acid, carried into the earth by rain, played a more important part than the one usually assigned to it if acting under favourable geographical and climatal conditions. I have had to modify my convictions regarding the necessity for heat, for the Vogelsberg laterites, etc., were formed at the threshold of the Glacial Period, as has been shown above, and my belief that CO_2 played a very important part has been strengthened. Abundant forest growths often accompany deposits of laterites and bauxites, the decay of which would have given off quantities of this gas. But where no obvious proof of former vegetation exists, as, in my experience, is the case in Hesse, CO_2 issuing from fissures as a post-volcanic product, as suggested by the carbonated springs at Nauheim and at several

[1] Geol. Mag., 1906, p. 546.

[2] Some 9,500 feet. Op. cit., p. 42. If tropical heat were the determining condition, should we not expect lateritic deposits everywhere throughout the tropics, declining in importance northward and southward in the temperate zones, wherever basalts, dolerites, etc., appear at the surface? Münster, while questioning the existence of tropical conditions during the formation of the laterites at Mücka, resorts to thermal springs, with Chelius and Delkeskamp (op. cit., p. 257), as the effective cause. The carbonated waters of the springs, he believed, brought up iron and bore it into the laterite layer, as well as promoting the weathering of the basalt. As to this I would remark—

(1) The laterite layer, always superficial (practically), occurs from 1 to 3 kilometres from the fault along which the supposed springs issued. Could the waters have retained heat to such distances and have affected only a superficial layer of rock?

(2) The peculiar weathering has proceeded from above downward, the greatest concentration of iron-oxide being at the bottom. Is this not analogous to the case of iron-pans in soils on a larger scale?

(3) The amount of iron given up by the basalt, in weathering to clay in the uppermost 20 feet, could easily account for the aggregate of limonite deposited in the lower 20 feet.

(4) May not the CO_2 given off by springs, such as those now at Nauheim and along other lines of post-basalt dislocations, including that at Mücka, have been carried into the earth from the atmosphere, and affect the rock more generally than when issuing only at points here and there?

[3] G. H. Kinahan relied upon the leaching action of the organic acids from decomposing peat to account for the formation of bauxite. Trans. Manch. Geol. Soc., 1894, vol. xxii, p. 458. This is mentioned by Clarke, op. cit., p. 420.

points in the Vogelsberg region, may formerly have been so copious as to increase largely the proportion of this gas in the lower strata of the atmosphere, when still, over the tracts where bauxite and laterite are now found. Dr. Schottler believes that post-basalt faults traverse the ground north and south of Watzenborn, i.e. each side of the rothen Hang bauxite tract.

E. Kaiser, as well as Münster, rely upon carbonated waters to have effected transformations of the German basalts,[1] and Maclaren assumes, and in part discusses, the reactions of CO_2 in water in the solution of silicates.[2] In a preceding footnote I raise the question whether spring water, either as a warm solvent or one acidified with CO_2, can penetrate throughout a *superficial* layer of rock or clay, as far as would be necessary to suppose it effective; and if this were doubtful in a layer 50 feet deep, in proximity to the fault at Mücka, it would seem much more doubtful east of Garbenteich, where the layer is little more than a tenth of that depth. The circumstances of distribution of the ores in both places strongly suggest that, if CO_2 were the solvent, it must have been borne to the earth from an atmosphere heavily charged with it, given off by fissure springs such as those previously mentioned.

It has naturally been questioned whether CO_2 can be regarded as an adequate solvent, and some observers have appealed to the action of stronger acids. J. Walther, and especially Passarge,[3] appealed to nitric acid supplied by decaying rich tropical vegetation, and formed during thunderstorms; but this, in quantity at least, would seem very inadequate. Others have favoured H_2SO_4 and H_2SO_3.[4] Such acids, formed from pyrites (say) in the Vogelsberg 'Traps,' could not affect the alumina, for in the weathered layer the amount of SO_3 would be immeasurably smaller than is requisite, even for the solution of Mg and Ca, as may be seen by the following analyses. A is an average of ten analyses of *Trappgesteine* after Schottler, B and C are analyses of bauxite and bauxitic clay given by Liebrich (p. 71):—

	A.	B.	C.
SiO_2	50·34	1·10	26·84
TeO_2	2·06	3·20	—
Al_2O_3	13·11	50·92	33·89
Fe_2O_3	4·53	15·72	20·21
FeO	6·25		
MgO	8·34	·16	·23
CaO	8·07	·80	·42
Na_2O	3·10		
K_2O	·96		
P_2O_5	·49		
SO_3	·006		
CO_2	·16		
OH_2	2·24	28·60	18·50

[1] Clarke, "Data of Geochemistry," p. 424.

[2] Particularly if present in such strength as to produce intensive action (Geol. Mag., 1906, pp. 539–40).

[3] "Petrogenesis," p. 235.

[4] Amongst the first to propose this was Professor G. A. Cole; see "The Rhyolites of the County of Antrim," p. 108. Clarke mentions the emanations from volcanoes, as in Java, Sumatra, and Hawaii, op. cit., p. 425. See also G. C. du Bois and Bauer, quoted by Doelter, "Petrogenesis," p. 235; and Hayes and Liebrich, referred to by Clarke, p. 421.

The sulphuric acid brought up with CO_2 in springs, as that at Carlsbad,[1] could only be effective very locally, and, when we turn to the consideration of sulphurous acid vapours, we cannot overlook the following points, viz.:—

1. The deleterious, if not death-dealing, effect of such vapours on vegetation; workable seams of lignite sometimes exist side by side in the same zone, and of contemporary formation, with a rich seam of iron-ore over a deep and wide-spreading lithomarge.

2. Nothing is more striking than the even way in which solution and deposition of Al_2O_3, as hydrate, must have balanced each other in the aluminous layers of rothen Hang. Solution and deposition must have been all but simultaneous; more correctly, perhaps, they rapidly alternated. In following the process, if we regard the solvent as H_2SO_4, and the precipitant $CaCO_3$ in solution, then, although Al_2O_3 could have been precipitated freely by $CaCO_3$ in lake waters, as is suggested by Coquand for the occurrence of bauxite in Bouches du Rhone, it is extremely difficult to imagine how rapid alternations of the process could have gone on in close, deep rock interstices where we assume ordinary percolation and capillary action. For when $Al_2K_2(SO_4)_4$ in solution below, meets $CaCO_3$ in solution, descending, the interstices would become choked with precipitated $CaSO_4$ and $Al_2O_2\,3\,OH_2$ to impede, if not entirely hinder, both percolation and capillarity.

Strong acids were no doubt engaged in the processes, chiefly in the initial stages, after which the chief solvent would have been CO_2. Maclaren maintains that "energetic chemical action in the presence of abundant carbon dioxide" effected complete decomposition in the conditions under which Indian laterites were formed. It is hazardous to propose definite formulæ in attempting to represent what probably takes place, where reactions must obviously be so complex. Many processes are probably at work, simultaneously; and it is very doubtful if the simple formulæ proposed by Maclaren,[2] or that by Van Hise quoted by the Editor of the Geological Magazine, for the sericitization of felspars, or any representing transformations through zeolites[3] or substances allied to them, could—however tempting such formulæ might appear—present all that takes place, or even the main line of reactions along which alteration would run. Keeping in mind the chief desiderata, viz., the detachment and bearing away, in soluble form, of silica in some proportion from the silicates; also the detachment of alumina, and its retention in a nicely balanced condition—now in solution, now precipitated as hydrate—the following general formulæ representing mass-action would seem to include the principal stages in the process of transformation. Let R'_2O be the alkalies; R''_2O the alkaline earths and ferrous oxide; and R_2O_3 the alumina and ferric oxide; also let a compound silicate be affected in the first instance by H_2SO_4; then $a(R'_2O),\ b(R''O),\ c(R_2O_3),\ d(SiO_2) + n\,H_2SO_4 \rightleftarrows x\,R'_2SO_4 + y\,R''SO_4 + z\,R'_2R_2(SO_4)_4 + X$, where X represents

[1] Watts' Chem. Dict., vol. v, p. 1017.

[2] Geol. Mag., 1906, pp. 539–40.

[3] I have found compact basalts as highly transformed as were those which had been manifestly zeolitic, and under similar circumstances.

the shaken siliceous compound after some of the alkalies, alkaline earths, iron oxide, and alumina have been withdrawn as sulphates. Again,

$$X + z\,R'_2\,R_2\,(S\,O_4)_4 + p\,C\,O_2 + q\,O\,H_2 \rightleftarrows$$
$$r\,Si\,O_2\,(O\,H_2)_2 + s\,(Al_2\,O_3,\,n\,O\,H_2) + u\,R'_2\,C\,O_3 + v\,R''\,C\,O_3 + Y,$$

where Y represents the still more shattered compound.

Here now we have colloid silica, which will dissolve in an abundance of the newly formed alkaline carbonates, and either entirely disappear or become diffused through the mass perhaps to form secondary quartz; and free alumina, to form perhaps its unstable carbonate, say when the supply of $C\,O_2$ is abundant, and precipitate, when that supply slackens, as well as to go afresh into solution when the supply again increases.

If we suppose $H_2\,S\,O_4$, formed from pyrites in the rock, as suggested by Hayes; or, as suggested by Professor Cole, from post-volcanic vapours—present, say, in such small quantities as not to be injurious to vegetation—this acid would have been likely to initiate the attack upon the silicates. The molecular constitution of these compounds having been thus shaken or disturbed, the remaining substance, made up of constituents in a nascent state, would have been laid open to further attack, and probably wholesale solution as shown above, by $C\,O_2$ in abundance, in rain-water carried down from a heavily charged atmosphere: in this regard, Maclaren suggests, would the conditions differ from those under which common clays are formed, namely, those in which $C\,O_2$ is small in quantity and consequently weak in action.[1] The conditions also differed from those in which kaolinization of granite, etc., takes place, by the action, as H. Rösler shows, of thermal springs and vapours.[2] The alkalies, Mg O, Ca O, and $Al_2\,O_3$, it is believed, would all be attacked and in time go into solution; and, wherever the acid became satisfied, the nascent $Si\,O_2$ would become dissolved by the alkaline carbonates—present, we may suppose, in large quantity. Thus would the delicately balanced state be reached in which, while capillarity is maintained in free play, a large quantity of $Si\,O_2$ might be carried off or be deposited at certain points, according as the solution remained alkaline or became acid; and the alumina could be transferred from point to point throughout the weathered mass to concentrate in bauxite above[3] or in the interstices of lithomarge below.

Replying to queries of mine regarding the possibility of accounting for the Vogelsberg bauxite by supposing the former existence of forests in the region, or decaying vegetation yielding humous and carbonic acids, Dr. Schottler has sent me the following note, November 9, 1908, viz.: "Unsere Bauxite liegen vielmehr stets an der Oberfläche; auch sind keine Anzeichen dafür vorhanden, dass er sich unter einer dichten Vegetationsdecke oder unter Waldbestand gebildet hat. Ebenso hat man noch nie versteinertes Holz in dem Ton vom roten Hang gefunden. Verkieselte Hölzer kommen nur als Seltenheit hie und da im Tuff vor."

[1] Geol. Mag., pp. 539–40.

[2] Zeitschr. für Prak. Geol., 1905, p. 333. Paper by O. Stutzer in which he gives, with approval, Rösler's view.

[3] Liebrich, op. cit., p. 96. The author believes that $Al_2\,O_3$ was dissolved out of the rothen Hang clay and concentrated in crevices, etc., of the bauxite lumps, as hydrargillite.

III.—Studies in Edrioasteroidea.[1] III. *Lebetodiscus*, n.g. for *Agelacrinites Dicksoni*, Billings.

By F. A. Bather, M.A., D.Sc., Brit. Mus. (Nat. Hist.).

(PLATE XXV.)

Previous History.

