THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE V. VOL. VI.

JANUARY—DECEMBER, 1909.

NH

Geology

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. DXXXV TO DXLVI.

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., F.R.M.S.,

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NEW SERIES. DECADE V. VOL. VI.

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LONDON:
DULAU & CO., LTD., 37 SOHO SQUARE, W.
1909.

HERTFORD:

PRINTED BY STEPHEN AUSTIN AND SONS, LTD.

LIST OF PLATES.

LIST OF ILLUSTRATIONS IN THE TEXT.

No. 535. Decade V.—Vol. VI.—No. I. Price 1s. 6d. net.

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JANUARY, 1909.

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

Yours faithfully
J. J. H. Teall

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. I.—JANUARY, 1909.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

Jethro Justinian Harris Teall, M.A., D.Sc., F.R.S., F.G.S.,

Director of the Geological Survey of Great Britain and of the Museum of Practical Geology.

(WITH A PORTRAIT, PLATE I.)

MR. TEALL, who was born on January 5, 1849, in the Oolitic region of the Cotteswolds, at Northleach, a small market town on the Fosse Way between Cirencester and Stow-on-the-Wold, was the only child of Jethro and Mary Teall (*née* Hathaway). His father inherited some landed property in East Kent, and resided after his marriage for about two months at Sandwich, where he died in 1848 of some epidemic that was raging in the place. Mrs. Teall then returned to her relations at Northleach, where her son was born.

His early education was received at the Northleach Grammar School, and afterwards at Berkeley Villa School in Cheltenham. His first instruction in science was given by a Mr. Notcutt, a pharmaceutical chemist living at Cheltenham, who gave lectures to the boys on chemistry during the winter and on botany during the summer. Among the pleasantest recollections of his school life are these lectures, and the rambles he took over the Cotteswold Hills, where the abundance of fossil shells in the rocks excited his wonder. Otherwise much time at school was spent in trying to write Latin and Greek verses, in which he never took the slightest interest. The subject of mathematics was, however, well taught at the Cheltenham School, and fully benefiting by this, Teall was sent to Cambridge to take a Mathematical degree. With this object in view he began residence at St. John's College in the Michaelmas Term of 1869, but after a course of reading for the Mathematical Tripos he was led to attend lectures on Geology by his College Tutor, Professor T. G. Bonney, and was thereby so attracted that he devoted himself wholly to the study of Natural Science. He was fortunate also in being able to attend the last course of lectures given by the veteran Professor of Geology, Sedgwick, as well as other courses given by Professor John Morris, who acted as Deputy Professor until the appointment of Professor McKenny Hughes in 1873. A certain delicacy of constitution, long since outgrown, obliged Teall to be non-resident during the Lent Term of 1871, but notwithstanding this he obtained a first class in the Natural Science Tripos of 1872, graduated B.A. in 1873, and proceeded to M.A. in 1876.

Teall was elected to a Fellowship of his College in 1875, which he vacated four years later on his marriage with Harriet, daughter of the late G. R. Cowen, of Nottingham.

In 1874, while still partially resident at Cambridge, he obtained the Sedgwick Prize for an essay on the Potton and Wicken Phosphatic Deposits. This was the first award of that prize, and the essay was published, with some additions, in 1875.

After taking his degree Teall was engaged for several years in lecturing on Physics, Physical Geography, Geology, and other scientific subjects under the University Extension Scheme, attracting large classes at Derby, Nottingham, and other towns in the Midland counties, in the north and west of England, and in the London district.

Ultimately Teall began to give his special attention to the microscopic structure of rocks, in which he received much encouragement from his former Tutor, and afterwards from Professor Rosenbusch.

Among his earlier contributions to petrological science were researches on the Cheviot Andesites and Porphyrites, on the North of England Dykes, and on the Whin Sill. Their publication at once gave him a high place among petrologists, and he soon increased his reputation by important papers on the metamorphism of Dolerite into Hornblende Schist, on the Lizard Gabbros, and on the origin of certain Banded Gneisses.

In 1886 he commenced the publication, in parts, of his *magnum opus*, the *British Petrography*, a work for which he was exceptionally qualified by his knowledge of chemistry and mineralogy, his experience in field-geology, and his acquaintance with geological literature. This volume, characterized like all his work by thoroughness, embodies, in addition to the necessary summary of the researches of others, a large amount of original research and many suggestive observations; while the coloured plates of microscopic sections were far superior to any that had appeared in this country. Not only so, but unless the author had incurred serious pecuniary risk in addition to his heavy labour, the book, owing to the failure of the original publisher, would have remained incomplete. The original drawings for several of the plates were made by Mrs. Teall.

In 1888 Mr. Teall was appointed to the post of Geologist on the Geological Survey of the United Kingdom, under Sir Archibald Geikie, to take charge of the petrographical work and to deal more especially with the crystalline schists. Here it may be mentioned that this branch of the work of the Geological Survey had been initiated in earlier days by Sir Archibald Geikie, when Director in Scotland, and by J. Clifton Ward in the Lake District. It was afterwards specially attended to in the Geological Survey Office in London by Frank Rutley, who formed the first Petrographical Laboratory. On his retirement in 1882 Mr. F. W. Rudler was deputed to deal with the subject so far as his time permitted, but needless to say he could not be spared for any continuous research.

In consequence Dr. F. H. Hatch was appointed in 1886, and his attention was given mainly to the eruptive rocks.

At this time the problems connected with the age and structure of the schistose rocks of the Highlands were attracting particular attention on and off the Geological Survey, and it was of paramount importance that the field-staff should have the advice and assistance of one who would bring to their aid the precise methods of petrological science.

To quote the words of Sir Archibald Geikie—

"The duties devolving on the Petrographical Department of the Survey have increased so much in recent years, and are of such essential consequence for the field-work and the Memoirs, as well as for the Museum, that I found it necessary to apply for additional assistance. Taking advantage of Mr. Bristow's retirement, I submitted to the Department a proposal for the appointment of a trained petrographer and chemist with the rank and pay of a geologist. This proposal having been sanctioned by the Treasury, Mr. J. J. H. Teall, whose published work has placed him in the very front of English Petrography, was appointed on 20th June, 1888. I arranged that he should have charge of the determination of the schistose rocks of the Highlands, so as to be able to aid the progress of the mapping. In order to make himself acquainted with the practical difficulties encountered in the field-work, he started at once for the field and spent some weeks with the surveyors, accompanying them in their daily explorations in the various districts of the Scottish Highlands, and collecting a large series of specimens for determination in the office. His time since then has been mainly occupied in the study of these specimens, and in such rock-determinations as were from time to time required for the guidance of the mapping." [1]

From 1888 until his appointment as Director in 1901, Mr. Teall was for the most part occupied in a detailed study of the Highland rocks, but he spent a short time in mapping on the six-inch scale certain areas of Lewisian Gneiss in Rona and the northern part of Raasay. During the earlier of these years he likewise examined and reported on a considerable series of Jurassic sedimentary rocks. It was hoped that he would produce in his leisure time a companion volume to his British Petrography, and deal more fully than he had previously done with the sedimentary rocks and the crystalline schists; but this anticipation, which he himself had cherished, has unfortunately not been realized.

Dr. Hatch retired from the Geological Survey in 1892, and in the following year Mr. Teall received help in the Petrographical Department from Mr. (now Professor) W. W. Watts, who had been previously acting as petrographer on the Irish Staff. Mr. Watts resigned in 1896, and in the following year his place was filled by the appointment of Dr. William Pollard as 'Geologist' to undertake the chemical work which is inseparable from the study of petrology.

Records of the results achieved by Mr. Teall in the Petrographical Department have been given in the amplified Annual Reports of the Director General for the years 1892 to 1896, and later in the *Summary of Progress* for 1897 onwards. We read of his discovery of Riebeckite in the granophyre of Skye (1893), of a report on rocks from the Tonga Islands (1897), of his researches on Contact Metamorphism around the Ben Cruachan granite, with especial reference to the Cordierite rocks containing Corundum (1898), on the volcanic

[1] Ann. Rep. of Director General of Geol. Survey for 1888, p. 257.

rocks of the Exeter district, on a Manganese deposit at Hockworthy (1899), and on the Marbles of Assynt (1900).

On March 1, 1901, Mr. Teall was appointed Director of the Geological Survey of Great Britain and Ireland in the room of Sir A. Geikie, Director General, who retired on February 28. The change in title was probably due to the fact that the severance of the Geological Survey of Ireland was then contemplated, and it took place on April 1, 1905. Prior to this application of Home Rule to the sister country the Geological Survey underwent a thorough re-organization, under the administration of Mr. Teall. The field-work was carried on in a more systematic way in defined areas under district geologists, and it was arranged that the one-inch maps and accompanying memoirs should be published simultaneously.

The colour-printing of maps, which had been initiated in England and Wales under the direction of Sir A. Geikie, was now extended to the new Drift maps in Ireland and to the Index Map in Scotland. A very useful geological map of the British Islands on the scale of 25 miles to an inch was issued in 1906. A new series of the Index or General Map of England and Wales on the scale of an inch to 4 miles has been nearly completed, and a similar map for Scotland has been commenced. The publication of the six-inch maps of the Coalfields, long abandoned, has again been undertaken, and these maps, so important for economic purposes, are now issued both coloured and uncoloured.

The *Summary of Progress* has been somewhat modified so as to include a number of original articles and reports by various members of the Staff; and among numerous other publications it may be mentioned that the great memoir on the Geological Structure of the north-west Highlands of Scotland, promised in 1888, has at length been issued to the public, under the editorship of Sir A. Geikie. In this volume are incorporated some of the more important petrological researches carried on by Mr. Teall during the first seven years of his official service.

At the time of the reorganization new survey offices were constructed for the field-staff, with excellent rooms for the Petrographical and Chemical Departments, the former under the charge of Dr. J. S. Flett. The Museum itself was considerably modified; many manufactured articles were taken away, notably the fine collection of British pottery and porcelain, to make room for the further display of purely geological objects. In place of the Metallurgical specimens (removed to South Kensington) a fine collection of British Minerals has been arranged topographically and accompanied by a most excellent handbook prepared by Mr. Rudler. The economic applications of geology, the most important part of the official work, have been dealt with much more effectively both by the Survey and Museum. The collections of clays and building-stones have been considerably extended. The series of county memoirs on Water Supply, of which one had previously been published, has been continued, and memoirs have been issued on the Coals of South Wales and on the Oil Shales of the Lothians. Structural improvements have been made in the Museum, including the conversion of the old lecture theatre in part into an extension of the Museum and in part into a consulting room, in connexion with the Library, where maps can be spread out and examined. Instructive geological models of the Isle of Purbeck and of Assynt have been prepared and placed in the Museum. Exhibits have also been introduced to illustrate new Geological Survey Memoirs and Maps by means of specimens and photographs from the area described. The photographic work, especially in England and Wales, has been greatly amplified.

There was a time, so we have been told, before Mr. Teall had been appointed Director, and while his attention was absorbed to a large extent by Highland schists and various altered igneous rocks, when he would not look at a fossil. As Director his attitude in this respect became greatly modified. The zonal work carried on in the Chalk by Dr. Rowe, and in Carboniferous strata by Dr. Kidston and Dr. Vaughan, stirred his enthusiasm. He has also given practical proof of his interest in palæontology by starting a series of monographs, the first of which, by Dr. Peach, on Scottish Carboniferous Schizopods, has just appeared. Although Mr. Teall was not brought up to official routine, few men could have entered with more zeal than he did upon the duties of a Director, or discharged the ofttimes arduous duties with more success in the interests of the public service and of the Geological Survey in particular, a fact to which the above remarks on the progress of the Institution sufficiently testify.

Mr. Teall, who had been elected a Fellow of the Geological Society in 1873, was chosen a Member of Council in 1884, he served as Secretary from 1893 to 1897, and was elected President in 1900. Here his firmness and courtesy, combined with his businesslike habits, made him an excellent chairman. He was also President of the Geologists' Association during the years 1898 to 1900, and President of Section C of the British Association at Nottingham in 1893. He was elected a Fellow of the Royal Society in 1890, served on the Council in 1899–1901, and was a Vice-President during the latter part of the time. He was awarded the Bigsby Medal by the Geological Society in 1889, and received their highest honour, the Wollaston Medal, in 1905. The Academy of Sciences in Paris in 1907 awarded to him the Delesse Prize for his researches in Petrography. Other marks of appreciation have been conferred in the degrees of D.Sc. Dublin 1904, Sc.D. Cambridge 1905, and D.Sc. Oxford 1908.

LIST OF SCIENTIFIC PUBLICATIONS.

A. Unofficial.

1875. "The Potton and Wicken Phosphatic Deposits": 8vo; pp. 44; Cambridge.

1879. "A Description of the Microscopic Structure of the Pitchstone from the Scuir of Eigg": Midland Nat., vol. ii, pp. 107–8.

1880. "The Pennine Chain": Geol. Mag., Dec. II, Vol. VII, pp. 92–3 and 331 (reply to Professor Hull).

"Influence of Earth Movements on the Geological Structure of the British Isles": ibid., pp. 349–57.

"A Criticism of Dr. Croll's Molecular Theory of Glacier Motion"; 8vo; pp. 12; London and Nottingham.

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1884. "Petrological Notes on some North of England Dykes": Quart. Journ. Geol. Soc., vol. xl, pp. 209–47, 2 pls.

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1885. "The Metamorphosis of Dolerite into Hornblende-schist": Quart. Journ. Geol. Soc., vol. xli, pp. 133–44, plate.

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1886. "Petrographical Notes on some of the Igneous Rocks of Northumberland": Proc. Geol. Assoc., vol. ix, pp. 575–81.

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1887. "On Granite containing Andalusite from the Cheesewring, Cornwall": Min. Mag., vol. vii, p. 161.

"On the Occurrence of Rutile-needles in Clays": ibid., pp. 201–4.

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1889. "On the Amygdaloids of the Tynemouth Dyke": Geol. Mag., Dec. III, Vol. VI, pp. 481–3, plate.

1890. "Notes on some Rocks from North Pol Cornick": Trans. Roy. Geol. Soc. Cornwall, vol. xi, p. 217.

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1891. (With Howard Fox.) "Picotite in Serpentine": Trans. Roy. Geol. Soc. Cornwall, vol. xi, p. 336.

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1892. "The Sequence of Plutonic Rocks": Nat. Sci., vol. i, pp. 288–99.

(With J. R. Dakyns.) "On the Plutonic Rocks of Garabal Hill and Meall Breac": Quart. Journ. Geol. Soc., vol. xlviii, pp. 104–20, with a map.

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(With Howard Fox.) "Notes on some Coast-sections at the Lizard": ibid., pp. 199–210.

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1895. (With Sir A. Geikie.) "On the Banded Structure of some Tertiary Gabbros in the Isle of Skye": Quart. Journ. Geol. Soc., vol. l, pp. 645–59, 3 pls.

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1897. (With E. T. NEWTON.) "Notes on a Collection of Rocks and Fossils from Franz Josef Land, made by the Jackson-Harmsworth Expedition during 1894–6": Quart. Journ. Geol. Soc., vol. liii, pp. 477–518, plate.