The specimen herein to be considered is one of great historical interest, for it was the first specimen of an Edrioasteroid made known to science. It was discovered by Dr. J. J. Bigsby in limestone now recognised as of Lower Trenton age, forming Table Rock at the Chaudière Falls on the Ottawa River at Ottawa (then called Bytown), Canada, in 1822. Brought by Bigsby to England, it was figured and described, though not named, by G. B. Sowerby in 1825.[2] E. Forbes, who had the specimen for study, referred to it in his memoir "On the Cystideæ of the Silurian Rocks of the British Islands,"[3] since the "aspect" of his *Agelacrinites Buchianus* "immediately called [it] to mind"; he even went so far as to say that there could "be no question . . . of its being generically allied" to that species. Considering the not unnatural inadequacy of Sowerby's description and figure, the reputation that Forbes had as an authority on echinoderms, and the comparative imperfection of the first found specimens of *Edrioaster*, it was not surprising that E. Billings in 1856[4] should have supposed a new Trenton fossil, undoubtedly congeneric with *Agelacrinites Buchianus*, to be of the same species as that found by Bigsby, and should therefore have applied to it the trivial name '*Bigsbyi*,' while giving to a fossil of obviously different structure the name '*Agelacrinites Dicksoni*.'[5] In February, 1858, Billings travelled to London with the fossils in question, and found that Bigsby's specimen was not, after all, the same as his *Cyclaster Bigsbyi*, but was specifically identical with his *A. Dicksoni*. He redescribed the species, and had his type-specimen, as well as Bigsby's fossil, figured by C. R. Bone.[6]

The latter specimen was said by Billings to be then "in the Museum of Practical Geology, Jermyn Street, London." I therefore supposed that it had been transferred to the British Museum when all the foreign fossils were so transferred some years ago. But when no trace of it could be found either in the collections or the registers of that establishment, I applied to Mr. E. T. Newton, palæontologist to the

[1] Studies I and II were published in the Geological Magazine for December, 1898, and May, 1900. Publication of the present Study, written in 1899, was delayed owing to an unwillingness to load Zoology with a new generic name without further confirmation from all available evidence. Since that date so much Edrioasteroid material has passed through my hands that the publication of these Studies is resumed with more confidence.

[2] "Notice of a Fossil belonging to the Class Radiaria, found by Dr. Bigsby in Canada": Zool. Journ., vol. ii, pp. 318–20, pl. xi, fig. 5; London, October, 1825.

[3] Mem. Geol. Surv. Gt. Brit., vol. ii, pt. ii, 1848; see pp. 519 and 520.

[4] Rep. Progress Geol. Surv. Canada, 1853–6, p. 292; Toronto, Autumn of 1857.

[5] Op. cit., p. 294.

[6] Canadian Organic Remains, dec. iii, p. 84, pl. viii, figs. 3 and 3*a* (the holotype), 4 and 4*a* (Bigsby's specimen).

Geological Survey, and he kindly made a search which was at last successful. I have to thank him and the then Director General of the Survey for graciously allowing me to retain this specimen from 1897 till the end of 1898. It bears the following labels:—"Agelacrinites Bigsbii / Falls of the Chaudière / Ottawa Rivr. Canada / Pres. by Dr. Bigsby 1848 / E F △", "M.P.G.," "6259." The label suggests that Forbes really did fully share the original misapprehension of Billings.

In 1881 a figure described as "Specimen of *Agelacrinites Dicksoni* from the Cabinet of Dr. Grant" was published as fig. 9 of a plate illustrating "Description of a new species of Porocrinus, &c.," by James Grant, M.D., etc. (Trans. Ottawa Field-Nat. Club, No. 2, pp. 42–4). No reference to the specimen was made in the paper or elsewhere in the number.

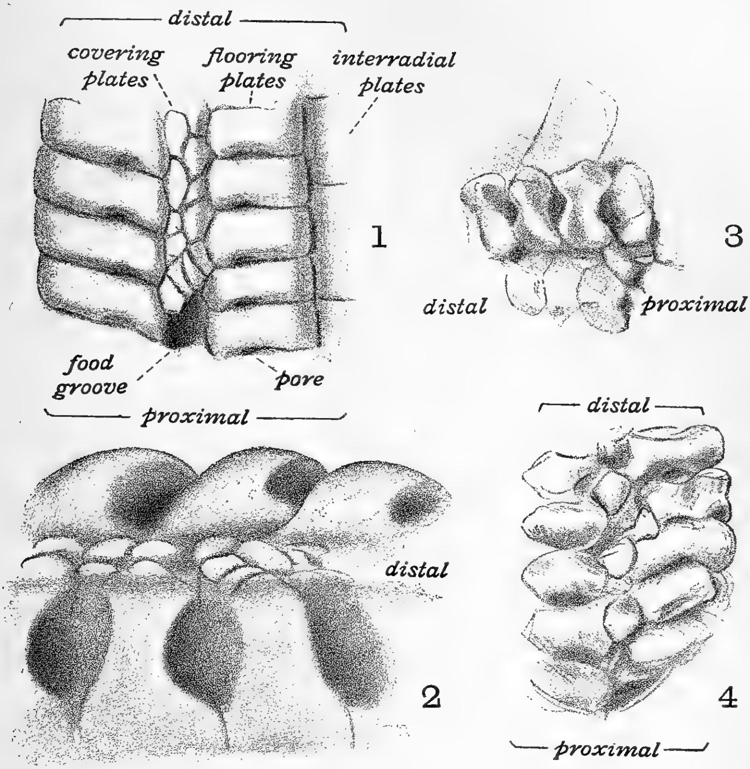
Description of Bigsby's Specimen.

The specimen overhangs the edge of a triangular fragment of limestone, with sides respectively 56, 70, and 76 mm. long. The rock is composed of fragments of coral, monticuliporoids, and pelmatozoa; bits of undeterminable brachiopod shells are visible, but I cannot detect the "single spiral univalve" which Sowerby says "is also to be observed." There is, however, on one side a fragment of some subcylindrical object, with irregular longitudinal striæ on its surface; it is fully 6 mm. long and 2 mm. in diameter. The whole has the characteristic black tint of Trenton Limestone. The upper surface is curiously weathered, and on it lies a fragment, apparently of a *Pleurocystis*, with a part of one of the brachioles. The two echinoderms have the actual test preserved in highly crystalline carbonate of lime coloured by iron rust. The rugose surface of the Edrioasteroid may be due to partial solution and redeposition of calcite; the study, and especially the figuring, of the specimen is thus a task of much difficulty. The under surface of the specimen is obscured by the matrix, even where it overhangs. An attempt to remove some of this has revealed a few doubtful traces of plates. The posterior and right and left posterior interradii are fairly preserved, but the other two are incomplete, and from the left anterior the greater part of the test has been removed.

The periphery is very obtusely pentagonal; as to this I do not share Sowerby's hesitation. The theca rises above the periphery to a height of about 5 mm., which height is attained by the plates of the radial grooves and of the right posterior interradius. The plates in the latter, however, have been raised since death. The above-mentioned traces of plates suggest that the under surface was not flat, and one might hazard a conjecture that the total height of the animal was about 6 mm.; but it may have been excavated around the abactinal pole. The sagittal diameter was about 20·5 mm. The greatest width, measured along the right posterior interradius and left anterior radius, is 23·5 mm. The length of a side is roughly 11·5 mm.

On the Upper Surface the five Subvective Grooves radiate with a sinistral curve, which, to a distance of about 6 mm. from the actinal centre, is hardly perceptible, but then becomes more pronounced.

The grooves reach the periphery, but do not curve round it or pass over it. They would therefore have been invisible from the under surface. The left posterior groove attained a length of 19 mm. from the actinal pole; the left anterior and right posterior were about 1·5 mm. shorter; the others are too imperfect to measure accurately.



SUBVECTIVE SKELETON OF *Lebetodiscus Dicksoni.*

FIG. 1.—Portion of a ray, showing relations of covering-plates to food-groove and flooring-plates; slightly diagrammatised. × 6 diameters.

FIG. 2.—Portion of a ray, seen in three-quarter perspective, showing covering-plates and the excavation of the flooring-plates; slightly diagrammatic. × 20 diam.

FIG. 3.—Portion of the anterior ray, showing how pores are formed by lateral excavation of flooring-plates; sketched under the microscope. × 6 diam.

FIG. 4.—Similar appearances in another part of the same ray, with some covering-plates; sketched under the microscope. × 6 diam.

(All drawings made from Bigsby's specimen.)

The skeleton of the subvective grooves is stout and raised above the general surface to a height of about 1·2 mm. in their proximal regions. The width near their proximal ends is 2·8 mm.; they taper gradually distalwards, and are rounded off rather bluntly. Each is clearly seen to be composed of a double row of flooring-plates, alternately arranged. These are rounded, and have in places a slight appearance of overlapping by their proximal margins. In the proximal region of a groove, the long axis of any one of these plates is directed almost at a right angle to the median line of the groove, but tends in a distal direction; its length is 1·6 to 2 mm.; the breadth of such a plate is ·9 to 1 mm. There are from 21 to 25 plates along each side of a groove: the lower numbers are on the adjacent sides of the right and left pair. The greatest number is on the adanal side of the left posterior ray.

Each of these plates is excavated on its sides, but more on the side towards the distal end of the ray (Fig. 2), so that the adjacent excavations form a pore, which lies about half-way between the middle line and the outer margin of the whole ray. The actual food-groove was very narrow, and appears to have been covered with irregular plates, some of which are preserved in places (Fig. 1). These covering-plates, though small in proportion to the whole structure, are large compared with the food-groove and do not seem to have had a regular alternating arrangement. As to their existence, I have no doubt; but the state of preservation of the fossil forbids a more accurate account.

The actinal centre is roofed over by relatively large irregular plates, one or two of which are broken away on the right side, so that one gets a suggestion of the underlying hollow, or vestibule of the mouth. These covering-plates appear to be serially homologous with those of the grooves, and their relations to them and to the flooring-plates are best seen in the right posterior ray.

The Interradial Areas are bounded by the flooring-plates of the grooves and by the periphery, but were not separated by any differentiated area from the under surface. They are covered with relatively large and apparently thick plates of irregular shape. The adoral margin of each plate slightly overlaps the adjoining margin of the adjacent plate. This gives the effect of a slight adoral imbrication, more perceptible the nearer the periphery. The plates become a trifle smaller towards the periphery, but there is no sudden diminution of size, and no break in their continuity with the peripheral plates of the under surface. The plates are rugose, but it is hard to determine precisely how far this is due to original ornament. At about half-way between the actinal centre and the periphery the width of the right posterior area is 5·4 mm., that of the posterior area 8·5 mm. The distance from the distal extremity of the left posterior ray to that of the right posterior ray is 15·1 mm., to that of the left anterior is 13 6 mm. The distance between the distal extremities seems to have been a little less than 13·6 mm. in the other interradii, but exact measurements are not obtainable.

The conspicuously greater width of the posterior interradius is due to the presence of the Anal Opening, clearly recognisable as such. Its centre is 6·5 mm. from the actinal centre, and nearly on the middle line of the interradial area. The plates of the valvular pyramid, if they ever existed, have disappeared. The opening which remains is surrounded by a border of plates smaller than the others of the same area, into which they merge, and slightly raised above them, but not governed by a definite arrangement. The diameter of the opening is about 2 mm.; that of the whole ring is about 4·5 mm.

The Under Surface is so obscured by a hard matrix that one cannot, even after many days labour, be sure of its structure. Fragments seen below the end of the left posterior ray and of the posterior interradius, towards its right side, suggest that there was a pavement of irregular polygonal plates, about 9 to a square millimetre, not imbricating, but probably set in a flexible integument. A broken edge visible in the left anterior interradius, suggests that the larger plates around the periphery formed a stoutish frame, and that the minutely plated central integument stretched loosely across from this frame. Such a suggestion is at least in accordance with the little that we know of this region in the Edrioasteridæ. At the same time there is room for doubt whether all the appearances actually proceed from portions of the individual.

Remarks on the Holotype and on Billings' Description.

The type-specimen of this species is "a fragment, consisting of one perfect ray and two of the interradial spaces," preserved in the Museum of the Geological Survey of Canada, at Ottawa. Since this was the only specimen in the possession of the Survey in 1856, I assume it to be the same as that taken by Billings to London, and figured in Decade iii, pl. viii, figs. 3, *3a*. These figures, however, show two complete rays and considerable portions of three others. Only two interradial areas, however, are at all complete, and neither contained the anus. No central aperture is to be distinguished. The specimen "is quite flat, and appears to have been firmly attached." There is no reason to doubt that Bigsby's specimen, as well as the "other specimens" alluded to by Billings, were rightly referred by him to this species.[1] Moreover, since his second account was actually based largely on Bigsby's specimen, any differences between that account and the description now given must be differences either of observation or interpretation. Let us consider them.

"The diameter . . . is from three-quarters of an inch to an inch and a half." Billings' fig. 4 represents our specimen as $1\frac{1}{16}$ inch along a diameter which is really $\frac{15}{16}$ inch. It is therefore a medium-sized specimen. The type-specimen, as drawn, would have had a diameter of $\frac{19}{32}$ inch, and is therefore a very small specimen.

"The rays . . . are bounded by two rows of small plates, which . . . arch over the grooves. The upper ends of the plates on one side meet those of the opposite side, in a line along the centre of the ray, thus forming for each ray a sort of covered way." In other words, the plates called by me 'flooring-plates' were regarded by Billings as covering-plates, and he did not see the true covering-plates at all, which he was hardly likely to do unless he specially looked for them. But, besides this, the plates in question do not arch over so as to form a covered way, but occupy the full thickness of the ray, as may be seen in section at the end of the anterior ray of Bigsby's specimen.

[1] Should it ever be proved that Bigsby's specimen is of a different species, it will have to receive a new name; and that new species must then be taken as the genotype of *Lebetodiscus*.

"In all the specimens . . . the rays curve round to the right hand." As the figures show, this means sinistrally or contra-solar, as is actually the case in Bigsby's specimen.

"The marginal plates of the rays do not appear to alternate regularly." They do alternate, however, and the contrary appearance is due to the irregularities of the covering-plates.

"There are two rows of small circular indentations on each side of the rays, corresponding in their position to the ambulacral pores of *E. Bigsbyi*, only that in the latter they are in the bottoms of the grooves." I only see one row of 'indentations,' but the appearance of another row is occasionally produced on the extreme edge of the ray by the rounding of the ends of the flooring-plates. The structure of the anterior ray in our specimen leaves me in no doubt that the indentations were actual pores, corresponding to the pores of *E. Bigsbyi*, which had only one row of pores, not two, as Billings supposed.[1] The difference between the two forms really is that here the pores are well outside the covering-plates, whereas in *Edrioaster* they were roofed in by them, a fact not known to Billings.

Remarks on other Specimens referred to *A. Dicksoni*.

The specimen formerly belonging to Dr. James Grant has already been mentioned. Since the present paper was first written, Dr. J. M. Clarke, in a valuable article entitled "New Agelacrinites" (Bull. N.Y. State Mus., vol. xlix, pp. 182–98, pl. x, December, 1901), has published a diagram based on Grant's figure (p. 190, fig. 3), and from his legend it appears that the diameter of the specimen is only 21·5 mm., and not 48 mm. as it appears in the original drawing. These illustrations indicate some resemblance to Bigsby's specimen, but the small adorally imbricating plates seen on the margin in the right anterior interradius do not appear in harmony with the adjoining plates of the periphery, which are all large, just as they are in Bigsby's specimen. At all events, such a figure, unsubstantiated by any description, cannot be held to prove the existence of the imbricate border characterising *Agelacrinus*, *Lepidodiscus*, and a few other genera.

A distinct imbricate border of *Agelacrinus*-type is shown in pl. ii, fig. 2, of Professor Otto Jaekel's "Stammesgeschichte der Pelmatozoen" (Berlin, 1899). The specimen, which is in the collection of Professor Frech at Breslau, and comes from the Trenton Limestone of Ottawa, is assigned by Dr. Jaekel to *A. Dicksoni*. On p. 50 he says of this species: "Thecalplatten zwischen den Ambulacren besonders gross, Ambulacra ziemlich kurz gedreht, Saumplättchen stark skulpturirt." The word 'Saumplättchen' is usually translated by 'covering-plates' or 'ambulacrals,' and in the explanation to pl. ii Dr. Jaekel applies the word 'Ambulacralia' to two of the plates that in his opinion cover the subvective groove. These are strongly pitted on the sides

[1] See the diagrams and brief account of *Edrioaster Bigsbyi* in "A Treatise on Zoology," ed. E. Ray Lankester, vol. iii, Echinoderma, p. 209. Also F. A. Bather, "What is an Echinoderm?" 1901, and Encycl. Brit. Suppl., Art. Echinodermata, 1902.

(perhaps for the reception of smaller plates), but do not appear to be of the same character as either the flooring-plates or the covering-plates in Bigsby's specimen of *A. Dicksoni.* It is, in fact, clear that the specimen figured by Dr. Jaekel differs in its peripheral zone and in its subvective skeleton from our species, and that in those points it has the character of an ordinary *Agelacrinus.*

With the language used by Dr. Jaekel it is not easy to reconcile the following sentences in Dr. Clarke's paper (op. cit., p. 191):—"Billings claimed that in the Trenton species *A. dicksoni*, perforated ambulacral plates were exposed, but this observation has not been confirmed and Jaekel holds that no ambulacral plates were present in these bodies. At all events usually only the cover plates have been observed." I am not sure what this means, but it is certain that the plates between which Billings described 'indentations' were those here called flooring-plates, and it is highly probable that these indentations were podial pores. It is also certain that these same plates were identified by both Billings and Jaekel with the 'covering-plates' or 'ambulacrals' of a crinoid arm, and that they did not mention the smaller covering-plates, which, in my opinion, are the only homologues of crinoid 'Saumplättchen.'

Of recent years the only other reference to the species has been the record of its occurrence in Trenton Limestone at Pakenham, Ontario, by Dr. H. M. Ami (Ann. Rep. Geol. Surv. Canada, xiv, p. 84 J; January, 1905).

Systematic Relations of the Species.

There still are problems to solve with regard to *Agelacrinites Dicksoni*; but there are problems presented by the majority of Edrioasteroidea, and we certainly know enough to make comparison with other forms profitable.

Taking the families of Edrioasteroidea as defined in Lankester's "Treatise on Zoology" (vol. iii, pp. 207–9, 1900), we may at once set aside the Cyathocystidæ with their massive theca, and the Steganoblastidæ with their stem.

Turning to the Agelacrinidæ, with which the species has always been placed, we see that from *Stromatocystis* it is separated by the imbrication of the interradial plates and the curvature of the rays. The latter feature also distinguishes it from *Cystaster* and *Hemicystis.* It is further separated from *Cystaster* by the large size of its interradials, and from *Hemicystis, Agelacrinus, Streptaster,* and *Lepidodiscus* by the absence of the differentiated marginal zone, which in those forms is always obvious and often highly differentiated. I also incline to regard it as having had a less flattened and less sessile habit than the genera just mentioned. Similar features, as well as the clear alternation of the flooring-plates of the grooves, enable us to discriminate between it and the little-known *Haplocystis* of Roemer. As for the Carboniferous form to which in 1897 Gregory gave the name *Discocystis*, we know, at all events, that it had no imbricating plates, and that the margin was more distinct than in *A. Dicksoni.*

A more important character than any of those mentioned is presented by the structure of the subvective skeleton. It seems clear that the side-plates, here called flooring-plates, are homologous with the flooring-plates of *Edrioaster*. Whether those plates have homologues in the Agelacrinidæ is matter for debate; at any rate, no genus of that family has similar plates with intervening depressions so like pores. The covering-plates also seem homologous with the covering-plates of *Edrioaster*, and it is doubtful whether the so-called 'ambulacrals' of the Agelacrinidæ are of the same nature; if they are, they have, at any rate, different relations to the adjoining plates.

Proceeding then to compare the species with other Edrioasteridæ, we note that it differs from them in the restriction of the grooves to the actinal surface, in the small size of the covering-plates, and in the absence or very slight development of an abactinal frame.

The species therefore appears to represent a generic type hitherto unrecognised, and a type of considerable interest in that it is intermediate in so many features between Edrioasteridæ and Agelacrinidæ. What bearing this may have on the classification of the Edrioasteroidea must be reserved for discussion after more of these Studies shall have been published. For the present, the following diagnosis may be offered.

Lebetodiscus[1] gen. nov.

An Edrioasteroid, with theca flattened below, convex above; no marginal zone on actinal surface; no definite abactinal frame; interradial thecal plates relatively large, with slight adoral imbrication; rays curved [contra-solar in genotype], and reaching but not passing the periphery; subvective skeleton of alternating flooring-plates, with intervening pores, and small irregular covering-plates.

Genotype: *Lebetodiscus Dicksoni* (E. Billings, sub *Agelacrinites*).[2] Lower Trenton Limestone, Ottawa.

It may be worth noting that a restored representation of the fossil herein described, by J. S. and A. B. Wyon, adorns the reverse of the Medal founded in 1887 by Dr. Bigsby and awarded biennially by the Council of the Geological Society of London. To judge from the illustration facing p. 252 of Mr. Horace Woodward's "History" of the Society (1907), the medal gives a good general idea of *Lebetodiscus Dicksoni*.

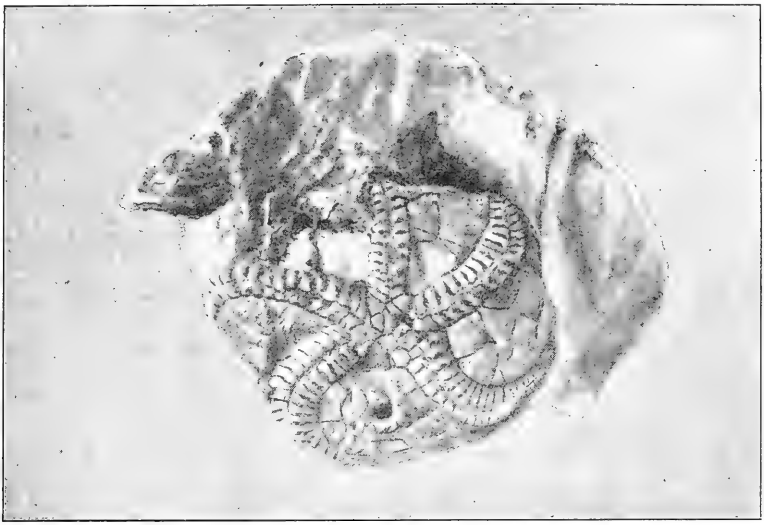
EXPLANATION OF PLATE XXV.

The Upper Figure is taken from a photograph of Bigsby's specimen of *Agelacrinites Dicksoni* Billings, the type of *Lebetodiscus*, enlarged two diameters. Only a part of the matrix is shown. The posterior interradius, with the anus, is towards the observer.

The Lower Figure represents the Lower Trenton Limestone of Table Rock at Chaudière Falls, Ottawa River, where Bigsby collected the specimen figured above.

[1] *Lĕbētodiscus*, from λέβης, a cauldron; after the Chaudière Falls; and δίσκος, a round plate.

[2] But see footnote 1, *ante*, p. 547.



LEBETODISCUS.

IV.—Sedgwick Museum Notes.

A New Species of *Cyclus* from the Carboniferous Limestone of Ireland.

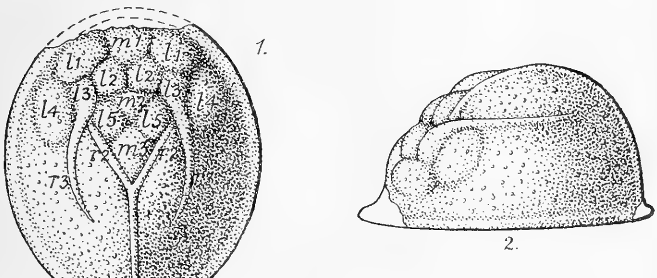
By F. R. Cowper Reed, M.A., F.G.S.

A SPECIMEN of *Cyclus* has lately been acquired from the Carboniferous Limestone of St. Doulaghs, co. Dublin, which indicates a new species, though it is allied to several which have been described by Dr. Henry Woodward. The latter[1] gave in 1894 a review of our knowledge of this curious little Crustacean genus, and his view that it is an Entomostracan and probably one of the Phyllopoda has been generally accepted, though more recently[2] (1905) he has suggested that the members of this genus are but the larval stages of Coal-measure Limuloids.

Our specimen is in a good state of preservation and is perfect, except round the anterior end, where the border is rather hidden by hard matrix, but all the bosses on this part of the carapace seem to be exposed.

Cyclus simulans, sp. nov.

Diagnosis.—Carapace oval in outline, convex, nearly hemispherical, greatest height somewhat behind middle, posteriorly descending more steeply to margin; surrounded by narrow border of regular width, horizontally extended, with rounded raised rim and shallow marginal furrow.



Cyclus simulans, sp. nov.
Fig. 1.—Top view. × 12.
Fig. 2.—Side view. × 12.

Anterior third of carapace elevated into regularly disposed contiguous bosses, and divided from hinder part by curved transverse cervical furrow. Four pairs of lateral bosses and one unpaired median one present. Innermost posterior pair (l_2, l_2) subquadrate, in contact in middle line and with median boss (m_1) in front and with cervical furrow behind. Outer posterior pair (l_3, l_3) subtriangular, lying along cervical furrow, wedged in between innermost posterior pair (l_2, l_2) and outermost posterior pair (l_4, l_4), and in contact with anterior pair (l_1)

[1] Woodward, Geol. Mag., 1894, Dec. IV, Vol. I, pp. 530–539.
[2] Ibid., 1905, Dec. V, Vol. II, pp. 490–492.

in front; prolonged backwards into curved lateral ridges (r_3, r_3) on slopes of hinder part of carapace. Anterior lateral pair (l_1, l_1) transversely oval, lying in front of l_3 and l_2, and touching median unpaired boss (m_1) and outermost posterior pair (l_4). Median anterior unpaired boss (m_1) small, subrhomboidal. Outermost posterior bosses (l_4, l_4) largest of all, obliquely placed, oval, touching in front the lateral bosses l_1 and l_3, and the curved lateral ridges above, surrounded by rather strongly marked furrow.