(With E. T. NEWTON.) "Notes on a Collection of Rocks from the Tonga Islands": GEOL. MAG., Dec. IV, Vol. IV, pp. 151–3.

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1901. Presidential Address, "The Evolution of Petrological Ideas": Quart. Journ. Geol. Soc., vol. lvii, pp. lxii–lxxxvi.

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(With T. C. PORTER & J. D. FALCONER.) "Volcanic Dust": Nature, vol. lxvi, pp. 130–1.

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B. OFFICIAL.

(Petrological Notes contributed by Dr. Teall to Memoirs of the Geological Survey of Great Britain and Ireland.)

1. *General Memoirs.*

1893. "The Jurassic Rocks of Britain." Vol. iii: "Notes on Lias Limestones and Oolitic Ironstone," pp. 33, 302.

1894. Ibid. Vol. iv: "Petrological Notes on the Oolitic Rocks," pp. 8–12, 26–9.

1895. Ibid. Vol. v: "Microscopic Structure of Portland Beds," p. 186; "Of Purbeck Beds," pp. 233–4; "Westbury Iron-ore," p. 324.

1899. "The Silurian Rocks of Britain." Vol. i: Scotland. "The Galloway Granites and Associated Igneous Rocks," pp. 607–31. "Contact-metamorphism around the Galloway Granites," pp. 632–51.

1907. "The Geological Structure of the North-West Highlands of Scotland."

"Petrography of the Lewisian Gneiss. A. The Fundamental Complex" (written in 1894–5), pp. 42–70.

"Architectural Features of the Fundamental Complex," pp. 71–4.

B. "Rocks of presumably Sedimentary Origin in the Lewisian Gneiss," pp. 75–84.

"Pre-Torridonian Intrusive Rocks associated with the Lewisian Gneiss," pp. 85–102.

"Lewisian Gneiss of Rona and Raasay," pp. 259–61.

"Petrography of the Torridonian Formation," pp. 278–90.

"Post-Cambrian Igneous Rocks of older date than the Great Thrust-Movements of the Region: their Petrography," pp. 440–52.
"Contact Metamorphism of the Cambrian Dolomites and Limestones," pp. 453–62.
"The Eastern Schists." General Description (with J. Horne), pp. 595–601.

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1897. "Geology of Cowal." General Remarks on the Petrography of the Cowal District, pp. 295–9. Description of an Albite Schist, pp. 299–300.

3. *Sheet Memoirs.*

Ireland.

1891. Sheets 31 (part) and 32 (parts of Donegal, etc.).

Scotland.

1896. Sheet 5 (part of Kirkcudbrightshire).
Sheet 75 (parts of Aberdeen, Banff, etc.).
1905. Sheet 37 (Mid-Argyll).
1907. Sheet 20 (Islay, etc.).

England and Wales.

1902. Sheet 325 (Exeter).
1904. Sheets 355 and 356 (Kingsbridge and Salcombe).
1907. Sheet 353 (Mevagissey).

II.—On Convection Currents in the Earth's Interior.

By Rev. O. Fisher, M.A., F.G.S.

In this Magazine for November Mr. Mellard Reade referred to the difficulty of imagining the adequacy of any known force to accomplish such tremendous effects as to produce overthrusts like those which have been lately described as occurring in the North-West Highlands,[1] and he consequently appears to be a little doubtful of the reality of the phenomenon. I think, however, that the conclusion of so many competent field geologists must be accepted, and that our theories of mountain-building must be made to fit the facts rather than the facts the theories.

An overthrust is only one of the ways in which a region of the earth's crust may be compressed into a smaller area by horizontal pressures acting in opposite directions, and enormous as the stress must be, it does not seem that it need be greater to cause an overthrust than what would be required to produce the folding and consequent elevation, which is the more usual manner in which the compressing force has been satisfied; for if we suppose the mean elevation of a tract produced to be the same in the two cases, the work against gravity would be the same, and what we have to compare is, in the one case the friction along the thrust-plane, and in the other the bending and fracturing of the rigid rocks. It is not obvious that the former need require more force than the latter.

I have elsewhere endeavoured to explain the mechanism of an overthrust by the analogy of what may be observed in the behaviour of ice on a frozen river.[2] If the edge of a piece of floating ice gets

[1] Survey Memoirs, *The Geological Structure of the N.W. Highlands of Scotland*, 1907.
[2] *Physics of the Earth's Crust*, 2nd ed., p. 321.

to overlap the edge of a fixed sheet, the stream pushes the former onwards and causes an overthrust. But if an overthrust in the rocks is produced in a similar manner, we must postulate a liquid substratum, whose surface is locally moving horizontally; and if the earth is a cooling body, and if there is liquid matter in the interior, this kind of movement must needs occur. The reason of this is that the mode of cooling of a mass of liquid is by convection, the currents ascending in some places and descending in others, while the liquid flows horizontally at its surface from the ascending to the descending portions.

I am aware that at the present day (at least in Britain) a belief in the liquidity of the earth's interior is heresy. The orthodox opinion appears to be that it is neither liquid nor solid, but both at once, and so we run with the hare and hunt with the hounds. But such a state of affairs would not admit of convection currents.

I will briefly mention some phenomena which appear to be explicable on the hypothesis of a liquid substratum holding water-gas in solution and cooling by convection—

(1) Obviously volcanic action stands first, where we see frequent ebullitions of fresh lava, varying in character from one eruption to another, and building up great mountains as if supplied from an inexhaustible reservoir below.

(2) The same agency, viz. horizontal flow, which, as above suggested, might cause compression to be satisfied with an overthrust, would also account for other forms of compression, such as are more usually characteristic of mountain ranges.

As to whether the friction of a flow of the substratum would be adequate to supply the force which has compressed the crust in mountain ranges, we may again refer to the analogy of ice. Nansen found that in the Polar regions the thickness of the ice under direct freezing does not usually exceed 4 metres. But it becomes very much thicker by the piling up of broken ice-sheets, driven together and mounting one above another, and he says that the pressure is largely dependent upon the tidal current, especially at the margin of the ice-field.[1] Now the ratio of the densities of the crust and substratum is probably very close to that of ice and water, so that a similar action of currents in the two cases would be likely to produce similar effects of compression.

(3) Variations of level, especially such as have been described by Professor Hull and Dr. Spencer, appear to be most readily accounted for by convection currents, the surface rising over upward and sinking over downward currents, as I have endeavoured to explain elsewhere.[2]

(4) Another phenomenon which may possibly be due to convection currents is the irregularity in the small changes of latitude which arise from slight variations in the position of the axis of rotation within the earth. Mathematicians tell us that the anomalies of these movements can be explained by elasticity. But it seems that, although elasticity might modify the period of a regular movement of the pole of

[1] *Nature*, February 11, 1897. [2] American Journal of Science, 1906.

rotation around its mean position, it would not explain the remarkable irregularity both in amplitude and period with which its wanderings are affected.[1] Professor Milne is of opinion that some connection exists between these irregularities and the frequency of large earthquakes.[2] Might not convection currents, by slightly altering the distribution of mass within the earth in an irregular manner, account for these irregular wanderings of the pole?

(5) Observations upon the force of gravity in India have revealed the remarkable result that changes appear to have taken place within the last thirty years. At Dehra Dun, at the foot of the Himalayas, there has been found a notable increase of gravity corresponding to four swings of the second's pendulum in twenty-four hours.[3] If the two sets of observations that show this are to be depended on, we have here an absolute proof that there has been a change of density and consequently movement in the substratum of that neighbourhood; and it is noticeable that, in the interval between the two dates, a severe earthquake was experienced at that place.

(6) Making use of the best data newly available, I have calculated by a mathematical method that, on the hypothesis that the crust of the earth is being formed by congelation out of a liquid subjacent magma, the age of the world would not be greater than about eight million years unless there are convection currents in the interior.[4] Dr. See, Professor of Mathematics to the U.S.A. Navy, has accepted my calculation, and also the conclusion at which I have arrived regarding the corresponding age of the world, and, not believing in the existence of convection currents, he has been led to argue that geological phenomena do not require a longer period for their accomplishment than about eight million years.[5] Few geologists, I think, will be willing to accept so short a time. It follows that we have the opinion of an accomplished mathematician to endorse the result of my calculations, which, on any reasonable estimate of the world's age, go far to prove the existence of convection currents.

The two principal objections to the hypothesis of a liquid interior appear to be (1) the existence of a fortnightly tide, and (2) the two phases of the preliminary tremors of a world-shaking earthquake. The argument for rigidity from the fortnightly tide is so extremely technical and refined that it is not for the ordinary geologist to follow it.[6] It is based on the average of observations taken in India, Britain, and France;[7] but, confining our attention to India, it seems doubtful whether that tide can be detected.[8]

The argument for rigidity from the different velocities of the two phases of the preliminary tremors of an earthquake assumes that

[1] *Nature*, February 27, 1896, also May 12, 1898.
[2] British Association Report, 1903 and 1906.
[3] Colonel Burrard, Phil. Trans., vol. clv, A 394, p. 294.
[4] *Physics of the Earth's Crust*, 2nd ed., Appendix, ch. xxvii.
[5] Proc. American Phil. Soc., 1907, vol. xlvi, p. 221.
[6] Thomson & Tait's *Natural Philosophy*, 1883, pt. ii, p. 442.
[7] Knott's *Physics of Earthquakes*, p. 104.
[8] *Physics of the Earth's Crust*, Appendix to 2nd ed., p. 34.

the second phase is propagated as a distortional wave, for, "among material bodies, a solid alone really possesses the rigidity sufficient for the production within it of transverse vibrations and for their maintenance during their propagation."[1] But I have suggested an alternative explanation of the two phases, depending upon the presence of water-gas in the magma, which, from volcanic eruptions, we know to be a constituent.[2]

The cause usually assigned for the supposed rigidity of the interior is the enormous pressure to which it is exposed. It is held that this would so increase the viscosity as to render it practically solid, but I am not aware that any experimental fact has shown this to be probable; for it is a different question from that of the melting temperature being raised by pressure. We know that in the case of a vapour there is a certain critical temperature, above which no pressure will reconvert it into a liquid. Is it not possible that in the case of a liquid there may be a critical temperature above which no pressure will convert the liquid into a solid? And this may be the case in the earth's interior.

III.—On the Affinities of the Triassic Plant *Yuccites vogesiacus*, Schimper & Mougeot.

By E. A. Newell Arber, M.A., F.L.S., F.G.S., Trinity College, Cambridge; University Demonstrator in Palæobotany.

In a paper published in 1907, in the Transactions of the Linnean Society of London,[3] I described and figured, under the name *Zamites grandis*, sp. nov., some excellent specimens of detached leaves recently collected by my friend Mr. L. J. Wills, B.A., F.G.S., from the Keuper rocks of Bromsgrove (Worcestershire).

These fossils were regarded as identical with the specimens from the Bunter of the Vosges, first described by Schimper & Mougeot[4] under the name of *Yuccites vogesiacus*.

In discussing the affinities of this plant I pointed out[5] that this question had been "a subject of much confusion in the past, and the cause of considerable difficulty at the present". The difficulty lay in the fact that these large, lanceolate, Monocotyledonous-looking leaves, with close, stout, and strictly parallel nerves, were almost invariably detached, and with one possible exception, which, however, was not very conclusive, there was no direct evidence, either from the British or the Continental examples, as to the manner in which they were borne. Consequently direct evidence as to their affinities was lacking.

On the other hand, these leaves presented a very close resemblance to the pinnæ of a Zamitean frond except in size, in which respect they were very dissimilar. I concluded, however, that they were the detached pinnæ of a Zamitean frond of large size.

[1] Poincaré, *The New Physics*: International Scientific Series, 1907, vol. xc, p. 173.
[2] Proc. Cambridge Phil. Soc.
[3] Arber, Trans. Linn. Soc. London, 1907, ser. II, Bot., vol. vii, pt. vii, p. 109.
[4] Schimper & Mougeot, Monogr. Plant. foss. Vosges, 1844, p. 42, pl. xxi, figs. 1 and 2.
[5] Arber, ibid., p. 115.

In this conclusion I was in agreement with Professor Seward, who had recently attributed to the same genus some very similar fossils from the Stonesfield Slate of Oxfordshire, which he described under the name *Zamites megaphyllus* (Phillips).[1] In referring Schimper & Mougeot's specimens from the Bunter, and the examples collected from the English Keuper, to this genus, it was found necessary, for reasons fully explained in my former paper,[2] to change also the specific name, and the term *Zamites grandis*, sp. nov., was instituted for their reception.

Quite recently, however, Mr. Wills has brought to light a further specimen from Bromsgrove, of great interest as showing the bases of several leaves still attached to an axis. From this example there appears to be no doubt that these fossils were not the detached leaflets of a pinnate frond of Cycadophytean affinity, but *leaves spirally arranged on a stem or shoot.*

This exceptional specimen will be fully described by Mr. Wills in his forthcoming memoir on the Keuper rocks of Bromsgrove. It may suffice to state that it shows a flattened axis, some 8 cm. long, on which portions of some nine leaves are seen spirally arranged, their bases, in three or four instances, being in continuity with the stem or branch.

It is, however, proposed to discuss here the affinities of this fossil, which can no longer be regarded as a member of the Cycadophyta.

In the first place, it is unfortunate that this recent discovery, while of great interest, hardly sheds any definite light on the question of affinity. The fructification of this plant is still unknown, and, until it has been correlated with the leafy shoot, all conclusions must, at the best, be of a provisional nature. As compared with Upper Palæozoic plants, the Bunter and Keuper fossils recall very vividly the leaves of *Cordaites*. Compter,[3] in describing similar, if not identical, specimens from the Lower Keuper of East Thüringia, attributed them to this genus under the name *Cordaites keuperianus*, sp. nov. Zeiller[4] has supported this conclusion, and has drawn attention to the fact that the occurrence of *Artisia* (*Sternbergia*)-like pith-casts in the Lias, as recorded by Lignier,[5] lends probability to this view. Further support is also afforded by the reflection that if the Bromsgrove specimens had been obtained from Palæozoic rocks they would undoubtedly have been referred to the genus *Cordaites*.

On the other hand, it is now apparent that plants of similar habit to those under discussion from the Bunter and Keuper are not uncommon in the Mesozoic rocks. I have recently examined, by the kindness of Professor Sollas, one of the type-specimens[6] from the Stonesfield Slate of *Zamites megaphyllus* (Phillips), refigured by Professor Seward,[7] in which some of the leaves are still attached to

[1] See Arber, ibid., p. 117. [2] See Arber, ibid., p. 115.

[3] Compter, Zeitsch. Naturwiss. Leipzig, 1894, vol. lxvii (ser. v, vol. v), p. 225, pl. iv, fig. 9.

[4] Zeiller, *Élém. de Paléobotanique*, 1900, p. 213.

[5] Lignier, Mém. Soc. Linn. Normandie, 1895, vol. xviii, p. 135, pl. vii, fig. 13.

[6] No. $\frac{MM}{748}$ in the Oxford University Museum.

[7] Seward, *Jurassic Flora*, vol. ii (Brit. Mus. Cat.), 1904, p. 114, text-fig. 11.

the axis. In the light of Mr. Wills' new discovery, I am now of opinion that the mode of attachment here, though not very clearly seen, is probably spiral, and that we are not dealing in this case with a pinnate frond.

Other fossils of a similar type are to be found in the Cretaceous *Krannera mirabilis* of Velenovský and the *Eolirion* (*Elolirion*) *primigenium* of Schenk.[1] The latter strongly recalls the Bromsgrove specimens, and in Schenk's example the leaves are obviously attached spirally to an axis or shoot, with which many of them appear to be in continuity. We have, therefore, a family of plants including the genera *Yuccites*, Schimp. & Moug., *Palæozamia*, Phillips, *Krannera*, Vel., and *Eolirion*, Schenk, existing in both Triassic, Jurassic, and Wealden times, with large Monocotyledonous-like leaves, spirally arranged on the shoot. The question is, are these fossils best regarded as Monocotyledons, or as members of the Cordaitales or Coniferales, or again as a distinct family possibly intermediate between the Cordaitales and Coniferales? For a complete answer we must wait until the fructification is known. At present the balance of probability does not appear to me to lie more in one direction than in another, if we exclude the possible attribution to the Monocotyledons, which, on general grounds, is by far the least probable. It is generally agreed that Monocotyledons did not exist before Lower Cretaceous times, and that the earliest remains of this group come from rocks of slightly more recent age than the British Wealden.

With regard to the possible Cordaitean affinity, there is much to be said in its favour, as Zeiller[2] has already pointed out. The fact that no *Artisia*-like casts have been collected from the Keuper of Bromsgrove is hardly trustworthy evidence, either for or against the argument. They are already known from a higher horizon, and negative evidence is rarely reliable if unsupported by other data. If the attribution to the Cordaitales proves to be correct, then this group must have been most remarkable in regard to its long persistence in geological time. It occurs in the Lower Carboniferous, if not in the Devonian, and in Upper Carboniferous and Permian times it formed one of the dominant elements of the flora. The argument that, because most of the great dominant Palæozoic groups had either died out, or sunk to the position of subsidiary or insignificant factors in the flora by the time we reach the Rhætic, the Cordaitales were unlikely to have persisted throughout Mesozoic times, is not, however, in itself conclusive, if unsupported. The Leptosporangiate Ferns, for instance, have maintained their place as dominant elements in the flora throughout the Mesozoic and Tertiary periods even to the present day.

Yet in the absence of any knowledge of the fructification I hesitate to accept this view even provisionally. It is possible that the fructifications of these Mesozoic plants may prove to be more nearly related to the Coniferales than to the Cordaitales, or even occupy an intermediate position between the two. The theory that

[1] Schenk, *Palæontogr.*, 1869, vol. xix, Lief. i, p. 20, pl. vii fig. 4.
[2] Zeiller, ibid., pp. 212–13.

the Coniferales themselves sprang from the Cordaitales, which is widely but not universally accepted as a working hypothesis, would then receive strong support, and the Cordaitean-like leaves would be easily explained. Even in some modern Araucariæ, such as *Agathis* (*Dammara*) *loranthifolia*, Sal., the leaves also to some extent recall those of a modern Monocotyledon, and are not entirely dissimilar to those of *Cordaites*.

I am thus inclined to regard the question of the affinities of this family of Mesozoic plants as an entirely open one until the fructification is discovered. At the same time I think it probable that the fructification will be found eventually to have departed somewhat from the type characteristic of the Cordaitales.

There remains the discussion of the name by which these Bunter and Keuper fossils should be known. Unless we adopt the attribution to *Cordaites* outright, which seems to me to be hardly justifiable, and if we regard the affinities of this plant as still wholly obscure, there seems to be no better course than to fall back on the original name *Yuccites rogesiacus* of Schimper & Mougeot, as a temporary and provisional expedient until more information is available. At present the genus *Yuccites* does not appear to have any established position. The name is of course open to the grave objection that it suggests affinity with the Monocotyledons, to which group, as also in the case of *Eolirion*, it was originally referred. Yet, on the other hand, there do not appear to be any species of *Yuccites* known beyond doubt to belong to the Monocotyledons, and the invention of a new genus, whether implying affinity to the Cordaitales on the one hand or to the Coniferales on the other, does not appear to me to be advisable on the present evidence. I propose, therefore, to retain temporarily the name *Yuccites rogesiacus*, Schimp. & Moug., for these specimens from the Bunter of the Vosges and the Keuper of Bromsgrove.[1]

IV.—*Limulus Woodwardi*, sp. nov., from the Lower Oolite of England.

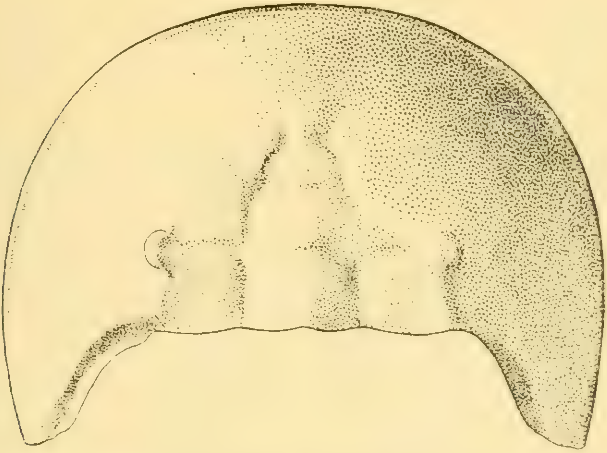
By D. M. S. Watson, B.Sc., Beyer Fellow of the Victoria University of Manchester.

My friend Mr. F. H. Gravely during September, 1908, obtained from the ruins of an old wall at Doddington, near Wellingborough in Northamptonshire, the carapace of an Arthropod, the value of

[1] I take this opportunity of correcting two slips which appeared on p. 110, paragraphs 2 and 3, of my previous paper with regard to the horizons on which some of the earlier Cycadophytean fronds occur in the Palæozoic rocks. I am indebted to Professor Zeiller for calling my attention to these errors. The oldest known specimens of *Zamites*, *Plagiozamites*, and *Pterophyllum* should there be stated to be derived from the Stephanian, and not from the Westphalian. Similarly, the beds in the Vosges from which *Plagiozamites* was obtained are of Permian age, and not Westphalian as stated. Professor Zeiller also informs me that the fossil recorded by Zalessky as *Plagiozamites* from Manchuria has proved to be a *Rhacopteris*. Professor Zeiller, in his "Bassin Houiller et Permien de Blanzy et du Creusot", a memoir which I did not see until after my paper had appeared, includes the *Zamites Planchardi* of the Commentry Flora in the genus *Plagiozamites*. Consequently the genus *Zamites* is as yet unknown from the Palæozoic rocks, and it is doubtful if any typical representatives have been described of earlier age than the Rhætic.

which he at once recognized. This specimen he has now presented to the Manchester Museum, and by his kindness I am enabled to offer a short description of it here.

The fossil consists of an iron-stained cast of the dorsal surface of a carapace, the left side of which had suffered considerable abrasion before the specimen was collected. The matrix is a grey, fine-grained sandstone, somewhat calcareous, and containing small Pelecypods and apparently some oolitic grains. I do not know any rock exactly like it from any other locality, but it considerably resembles some types of the Northampton sand to which it almost certainly belongs, as most walls in the neighbourhood are built with rocks belonging to that formation. Despite this uncertainty as to the exact horizon of the specimen, it seems to me worth description as being the only known example of a Mesozoic Merostome in Britain.



Cephalic shield or carapace of *Limulus Woodwardi*, Watson, sp. nov. Natural size. From the Inferior Oolite (?) of Doddington, Northamptonshire.

The anterior edge of the carapace is smooth and forms a large arc of a circle, considerably more than 180°.

The posterior edge of the carapace is bounded by three distinct lines; these are a central, nearly straight edge, to which the abdomen was attached. This attachment is about half the entire width of the carapace, and is considerably in advance of the genal angles. From the ends of this line two other edges curve out in gentle ogees to the genal angles. These angles are not produced, but end in blunt spines. The edge of the carapace along these lateral portions is curved downwards, forming a groove.

The carapace bears the following marks:—In the centre, starting from the back, is a distinct area—the glabella—separated by grooves from the general surface. These bounding grooves approach each other anteriorly, and then rather suddenly separate before quite touching; they then shortly die out. The glabella is divided transversely by two grooves, one a little behind the point of minimum width, the other half-way between that and the back of the carapace.

In the same line as this last groove are the lateral eyes. They are situated about three times the width of the glabella apart and stand up above the general level, just as in *Limulus Polyphemus*. Their structure cannot be seen.

On the right side is a trace of a small projection continuing the line of the eye ridge at the extreme back of the carapace. The carapace is strongly arched from side to side and is quite uncrushed.

The measurements are as follows:—

	cm.
Width between genal angles	7·64
Greatest width	8·1
Length on median line	4·2
Width on glabella at back	1·5
Width of attachment of abdomen	4·2
Distance of eye in front of line of attachment of abdomen	1·1
Distance apart of lateral eyes	4·2
Depth of carapace at back	1·8

There can be no doubt that the carapace described above is that of a *Limulus*. Its resemblances to the recent *L. Polyphemus* are extremely striking, the differences being slight variations in certain proportions.

In *L. Polyphemus* the carapace is longer than wide, and the articulation of the abdominal dorsal shield is wider than in the British form. The lateral eyes are placed somewhat further forward, and the glabella is not so obviously divided by transverse grooves.

The British specimen differs considerably from *L. Walchi*, the species which occurs in considerable abundance in the Solenhofen Slate; in *L. Walchi* the glabella is not divided by transverse grooves, and the lateral eyes are apparently not mounted on a distinct projection as they are in the new species. On the other hand, the upper oolitic species has the same downturned edge of the lateral parts of the posterior edge which is such a feature of the Northamptonshire species. *L. syriacus* from the Cretaceous of Hakel, Syria, differs greatly in the general shape of the carapace and in the crimping of the very narrow glabella.

There remain only *Limulus Decheni* from the Oligocene of Tenchern near Merseborg, which is a large species; two small and simple species from the Trias of Germany, and one from the European Rhætic. These last are forms with a simple carapace of small size. It thus appears that the Doddington specimen is distinct from all known species, and I suggest that it be called *Limulus Woodwardi* after Dr. Henry Woodward, to whom our knowledge of the British Merostomes is so largely due.

V.—Note on the Igneous Rocks of Singapore, with special reference to the Granite and Associated Rocks carrying Rhombic Pyroxene.

By J. B. Scrivenor, F.G.S., Geologist to the Federated Malay States Government, and formerly of H.M. Geological Survey of Great Britain.

In a former paper[1] the writer endeavoured to show the connection between the sedimentary rocks of Singapore and certain rocks in Pahang. On the occasions when opportunities for geological work in Singapore have presented themselves numerous specimens of igneous rocks have been collected, and it is the purpose of the present paper to describe briefly the observations recorded. It is hoped that this will give some further idea of the geology of the island of Singapore; but apart from a general description the pyroxene-bearing rocks associated with the granite appear to the writer to require a note as being of exceptional petrological interest.

The island of Singapore is composed, as far as is known at present, of a series of estuarine rocks, which are a continuation of the Tembeling Series in Pahang, granite, with associated rocks to be described later, and some other igneous rocks, most of which are referred to an extensive series of volcanic rocks in Pahang associated with Permo-Carboniferous beds. The estuarine series may be referred to the Upper Gondwana on the one hand, while on the other it is probably represented by some of the West Borneo Beds described by Mr. Wing Easton.

The granite is certainly later than the sedimentary rocks, which are, in some parts of the island, highly disturbed; therefore it may be assumed that the granite is at any rate post-Triassic, perhaps post-Inferior Oolite. In the peninsula the writer's observations have led him to believe that there are two types of granite which may be of different age, a porphyritic and a non-porphyritic type. As pointed out before, however, "against a difference in age may be urged the fact that both facies are connected with deposits of tin-ore, and also that beyond areas of gneiss, produced apparently by movements in the partially solidified magma, no evidence has been found of disturbances on a large scale affecting either." The Singapore granite belongs to the non-porphyritic facies.

Mr. R. B. Newton[2] gives a list of the early literature dealing with Singapore in his "Notes on Literature bearing on the Geology of the Malay Peninsula, etc.". Logan[3] says that in Bukit Timah "solid greenish granite and syenite, passing in some places into compact laminated felspar", are seen, while on Pulau Ubin are "various forms of granite and syenite (often approaching and sometimes passing into greenstone)", and hornblende occurs, both on Pulau Ubin and elsewhere.

Rocks of the Pahang Volcanic Series.—None of these rocks have

[1] Geol. Mag., 1908, pp. 289–91. The map with this paper will serve to show the position of Pulau Ubin in Changi.

[2] Geol. Mag., 1901, pp. 128–34.

[3] J. R. Logan, "Notices of the Geology of the Straits of Singapore" (with geological map): Q.J.G.S., 1851, vol. vii, p. 310.

been seen *in sitú*. They are the only evidence at present of pre-Triassic rocks in the island. Close to the Ballestier Road, and not far from the junction with the Thomson Road, small boulders were found exposed on the site for a hospital. These consist of trachyte. At the corner of Grange and Orchard Roads small boulders of andesitic tuffs were found, similar to the tuffs in Pahang.

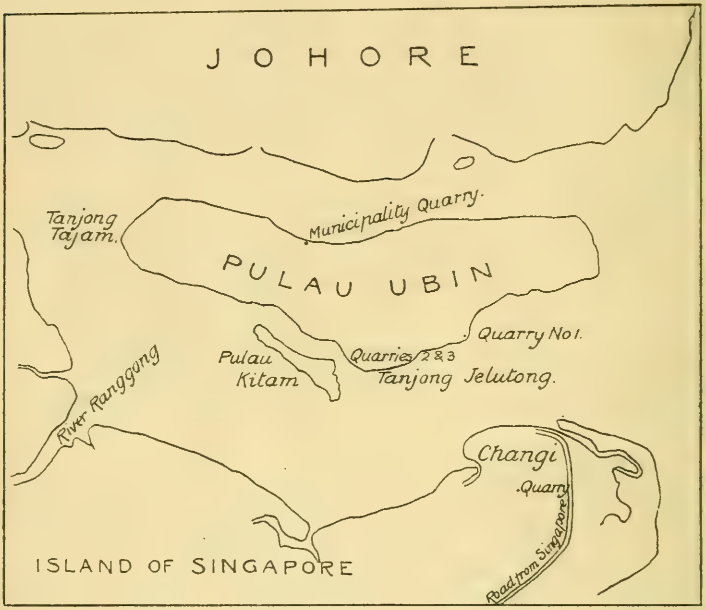


Fig. 1.—Sketch-map showing Pulau Ubin and Changi, Singapore.