Posterior part of carapace divided in half by narrow median dorsal ridge (r_1) running forwards from posterior margin to middle of carapace, then bifurcating so as to enclose a triangular space (cardiac region) between its branches (r_2, r_2) and the cervical furrow, against which they end. Cardiac region triangular, occupied by a large rhomboidal posterior median boss (m_3) and a smaller anterior triangular boss (m_2), the latter flanked by a pair of subrhomboidal lateral bosses (l_5, l_5). Lateral ridges (r_3, r_3) proceeding from outer posterior bosses (l_3, l_3), curved, narrow, rounded, thinning and dying out at about two-thirds the length of the carapace without meeting dorsal ridge (r_1). Surface of carapace coarsely granular, with minute scattered puncta on lateral slopes, which become rather larger and more numerous near the marginal groove.

Length	. . .	5·50 mm.
Width	. . .	4·75 ,,
Height	. . .	2·50 ,,

Affinities.—This species shows points of resemblance to several British forms already described. The bosses on the cardiac region and bifurcation of the dorsal ridge resemble *C. Harknessi*, Woodw.,[1] but the posterior and lateral parts of the carapace are quite different. In the dorsal ridge, lateral ridges, smooth sides, and border we are reminded of *C. Wrighti*, Woodw.,[2] but the bosses on the anterior and cardiac portions are differently developed. *C. bilobatus*, Woodw.,[3] is less closely allied. In *C. Scotti*, Woodw.,[4] the lateral ridges join the dorsal ridge behind, and the carapace is emarginate, but the ornamentation seems similar. The Irish species *C. Jonesianus*, Woodw.,[5] may also be compared.

V.—The Age of the 'Old or Grey Granite' of the Transvaal and Orange River Colony.

By Dr. C. G. S. Sandberg.

It may be taken for granted that everybody agrees with Dr. Molengraaff when, in discussing Dr. Hatch's paper on "The Oldest Sedimentary Rocks of the Transvaal," he says:[6] "There must exist, or have existed,

[1] Woodward, Geol. Mag., 1870, Dec. I, Vol. VII, p. 556, Pl. XXIII, Figs. 6, 6*a*.
[2] Ibid., p. 555, Pl. XXIII, Figs. 5, 5*a*.
[3] Ibid., p. 554, Pl. XXIII, Figs. 3, 3*a*.
[4] Ibid., 1893, Dec. III, Vol. X, p. 28, woodcuts A and B; 1894, Dec. IV, Vol. I, p. 536.
[5] Ibid., 1870, Dec. I, Vol. VII, p. 557, Text-figures 1, 2 on p. 558; 1894, Dec. IV, Vol. I, p. 535, Pl. XV, Figs. 1*a*, 1*b*.
[6] G. A. F. Molengraaff: Proc. Geol. Soc. S. Africa, to accompany vol. vii of the Transactions, p. xxix.

a formation older than the Witwatersrand Beds, because even at the very base of the Hospital Hill series conglomerates are known, the pebbles of which cannot obviously have been derived from the Hospital Hill series by denudation." It has, therefore, I take it, not been the intention of various authors to prove this self-evident truth, but only to try and definitely settle the still open question whether this older rock is yet represented in the geological sequence of the country, and, if so, what strata should be identified as such. The relative age of the 'old granite' or 'grey granite' has been the base and the cornerstone of controversy on this subject, and it therefore becomes imperative to put on record and to continually keep in mind the only reliable mode of determination of the age of eruptive rocks which we yet possess. It would be out of place here to insist upon the origin of abyssal eruptive rocks of the granite family (Rosenbusch's Tiefengesteine).

The eternal cycle may be considered generally recognised to-day as answering to the formula: Eruptive rocks are in part or *in toto* the product of the transformation at some considerable depth and under the influence of heat, pressure, time, 'agents-minéralisateurs,' etc., of sedimentary strata, which in their turn originated from eruptive rocks by their disintegration and the transport, sorting, and redeposition of the disintegrated elements.

It is self-evident that in general the basal sedimentary strata are most exposed to this intra-telluric transformation, whilst on the other hand it generally requires the abyssal rocks to get at or near to the surface before their disintegration can take place. Eruptive rock would, therefore, always be restricted to the base of the geological sequence but for the action of mountain-folding forces, and of the corrosive digestion by the unconsolidated magma of the superposed strata, along lines of least resistance, progressing more or less intensely in different parts of the sedimentary envelope. Although consequently eruptive rock is, generally speaking, a direct product of such sedimentary rock, older than those indubitably recognisable as such and covering it, it has been universally agreed to assign such geological age to an eruptive rock which corresponds with the time of its consolidation. This geological date is fixed by the age of the youngest sedimentary deposit, traversed, injected, or altered by the non-consolidated magma; and as it has now been conclusively proved that the action of an internal magma on the overlying sedimentary strata is most erratic, so that the lower strata might seem *not* to have been affected at all in one place, whilst in its immediate vicinity conclusive evidence of its intense action on the same and even very much younger strata is abundant, we may not under any circumstance reverse the rule and deduct the relative age of sedimentary strata from their seeming to have been or not to have been affected by a given eruptive rock before its consolidation.

Strange as it may seem, this is what has deliberately been done with regard to the question of the basal sedimentary deposit in the Transvaal and South Africa.

It may be that D. Dorffel started this topsy-turvy way of reasoning. It is certain that Dr. F. H. Hatch and Mr. E. Jorissen, relying on the result of Dr. G. S. Corstorphine's conclusions, dispute with each other the title of being its strongest advocate.

Dr. A. Schenck,[1] in 1888, first made a distinction between the Witwatersrand Beds[2] and the Swazi Beds, placing the latter at the bottom of the sedimentary series, evidently exclusively because of the then prevalent ideas which assigned all gneiss and crystalline schists, as a matter of course, to the Archæan system. Dr. G. A. F. Molengraaff,[3] who was naturally impressed by the great similarity both in the composition of the individual members and in the succession of the component strata of the Barberton (Swazi) and W.W.R. Beds,[2] who was struck by the perfect conformability between the Barberton Schists and the enclosed conglomerate formation so identical with the W.W.R. Beds,[2] who lastly found both unconformably covered by much younger and identical formations, naturally placed them in the same system and on the same geological horizon at the base of our geological sequence. His ruling was for some time generally accepted, until in 1903 Mr. Dorffel[4] reopened the question with a paper, the essence of which is contained in his final remarks—"At present I am not of opinion that the old granite is intrusive in the Witwatersrand Beds. . . . *If the old granite be not intrusive in the W.W.R. Beds, we have to assume the existence of an Archæan formation.*" (The italics are mine.) Dr. G. S. Corstorphine, taking up this line of argument, soon afterwards concludes as to the non-intrusiveness of the old granite in the W.W.R. Beds, and to the 'consequent' existence of an Archæan formation, on the following grounds:—[5]

"On *one* farm (east of Heidelberg, Uitkyk No. 97) Dr. Corstorphine finds the actual contact of the 'old granite' and the Lower W.W.R. Beds *along an exposure of* 200 *yards.* He cannot discover any intrusion of granite in the quartzites, nor any contact-phenomena between the two rocks. He furthermore cannot find any granite pebbles in the superposed quartzites. Rounded, water-worn boulders of white and bluish vein-quartz, which he is convinced originated from the breaking up of some of the numerous veins in the granite, are, however, conspicuous in these lower quartzites. He is impressed by the granite under the quartzites here showing a rounded and worn surface, and finally declares that he has not been able in any of the localities which he had the opportunity of examining elsewhere to recognise a series of schists forming the lowest portion of the W.W.R. series. What have been taken for schists and even for quartzites in several localities are really, according to Dr. Corstorphine, differentiations and variations in the granite itself."

It must at once strike the mind of the reader that Dr. Corstorphine

[1] A. Schenck, "Die Geologische Entwickelung Süd-Africas": Petermanns Mitteil., 1888, Bd. xxxiv, pp. 225–32.

[2] For Witwatersrand Beds we shall henceforth simply write W.W.R. Beds.

[3] G. A. F. Molengraaff: "Geologische Aufnahme der Süd-Afrikanische Republik" (79 + xvii pp. in 4to, Pretoria, 1898), pp. 10, 27, and 35–8.

[4] D. Dorffel, "Note on the Geological Position of the Basement Granite": Trans. Geol. Soc. S. Africa, 1903, vol. vi, pt. v, pp. 104, 105.

[5] G. S. Corstorphine, "The Geological Relation of the Old Granite to the Witwatersrand Series": Trans. Geol. Soc. S. Africa, vol. vii, pt. i, pp. 9–12.

distinctly disowns the well-known most erratic manner in which igneous rock in its unconsolidated state affects adjacent sedimentary strata. Still, I am convinced that he is not ignorant of the fact that eruptive rocks send out intrusive offshoots, sometimes high into the covering sedimentary strata, right into very recent deposits at one place, whilst their action appears hardly perceptible even at their contact with the oldest covering rock at another place. It is also surely not unknown to him that such extreme effects may be situated in immediate vicinity to one another.

Lastly, may it now be taken as generally recognised that the intensity of the action of the unconsolidated eruptive magma on the sedimentary strata is more or less proportionate to the intensity of the effect of the mountain-folding energy which was brought to bear upon them, and stands in distinct relation to the position of the respective rocks in the tectonic structure thus engendered.[1]

That Dr. Corstorphine should generalise and conclude that the 'old granite' is not intrusive in the W.W.R. Beds, because over the vast 'old granite' area of the Transvaal, the Northern Orange River Colony, North-Eastern Cape Colony, and Southern Rhodesia he discovers one single place where over the extent of the exposed contact between this granite and the overlying W.W.R. Beds (200 yards) he is unable to find any evidence of contact-metamorphism, seems rather hazardous and a somewhat premature conclusion.

Neither the discovery in the W.W.R. quartzites of the rounded bluish quartz-pebbles, of extremely problematic origin, at the contact of the granite and these W.W.R. Beds, nor the determination of the sericite-schists occurring below the Orange Grove quartzites to be segregations of the granite (in spite of the absolute conformability of these schists to the lowest W.W.R. Beds and the presence of conglomerates composed of quartz-pebbles[2] in them), seems to render more satisfactory the conclusions arrived at. Nevertheless, they are eagerly seized upon by Dr. F. H. Hatch and Mr. E. Jorissen to serve as the basis of their arguments for 'proving' the existence of an Archæan formation older than and unconformable to the W.W.R. Beds.

Even supposing that it had already been demonstrated beyond the possibility of a doubt that in the Zoutpansberg district (and Barberton district, etc.) the granite is of the same age as the 'old granite' (of Vredefort, Johannesburg, and Heidelberg bosses), Dr. Hatch's reasoning must forcibly strike the unbiassed mind as singular.[3] He describes[4] the complex of highly altered crystalline schists at Mount

[1] C. G. S. Sandberg: "Etudes géologiques sur le Massif de la Pierre-à-voir (Bas Valais)," 129 pages in 8vo, Paris, 1905, pp. 108–10; "L'âge du granit des Alpes occidentales et l'origine des blocs exotiques cristallins des Klippes," C.R. Ac. Sc., 1905, t. cxl, pp. 1072, 1073 (10 avr.); "L'âge du granite Alpin," Arch. Sc. phys. nat. (4), Genève, 1907, t. xxiii, pp. 581–94. E. Weinschenk, "Grundzüge der Gesteinskunde," 2 vols., Freib.-i.-Breisgau, 1906.

[2] G. A. F. Molengraaff, discussion on Mr. Jorissen's paper, "Note on some Intrusive Granites, etc.," Proc. Geol. Soc. S. Africa, to accompany vol. vii, p. xxxii.

[3] Dr. G. A. F. Molengraaff: Discussion of above paper, Proc. Geol. Soc. S. Africa, to accompany vol. vii, pp. xxix–xxxi.

[4] Dr. F. H. Hatch, "The Oldest Sedimentary Rocks of the Transvaal": Trans. Geol. Soc. S. Africa, vol. vii, pt. iii, pp. 147–50.

Maré (Pietersburg), which, notwithstanding their altered state through contact-metamorphism, still surprisingly resembles, by his own admission, the Lower W.W.R. Beds. He cannot, either here or in the Barberton–Swaziland area, mention one single locality where to his own satisfaction undoubted W.W.R. Beds are found together with these highly metamorphosed rocks, and where they occur in a mutually unconformable relation. Everywhere the covering (if any) of these crystalline schists consists of strata considerably younger than even the Upper W.W.R. Beds. Still, he does not accept the probability of being in the presence of metamorphosed W.W.R. Beds, but jumps to the conclusion that these metamorphic rocks, so similar to the W.W.R. Beds, must be much older and belong to the Archæan system, simply because the 'old or grey granite' is supposed to be intrusive in these schists, and is 'proved' to be non-intrusive in the W.W.R. Beds!

Mr. Jorissen's reasoning by which he arrives at the same conclusion is stranger still, if possible.[1] He describes some eight different localities distributed over the whole of the Transvaal where he discovered the 'Archæan formation.' Like Dr. Hatch, he evidently cannot mention one single instance where he found W.W.R. Beds and the so-called older (Archæan) rock together. Like Dr. Corstorphine, he is satisfied that the sericite-schist separating the Orange Grove quartzites (and evidently conformable therewith, since he also does not mention the all-important fact of their being unconformable) from the granite on the farm Vergenoeg, No. 220,[2] is a segregation from the granite, and not due to the metamorphic action on quartzites of the yet unconsolidated granite (see above, p. 554). Further, on the farm Nooitgedacht, No. 565 (Pretoria District), Jorissen describes a patch of crystalline schists which he discovered in the 'old granite,' and by which it is transformed through contact-metamorphism.[3] This 'old granite' now occurs as a welcome oasis in the surrounding endless desert of typical new or red or Bushfeld granite right in the classical region from which the new granite derives its name, in the Bushfeld. It is clear that the only reason why Jorissen could assimilate the granite patch there with the 'old granite' is the presence of 'Archæan schists' evidently metamorphosed by it, whilst the only reason for concluding that he was in the presence of 'Archæan schists' here, must have been the fact of these schists having been transformed by contact-metamorphism with the 'old granite'![4] On the farm Malipskraal, No. 406 (Lydenburg), he describes some more 'Archæan rocks' which, according to Mr. Kynaston, are most likely a foliated norite belonging to the *Bushveld Series*.

Finally, Mr. Hall & Dr. Humphrey, of the Geological Survey of the Transvaal, accepting this topsy-turvy reasoning, assign certain

[1] E. Jorissen, "Notes on some Intrusive Granites in the Transvaal, the Orange River Colony, and in Swaziland": Trans. Geol. Soc. S. Africa, 1905, vol. vii, pt. iii, pp. 151–60; and discussion of Dr. G. A. F. Molengraaff on the above, Proc. Geol. Soc. S. Africa, to accompany vol. vii, pp. xxxi–xxxiii.

[2] E. Jorissen, loc. cit., p. 156.

[3] Loc. cit., p. 154.

[4] As a matter of fact, it is just possible that these schists, far from being Archæan, will prove to be nothing less than metamorphosed Pretoria series.

rocks of the Zwartkop,[1] which lithologically and in their mutual succession (only the order being reversed) are identical with Lower W.W.R. Beds, to this same Archæan system.

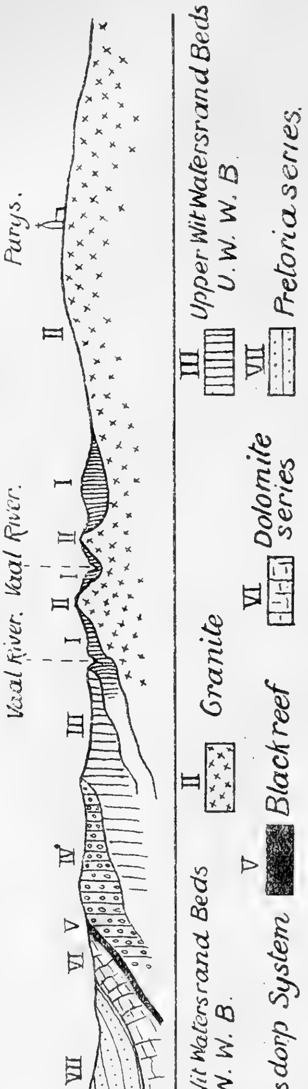
From the above it is clear that (*a*) no valid argument to prove the actual existence of pre-Lower W.W.R. Beds has yet been put forward; and (*b*) that even had Dr. Hatch's and Mr. Jorissen's conclusions been the logical outcome of their investigations, they must still be deemed unacceptable, being founded, as they are, upon the absolutely inadmissible basis of Dr. Corstorphine's conclusions. But if it is inadmissible to concede the non-intrusiveness of a granite mass from the fact that no injection nor any metamorphic action could be observed along *one* line of contact between that igneous rock and the overlying sedimentary strata, exposed over some 200 yards, it only needs the proof of the existence of *one single spot*, be it ever so small, where indubitable contact-metamorphism has taken place, to at once prove this igneous rock to be younger than the transformed sedimentary one. It is clear that the sericite-schists, separating over large areas in different regions the Lower W.W.R. quartzites from the underlying granite, are intimately connected with magmatic action, being the result either of magmatic segregation or of magmatic transformation of sedimentary rocks. And where now Molengraaff has been able to establish the presence in these sericite-schists of conglomerates (composed of quartz-pebbles), lying in absolute conformable position with and below the Orange Grove quartzites, there seems to be no more opening for doubting their sedimentary origin.

The conclusions arrived at from the study of these sericite-schists is materially strengthened by evidence from the Vredefort Massif. Certain strata of the Lower W.W.R. Series are here conspicuous by their peculiar and extensive development of corundum, which can only be attributed to the action on the overlying sedimentary strata of the yet unconsolidated magma.

But if, as evidence now already available seems to prove, the 'old granite' is post-W.W.R., where then have we to fix its approximate geological age? It is here where the great importance of the question lies. It is evident that the crystalline rock has participated in the orogenic movement, and that it has been folded together with the overlying W.W.R. Beds.[2] This fact finds its expression in the tangential direction to the granite mass periphery of the axes of the folds of the surrounding sedimentary strata, a phenomenon which is magnificently developed round the Vredefort granite mass. It is also evident from an examination of the contact region between this granite mass and the Lower W.W.R. Series, and of the small granite masses which come peeping through the overlying W.W.R. Beds on the farms Brakfontein (673), Koedoeslaagte (59), and Aasvogelrand (see Figure, p. 558). These granite protuberances, as well as the one situated further

[1] A. L. Hall & W. A. Humphrey, "The Blackreef Series and the underlying formation in the neighbourhood of Kromdrasi and Zwartkop, north of Krugersdorp": Trans. Geol. Soc. S. Africa, 1906, vol. ix, pp. 10–15.

[2] C. Sandberg, "Notes on the Structural Geology of South Africa": Trans. Inst. Min. Eng., vol. xxxiii, pt. v, pp. 540–57.



IDEAL SECTION THROUGH THE VREDEFORT MASSIF FROM PARYS; W.N.W.

Basis, Dr. F. H. Hatch's Geological Map of Southern Transvaal.

north on the farm Rietfontein (No. 555), near the contact of the Blackreef and Ventersdorp series, most convincingly convey the impression of being situated on the anticlinal axis of the respective subordinate folds. They are consequently drawn out in the direction of the axes of these folds, and thus stretch in a curved line parallel to the semicircular periphery of the main granite mass.[1] Much further north and west we again find indubitable evidence, and now on a more gigantic scale, of the granite having been folded together with the overlying W.W.R. strata,[2] the Klerksdorp–Johannesburg granite masses being situated on the axes of the Pretoria–Blackreef anticlinal.

The Vredefort granite, as well as that of the Klerksdorp and Johannesburg (as also the Barberton and Zoutpansberg) regions (all supposed to be 'old or grey granite'), is, however, a homogeneous rock, hypidiomorphic in grain and massive in structure, showing no signs of crushing or contortion either macroscopically or microscopically. *It could therefore not have been folded after its consolidation.*[3] And as the W.W.R. Beds (at least during their last period of folding) have been folded together simultaneously with the younger deposits covering them, right up to and including the Pretoria Series, it would logically follow that the time of the consolidation, *that is, the age*, of the Vredefort, Johannesburg, and Klerksdorp granite masses must be fixed as *post-Pretorian*, that is, near to, perhaps even synchronous with, that of the so-called *Bushveld or new or red granite.* Since during the last couple of years the Bushveld area attracted considerable attention economically, our knowledge of the typical rock of the region was consequently considerably extended. It gradually became evident that all the features which once seemed to constitute characteristic differences between this red granite and the old or grey granite equally pertain to both rocks. There thus seems to exist a distinct consanguinity of the magmas. This and the great probability above demonstrated of these two igneous rocks being of approximately equal age, make it just possible that the old and the new or Bushveld granite are in reality identical, and derivatives from one and the same magma at the same period of 'eruption.' The numerous and powerful syenite dykes striking north and south, and evidently connecting the Johannesburg and even the Vredefort granite masses with the Bushveld igneous rock,[4] might then, perhaps, be explained as representing an endomorphic modification of this common magma due to the influence thereon of the overlying dolomite.

[1] On Dr. Hatch's geological map of the Southern Transvaal the phenomenon of the above-mentioned granite *fenêtres* is clearly expressed (Koedoeslaagte, No. 59).

[2] See also A. R. Sawyer, "New Rand Gold Fields, Orange River Colony": Trans. Inst. Min. Eng., vol. xxxiii, pt. v, pp. 530–4.

[3] E. Weinschenk: "Grundzüge der Gesteinskunde," i, pp. 168, 169. Since the assimilation of the Johannesburg–Vredefort–Klerksdorp 'old granite' with the Zoutpansberg–Swaziland–Rhodesia rock is exclusively based on lithological grounds only and must therefore be considered as inadequate, I have purposely, although personally inclined to regard these igneous rocks as identical, *not included* them directly in the summary of my argument.

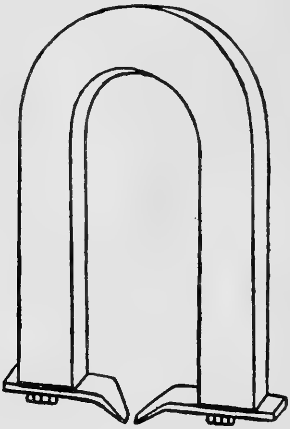
[4] A. L. Hall & W. A. Humphrey, loc. cit., p. 11, pl. iii.

VI.—A Simple Form of Permanent Magnet suitable for the Separation of Weakly Magnetic Minerals.

By T. Crook, F.G.S.

THE separation of the weakly magnetic minerals of crushed rocks, sands, etc., is best effected by using an electromagnet, which, if suitably constructed, is, for any given size, much stronger than a permanent magnet.[1] The electromagnet exerts no attractive force when the current is shut off, and for this reason the process of separation is made easy, as the grains which have been attracted to the poles drop when the current is switched off.

An ordinary permanent magnet of considerable strength has to be rather large; it requires re-magnetising at intervals; and to detach grains which have been attracted, it is necessary to strike them sharply with some object such as a suitably folded piece of paper or cardboard. Hence for speed, efficiency, and convenience in use, the electromagnet easily supersedes the permanent magnet. However, if an electric current is not available, as happens to be the case with the prospector, it becomes a decided advantage to have some handy form of permanent magnet capable of yielding an intense magnetic field. An electromagnet put into action by a hand dynamo has been tried, but such an apparatus makes a heavy load, and the dynamo readily becomes impaired. Indeed, under any conditions the use of a hand dynamo in making mineral separations is clumsy and inefficient, and involves unnecessary expense.



Permanent magnet with adjustable poles for securing a magnetic field of high but variable intensity.

It is therefore of interest to note that a simple permanent magnet of handy size can be made use of quite effectively in examining a small quantity of sand or crushed rock. It is convenient to have the magnet made U-shaped, the limbs being about 6 inches long. The

[1] For an account of the use of the electromagnet in this way see "The use of the Electromagnet in Petrography," *Science Progress*, No. 5, July, 1907.

bar of steel, of which the magnet is made, need not be more than an inch wide and half an inch thick. As shown in the accompanying figure, two adjustable pole pieces, made of soft iron, fit against the smooth free ends of the limbs, to which they are secured by binding screws. These pole pieces should be about half an inch wide and rather less than a quarter of an inch thick; they should be slotted so that the gap between the tips of the poles can be enlarged or diminished according to requirements. The adjacent portions of the pole pieces should be bent downwards, not perpendicularly, but as shown in the figure, narrowing gradually to a width of about three-eighths of an inch at the tips. The bent down portions of the poles should also thin gradually towards the tips. In this way a fairly strong magnetic field can be obtained between the tips of the adjustable poles.

Theoretically, a compound magnet should be more efficient than a simple magnet of the same size. In practice, however, one finds that there is no appreciable advantage in using a compound magnet, perhaps owing to the less perfect fitting of the adjustable poles. The use of a simple magnet is therefore recommended, as it is much cheaper and is more readily re-magnetised.

Using a magnet such as the one here described, a good separation of weakly magnetic minerals can be made. Magnetite, pyrrhotite, and highly magnetic hæmatite, if present, should first be separated by a small, weak magnet. Ilmenite, garnet, hornblende, augite, hypersthene, etc., can be extracted with the tips of the adjustable poles well apart; while by bringing the poles nearer together monazite can be extracted quite easily.