Rocks of Doubtful Position: Quartz Porphyry.—At Pulau Pergam, in the Straits of Johore, is a mass of 'core-boulders', i.e. hard unweathered cores left from the denudation of a bed or mass which once occupied approximately the same site, lying on the same rock *in sitú*. It consists of blebs of quartz and crystals of orthoclase, with some of plagioclase and microperthite, crowded together in a green chloritic base. A little biotite occurs, and in one slide flow-structure was seen. This quartz porphyry may belong to the same period of eruption as certain masses of quartz porphyry in the Federated Malay States connected with the granite, or it may be referred to certain masses of quartz porphyry that occur isolated from other igneous rocks. The data are too few to speak with anything approaching certainty.

Ophitic Dolerite or Diabase.—On the hospital site near the Ballestier Road the writer found two boulders of an altered ophitic rock with pale-green secondary amphibole, epidote, and masses of minute flakes of biotite. The rock recalls certain diabases in the peninsula; but, like them, cannot yet be assigned to any particular group. At the corner of Grange and Orchard Roads again, boulders of a less altered ophitic rock were found containing violet augite, olivine, calcite, and plagioclase. Dolerite dykes are known to traverse the granite in the Peninsula; therefore it is quite probable that these boulders were derived from similar dykes in Singapore. On the other hand, they may be remnants of basic lavas of the Pahang Volcanic Series.

The Granite.—In the Federated Malay States granite immediately suggests the possibility of the occurrence of tin-ore, and it would appear that at one time tin-ore was worked in Singapore, because the name "Bukit Timah", which is given to a granite hill in the interior of the island, signifies the "Tin Hill". The writer is not aware of any records of tin-working there, however, and no traces of cassiterite, or indeed of any of the granite modifications which may generally be taken as guide to tin deposits, were discovered. But at Bukit Panjang, farther to the north, the writer found a small pocket of cassiterite, molybdenite, chlorite, and calcite in the granite. The weight of the cassiterite is considerably under a gram; therefore the first recorded occurrence of tin-ore in Singapore cannot be said to be encouraging from a commercial point of view. The normal granite is a medium-grained, non-porphyritic rock, with biotite and varying amounts of green hornblende. Sometimes the biotite occurs alone. A considerable proportion of the felspar is plagioclase.

At Bukit Timah the granite contains comparatively little biotite, and was found in one place to pass into a rock consisting of crystals of orthoclase, and quartz generally showing crystal outline, together with a biotite, in a ground-mass of even-grained mosaic of quartz and felspar.

At Changi the granite contains more hornblende than biotite, and in this hornblende-granite was found a vein of rock strongly resembling, in a hand-specimen, a tourmaline bearing modification of granite. Under the microscope, however, it proved to consist of quartz grains and poorly formed crystals of orthoclase, with irregular masses of dark-green hornblende.

On Pulau Ubin the normal type of granite is predominant. It is worked in large quarries along the coast of the island. The most interesting specimens collected on Pulau Ubin, however, are certain pyroxene-bearing rocks which require more detailed description. They were found in the Municipality Quarry on the north of the island.

Slides from a piece of the ordinary granite in this quarry do not show anything of particular interest. The proportion of ferromagnesian minerals (biotite and hornblende) and iron-ores is not large. One specimen (*a*) was collected, however, that is much darker than this granite. In the hand-specimen the felspar appears fresh, and the quartz cannot be distinguished with certainty. Biotite is plainly visible. Sections show that quartz is not very abundant, and that there is more plagioclase than orthoclase. The ferromagnesian minerals are biotite, fibrous amphibole, and rhombic pyroxene. The three are as a rule closely associated, and there is good reason to suppose that the amphibole has been derived from rhombic pyroxene. When the three minerals occur clustered together they are generally accompanied by a considerable quantity of iron-ore.

The rhombic pyroxene rarely shows good crystal outline, and then only in the case of basal sections. The outline of the longitudinal sections is generally rough, but the straight extinction can be plainly seen parallel to the long axis of the sections and the cleavage. In thin section the mineral is colourless or almost so. In sections slightly thicker than the usual rock slide, however, and in grains from the crushed rock, it appears coloured and gives a pale-green and pale-orange pleochroism. The colour is faint, and the mineral must be considered as being much nearer enstatite than hypersthene.

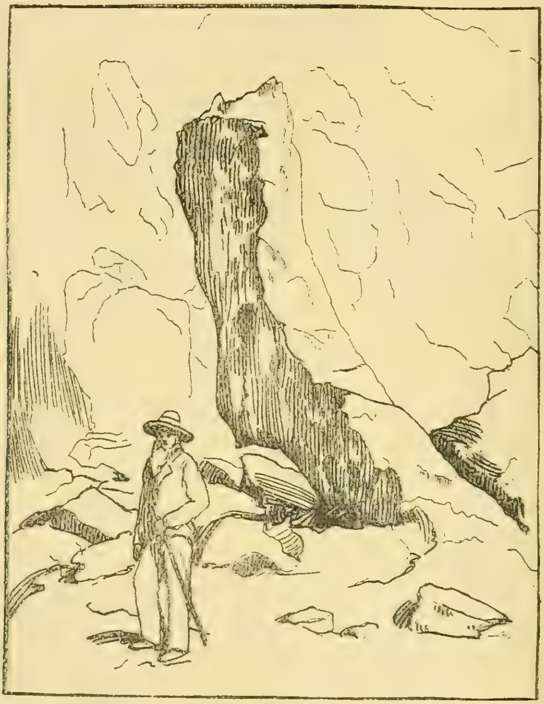


Fig. 2.—Dyke-like mass of enstatite-vogesite in the hornblende-granite of Pulau Ubin, Singapore. (From a photograph.)

Another specimen (*b*) was finer in grain than the last, and contains the same minerals. The amount of quartz present is small.

In the same quarry a big vein of a still finer-grained, dark reddish brown rock (*c*) was seen standing out from the working face, where the granite was being worked away on either side of it like a dyke, and the same rock occurred close by mingled with the granite in such a way that it was impossible, viewing this mass alone, to tell which rock was the later.

This rock proved very interesting in section. There are three ferromagnesian minerals in a clear base consisting of small grains of orthoclase, quartz, and a little plagioclase. They are biotite (the least abundant), brownish-green hornblende in ragged flakes (abundant), and numerous granules and ragged prisms of rhombic pyroxene, showing the same pale-green and pale-carmine pleochroism as the mineral in the rocks described above.

Traversing this dark reddish brown rock the writer found a small white and pale-brown vein, which on examination proved to consist of grains of pink garnet, pale-green monoclinic pyroxene, wollastonite (largely altered to calcite), and a little quartz.

At Changi large masses of a fine-grained rock (*d*) were found in the granite resembling the reddish-brown rock from Pulau Ubin, but under the microscope the resemblance proves to be deceptive. It consists of orthoclase in short, well-formed prisms, a little plagioclase, abundant interstitial quartz, which is in optical continuity over large areas of the field, a little biotite in small ragged flakes, green hornblende, and abundant apatite.

"Basic patches" are rare in the Pulau Ubin granite. Those that do occur are large and angular, and slides were cut from a good example (*e*) (in quarry No. 1) with a view to comparing it with the rocks just described. It proved to consist of plagioclase with some orthoclase, abundant apatite, and equal quantities of biotite, pale-green monoclinic pyroxene, and green hornblende, part of which at any rate is derived from the pyroxene.

The following determinations of specific gravity have been made:—

Hornblende granite from the Municipality Quarry . . .	2·68
Dark hornblende granite from Tanjong Jelutong . . .	2·71
The rock *a* from the Municipality Quarry	2·89
The rock *b* from the Municipality Quarry	2·83
The rock *c* from the Municipality Quarry	3·01
The rock *d* from Changi	2·76
The basic patch *e* from quarry No. 1	2·88

It was thought at the time of collecting the specimens that *a* and *b* were but variations of the granite due to local differentiation, and there was no field evidence to show that they were of a different date of intrusion. But the fine-grained rock *c* is, in part at any rate, of later date than the granite, and the occurrence of the rhombic pyroxene in *a*, *b*, and *c*, and its (apparent) absence[1] from the granite and the basic patches, make it probable that this view was incorrect. Supposing, however, that it be granted that the rocks *a*, *b*, *c* all come from a separate magma, a further complication is introduced by the absence of rhombic pyroxene in the fine-grained rock *d* at Changi.

Granite containing rhombic pyroxene is not unknown in the Malay Archipelago. Mr. Wing Easton, describing the granite of West

[1] A quantity of granite, from the part of the quarry where the rock *c* is described as being mingled with it, was crushed, and the heavy minerals concentrated. Among them a few grains of the rhombic pyroxene were found, but this cannot be accepted as conclusive proof of the rhombic pyroxene being a constituent of the granite, as it may possibly have come from the other rock.

Borneo,[1] says that pyroxene seldom occurs, and is restricted to the varieties rich in hornblende. It occurs as monoclinic augite or rhombic hypersthene. The specific gravity of the Pulau Ubin rocks makes it hard to regard them as pyroxene-bearing granites; still, it may be noted here that in his *Beschrijving van een gedeelte van Sumatra's Westkust*[2] Dr. R. D. M. Verbeek describes "augite-bearing granite or quartz-augite-diorite",[3] and "augite-bearing syenite-granite"[4] whose chemical composition probably approximates that of the Pulau Ubin rocks. On the other hand, Charnockite[5] (sp.g. 2·67), the hypersthene-bearing granite of the Indian Peninsula, is distinctly separated from these rocks, not only in point of age but in mineral composition; while the references made by Rosenbusch,[6] Zirkel,[7] and Dr. Teall[8] to granite containing rhombic pyroxene do not favour their being regarded as phases of the normal granite.

The rocks *a* and *b* are not unlike some hypersthene-bearing rocks found by the writer in Sarawak. These are quartz-hornblende-norites, and the Pulau Ubin rocks *a* and *b* might be described as quartz-biotite-norite, but the amount of quartz present is considerable, and the extinction angles of the plagioclase are not high. The quartz-hornblende-norites of Sarawak are connected genetically with hypersthene andesites, lavas that are wide spread in the Malay Archipelago, and regarded as dating from the close of the Eocene. The granite of the Archipelago being earlier, it is possible that the Pulau Ubin rocks were derived from the same magma as the Sarawak norites, and should be regarded as belonging to a later period of eruption.

Considered apart, the fine-grained rock *c*[9] on Pulau Ubin, and the fine-grained rock *d* at Changi, are interesting on account of their resemblance to lamprophyres. The former might be described as enstatite-vogesite,[10] while the latter is an amphibole vogesite.

[1] N. Wing Easton, "Geologis eines teiles von West Borneo": Jaarb. v. h. Mijnwezen in Ned-O.-Indie, Wetenschap. Gedeelte, Batavia, 1904.

[2] Batavia, 1883. [3] Op. cit., pp. 205–6. [4] Op. cit., p. 210.

[5] T. H. Holland, Mem. Geol. Surv. India, vol. xxviii, pt. ii, "The Charnockite Series, a group of Archæan hypersthenic rocks in Peninsular India."

[6] Rosenbusch, *Massige Gesteine*, p. 60.

[7] Zirkel, *Petrographie*, vol. ii, p. 13.

[8] J. J. H. Teall, "On some Quartz-Felsites and Augite Granites from the Cheviot District": GEOL. MAG., 1885, p. 115.

[9] In "The Rocks of Pulo (= Pulau) Ubin" (Verhandel. Bataviaasch. Genootsch. Kunst. Wetenschap., vol. xxii, also published in *Essays relating to Indo-China*, ser. II, vol. i, pp. 21–71) Logan notes a fine-grained rock, "blackish-green hornblende, or a very fine-grained black greenstone approaching basalt." This may be the writer's *c* weathered. Logan also mentions, however, a remnant of a basalt dyke between Pulo (= Pulau) Tam (Kitam?) and the west point of Pulo (= Pulau) Ubin, and he noted a bit of basalt adhering to a large syenitic block. This very likely refers to basic dykes cutting the granite such as are known elsewhere. Logan's observations were made prior to 1847, and those acquainted with the tropics will realize that all trace of the exposures mentioned may have disappeared.

[10] Rosenbusch (op. cit., p. 511) mentions hypersthene in a minette from near Freiburg and bronzite in Hartz Kersantites. The subordination of the biotite to the other ferromagnesian minerals in the Singapore rocks makes it necessary to regard them as vogesites.

VI.—The Mutual Interference of Artesian Wells.

By H. J. Llewellyn Beadnell, Assoc. Inst. M.M., F.G.S., F.R.G.S.

In the February and March issues of the Geological Magazine for 1908 I published a general account of the underground water-supply of the oasis of Kharga, in the Libyan Desert, and briefly referred to the influence of one bore on another.

Although the mutual interference of wells, a question of the highest importance in the development of artesian basins, has been touched on by several writers, I have not come across any published accounts of detailed experiments. It is indeed seldom that opportunities for such observations, on wells of which full boring records are available, present themselves. The results of certain experiments which I was recently able to carry out in the oasis of Kharga may therefore be of some value to geologists and engineers interested in water-supply.

The first observations I propose to record were made on two wells comparatively close together, Bore No. 5 being 570 metres W.S.W. of Bore No. 6, the outlet of the former being at 57·38 metres and of the latter at 59·18 metres above sea-level, a difference of 1·8 metres. No. 5 has an internal diameter of 5⅝ inches, is 645 feet deep, and 310 feet into the water-sandstones; No. 6 has a diameter of 8 inches, is 480 feet deep, and 200 feet into the sandstones. The two wells had been flowing continuously for a considerable period, and during the experiment neighbouring wells were kept shut down, so that there is no reason to suppose that the observations were affected by other bores. Bore No. 5, discharging 114 gallons per minute, was closed at 7 p.m. on June 12, 1907, and reopened after twelve hours, at 7 a.m. on June 13. The following hourly observations show the effects produced on Bore No. 6:—

Bore No. 5 closed at 7 p.m., 12/6/07.				Bore No. 5 opened at 7 a.m., 13/6/07.			
Time p.m.	Discharge of Bore 6. g.p.m.	Time a.m.	Discharge of Bore 6. g.p.m.	Time a.m.	Discharge of Bore 6. g.p.m.	Time p.m.	Discharge of Bore 6. g.p.m.
7.0	61·2	1.0	76·6	7.0	83·7	1.0	69·0
8.15	65·6	2.30	77·4	8.0	78·4	2.0	67·7
9.0	68·4	3.0	79·2	9.0	75·0	3.0	66·8
10.0	69·6	4.0	79·7	10.0	73·0	4.0	66·2
11.0	73·2	5.0	82·1	11.0	70·8	5.0	66·6
12.0	74·7	6.0	83·1	12.0	69·6	6.0	65·3
						7.0	64·0

This experiment shows that the closing of a flowing or the opening of a closed well, may produce a most marked effect on a neighbouring well within the short space of 60 minutes, even when the intervening distance is over 500 metres. In the above case the effect was most noticeable at first, there being a gain of 7 gallons per minute, equivalent to about 12 per cent., in the first two hours. The total increase in the twelve hours amounted to 22½ g.p.m., or about 37 per cent. On reopening Bore No. 5 it is seen that the discharge of No. 6 at once commenced to fall, the loss being nearly 9 g.p.m. in the first two hours; afterwards the rate of decrease gradually diminished, until at 7 p.m., when the observations were discontinued, the flow had fallen to within 3 gallons of its normal.