A magnet having approximately the specifications here given was made recently for Mr. A. E. Kitson, F.G.S., by Messrs. Baird & Tatlock, at the writer's suggestion. It worked quite satisfactorily, although the fittings were in some respects defective. It was found that, using a small trial specimen of ilmenite-monazite-zircon sand, the magnet extracted the ilmenite with the poles well apart; adjusting the poles with their tips nearer together, the monazite was completely extracted, and an almost perfect separation of the three constituents was thus made.

This simple permanent magnet is also a useful piece of apparatus for class demonstration. It is comparatively cheap, and a geological laboratory can be equipped with several of them without much expense; and certainly no course of laboratory work in petrology can be considered complete, that does not equip a student with a practical knowledge of the usefulness of the magnetic method of isolating and separating minerals.

VII.—Burning Cliffs.

TOWARDS the end of January last the inhabitants of Lyme Regis were somewhat alarmed by the announcement that a portion of the cliffs on the eastern side of the town, towards Black Ven, was "on fire"; a "Full Report of the Volcanic Eruption" was soon afterwards published in the *Bridport News* for January 24. It was then stated that on Sunday, January 19, "dense vapour appeared at intervals to rise from a mound on the edge of the cliffs, about half-way between Lyme and Charmouth," and that the burning portion "consisted of a large fallen mass of the cliff which had some time since slipped away from the body of the cliff." Mr. A. C. G. Cameron, who was at the time resident at Lyme Regis, explained that the case was one of spontaneous combustion, due to the decomposition of iron pyrites and the consequent generation of heat sufficient to ignite the bituminous shales of the Lower Lias.

Iron pyrites and marcasite (rhombic iron pyrites) are found more especially in the Lias shales. They are most abundant in the shales of the Lower Lias. At Black Ven, near Lyme Regis, there is a 'Metal Bed,' and material derived from this and other layers was formerly collected during the winter months for the preparation of copperas (sulphate of iron), sulphuric acid, and sulphur. Examples of marcasite from Lyme Regis are sold to visitors as 'angels' wings.'

In August, 1751, spontaneous combustion occurred in the bituminous shales of the Lower Lias near Charmouth.[1] This took place among fallen masses of the strata, owing to the decomposition of pyrites. In 1890 similar combustion took place further east, and in the *Daily Graphic* of February 19 there appeared a picture of the 'eruption' of Golden Cap.

In September, 1826, spontaneous combustion took place in the Kimeridge Clay near the east extremity of Ringstead Bay, at Holworth Cliff, adjacent to the promontory of White Nore. This combustion continued until 1829, although the extent of the surface of the clay which was burnt did not exceed 50 feet square.

Buckland and De la Beche state that "within this space are many small fumaroles that exhale bituminous and sulphureous vapours, and some of which are lined with a thin sublimation of sulphur; much of the shale near the central parts has undergone a perfect fusion, and is converted to a cellular slag. In the parts adjacent to this ignited portion of the cliff where the effect of the fire has been less intense, the shale is simply baked and reduced to the condition of red tiles, like that on the shore near Portland Ferry."[2] The occurrence of the burnt shale at Portland Ferry indicates that there a similar combustion took place.

Some of the above details are taken from the Geological Survey Memoir on the Jurassic Rocks of Britain, vol. iii, p. 308, and vol. v, p. 331.

H. B. W.

VIII.—Burning Cliffs on the Banks of the Mackenzie River, etc.

As bearing upon the phenomenon of the spontaneous combustion of bituminous beds of coaly or carbonaceous matter of any geological age (charged with pyrites) *in sitû*, the account given by Sir John Richardson, C.B., F.R.S., in his "Arctic Searching Expedition; a Journal of a Boat-voyage through Rupert's Land and the Arctic Sea," 1851, vol. i, may not be without interest in this connection.

He writes (p. 176): "On the Mackenzie a shaly formation makes

[1] See J. Stephens, "An Account of an uncommon Phenomenon in Dorsetshire": Phil. Trans., vol. lii, p. 119.

[2] Trans. Geol. Soc., ser. II, vol. iv, p. 23.

the chief part of the banks and also much of the undulated valleys between the elevated spurs. It is based on horizontal beds of limestone and in some places of sandstone. Covering the shaly beds, there exists in many places a deposit of sand, sometimes cohering as a friable sandstone. . . . The shale crumbles readily and often takes fire spontaneously, occasioning the ruin of the bank; it is only by the encroachments of the river carrying away the débris that the true structure is revealed."

"When exposed for even a short time to the atmosphere, the coal, which is probably all or mostly of Tertiary age, splits into rhomboidal fragments, which again separate into thin layers, so that it is difficult to preserve a piece large enough to show the woody structure in perfection. Much of it falls eventually into a coarse powder; and if exposed to the action of moist air in the mass it takes fire and burns with a fetid smell and little smoke or flame, leaving a brownish-red ash, not one-tenth of the original bulk of coal taken from the purer beds, for some contain much earthy matter." (p. 187.)

"From the readiness with which the coal takes fire spontaneously, the beds are destroyed as they become exposed to the atmosphere; and the bank is constantly crumbling down, so that it is only when the débris has been washed away by the river that good sections are exposed. The beds were on fire near Bear River when Sir Alexander Mackenzie discovered them in 1785, and the smoke, with flames visible by night, has been present in some part or other of the formation ever since." (p. 188.)

"Potter's clay, of a grey or brown colour, alternates with the beds already named, in layers varying from one foot to forty or more in thickness. This clay is often highly bituminous, and is penetrated by ramifications of carbonaceous matter, resembling the roots of vegetables. About 10 miles above Great Bear River, a layer of this material, lying immediately over a bed of coal which was on fire, has been baked so as to resemble a fine yellowish-coloured *biscuit porcelain.*[1] In a part of this I found numerous impressions of leaves, most of them Dicotyledonous, but one of them apparently coniferous and belonging probably to the yew genus." (p. 190.)

"Chief Factor Alexander Stewart told me that beds of coal are on fire on the Smoking River, which is a southern affluent of the Peace River, and crosses the 56th parallel of latitude, and also that others exist on the borders of Lesser Slave Lake, that lies between Smoking River and Edmonton. There are coal beds on fire, also, at the present time near Dunvegan on the main stream of the Peace River. All these places are near the base of the Rocky Mountains or the spurs issuing from that chain, and their altitude above the sea varies from 1,800 to 2,000 feet and upwards. The beds at Great Bear River are probably not above 250 feet above the sea-level." (p. 195.)

H. W.

[1] These porcellanous shales, with plant impressions of Tertiary Dicotyledonous leaves, etc., collected by Sir John Richardson on the cliff banks of the Mackenzie River from above the burning coal-seams, are now preserved in the Geological Department of the British Museum (Nat. Hist.), Cromwell Road. Many of the species agree with those from the plant-beds of Atanekurdluk, Greenland.

IX.—Additional Note on *Loricula.*

By H. Woodward, LL.D., F.R.S.

SINCE the appearance of my paper on *Loricula Darwini* in the November Number of this Magazine (pp. 491–9) my attention has been called by Mr. C. D. Sherborn to two American *Loriculæ* described by W. N. Logan, "On some new Cirriped Crustaceans from the Niobrara Cretaceous of Kansas," U.S.A., published in the Kansas University Quarterly (series A, October, 1897, vol. vi, No. iv, pp. 187–9, 8vo) and in the University Geological Survey of Kansas (vol. iv (Paleontology), pt. viii, 4to, Arthropoda, pp. 498–501, pl. cxi) under the names of *Stramentum haworthii*, Williston, type-specimen figured much enlarged, and *S. tabulatum*, Logan. The other two species on pl. cx, figs. 3–5, of the same work, described under the name of *Squama spissa* and *S. lata*, Logan, are quite distinct from *Loricula*, but are said to have been found adhering to a fragment of shell of *Inoceramus* by their entire length. The arrangement of the capitulum and peduncle differ very widely from those of *Loricula* and resemble *Pollicipes.*

The type of *Stramentum haworthi*, Williston, is said to be attached to a shell of *Ostrea congesta*, "by the extremity of its peduncle." (Possibly this remark applies to the genus *Squama*, as the description of the mode of attachment of *Squama* certainly applies to *Stramentum.*) The series of *Stramentum* preserved in the British Museum (Nat. Hist.) are certainly attached by their entire length upon the surface of some curious strap-like organism which might have been once a vegetable substance such as a *Laminaria*, but of which now only a stain remains on the slab. The specimens are very minute, only a few lines in length, but are illustrated by a copy of an enlarged figure of the type. The rostrum is certainly absent as in *Loricula* from the English and Bohemian Chalk, with which the type of *Loricula* (*Stramentum*) *haworthi* from the Yellow Chalk of Gove City, Gove County, Kansas, closely agrees. The other species mentioned, *Loricula* (*Stramentum*) *tabulatum*, is from the Upper Niobrara Chalk of the Smoky Hill River.

NOTICES OF MEMOIRS.

I.—Is China Clay a Mineral?

OF considerable interest to geologists is the judgment delivered by Mr. Justice Eve in the case of the Great Western Railway Company *v.* the Carpalla United Clay Company. The action was brought by the Railway Company to restrain the working of china clay in certain lands—the right to work the clay depending upon the question whether china clay was a mineral within the meaning of the Railway Clauses Consolidation Act, 1845. The following are the concluding portions of the judgment:—

This is the substance which the defendants contend is a mineral within the statute, and which the plaintiffs allege to be the soil or subsoil which they have already purchased, and on which their railway has been built. In order to determine which of these contentions is right it is necessary to inquire into the composition and origin of the china clay. As I have already said, the china clay rock occurs in the granite formation only. Granite is an igneous rock the mineral constitution of which differs in various places, but which may be said to be practically of general uniform crystalline constitution composed of felspar, quartz, and mica. Granite when exposed to atmospheric or other agencies becomes decomposed to an extent varying with its mineral constitution, and the first element which is the subject of decomposition is the felspar. The decomposed felspar results in the formation of a clayey material, and china clay rock is granite in which the felspar has been wholly decomposed and replaced by this clay. Different opinions are held by geologists and others as to the agency by which this complete decomposition has been brought about. Some contend that the decomposing agent is the carbonic acid in the rain-water. Others, again, reject the rain-water, or subaerial theory, and insist that all the known facts combine to prove that the agency by which such complete decomposition has been brought about had its origin in subterranean depths, and that the agent penetrated to the decomposed mass by means of cracks and fissures, many of which are now filled up with minerals which admittedly came from lower depths. A third class of scientists, represented by some of the most eminent who have given evidence in this case, incline to the view that both causes—subaerial and subterranean, or pneumatolytic as the latter has been called—may have contributed to the result. Between these conflicting opinions it is fortunately not necessary for me to decide. It is sufficient for my purpose to find as a fact that there are in the granite formation in the part of the country with which I have to deal in this case nests or pockets of varying superficial areas, and in most instances of unknown depths, wherein is to be found a granite in which the felspars have been wholly decomposed and replaced with the clayey material I have already mentioned. It is further established by the evidence that these nests or pockets are sporadic, and that their existence adds materially to the value of the land, and that their presence or absence is not to be accounted for by any apparent differences in the overlying granite or other materials. As a general rule it may, I think, be said that they occur under an overburden of less decomposed granite, but, as I have already stated, they have been found under hard undecomposed granite, and under a wholly alien overburden such as the killas. Even when it occurs under an overburden of decomposing granite china clay rock has, I think, characteristics apart from colour which differentiate it sufficiently from the overburden to enable those acquainted with the local formation to fix approximately the line of demarcation between the overburden and the china clay rock. The decomposed felspar—the clayey substance which has replaced the felspar—constitutes, say the defendants, the china clay. All we do, they add, is to extract this clayey substance by a sifting or washing process, whereby we disengage it from the other material with which it is found in mechanical combination. I cannot myself see that it is any answer to this contention to say that in the china clay of commerce there is still to be found a proportion of the other materials with which the clayey substance was originally completely combined. Take, for example, the presence of mica crystals in the commercial china clay. It is admittedly one of the objects of the washing process to separate the clayey substance from the mica, and this to a large extent is achieved, but because it is not wholly effected, and because the china clay is merchantable, notwithstanding the continued presence of some mica crystals, can it logically be asserted that mica is an essential constituent of china clay? I cannot bring myself to adopt any such view. In my opinion china clay or kaolin is the clayey substance in the china clay rock representing the decomposed felspar, and the mere fact that in the process of separating and extracting it from the rock a condition of disengagement is reached which is sufficient for practical commercial purposes, and beyond which it is therefore unnecessary to prolong the process, cannot, in my opinion, alter the real nature of the substance or convert the resultant product from a natural substance into an artificial combination of diverse elements originally combined in wholly different proportions.

On the evidence, therefore, I come to the conclusion that china clay is a natural product—that is, the substance representing felspar in granite which has been converted into china clay rock by the complete decomposition of one of its three essential constituents. The question I have now to decide is whether such a clay as I have described is a mineral. It is common ground that it has been so regarded by geologists, mineralogists, and textbook writers for very many years past, not only in this country, but in America, France, and Germany. Jameson as early as in 1820, Professor Lapworth himself as late as in 1899, and Dr. Hatch and Professors Dana and Miers—the latter the well-known Professor at Oxford—at intermediate dates are all responsible for well-known and authoritative works, wherein it is classed as a mineral. It is true that when the witnesses for the railway company were confronted with these authorities they drew a distinction between kaolin and the china clay of commerce, and suggested that the former might possess attributes which would qualify it as a mineral, but which were not to be found in the latter; but I attach no importance to this distinction, in that I regard kaolin and china clay as convertible terms, and the mere fact that the clay can be turned to commercial uses without being altogether dissociated from foreign substances cannot, in my opinion, alter its real character. But the question does not really rest on the printed authorities to which I have just alluded. The scientific witnesses who were called on behalf of the railway company frankly admitted that down to some time in the latter part of last year they shared in the generally accepted view that kaolin or china clay was a mineral. Indeed, in a case tried in 1904—North British Railway Company *v.* Turners (Limited)—Professors Boyd Dawkins and Lapworth, two of the witnesses who in this case have been called to prove that it is not a mineral, gave evidence that kaolin or china clay—treating the two words as synonymous—is a mineral of a definite chemical composition, and having very frequently a definite crystalline form. These views they have been led to discard, so they told us in the box, by more careful microscopic and local examinations of china clay, and the sources from which it is derived, and the conclusions to which these examinations have led them are directly opposed to those in which they shared with the scientific world generally down to the summer of last year. They now degrade china clay to an artificial product, a heterogeneous compound or mixture of everything that is in the china clay rock, and unredeemed by any one of the qualities which Dr. Hatch says are the essential characteristics of a mineral—that is to say, definite mineral composition, definite physical qualities, and definite crystal form. On the other hand, Professor Gregory, with whose evidence I was much impressed, would be no party to what I have called the degradation of kaolin or china clay. In his opinion it is a mineral, the main bulk of which is kaolinite—a crystalline substance which all parties agree is in all senses of the word a mineral. It is right that I should add that none of the plaintiffs' witnesses would admit the presence of kaolinite in the Carpalla kaolin, and on the evidence as it stands I should not be prepared to hold that this has been conclusively established. But again I am not really called upon to decide between the conflicting views of scientific men as to the exact category in which this china clay should be included to secure that accuracy of expression at which science is always aiming. What I have to determine is whether the substance is a mineral within the meaning of the Act of Parliament. Having heard all the evidence and listened to the forcible arguments which have been addressed to me, I cannot entertain any doubt as to its being such a mineral. It is found in intimate combination with elements which go to make up the subsoil of the district, and it owes its origin to the decomposition in past ages of constituent parts of that subsoil; but in its present condition, occurring sparsely and sporadically, and always under an overburden of a character distinctive from the rock in which it is found, it cannot, I think, with any justice be regarded as constituting the land soil. It is a sedentary deposit occupying the space formerly occupied by the felspars. It can only be abstracted by the disintegration of that wherein it is deposited, and when so abstracted it is a thing which (to use Mr. Justice Buckley's words, 1901, 2 Ch., at p. 638) "has a value of its own apart from the soil in which it is found." It is not, in my opinion, the soil itself. Whatever be the true scientific definition of a mineral, and whatever be the correct classification of kaolin thereunder, I cannot bring myself to hold that a substance universally regarded as a mineral before, and for more than sixty years after the passing of the Act which I am construing, ought now to be treated as not falling within the class of substances therein referred to as minerals. Under all the circumstances, therefore, I do not consider the facts of this case bring it within either of the authorities which have been so fully discussed, and holding as I do that the china clay is a mineral within the meaning of the Act of 1845, I have no alternative but to dismiss the action with costs.—Abstracted from the *Times*, 1908.

II.—Brief Notes on Nova Scotian Geology.

1.—A Review of the Flora of the Little River Group. By G. F. Matthew, D.Sc., etc. Trans. Roy. Soc. Can., Second Series, 1906, vol. xii, sec. iv, p. 99.

THIS is the first of a series of articles by Dr. Matthew on the ancient flora, the species of which were described by Sir W. J. Dawson many years ago. The present paper is devoted to the Equisetales, and a number of new forms are described in it. Two new genera are described, found in the lowermost group of plant beds—*Ramicalamus* and *Lepidocalamus*. Dr. Matthew finds *Calamites Suckovii* common, a species which is found in the uppermost beds of the Carboniferous, and therefore must have had a great vertical range. The genus *Asterocalamites* (*Calamites transitionis* of Dawson) is found to be common.

Asterophyllites and Annularia are represented in a number of species, including some in which the leaves are clustered in whorls, and so not evenly distributed. The early development of the Equisetales, as shown by this flora, is commented on in the closing paragraphs of this article.

2.—A New Species and a New Genus of Devonian Plants. By G. F. Matthew, F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, 1906, vol. v, pt. iv, p. 393.

THE plant here described is referred to the Ferns, and thought to be related to *Eremopteris* and *Triphyllopteris*. The leaves of the barren frond were narrowly wedge-shaped, and there was a fertile pinnule with pod-like receptacles. The name adopted for this plant is *Pseudobaiera McIntoshi*. With this occurs a vigorous-growing mutation of *Annularia longifolia*, Brong., and other species of plants. The locality is near St. John, N.B., Canada.

3.—On some Species of Silurian and Devonian Plants. By G. F. Matthew, LL.D., etc. Trans. Roy. Soc. Can., Third Series, vol. i, sec. iv, p. 185.

A FEW Acrogens from various localities in the provinces of New Brunswick and Nova Scotia in Canada are described in this paper. A cone of Lepidodendron of Eo-Devonian; a supposed lichen of the same age or older, and plants from the Upper Devonian of Nova Scotia and N.B. Two interesting fungi which grew between the wood and epidermis of certain large ferns are described, and also a new species of *Psilophyton* which may have been of greater antiquity. *Lepidodendron corrugatum* and *Aneimites Acadica* are common forms of the Upper Devonian flora.

4.—Notes on Archæozoon. By G. F. Matthew, LL.D., F.R.S.C. Bull. Nat. Hist. Soc. of New Brunswick, 1906, vol. v, p. 547.

A LOW type of calcareous organism found in the pre-Cambrian rocks of St. John, N.B., Canada, and thought to be related to the Cryptozoon found in the pre-Cambrian deposits of the Rocky

Mountains by officers of the United States Geological Survey. It consists of calcareous columns with convex layers. Three localities are known where it has been found, and in a plate accompanying the paper its structural characters are exhibited.

5.—A New Genus and a New Species of Silurian Fish. By G. F. Matthew, LL.D., etc. Trans. Roy. Soc. Can., Third Series, vol. i, sec. iv, p. 7.

THIS is a description of an ancient and interesting type of fish of early Silurian age. The form is related to *Phaneropleuron*, from which it differs in the arrangement of the fins, etc. It is from strata in King's County, New Brunswick, Canada.

6.—The Physical Evolution of Acadia. Part I: The Insular Stage, etc. By G. F. Matthew. Bull. Nat. Hist. Soc. of New Brunswick, 1907, vol. vi, p. 3.

IN this article the bearing of the geological changes which occurred in the maritime provinces of Canada prior to Devonian time is shown. The history is divided into several periods by the physical revolutions that occurred. The first period (called the Laurentian phase) is marked by the occurrence especially in Southern New Brunswick and in Cape Breton of abundant limestones, which are compared to the Granville limestones of the Ottawa valley.

The second great period (Huronian phase) is marked in Nova Scotia by the enormous deposits of the gold-bearing series of that province, and is compared to clay slates, chloritic slates, and other rocks in Southern New Brunswick, which are thought to be a deep-water representation of the gold-bearing series of Nova Scotia.

The third great period of deposition of sediments is marked by the widespread Cambrian deposits of the Atlantic region of Canada, which are best shown in Southern New Brunswick and Cape Breton Island in Nova Scotia. This great series in both provinces runs up into and includes the lower part of the Ordovician.

This series is followed by an important geological hiatus, the upper Ordovician being absent from all this region, and the first rocks which succeed the Cambrian series are of the age of the Ludlow or thereabouts. This is the Silurian phase, and extends upward to include the base of the Devonian (if the Upper Helderburg formation be regarded as such).

Up to this time in its geological history Acadia when submerged in part was insular, or divided from the rest of the American continent by one or more sounds, extending from the present Gulf of St. Lawrence to the Gulf of Maine, and further inland in New England. Southern Acadia up to this time was dominated by insular conditions, and for most of the time prior to the Devonian age was an island cut off from the mainland of America.

Two maps are given to illustrate this history, one showing the conditions in the middle Lower Huronian time, and the other drawn to show its aspect in Upper Silurian time (Clinton to Niagara).

REVIEWS.

I.—The Face of the Earth. By Edward Suess. Translated by Hertha B. C. Sollas, Ph.D.; under the direction of Professor W. J. Sollas, LL.D., F.R.S. Vol. III. 8vo; pp. vii, 400, with one map (in pocket), 6 plates, and 23 other illustrations. Oxford: at the Clarendon Press, 1908. Price 18*s*. net.

ATTENTION has been drawn in the Geological Magazine (for May, 1905, and July, 1906) to the first and second volumes of the English edition of Suess's great work. The present volume constitutes part 4, or vol. iii, part 2, of the original German edition. It is divided into seven chapters, and Professor Sollas, who has continued his labours as editor, has been assisted in the revision of the translator's rendering by Sir Archibald Geikie, Dr. Teall, Professor Edgeworth David, Professor Watts, Mr. R. D. Oldham, Professor T. C. Chamberlin, Professor Lapworth, and Professor Bonney. We give the names in sequence according to the chapters revised by them; but Professor Sollas remarks in his preface, "The reverence due to a great classic has restrained us in this, as in previous volumes, from taking any liberties with the text, whether by comment or emendation."

The footnote references have been extended so as to include researches published during the present century, but we miss a reference to the Geological Survey Memoir on "The Geological Structure of the North-West Highlands of Scotland," 1907, which might have been given on p. 387. Britain, however, occupies but little space in the present volume, and only in connection with the Caledonian lines of disturbance.

An interesting outline of the contents is given in the introductory chapter, where we find remarks on the folding of the oldest rocks and the trend of the systems of folds which form the mountain chains; on the distinction between longitudinal volcanic lines and independent volcanic lines, and the impossibility of considering folds and volcanoes apart from one another; and on the need of studying the structure of mountain chains in plan as well as in section.

In reference to the subjects under discussion, it is remarked that "In the Southern Hemisphere the space covered by the sea is so great, and our knowledge so incomplete, that we can scarcely expect to arrive at any important conclusions. The present investigation is therefore almost exclusively confined to the Northern Hemisphere, and more especially to that region which lies north of the southern boundary of Eurasia and of the Caribbean Sea." The map appended to the volume does not include the entire area. It is a "Diagrammatic Representation of the Vertex of Eurasia," and it takes in the country between Lakes Balkhash and Baikal, the Thian-Shan, and the upper regions of the Hoang-ho. The region around Lake Baikal is described as "the most ancient vertex of the Eurasian folds."

In the Introduction it is pointed out that "all the Archæan rocks of the earth have suffered folding or an equivalent compression," and that "folded ranges had been already levelled down in times preceding the Cambrian. When these worn-down ranges are covered by undisturbed Cambrian strata, as in the vicinity of St. Petersburg, we are compelled to conclude that the ancient folding has not been continued or renewed since an extremely remote period. In these regions, as compared with those where recent sediments are involved in the folding, it would seem that the earth is slumbering or as if the folding force had become extinct."

Reference is also made to areas where the mainland is accompanied by trend-lines of folding, and to others where this is not the case.

The main body of the work is taken up with the great structural features of Northern and Central Asia and Europe, and with the evidence in certain regions of repeated folding or reconstruction. The Asiatic folding is shown to be connected through the Caucasus with that of Europe, while the system of movements between the Arctic Ocean and the Mediterranean is not to be separated from that of Eastern Eurasia.

II.—The Philippine Islands.

The Mineral Resources of the Philippine Islands, with a Statement of the Production of Commercial Mineral Products during the year 1907. Issued by Warren D. Smith, Department of the Interior, The Bureau of Science. 8vo ; pp. 39, illustrations and maps. Manila, 1908.

THIS is of necessity a preliminary account of work done, and it will be sufficient to call attention to the contents which follow :—The Non-metallic Minerals, by W. D. Smith; Metallic Mineral Resources, by Maurice Goodman; Statistics, by W. D. Smith; Mining and Geological Notes on a portion of North-Western Mindanao, by H. M. Ickis; Mining Prospects on and near the Zamboanga Peninsula (brief summary of the geology), by W. D. Smith; Summary of the chief characteristics of Philippine Ores, by W. D. Smith; Summary of the chief characteristics of Philippine Coals, by A. J. Cox. One of the maps shows the principal mineral districts of the country. We hope soon to possess a sketch-map of the geology of the whole group, which should prove of especial interest with regard to Japan on the one hand and the Javan-Bornean group on the other.