A second series of observations was made between two bores considerably further apart, No. 4 being 835 metres N.N.W. of No. 42.

The difference of level in this case was found to be 1·18 metres, the outlet of Bore 4 being at 60·74, that of Bore 42 at 59·56 metres above sea-level. No. 4 has an internal diameter of 4¼ inches, is 463 feet deep, and draws from 63 feet of sandstone; No. 42 is 6 inches in diameter, 715 feet deep, and 225 feet into the water-sandstone. Previous to the experiment the former was flowing 36·75 and the latter 68·5 gallons per minute. Precautions were taken against other wells influencing the results, the nearest bores having been opened twenty-four hours previously and being kept in the same condition throughout the experiment. Bore 42 was closed down at 9 a.m. on March 4, 1908, periodical observations being then made of the discharge of Bore 4 during the next thirty-six hours. Briefly stated, the results were as follows:—the discharge of No. 4 had not perceptibly increased at the end of the first half-hour, but had done so after one hour. It continued to increase at a very slow rate, the net increase after thirty-six hours only amounting to 3 g.p.m., or between 8 and 9 per cent. In this case the sensitiveness is very much less than that between Bores 5 and 6, due doubtless to the wells being a greater distance apart and to the lesser difference between their outlet levels. In all probability there are a number of other conditions which combine with the above in determining the amount of interference, such as the positions of the wells with regard to the main lines of underground flow, the relative depths of the bores, and the thickness of the beds from which they draw their supplies.

The most marked example of interference which I have met with was in the case of two ancient wells at Dêr el Ghennîma, near the eastern escarpment of the depression. These bores are sunk on the crest of an anticlinal fold running north and south, and are only 88 metres apart. They have recently been cleaned out and their flows restored. The difference of level in the outlets is 2·07 metres, the higher well being 34½ metres, the lower 41 metres in depth. The opening or closing of the lower well produces an almost instantaneous effect on the higher, the difference in flow within thirty seconds amounting to over 10 per cent. A considerable number of observations were made, but those mentioned on the opposite page are sufficient to show the rates of decrease and increase.

The closing of the lower well is seen to have influenced the discharge of the upper bore to the extent of 100 per cent. in the space of thirty minutes, while the flow was trebled in twenty-four hours; on reopening the lower well the discharge of the upper fell to within 50 per cent. of its normal within forty-five minutes.

Upper Well	flowed	13·2 g.p.m.	when	Lower Well	was open (flow 50·3 g.p.m.).	
,,	,,	20·5	,,	,,	had been closed	10 minutes.
,,	,,	23·7	,,	,,	,,	20 ,,
,,	,,	26·3	,,	,,	,,	30 ,,
,,	,,	39·4	,,	,,	,,	24 hours.
,,	,,	35·6	,,	,,	had been open	30 seconds.
,,	,,	32·5	,,	,,	,,	2 minutes.
,,	,,	26·7	,,	,,	,,	7 ,,
,,	,,	21·9	,,	,,	,,	9 ,,
,,	,,	23·4	,,	,,	,,	16½ ,,
,,	,,	19·7	,,	,,	,,	45 ,,

The rate of flow of water through porous rocks has been investigated by a number of engineers and geologists, among whom we may mention Darcy, Hazen, King, Slichter, Knibbs, and Baldwin-Wiseman. The rate of flow through an underground sandstone depends upon a number of conditions, the most important being the size and shape of the pores between the component grains, the porosity or water-holding capacity of the sandstone, the temperature of the water, and the pressure acting on it. The yield of a well will depend not only on these factors, but also on the diameter of the bore, its depth into the water-stratum, the size and number of fissures passing through the bore, and last and most important of all, on the absolute height of the outlet. Although some of the above conditions may be known beforehand, the resistance to flow of the strata immediately surrounding a bore can never be more than approximately conjectured, as the size and mode of arrangement of the individual grains of any arenaceous sedimentary rock must always vary to a very considerable extent both horizontally and vertically within comparatively short distances, and on these factors depends to a great extent the capacity of the strata to transmit water.

Considerable difference of opinion exists among geologists as regards the relative importance of fissures in the production of artesian flows. That fissures exist, and exist abundantly, in the Nubian Sandstone is, I think, almost a matter of certainty; as I have shown in a former paper, fissures are visible to the eye in the upper sandstone (which does not appear to differ in any important respect from the artesian-water sandstone), and it is through them that the bulk of the sub-surface water is obtained. Moreover, the above experiments appear to almost demonstrate their existence, as it seems hardly conceivable that the closing of a bore could markedly affect the flow of another half a kilometre distant, if there were not a direct connection between the two by means of fissures.

It does not, however, necessarily follow that strongly flowing wells cannot be obtained from an unfissured sandstone, for although rapid flow through a compact sandstone is impossible owing to friction, which increases as the size of the channels decreases, the hydrostatic pressure can never entirely disappear, the rate of loss of hydrostatic head being dependent on the rate of flow. A rapid flow from a bore does not in any way depend on an equally rapid flow of water through the sandstone surrounding the bore; for instance, G. H. Knibbs, F.R.A.S., of the University of Sydney, has calculated [1] that although in a ten

[1] "The Hydraulic Aspect of the Artesian Problem": Proc. Roy. Soc. New South Wales, vol. xxxvii, p. 30.

inch bore, discharging 700 gallons a minute from a ten foot stratum, the water would have a velocity of $5\frac{1}{2}$ feet a second at the bore itself, at a distance of one mile it would only be moving through the stratum at the rate of about $\frac{1}{200}$ inch per second, or 18 inches an hour.

Further consideration of the conditions governing artesian flows must, however, be reserved for a future occasion. In the meantime I have to tender my thanks to the members of my staff in the oasis for much valuable assistance in the keeping of records of all bores put down during the past three years.

VII.—Boulder Distribution from Lennoxtown, Scotland.

By A. MacEwen Peach.

ALTHOUGH the general path of the ice-sheet of the central valley of Scotland has been traced, no advantage has, up till now, been taken of the glacial distribution of boulders from a peculiar intrusive rock, which occurs in the Campsie Fells near Lennoxtown.

The rock of which the intrusion is composed was first described by Allport in the Quarterly Journal, Geological Society of London, 1874, vol. xxx, p. 559, as a porphyritic augite-olivine dolerite, and has later been determined by Mr. E. B. Bailey to be an essexite. He has also mapped the boundaries of the intrusion during the revision of that district by the Geological Survey.

From the distinctive characters of this rock, and the distribution of boulders from it in the neighbourhood of Milton and Kilsyth, Mr. Bailey was struck with its suitability as a means of determining the direction of ice-flow during the Glacial period, and it was at his suggestion that I undertook the task of extending his observations.

Mr. Bailey has shown that the Lennoxtown essexite is intruded into the lower portion of the interbedded volcanic rocks immediately overlying the Ballagan Beds of the Calciferous Sandstone Series, which forms the base of the Scottish Carboniferous formation. It borders the north side of the Crow Road leading from Lennoxtown to Fintry, about a mile north-west of the former, where the road crosses the great east and west fault which lets down the Hosies and Hurlet Limestones to the south against the volcanic series to the north. The outcrop of the intrusion is small, being only about 700 yards long and 100 yards wide; it has a roughly east and west trend, and lies between the 500 and 600 foot contour-lines.

In composition and structure the Lennoxtown essexite greatly resembles the well-known rocks of Brandberget in Kristiania and Crawford John in Lanarkshire. The variety which has been of most service in the present enquiry carries markedly porphyritic, idiomorphic, purple augites in a ground-mass much like that of a fine-grained gabbro, and thus presents a very distinct appearance, as, in the weathering of the rock, the augites remain prominent and more or less unaltered.

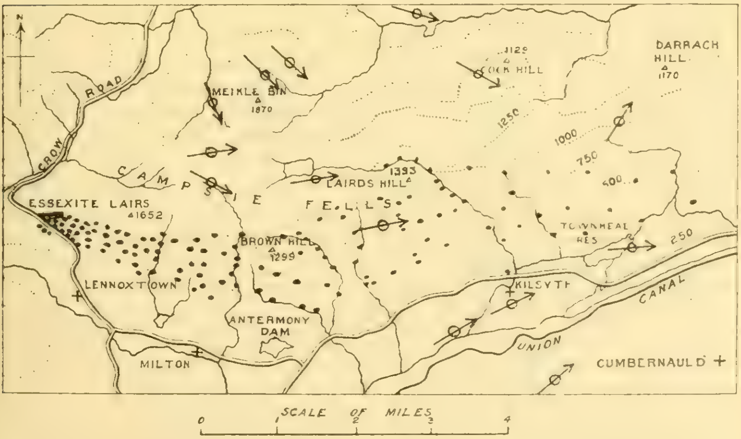
The only known rocks of similar external appearance, which are likely to be distributed as erratics in the district under consideration, are certain augite diorites of the West Highlands. Risk of confusion has been avoided by neglecting the very few boulders in regard to which there existed any room for uncertainty.

It has not been considered necessary to restrict the investigation to material occurring *in sitû* in the drift; the dry stone dykes, which are mostly composed of surface boulders gathered from the immediate neighbourhood, have afforded the means of finding most of the larger specimens, and, since the essexite has never been quarried, they clearly afford a legitimate source of evidence. Many boulders, too, have been found washed out along the courses of burns and also along the shores of the Firth of Forth.

As may be seen from the accompanying map, the cone of distribution in the immediate neighbourhood of the intrusion is well marked, and the carry is wholly eastwards; uphill to the north and north-west of the intrusion there are no boulders, and, although about 100 yards along the road to the west of the intrusion a couple of boulders were found in a wall, they have evidently been carried there for building purposes. Downhill, to the south of the igneous mass, there are numerous boulders, forming a distinct cone, with the west end of the intrusion for its apex, and spreading out eastwards, till at the east end of the intrusion the cone is some 450 yards wide. About 400 yards downhill from the west end of the intrusion there are one or two small blocks now built into a wall: these may, however, have fallen downhill since Glacial times; they are angular, and show no evidence of having been affected by ice.

The southern edge of the cone crosses the Crow Road about a quarter of a mile from Lennoxtown, and runs eastward from the mass of essexite, the erratics being more numerous in the centre of the cone; still farther east the boulder track begins to ascend the hill till its northern limit, at a point due north of Lennoxtown, is about 800 feet above sea-level, and its breadth is between 600 and 700 yards.

Map 1.



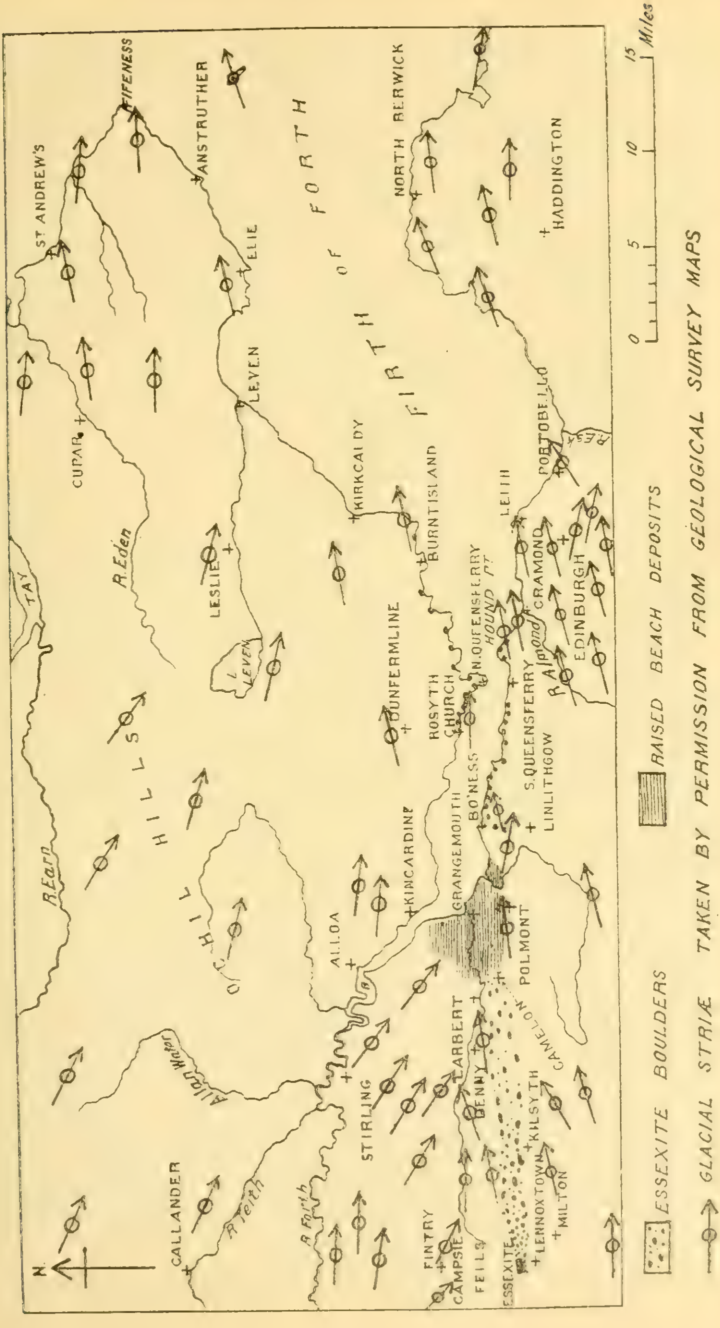
Map showing distribution of erratics in immediate neighbourhood of essexite intrusion.

Tracing the northern limit of the track as it passes eastward, we find that it ascends the higher ground which rises across its path. North of Milton the boulders of the northern limit have reached an elevation of 1,000 feet, while on Brown Hill they are more than 1,250 feet above sea-level. From Brown Hill the northern limit has a tendency to turn northwards, and from that point to Lairds Hill, due north of Kilsyth, the carry is E.N.E., the altitude at places being more than 1,300 feet. From this last point the carry is almost due east, the direction of ice-flow being unaffected by surface features. The northern limit is fairly well marked, and on the lower ground, north of Townhead Reservoir (see Map 1), its altitude is not more than 800 feet. To the east the boulders become scarcer, and the limit is not so well defined; it passes south of Denny and Larbert, and to the east of the latter place the trail is concealed, the drift being covered by the deposits of the various raised beaches of the Forth area.

The southern limit of the boulder track is also well marked. East from Lennoxtown the boulders do not come below the 300 foot contour-line till they reach a point east of Milton. Here also no influence on the direction of ice-flow can be attributed to the local surface features. For a short distance there is a slight southward deviation, but the eastern trend is resumed in the neighbourhood of Antermony Dam, between Milton and Kilsyth, and the direction even tends slightly to the north, running almost E.N.E. till at Camelon the boulder-clay is overlain by the Hundred Foot beach deposits already referred to. The boulder track up to this point, some 15 miles from its origin, is never more than $2\frac{1}{2}$ miles across. It is well defined, and the number of erratics is very large in consideration of the size of the parent mass. Farther eastwards the raised beach deposits and the gravels of the Kaimes for a time obscure the boulder-clay, till, east of Polmont and north of Linlithgow, boulders are again found, the northern limit of the track entering the Forth just to the east of Bo'ness.

The coast all along the shores of the Forth is very suitable for the detection of the boulders, as it is covered just about high-water mark with stones derived from the destruction of a large amount of boulder-clay. Along the shore from Bo'ness to beyond South Queensferry these essexite boulders occur till the southern limit of the track is reached between Hound Point and Cramond. From Cramond to Portobello no essexite erratics were found, although this shore is a very favourable one for their observation, the boulders on the shore representing the result of the destruction of a very large amount of boulder-clay. It has not been considered necessary to look for boulders on the shores immediately east of Portobello, but careful research on the promontory of North Berwick has failed to reveal any erratics from the Lennoxtown essexite, a result which might have been predicted from the trend of the glacial striæ. Thus the southern limit of the track evidently lies within the area now covered by the Firth of Forth. This conclusion has been drawn from a consideration of observations on the ice-mouldings and striæ between Edinburgh and North Berwick, which show that the direction

Map 2.


N.
CALLANDER
R. Teith
R. Forth
FINTRY
CAMPSIE
FELLS
ESSEXITE
LENNOXTOWN
MILTON
KILSYTH
STIRLING
Allan Water
R. Earn
OCHIL
HILLS
ALLOA
LARBERT
DENNY
CAMELON
POLMONT
GRANGEMOUTH
KINCARDINE
BO'NESS
LINLITHGOW
S. QUEENSFERRY
R. Almond
EDINBURGH
CRAMOND
N. QUEENSFERRY
HOUND PT.
ROSYTH CHURCH
DUNFERMLINE
L. LEVEN
LESLIE
R. Eden
TAY
CUPAR
BURNTISLAND
KIRKCALDY
LEITH
PORTOBELLO
R. Esk
LEVEN
FIRTH OF FORTH
ELIE
ANSTRUTHER
FIFENESS
ST ANDREW'S
NORTH BERWICK
HADDINGTON
0 5 10 15 Miles
ESSEXITE BOULDERS
RAISED BEACH DEPOSITS
GLACIAL STRIÆ
TAKEN BY PERMISSION FROM GEOLOGICAL SURVEY MAPS

of ice-flow was well to the north of east (Map 2). On the northern shore of the Forth the farthest west point at which the boulders have been found is Rosyth Church, which marks therefore the northern limit of the track, the tendency of the ice-carry from Linlithgow and Bo'ness, therefore, being approximately E.N.E. From Rosyth to a point considerably east of North Queensferry a number of essexite boulders are to be seen on the shore, and the northern limit is again reached between Burntisland and Kinghorn, and from this point eastwards along the shores of Fife to Fife Ness these essexite boulders have not been observed. The northern limit of the track, therefore, also lies within the boundaries of the Firth of Forth until as far east as Fife Ness. At Hound Point, 35 miles from the source, the last place at which an estimate can be taken, the track is only some 4 miles across. From this point eastwards the southern limit of the track lies within the Forth Estuary.

The trend of these essexite erratics agrees closely with the other indications of the ice-movement, such as the direction of the striæ, ice-mouldings, and drumlins. It may be noted that the striæ (see Map 1) on the high ground of the Campsie Plateau, north of the boulder track, run in a direction approximately E. 30° S., making an angle of about 60° with the direction of the boulder track. This apparent discrepancy is most probably due to the well-known phenomenon of differential movement in the different layers of the ice-sheet. The vertical distribution of the boulders is important, showing that nowhere has the existence of higher ground interfered with the course of the ice. During the eastward movement the erratics were carried directly up from the 500 or 600 foot level to over 1,300 feet in a distance of about 3 miles.

The distribution, both vertical and horizontal, of these essexite boulders points, then, definitely to the action of land-ice at a period when the minor surface features of hill and dale in the central valley of Scotland had little or no effect in determining the direction of the ice-flow—obviously, therefore, about the period of maximum glaciation.

The distribution of the essexite exclusively to the eastward of the intrusion seems to show that there cannot, at any stage of the glaciation, have been a reversal of the flow in the central valley of Scotland. Indeed, the narrowness of the trail formed by these boulders allows of but little variation in the direction of motion. Such variation might be expected if, as Professor Kendall suggests,[1] the Scandinavian ice ever exerted such a powerful damming effect at the mouth of the Forth as to intensify the congestion in the Clyde and Irish Sea Basins.

There is no evidence of any redistribution of these boulders by later local glaciation, although local corrie glaciers are known to have existed in many parts of the Campsie Fells.[2] Moreover, the fluvio-glacial conditions which prevailed during the retreat of the ice-sheet have evidently had but little effect in widening the track. On the shores of the Forth, again, the action of the sea at its successive

[1] P. F. Kendall, Q.J.G.S., 1902, vol. lviii, p. 563.

[2] See E. B. Bailey, Sum. Prog. Geol. Surv. for 1907, pp. 97–8.

levels must have tended to concentrate the coarser drift material, but we cannot suppose that the accompanying slight transportation has had any effect in modifying the general distribution of the boulders.

On considering the number of boulders observed, and the fact that these must of necessity be merely a small proportion of the total number derived from the intrusion, the result is somewhat surprising. If this may be taken as an indication of the transport of material throughout the whole Strathblane Valley, the amount of modification which that valley has undergone at the hands of the ice must have been very considerable. It is highly probable, however, that much of the material may have been in the condition of a talus before the advent of the ice, but that obviously does not affect the question of the extent of erosion by the ice.

Through the kindness of Dr. Horne I have been allowed to place on my maps a number of observations on Glacial Striæ from the 6 inch working copies of the Geological Survey Maps.

REVIEWS.

I.—The Geology and Scenery of the Grampians and the Valley of Strathmore. By Peter Macnair, F.R.S.E., F.G.S., Curator of the Natural History Collections in the Glasgow Museums, etc. 2 vols. 8vo. pp. xiv + 195 and xii + 199, with 163 plates and 10 folded and coloured maps and diagrams. James MacLehose & Sons, Glasgow.

IN two handy volumes abounding in a wealth of illustration the author presents an account of the geology of a wide but ill-defined tract which centres round Perthshire. That great structural break, the Highland boundary fault, cuts the region into two parts. The one lies within the Highlands upon the metamorphic rocks, whilst the other stretches over the foot-hills of Old Red Sandstone, the plain of Strathmore, and includes the volcanic ridges of the Ochil and Sidlaw Hills. The title of the book, therefore, is misleading, for only a portion of the mountainous region sometimes called the Grampians receives any attention, and by the inclusion of 'Scenery' in the title a fuller and more scientific treatment of its evolution might be anticipated. The area actually described presents such varied characters that naturally it includes many points of general interest to geologists. Some of the unsolved problems, such as the metamorphism, age, and structure of the Highland schists, are the largest with which the Scottish geologist has to deal. For his description the author has culled information from many available sources, whilst he has himself an intimate knowledge of certain tracts, which are treated in great detail. On most subjects the views here put forward do not differ essentially from those generally accepted. A special claim is made that the book contains a considerable amount of original research, but it would be difficult to show that its publication has advanced any of these problems a single step towards solution. Whole chapters of the book are simply reproductions of papers published elsewhere. The chapter on the physical conditions under which the Old Red Sandstone was laid down is taken practically verbatim from papers published twelve years ago by Mr. James Reid and the author in the GEOLOGICAL MAGAZINE. We must take exception to the reprinting, without emendation or comment, of personal statements, which on their first publication called forth a remonstrance, and then an explanation by the authors. Throughout the book generally we can only regard his handling of the opinions of well-known geologists as particularly unfortunate.

As a description of the geology of a highly interesting district the book meets a want. The author's enthusiasm is evident in his writing, and throughout the greater portion of the book he easily holds the reader's attention. Whilst the style helps to arouse interest in the theme, his descriptions suffer from a lack of clearness. They are too detailed and too technical for the general reader, and too inexact for the geological student. To give an instance, mica-schist is described thus: — "Mineralogically, mica-schist consists of an aggregation of quartz and mica arranged in alternating wavy laminæ-planes of schistosity. Structurally, the quartz presents a granular character, having been derived from the breaking up of the original quartz grains in the clastic rock. The mica, which may either be muscovite or biotite, is entirely authigenic, and takes the form of plates, which are generally basal sections of the mineral" (p. 115). Technical terms are occasionally introduced unnecessarily, and are often left unexplained, although the opening chapter would lead us to infer that the book is intended to appeal to the novice and the general reader. There is also an occasional lack of consistency in the statements of results. For example, the main mass of the mountain chain, whose basal wreck is now represented by the Highlands, is shifted about to suit requirements. In many references (e.g. p. 161) he places "the backbone or core of the great geanticlinal along the Ben Lawers ridge" in the Central Highlands. After studying his 'marginal fan', he concludes (p. 182) that "by carefully considering the fragments that are now left of this ancient chain, it appears that the great central massive must have risen over what is now the Midland Valley of Scotland". But when discussing the conditions under which the Lower Old Red Sandstone was deposited, this position is inconvenient, and we read (p. 23, vol. ii) that "the great mass of the mountain chain must have lain to the north-west of the present Old Red Sandstone area".

The work is illustrated by over 150 photographic reproductions of scenery, fossils, rock-specimens, and microscope sections, for which the author is indebted to numerous friends. The views illustrating hill-top scenery are amongst the finest we have seen. Many of them are really beautiful pictures, and they have been carefully reproduced. The photomicrographs are not all equally good, those illustrating the schistose rocks in particular being fuzzy. They should have had fuller descriptions attached, as it is impossible to recognize the minerals at sight. There are in addition seven geological sketch-maps printed in colours and other maps and sections.

The first volume is devoted to the Highland rocks. The opening chapter expounds some of the principles of geology, and is apparently intended for the novice. The following Historical Introduction plunges into technicalities at once, and is stiff reading for the novice who has only the first chapter to guide him. It consists mainly of an exposition of Nicol's work on the structure of the Southern Grampians and a summary of the author's views as developed in the succeeding chapters.

In chapter iii, which gives an outline of the physiography and geology, the former subject is largely taken up by lists of mountain summits, tributary streams, and the names of hills seen from certain view points, from which the reader is likely to emerge with the haziest of notions about the physiography of the region. The outline of the geology is a more useful summary, though such phrases as the "summit of the synclinal trough" are puzzling, and we note the remarkable statement that "the presence of *roches moutonnées* indicates the existence and work of the later glaciers".

Chapters iv and v contain a description of the rocks of the Highland area. They are classified into schists of sedimentary origin, schists of igneous origin, and intrusive rocks later than the foliation of the schists. The author points out that the bulk of the rocks were laid down as sediments of the ordinary type, and that many of them retain traces of their original fragmental character. The weak and fine-grained sediments are more affected by metamorphism than the harder rocks, but, apart from the original nature of the sediments, the metamorphism which is feeble in certain areas increases in intensity in others, often at no great distance. The author considers the metamorphism to be mainly dynamic, the rocks having been subjected to great pressure, accompanied by a high temperature, during the operation of the mountain-building processes which upheaved the Grampians. He does not distinguish any effects particularly due to thermal metamorphism, and whilst admitting "high degrees of heat" he offers no opinion as to its source. In areas of feeble metamorphism, such as the belt of slates on the margin of the Highlands, one set of cleavage planes only is recognized, but in the zone of the Ben Lawers schist the first cleavage planes are folded and crossed by a second set of cleavage planes developed during the folding of the first set. In some districts tertiary and even quaternary cleavages may be traced, and these, the author thinks, were produced by a series of intermittent movements. The author does not appear to distinguish cleavage from foliation, and slaty cleavage is not separated from the false cleavages. One of the latter structures, strain-slip-cleavage, is referred to as 'strain-slip', but if the full title be considered too unwieldy, 'slip-cleavage' would be a more suitable abbreviation. The mineral changes which accompany the development of foliation are scarcely mentioned.

It is well known that the schists which enter into the formation of the Grampians traverse that region in a north-west and south-east direction. These the author divides into the following zones, omitting a narrow band of black slates, cherts, and limestones, the supposed Arenig rocks of the Survey on the Highland frontier, and the Leny grits for consideration in a later chapter: (1) The Lower Argillaceous zone; (2) the Lower Arenaceous zone, with the 'green beds' at the top; (3) the Loch Tay Limestone; (4) the Garnetiferous Schist zone; (5) the Upper Argillaceous zone; and (6) the Upper Arenaceous zone. This terminology is somewhat cumbrous, and the use of 'Upper' and 'Lower' will appear premature to most geologists in view of the difficulties of reading the Highland sequence. The author writes with remarkable assurance on this point. His main argument appears to be that of Sir Archibald Geikie and the Geological Survey, viz. that the simplest interpretation of the structure places each inner belt above the succeeding outer one. This order is taken to be the order of original deposition, but it is quite possibly illusory. In fact, if the structural theory adopted in a later chapter were applicable to the Highlands as rigorously as the author would have us believe, we should expect the oldest beds just where he puts some of his youngest, i.e. along the axis of the denuded anticlinorium.

The author then proceeds to a more detailed description of the 'zones', which would have been much easier to follow had the names of the localities mentioned in the text been inserted in the large geological map (on a scale of 6½ inches to 1 mile) provided at the end of the volume. Many more place-names could have been inserted without obscuring the map. Commencing on the Highland border, we meet first the Lower Argillaceous zone, comprising the clay-slates of Aberfoyle, which on the Clyde pass into the condition of phyllites. Immediately to the north-west comes the Lower Arenaceous zone, containing the massive grits of Ben Ledi and other grits, greywackes, and more argillaceous schists, up to and including the 'green beds'. The intense metamorphism shown by these rocks around the head of Loch Lomond as compared with their development elsewhere does not receive adequate treatment, Cunningham-Craig's paper on the subject not being referred to. The peculiar 'green beds' receive a short description. Evidence proving their clastic origin is brought forward, but their distinction from the intrusive sills of epidiorite with which they have been confounded is left to be inferred. In the Loch Tay Limestone zone schists on both sides of the limestone are sometimes included. The course of the limestone outcrops in the neighbourhood of Loch Tay is traced in unnecessary detail, and the evidence afforded by the limestone of intense buckling and compression is pointed out.