III.—South African Palæontology.

The Invertebrate Fauna and Palæontological Relations of the Uitenhage Series. By F. L. Kitchin, M.A., Ph.D. Ann. South African Museum, vol. vii, pt. ii, pp. 250, 10 plates. 8vo. Cape Town (West, Newman, & Co., London), 1908. Price 12*s.* 6*d.*

A PORTION of this volume is devoted to descriptions of fossils collected by the members of the Geological Survey of Cape Colony and others. We hope the author has sent a copy of his work to the Stationery Office in London, in order that they may see how Cape Colony produces its prints and plates, which are quite in accord with the importance of the subject.

The collection here described was obtained mostly by Messrs. Rogers and Schwarz in 1900, but the author has availed himself of all other material on which he could lay his hands. Discussing first the age of the fauna, Dr. Kitchin has provided a careful summary of previous work in fourteen pages ranging from Hausmann's researches in 1837 to his own. He arrives at the conclusion that "no portion of the Uitenhage Series represents a period of time earlier or later than the Neocomian. It must be said, indeed, that the almost entire restriction of *Holcostephanus*, sensu stricto (= *Astieria* auctorum), to the upper part of the Valanginian and lower beds of the Hauterivian in Europe suggests much narrower limits, when we consider how important a place is taken by members of this genus in characterising the cephalopod-fauna of the Uitenhage beds."

The fauna is then compared with that of the south-west of Madagascar, the Oomia group in Cutch, certain Godavari and Hazara fossils, the Neocomian fauna of German East Africa, and the Neocomian fauna of Patagonia, and the author concludes his general remarks with a discussion on the distribution of the Uitenhage fauna in relation to some theoretical questions. These are the theory of an Indo-African land-barrier during early Cretaceous times and Neumayr's theory of distribution according to climatic zones. Then follows a description of the fauna and a bibliography.

The memoir, with its beautiful plates, cannot fail to be of the highest value, and marks a great advance in our knowledge of the fossil fauna of South Africa.

IV.—New Zealand.

THE most interesting paper in the Transactions of the New Zealand Institute, 1908, vol. xl, is Dr. Marshall's geology of the centre and north of North Island with its accompanying map. It seems that there is little evidence in regard to the structural meaning of the direction of the North of Auckland Peninsula. The plutonic rocks of Mangonui and Ahipara are diorites and norites, but no evidence is available as to whether they are intrusive or older than the Mesozoic sediments, and that the volcanic rocks are chiefly rhyolitic in the central region, but the rhyolites are penetrated by andesitic pipes, over which large cones have been built up. The lake-basins are probably areas of violent hydrothermal explosions, and from these explosions pumice was distributed. The sharp scarps of many of the rhyolite hills do not indicate the action of faults, but are due to erosion, and a sequence of eruptive rocks is suggested. J. A. Thomson writes on Tertiary fossils from Kakanui and R. Speight on some aspects of the Terrace-development in the valleys of the Canterbury Rivers. The Schists of Central Otago are described by A. M. Finlayson, who also writes on the Scheelite of the same district. The Westland Alkaline and Nepheline rocks are worked out by J. P. Smith, and a soda-amphibolite-Trachyte from Cass' Peak, Banks Peninsula, is described by R. Speight. The Gabbro of the Dun Mountain receives attention from Dr. Marshall.

V.—Notes on Fenno-Scandia.

J. J. Sederholm. Explanatory Notes to accompany a Geological Sketch-map of Fenno-Scandia. 8vo; pp. 31, map. Helsingfors, 1908.

THIS is one of those useful and comprehensive sketches of the geology of a large district so valuable to the busy geologist. The area included is the whole of Norway, Sweden, and Finland, and parts of Denmark, the North of Prussia, and North-West Russia. The map is 1 : 8,000,000, and is clearly printed in colour. The author points out that the material is of different value for different parts of the region, as large tracts are still untrodden by the feet of any geologist, but he has drawn on the publications of many colleagues, and produced a valuable compilation showing our present knowledge of this important northern European area.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 4, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

On the Admission of Women as Fellows.

The President announced that the result of the communication addressed to the Foreign and Colonial Fellows of the Society with regard to the admission of women was as follows:—

Papers sent out	313
Answers received	124

Analysis of Replies.

1. Are you in favour of the Admission of Women to the Geological Society of London?

Yes	97	
No	27	
		— 124

2. Are you in favour of the Admission of Women as Fellows, or as Associates only? The 97 in favour of admission voted—

As Fellows	70	
As Associates	25	
Not specified	2	
		— 97

3. If there should not be a majority of those voting in favour of Women as Fellows, are you in favour of their Admission as Associates?

Yes	93	
No	3	
Not specified	1	
		— 97

The Secretary read a note received from the Under Secretary of State for the Colonies, embodying extracts from the Report on a Scientific Expedition to the Falkland Islands (October, 1907–February, 1908) by Dr. Carl Skottsberg. It was stated therein that the Devonian formation, which constitutes the larger part of the islands, was closely surveyed, and fossils were discovered in several new localities. Also that new discoveries of fossil plants (*Glossopteris*, etc.) had proved that the whole southern part of the East Falkland Island, south of Wickham Heights, belongs to the Gondwana System.

The following communications were read:—

1. "The Relations of the Nubian Sandstone and the Crystalline Rocks of Egypt." By Hugh John Llewellyn Beadnell, Assoc.Inst.M.M., F.G.S. (late of the Geological Survey of Egypt).

The paper opens with an account of the general conclusions of previous observers, which are mainly in favour of the view that the granites are not intrusive into the Nubian Sandstone, but that the latter was deposited round denuded masses of the granite. The crystalline rocks, south of the Oasis of Kharga, are first dealt with. Eight exposures of crystalline rocks were met with. The sediments near the contact with the crystalline rocks are generally inclined at a high angle, and in some cases the former appear to undergo considerable alteration. The bedded rocks contain no fragments derived from the crystalline rocks. Hills of folded Eocene and Cretaceous strata seem to indicate that the intrusion of the granite may be of later date than Lower Eocene. These crystalline rocks do not appear to differ from those of the First Cataract and of the Eastern Desert and Sinai, where great vertical displacements have occurred, and where it seems likely that the sandstones were carried up when the great igneous core was elevated into its present position. Here too there seems to be no evidence of fragments of the crystalline rocks in question in the sediments. Thus the author concludes that the Nubian Sandstone was unconformably deposited, partly on pre-existing sedimentary formations, and partly on the planed-down surfaces of still older crystalline and metamorphic rocks. Subsequently it was invaded by outbursts from the underlying magma, the intrusions being probably connected with the elevation of the mountainous regions on the east side of the Nile.

2. "On the Fossil Plants of the Waldershare and Fredville Series of the Kent Coalfield." By E. A. Newell Arber, M.A., F.L.S., F.G.S.

At the boring at Shakespeare Cliff, Dover, Coal-measures were reached in 1890 at a depth of 1,100 feet, and subsequently penetrated to a depth of about 2,270 feet. Thirteen seams of coal, varying in thickness from 1 to 4 feet, were pierced. Coal-measures were struck at 1,394 feet at the boring in Waldershare Park, and pierced for 1,260 feet more. Five seams of coal, varying from 1 ft. 4 in. to 5 ft. 2 in. in thickness, were struck. The boring near Fredville Park reached Coal-measures at 1,363 feet, pierced three seams of coal, and was continued to a depth of 1,813 feet. The specimens of plants collected from the Waldershare and Fredville borings are dealt with in detail, and compared with plants found at Dover and in other localities in Britain and abroad. The more abundant and characteristic species are common to Waldershare and Fredville, and lead to the conclusion that the beds belong to the same horizon. The majority of species tabulated are either confined to the Upper Coal-measures and the Transition Series below, or are Middle and Lower Coal-measure forms which are known to occur in the Transition

Series. Indeed, all but two plants have been recorded from the last horizon. Thus the beds are the homotaxial equivalents of the Newcastle, Etruria, and Black Band horizons of North Staffordshire, the Hamstead Beds below 1,233 feet in South Staffordshire, the Coed-yr-allt Beds and Ruabon Marls of Denbighshire, the Ardwick Series and Beds above the Bradford Four Foot Coal in South Lancashire, the Lower Pennant Grit of South Wales, and the New Rock and Vobster Series of Somerset. The data with regard to Dover are too scanty for certainty, but they seem to indicate approximately the same horizon as the two other Kentish localities. The majority of species are also common to the highest zone, or the "Charbons Gras," in the Pas de Calais. The flora of these rocks, and of those on the same tectonic line, belongs to the lower of the two great Continental zones of the Upper Carboniferous—the Westphalian; and the higher zone, the Stephanian, is unrepresented in the Mendip-Artois series of basins. But, as this axis is followed from east to west, it appears that continuously higher horizons are met with.

CORRESPONDENCE.

HIPPONYX FROM THE WHITE CHALK.

Sir,—It may be of interest to note that a third specimen of *Hipponyx blackmorei* turned up almost immediately after the publication of my note in the Geological Magazine for October. This was recognised by Dr. Rowe in the collection of Mr. J. R. Farmery, of Louth, who, with other of our friends, has been patiently working out the Chalk fauna of Lincolnshire. The specimen came from the *Holaster planus*-zone of Boswell; it is affixed to a specimen of *Micraster præcursor*, is slightly better preserved than the type, and has an oval form, thus showing a characteristic variation of growth. The age of this specimen is of especial interest. Mr. Farmery has generously given this rare fossil to the British Museum.

C. Davies Sherborn.

FOREIGN FLINTS IN THE EAST COAST DRIFTS.

Sir,—Referring to Mr. Bullerwell's note on the number of flints in the old gravel-bed on the Northumberland coast, which appeared in the Geological Magazine for November (p. 525), I can endorse what he says as to the probable existence in the bed of the North Sea of chalk deposits. In our Holderness drifts we find quite a large number of masses of black flint and pink flint, both of which are different from anything occurring in this county. Formerly their presence was easily accounted for in the drift as being derived from Denmark. A Danish geologist, however, informed us that there is no flint in Denmark. In addition to the flint we obtain scores of chalk fossils, from a different horizon, however, from anything that occurs *in sitû* in the county. These include, principally, the flint casts of a small sea-urchin, resembling *Ananchytes ovatus* in general shape, and some well-preserved belemnites of the *lanceolatus* type, both these fossils occurring literally in hundreds in the drift. We have recently obtained two specimens of black flint in which these particular belemnites are embedded, and as the sea-urchins are usually in black flint, it would seem that all three are derived from an outcrop somewhere in the North Sea. In our lowest drifts, that is those which were deposited by the first advance of the glacier, are a number of green-coated black flints similar to those occurring in the Eocene deposits. These had been probably lying on the floor of the sea a considerable time before being taken up by the glacier.

T. Sheppard, F.G.S.

Hull.

OBITUARY.

WILLIAM JEROME HARRISON, F.G.S.

Born 1845. Died June 6, 1908.

We regret to record the death of W. J. Harrison, who did much to advance the progress of geological knowledge as an enthusiastic teacher and local worker in the neighbourhoods of Leicester and Birmingham, and also by means of bibliographic research.

Born at Hemsworth, near Doncaster, he early qualified as a science teacher, and ultimately wrote a number of elementary textbooks on natural science, chemistry, and physics. A fifth edition of his useful textbook of geology was issued in 1903, and he was author also of "Geology of the Counties of England and of North and South Wales," 1882. These works, as was the case with all his publications, were characterized by great care and accuracy.

For some years Mr. Harrison was Curator of the Leicester Town Museum. During this period, in 1874, he drew attention to his discovery of the Rhætic beds near Leicester, and in 1877 he issued "A Sketch of the Geology of Leicestershire and Rutland," reprinted from White's "History" and supplemented by twelve photographs.

In 1880 he removed to Birmingham, where he was appointed Chief Science Master under the Birmingham School Board. Here he devoted much attention to the Drift deposits, and published important bibliographies of Midland and Norfolk Glaciology, with brief notes of the contents of the papers, likewise a very full bibliography of Stonehenge and Avebury.

[A brief memoir of W. J. Harrison, with portrait and bibliography, to which we are much indebted, has been published in the *Naturalist* for September, 1908, by Mr. T. Sheppard.] H. B. W.

MISCELLANEOUS.

With the approval of H.M. the King, a Royal Medal has been awarded by the Council of the Royal Society to Professor John Milne, F.R.S., F.G.S., for his researches and investigations in Earthquake Phenomena in this country and in Japan, during more than thirty years.

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