To the north-west of the Loch Tay Limestone zone lies the Garnetiferous Schist zone. This comprises a belt of mica-schists, usually of considerable breadth, and traceable like the other zones from sea to sea. Garnets occur throughout this horizon, not only in the mica-schists, but also in the epidiorites and hornblende-schists. The author considers that the garnets are a product of dynamic metamorphism, apparently in the sense that they represent a phase of the regional metamorphism, which increases in a general way from the frontier towards the Central Highlands. Beyond the Garnetiferous Schist zone lies the Upper Argillaceous zone, comprising the belt of rocks known as Ardrishaig phyllites, calc-sericite schist, or Ben Lawers schist, in the different districts which it traverses. A band of black graphitic schist, cropping out along the north-west side of the calc-sericite schist of Central Perthshire, is also included in this zone. The metamorphism of these rocks increases along the course of their outcrop from Ardrishaig to the head of Loch Fyne, as shown by J. B. Hill. In the Upper Arenaceous zone the author would now include only the Central Highland quartzite, transferring the Blair Atholl limestone to the top of his Upper Argillaceous zone. He adopts Cunningham-Craig's conclusions for the Blair Atholl district that there is an upward succession from the Ben Lawers schist, through black graphitic schist and Blair Atholl limestone into quartzite. He also accepts the view that there was a period of local erosion at the base of the quartzite, when the boulder-bed of Schichallion and Islay was laid down. The Moine gneisses are classed with the quartzite in the Upper Arenaceous zone in the text, but in the tabular statement (p. 96) they are kept outside it and marked as of uncertain position. The author's acquaintance with these rocks must be slight. He adduces "their peculiar granulitic structure" as evidence of their sedimentary origin.

The age of the Highland schists cannot at present be determined. Pebbles of these rocks occur abundantly in the conglomerates of Lower Old Red Sandstone age, and they are also found in certain conglomerates of the Upper Silurian of the south of Scotland, but how much older they may be it is impossible to say. However, developing in a later chapter a theory to account for the structure of the Grampians, the author takes it that the sediments which ultimately formed the Highland schists were laid down in a sinking geosynclinal in the old continent of Archæan gneiss. And in the final chapter of the work we read that the first denudation of the upheaved Highland chain began with the deposition of the Torridon Sandstone, and was continued through Cambrian times. It is evident, therefore, that the author opines that the Highland schists belong to some formation intermediate in age between the Archæan gneiss and the Torridon Sandstones, but this is little more than a guess.

(*To be continued.*)

II.—A Treatise on Gold and Silver. By Walter Crane, Ph.D. pp. 727 + x, with 20 illustrations and 9 plates. New York, John Wiley & Sons; London, Chapman & Hall, 1908. Price 21*s*. net.

We learn from the preface that the Carnegie Institution of Washington has in hand an Economic History of the United States. Dr. Crane's elaborate treatise is the first instalment of that work, and is eloquent testimony to the comprehensiveness of the scale upon which it has been planned. The author has evidently spared no pains to make this history of the mining of gold and silver in the United States as complete and exhaustive as possible. Extensive quotations are introduced from original papers, particularly in the chapters dealing with the occurrence and association of gold and silver and their geological distribution, and references are in all cases given to enable the reader, who so desires, to look up the original sources. By giving the actual words of a writer the possibility of misinterpreting his remarks is removed; but this plan has the almost unavoidable disadvantage of entailing some repetition in statement and a want of smoothness in style, and leaves the reader in doubt as to what the author's views may be on debatable points.

After touching in the introductory pages on the influence of the mining of the precious metals upon the industrial life of the United States, and especially the development of railroads, Dr. Crane devotes a chapter to the history of the discoveries of gold and silver in North America, the earliest date given being as far back as 1513, when a cacique of gold was reported to Ponce de Leon while lying off the coast of Florida. The next chapter is concerned with the occurrence and association of gold and silver, and includes a discussion of the theory of ore formation and the occurrence of gold in gravel; it is followed by a short chapter on the companion question, viz. their geological distribution, showing that gold is to be found in rocks of all ages, contrary to the views of early geologists. The mining engineer will doubtless consider the succeeding chapters on the mining of the ores and gravels, the extraction of values, and the production of gold and silver the most important part of the book. A full and admirable account is given of the various methods of mining — gravel-mining, hydraulic-mining, river-mining, drift-mining, dredging; the modes of extracting the metal in wide veins, in narrow veins, in bedded deposits, and in masses, typical mines being described in full detail; various important practical points such as timbering, drainage, and ventilation; and the principal processes, both mechanical and chemical, of obtaining the metal from the ores, such as amalgamation, concentration, chlorination, and cyanidation. As an appendix we find a series of valuable tables—discovery of gold and silver mines and districts, occurrence and mineralogical association of gold and silver, geological distribution of gold and silver, yield of ores by districts and mines, yield of gravels by districts and mines, fineness and value of gold and silver. A copious index brings the book to a close.

The illustrations have mostly been used before in other publications; they are, especially in the case of the half-tone blocks, often far from distinct and not up to the standard that might have been expected.

III.—Triassic Ichthyosauria, with special reference to the American Forms. By John C. Merriam. Mem. Univ. California, 1908, vol. i, No. 1. pp. 196, with 18 plates and 154 text-figures.

Since 1895 Dr. John C. Merriam, of the University of California, has published several small papers on Ichthyosaurian remains from the Trias of California. Between 1901 and 1907 ten expeditions were sent out by the University of California to collect ample material, and the result was the acquisition of considerable parts of no less than fifty skeletons. Dr. Merriam visited and studied the European collections to prepare for the investigation of these new specimens, and he has now published an exhaustive memoir on Triassic Ichthyosauria in general, summarizing and extending his earlier work, and ending with a discussion of the classification of the Ichthyosaurian Order.

An exact description of the Ichthyosaurians of the Triassic period has long been wanted, because it seemed likely that they would prove to be links between the typical members of the order and some early group of marsh-dwellers or land-dwellers. Dr. Merriam, in the memoir before us, begins to produce the desired material, and shows how in many respects the few known genera are really links in the ancestral series. The Triassic Ichthyosauria have relatively larger limbs than their successors, and were probably less dependent on a tail-fin for locomotion. The number of phalanges in the digits is less than in *Ichthyosaurus* proper; the interclavicle is often triangular in shape (not T-shaped), thus approaching that of Labyrinthodonts and some primitive Rhynchocephalians; and the pelvis is large, with much-expanded pubes and ischia, as in many other early reptiles. The skull is short compared with the length of the trunk, and the eye is not so large as in later forms. The teeth are often fixed in sockets, and not quite similar in shape in different parts of the jaw. The atlas and axis are not fused together, and the end of the vertebral column is not so sharply bent downwards in the tail-fin as in *Ichthyosaurus.* The Triassic Ichthyosauria are therefore less completely adapted for an aquatic life than their successors in later Mesozoic periods.

Dr. Merriam classifies the Ichthyosauria in two families, Mixosauridæ and Ichthyosauridæ. The Mixosauridæ are exclusively Triassic, so far as known, and have been found in Europe, Spitzbergen, North America, and perhaps New Zealand. *Mixosaurus* is described from Europe, while *Cymbospondylus*, *Toretocnemus*, *Merriamia*, *Delphinosaurus*, and *Shastasaurus* occur in California and Nevada. The detailed descriptions are illustrated by numerous text-figures and eighteen plates.

IV.—Calcareous Concretions in Coal Seams. By M. C. Stopes and D. M. S. Watson. Phil. Trans., 1908.

An important and interesting paper "On the Present Distribution and Origin of the Calcareous Concretions in Coal Seams, known as 'Coal Balls'", has been contributed by M. C. Stopes and D. M. S. Watson (Phil. Trans., 1908, vol. cc, series B, pp. 167–218). While recognizing that the origin of the 'coal balls' or 'bullions' is distinct from that of the coal seams in which they occur, yet their investigation tends to throw light on the origin of the latter.

Analyses show that the coal balls are principally made up of calcium and magnesium carbonates, in many cases in the proportion in which these carbonates occur in dolomite, and altogether forming 90 per cent. or more of the mass. The amount of alumina and silicates was found to be so minute (averaging less than 0·2 per cent.) as to be negligible, showing that muddy or detrital matter was absent and that practically pure plant masses were mineralized by the mixture of carbonates.

Other concretions known as 'roof' or 'Goniatite nodules' frequently contain isolated plants, but are always found in the roof or shale above and not in the coal itself; and these, although otherwise very similar to the coal balls, were formed under conditions less free from detrital matter, as they contain from 1 to 6 per cent. of silicate of alumina.

The main conclusions are that (1) the coal balls were formed in the position in which they are now found, and probably also the coal itself was likewise formed *in situ*; (2) the sea water was fundamentally important during the coal ball formation in acting both as a temporary preservative and as the source of the calcium and magnesium carbonates required for petrifaction; and (3) the plants in the roof nodules represent a different flora from that found in the coal.

The conditions under which these phenomena were produced are to be found in the mangrove swamps to-day, where "Groves of large trees with smaller herbs and ferns finding place between and around their stems grew in the flat swampy levels between the higher ground and the sea".

The authors give an interesting word-picture of the features attending the formation of the coal balls, which are "relics of a forest which grew quietly in a swamp in the place where they are now found, while the plants in the shales and in the roof nodules above had drifted out to sea from other districts and bear in the character of their structures the impress of the different type of land on which they lived".

V.—The Geology of the Country around Andover. By A. J. Jukes-Browne, B.A., F.G.S.; partly from notes by F. J. Bennett, F.G.S., and H. J. Osborne White, F.G.S. pp. v, 67, with 12 text-illustrations. Price 1*s.* 6*d.* Colour-printed map, Sheet 283, 1*s.* 6*d.*

The Geology of the Country around Henley-on-Thames and Wallingford. By A. J. Jukes-Browne and H. J. Osborne White. pp. vii, 113, with 13 text-illustrations. Price 2*s.* Colour-printed map, Sheet 254, price 1*s.* 6*d.*

In the memoir on Andover we have a description of a large Chalk area which extends from the eastern borders of Salisbury Plain near North Tidworth, through Andover and Whitchurch to Overton. On the northern margin are included the eastern end of the Vale of Pewsey, and the famous 'Valley of Elevation' of Burghclere and Kingsclere, an inlier of Upper Greensand with steeply inclined Chalk on the north bounding a tract of the Eocene strata of the London Basin.

The greater portion of the work is occupied with an account of the stratigraphy and palæontological zones in the Cretaceous rocks, and here Mr. Jukes-Browne acknowledges aid given by Mr. C. Griffiths, of Winchester, and Mr. R. M. Brydone, who have zealously worked at the fossils in the Chalk. The Eocene strata include Reading Beds and higher divisions up to the Bracklesham Beds seen at Highclere. Clay with flints and other superficial deposits are likewise described, but we find no reference to the Palæolithic implements of St. Mary Bourne, a locality made famous by Mr. Joseph Stevens in "A Descriptive List of Flint Implements found at St. Mary Bourne", 1867.

The memoir on Henley on-Thames includes brief descriptions of the Kimeridge Clay, Portland Beds, and Lower Greensand which occur in the north-western portion of the area; but the bulk of the work is taken up with detailed accounts of the Upper Cretaceous rocks and fossils by Mr. Jukes-Browne, and of the Eocene and superficial deposits by Mr. Osborne White. The Chalk forms the dominant features over more than half of the area, and the junction of the middle and upper divisions occurs along the crest of the Chiltern Hills, overlooking the Thames Valley at Wallingford on the west and sloping towards Henley-on-Thames on the south-east, with a marked inlier of Middle Chalk bounded by the locally prominent Chalk Rock between Stokenchurch and Henley. This last-named feature is shown on a special map in the memoir, as the Chalk Rock was found by Mr. Osborne White to occur over a larger area than was depicted on the colour-printed map. Eocene formations (Reading Beds and London Clay) occur only as outliers, as in the picturesque regions of Nettlebed and Lane End.

Those concerned in studying the origin and history of the Thames Valley will find much to interest them in Mr. White's chapters on the Scenery and Superficial Deposits. His record of the occurrence of quartzose gravels in the Reading Beds of Lane End is noteworthy in connection with the origin of the 'Pebble Gravel'. In his opinion this much debated deposit may be ascribed mainly to the wasting of Lower Eocene pebble-beds, a process that may have commenced in Oligocene times and have continued ever since. The Clay-with-flints likewise has a long history, when regarded as "a product of the decomposition of the Chalk and the disintegration of the Eocene and later sediments formerly covering that rock".

With regard to the Plateau Gravels, they are divided by Mr. White into the 'Quartzite Gravel', characterized by liver-coloured and grey quartzites from the Bunter, and the possibly newer 'Angular Flint Gravel'. He observes, "That the quartzitic Plateau Gravel bordering the Thames Valley is largely of fluviatile origin can, however, hardly be doubted; and, although proof is lacking, the present writer is much disposed to think that the exotic material which occurs so abundantly in that drift, and which, in the Henley district, appears at first in rounded stones of small size in the upland Pebble Gravel, 400 to 500 feet above the Thames, was being carried into the region of the Upper Thames basin long before the commencement of the Pleistocene 'Ice Age'."

Mr. White further remarks that "The gravel is decalcified and, save for a few palæoliths, has yielded no fossils. As to its age, little is certainly known. The lower terrace deposits—i.e. those up to 200 feet above the level of the Thames in their neighbourhood—are probably all of Pleistocene date; the highest may be of Newer Pliocene age". These conclusions are of great interest, and will be helpful in all studies of the Thames Valley. Some of the Palæolithic implements above referred to have been found in Friar Park, Henley.

The newer 'Valley Gravel' is duly described, and, among other points of interest, attention is directed to the cones or fans of chalk-rubble and rubbly gravel which occur at the mouths of the combes in the neighbourhood of Henley.

The Geological Survey is to be congratulated on having obtained the services of Mr. Osborne White in the description of the later deposits in the area to which this memoir refers.

VI.—The Geological Structure of Western Cornwall. By Upfield Green, F.G.S. 8vo. Penzance, November, 1908. In advance from the 95th Report of the Royal Geological Society of Cornwall. Price 1*s*.

THE author's views as to the age of the rocks in Western Cornwall have been public property since his paper appeared in the Geological Magazine for August, 1904. In this pamphlet he gives the sequence of the beds, as he believes it, in detail, and contrasts it with that of the Geological Survey, who regard the beds between the known Devonian on the north and the south coast as Ordovician or Cambrian, although some of these beds have been shown to contain lenticles of Upper Silurian limestones. Mr. Green regards them all as Gedinnian, and gives a sketch-map and section in support of his views. He appears to suggest (on p. 2) that the published one-inch maps issued by the Survey do not agree with, and are not so accurate as, the six-inch maps on which the mapping was done. He promises further papers on the subject.

VII.—Brief Notices.

1. British Jurassic Echinoids.—The last number of the Proceedings of the Cotteswold Naturalists' Field Club (vol. xvi, pt. ii) contains "Notes on some Echinoids from the Lias of Worcestershire, Gloucestershire, and Somerset", by E. Talbot Paris, who has also contributed the systematic notes and descriptions to the following paper, "On the Stratigraphical and Geographical Distribution of the Inferior Oolite Echinoids of the West of England," by L. Richardson and E. Talbot Paris. The latter paper should be of particular service to those working on that wonderfully rich and condensed series of rocks known as the Inferior Oolite; it contains interesting remarks on distribution, migration, and parallel development. Mr. Paris must be welcomed as a new student in this field, and one who seems inclined to work on correct lines. In the arrangement of his matter the influence of Mr. Richardson is obvious, and we wonder sometimes that it was not carried a little further. In turning out new species Mr. Paris is a little rash; many are based on unique specimens, and when this is not the case a holotype (as Mr. Richardson would probably call it) is not selected. The new species *Diademopsis hettangiensis* is not figured, nor is it compared with the many other Hettangian species previously referred to that genus. Mr. Paris refers *Hemipedina Etheridgei* to *Diademopsis*, forgetting that it is the type species of *Hemipedina*. He states that in *H. perforata* there are only granules between the main interambulacral tubercles, but does not give his

evidence. His enclosure of authors' names within round brackets is not consistently carried out; but that is a trivial matter, and one gladly recognises that the meaning of brackets is understood. What, if we may judge from the list of helpers, is not understood is that before proposing new species and varieties the type-specimens of recognised species should be referred to, and that the rich collections of the British Museum are open to all serious students. The omission (so it seems) to consult them is not a trivial matter.

2. South Africa.—Further South African material reaches us in the shape of papers by W. D. Lang on Polyzoa and Anthozoa from the Upper Cretaceous Limestone of Need's Camp, Buffalo River, and H. Woods' paper on Echinoidea, Brachiopoda, and Lamellibranchia from the same district. Lang's researches lead him to conclude that the age of this deposit is Senonian or Danian, and Woods' refers it to "a late stage in the Chalk". F. R. C. Reed has examined a large series of additional fossils from the Bokkeveld Beds, and finds that his conclusions as to the characters and relations of these beds do not require any modification in consequence of the new material received. He gives a complete list of this interesting Devonian series and notices all the new species. Dr. Broom describes the greater part of a skeleton of *Propappus omocratus*, a Pareiasaurian found in 1907 near Graaff Reinet; *Alopecodon*, *Hyænasuchus*, *Trochosuchus*, and *Pardosuchus*, four new genera of Therocephalian reptiles, and a new Labyrinthodont *Rhinesuchus Whaitsi* of Permian age. All these papers appear in the Annals of the South African Museum, 1908.

Dr. A. W. Rogers has published in the Twelfth Annual Report of the Geological Commission of the Cape of Good Hope (1908) the result of his survey of parts of Vryburg, Kuruman, Hay, and Gordonia, a large area simple in the west and north-west, but complicated in the central part where the rocks are almost completely hidden under sand. Karroo beds occur in an extensive but thin layer, but beyond the recent fresh-water mollusca in a few pans no fossils appear to have been found. A. L. Du Toit has papers in the same publication on portions of Mafeking and Vryburg and portions of Hopetown, Britstown, Prieska, and Hay, and here again fossils are almost absent, a few plant remains alone rewarding the surveyor. Progress is steady and continuous, and in a few years time the devoted band of geologists now working in South Africa will be enabled to provide a geological map which will considerably advance our knowledge of that interesting area.

3. Canada.—A batch of papers from the Canadian Department of Mines dated 1907 and 1908 shows the usual activity in geological matters. The Similkameen district of British Columbia is described by C. Camsell, who finds there Post-Oligocene, Oligocene, Cretaceous, Post-Palæozoic, and Palæozoic deposits, fossils occurring only in the Oligocene lignites and the Cretaceous sandstones. D. D. Cairnes writes on a portion of the Conrad and White Horse mining districts of the Yukon, and his paper, chiefly devoted to mining, contains interesting particulars of the Carboniferous or Devonian, Triassic (?), Jurassic, and Cretaceous sediments, all of which are shown on a map accompanying the report. Dr. R. W. Ells writes on the Landslide at

Notre Dame de la Salette, Lièvre River, Quebec, and John A. Dresser on a recent discovery of gold near Lake Megantic, Quebec. Another report, by O. E. Leroy, which includes the coast from north of Texada Island to the United States boundary, is highly important, but the Government printer has been rather unkind to the author in that he has made up his report in pages as follows: 22, 23, blank, covering letter, 18, 19, 8, 9, 30, 31, 12, 13, etc., and thus makes it a little difficult to follow. We gather, however, that Devono-Carboniferous, Triassic, Jurassic, Cretaceous, and Eocene beds have been identified, and that the beds are a good deal disturbed by volcanic rocks.

4. Fossil Pearls.—Although John Woodward, in 1723, referred to the fact that fossil shells, as well as recent, had "pearls and the like still actually growing upon them", and Goldfuss had figured, in 1836, an example of *Inoceramus* showing the existence of pearls, it was not till 1851 that these bodies were definitely figured and described. In that year John Morris wrote a paper in the Annals and Magazine of Natural History upon material in the Wetherell Collection, and this material is still preserved in the British Museum. Mr. R. Bullen Newton has now collected together the previous information, added a sketch of the occurrence and formation of pearls in general, a note on fossil pearls, and then described and illustrated many examples which have come under his own observation. In this paper (Proc. Malac. Soc., 1908, vol. viii, pp. 128–39) Mr. Newton distinguishes between true pearls and 'blisters', which latter are caused by the intrusion of foreign bodies between the mantle and the shell, etc. True pearls are known by their radiating and concentric structures as shown in section. Fossil pearls are described from *Volsella*, *Inoceramus*, *Perna*, and *Gryphæa*, some of which are from half to three-quarters of an inch across. These large specimens present all the characters seen in sections of recent pearls as described by Dr. Herdman in his "Report to the Government of Ceylon on the Pearl Oyster Fisheries", and other works referred to. The *Inocerami* appear to have been great producers of pearls, some internal casts showing regular rows of pits between the ribs which can only be impressions of attached pearls. Most of the examples described by Mr. Newton are in the British Museum, but the finest of all, and one which shows the characteristic structure in a remarkable manner, is in the possession of Mr. B. B. Woodward. With two exceptions, all the shells showing pearl structures described in this paper are Cretaceous, and they include specimens from England, Japan, Pondoland, Germany, and the United States.

5. Silurian Bivalves of Victoria.—Sixty-two species of Silurian bivalves belonging to twenty-nine genera, including all forms known up to date, have been monographed by Mr. Frederick Chapman in the Memoirs of the National Museum, Melbourne, 1908, No. 2. These include the collections of Selwyn, McCoy, Cresswell, Spry, Jutson, and Kitson. Eleven of these are considered identical with European forms. The time has not yet arrived to zone up the series of beds from their contained fossils, as much more detailed collecting is necessary. This can only be done as more sections are made or more quarries opened in undeveloped areas. The fossils are all carefully

described, and six plates are given. Thirty-two forms are new, and the publication of this fauna in an accessible form is greatly to the credit of Mr. Chapman and the Museum authorities.

6. New Hebrides.—Chapman continues in the Proc. Linn. Soc. New South Wales for 1907 (vol. xxxii, pt. iv) his researches on the Tertiary Foraminiferal Rocks of the New Hebrides. In this paper he deals with Miocene and Post-Miocene beds from Malekula, collected by Mr. Douglas Mawson. The more important results of Chapman's work are distributional, and link up the New Hebrides with Southern Australia, the Philippines, and Japan to the north, and Java and Borneo on the west. One of the forms described, *Lepidocyclina munieri*, occurs at Vicentin in Italy. Curiously enough there is no reference to W. D. Smith's record of *Lepidocyclina* and *Lithothamnium* in the Philippines (Philippine Journ. Sci., 1907, vol. ii, No. 6, p. 396).

7. Stomach Stones.—Mr. W. H. Wickes has collected together the scattered information relative to Stomach Stones in Animals and printed it in the Proceedings of the Bristol Naturalists' Society, 1908, ser. iv, vol. ii, pt. i. He refers to the recent and fossil reptilia, fishes, mammals, and one bird (the penguin) as practising this habit, and notes that the stones are usually white and of quartz. As regards its interest to geologists, this stone-swallowing habit possibly explains the small nests of pebbles found in deposits to which they are entirely foreign, and their deposition on the death and decomposition of the fish or reptile to which they belonged is possibly quite as likely as the old theory of their being transported by floating roots or ice.

8. Colour-Markings on Fossil Mollusca.—The colour-markings preserved on fossil shells have long had a fascination for the collector, and some of these markings have been retained in a remarkable manner. Mr. R. B. Newton, in a recent paper (Proc. Malac. Soc., 1907, vol. vii, pt. v), has collected together the available material and illustrated many interesting examples. Shells showing colour-bands are known from the Silurian period to the Pleistocene, excellent specimens coming from the Carboniferous Limestone. The finest examples given by Mr. Newton are a *Naticopsis* from the Devonian and a *Mourlonia* from the Carboniferous. The fact of the colour-bands being preserved is of little or no importance geologically, but as a side issue has considerable interest.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 18, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communication was read:—

"On some Intrusive Rocks in the Neighbourhood of Eskdale (Cumberland)." By Arthur Richard Dwerryhouse, D.Sc., F.G.S.

There appear to be five well-marked groups of intrusions in this district—

(*a*) The andesitic dykes in the neighbourhood of Allen Crags and Angle Tarn.
(*b*) The dykes of the spherulitic and felsitic group on Yewbarrow and High Fell.
(*c*) The dioritic ('bastard granite') bosses of Peers Gill, Lingwell Crag, and Bursting Knotts, with their associated dykes.
(*d*) The Eskdale Granite, with the granite-porphyry dyke running from Great Bank to Wasdale Head and thence to Kirkfell Crags.
(*e*) The dolerite dykes, having a general north-west to south-east trend.

The dykes of series (*a*) bear a very strong petrological resemblance to the Borrowdale volcanic rocks, into which they were intruded. Furthermore, they are weathered to much the same extent and have developed the same secondary minerals, among which epidote is conspicuous. They appear to the author to be of Borrowdale age, and roughly contemporaneous with the lavas and ashes into which they are intruded. The spherulitic and more acid series (*b*) are considered to be also of Borrowdale age, though probably somewhat later than the andesitic series. The rocks of the dioritic group (*c*) are considered to be the holocrystalline and hypabyssal equivalents of the Borrowdale Lavas, and the author is of opinion that they also are of Ordovician age.

The Eskdale and Wasdale Granites (*d*) are much more acid, and show little sign of alteration except that due to weathering and dislocation. They are undoubtedly intrusive into the Borrowdale Series, but seem to be pre-Triassic. Thus the intrusion is probably Devonian, like the neighbouring granite of Shap, which, with the exception of its large phenocrysts of orthoclase, is not dissimilar to some of the varieties of the Eskdale granite. The basic intrusions (*e*) have only been examined where they come into proximity to the granite. They may well be connected with the great Tertiary basic flows of Antrim, as has been suggested by Mr. Harker.

The granite becomes progressively more and more acid as its margin is approached, until in some places the percentage of silica amounts to 96·16. This is explained by the assumption that the magma as a whole was more acid than the eutectic mixture of quartz and orthoclase, and that consequently the excess of silica separated in the marginal portions, which were the first to solidify.

December 2, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that a Special General Meeting would be held on Wednesday, February 10, 1909, in order to consider the result of the vote of the Fellows on the question of the Admission of Women into the Society.

The following communication was read:—

"The Geological Interpretation of the Earth-Movements associated with the Californian Earthquake of April 18, 1906." By Richard Dixon Oldham, F.G.S.

At the time of the San Francisco earthquake movement took place along a fault, known as the San Andreas Fault, which can be traced for a distance of about 200 miles. A remeasurement of the primary triangulation in the region shaken by the earthquake revealed considerable displacement, increasing in amount as the fault is neared, and of such nature that places to the east of the fault were shifted southwards while those to the west of it were shifted northwards. The author points out that the extent and peculiar distribution of these displacements negative the supposition that the fault was the cause—it must rather be regarded as a consequence of, or an incident in, the earthquake, this word being used to denote the disturbance in its entirety.

He also considers that the displacements cannot be explained in a satisfactory manner on the supposition that they are the result of strains affecting the crust of the earth as a whole, but may be explained by the difference in character and behaviour of the materials composing the greater part of it, where pressures are great enough to produce the phenomena of solid flow, and of those in the outer skin, where the pressures are not great enough to produce any material difference in the behaviour of rocks from that which we associate with solidity, as experienced at the surface of the earth. The surface-displacements constituting the earthquake, as ordinarily understood, arise from disturbances in the outer skin; but in great earthquakes, like the one dealt with in the paper, these may be the result of more deep-seated disturbances affecting the whole crust of the earth. A distinction is drawn between these two forms of disturbance, and the term bathyseism is proposed for the deep-seated disturbance: the wave-motion which impresses itself on distant seismographs and constitutes the teleseism or world-shaking earthquake being the product of the bathyseism.

The deep-seated cause, or bathyseism, of the San Francisco earthquake is regarded as the result of a widespread strain, of the nature of a shear, such as might have been produced by displacements approximately parallel to the general direction of the coastline, and by forces which must have been very different from those concerned in the formation of the San Andreas Fault. This fault cannot, consequently, be regarded as the cause of the earthquake, nor the earthquake as an incident in the growth of the fault.

Mr. W. Whitaker called attention to specimens of impressions of salt-crystals from a local sandstone in the Keuper Marl at North Curry (Somerset). Pseudomorphs of salt-crystals were well known, but, so far as he knew, the occurrence of impressions, not filled in (and which might be taken as arrested pseudomorphs), had not been hitherto recorded in this country. The only notice of such that he knew of was from America, in 1842. Now that this occurrence was recorded, probably other examples would be noticed.

II.—Mineralogical Society.

November 17, 1908.—Professor H. A. Miers, F.R.S., President, in the Chair.

On Mica from North Wales and Chlorite from Connemara; by Messrs. A. Hutchinson and W. Campbell Smith. A mica from Tan-y-bwlch, North Wales, is found in pale-green scales in quartz veins, and approximates closely in composition to the variety of muscovite known as sericite. A chloritic mineral from Recess occurs in transparent hexagonal plates in the quarry whence the Connemara marble is obtained. It is nearly uniaxial and positive, and was found on analysis to have the composition of penninite.—On the occurrence of the rare mineral Carminite in Cornwall; by Mr. Arthur Russell. This mineral, an arsenate of iron and lead, first found at Horhausen, Rhenish Prussia, and described by F. Sandberger in 1850, was discovered in Cornwall by the author in 1906. It occurs as carmine-red or brown needles on crystallized scorodite, mimetite, etc., from Hingston Down mine. This adds one more species to the already long list of rare minerals yielded by Cornwall.—Russian Universal Instruments and Methods; by Mr. T. V. Barker. Several of the universal instruments devised and kindly lent by Professor E. Fedoroff were exhibited and the method of working explained. Among the instruments described were: the hemisphere and graduated rotatory quartz compensator of Professor V. Nikitin, the stereographic rule, circle-ruler, graduated mica and quartz compensators, universal crystal mirror-models and globes, the micro-dichroscope, and the universal microscope-stage. The great utility of the latter was demonstrated by the actual determination (using a simple projection apparatus and screen) of the optical constants, twin-law, and chemical composition of a plagioclase twin. Methods of determining birefringence and the thickness of a section were discussed, and emphasis was laid on the special usefulness of the three-legged compasses in rapid calculations by graphical methods.—On the composition of the Chandakapur Meteoric Stone; by Messrs. H. E. Clarke and H. L. Bowman. This meteorite, which fell in India in 1838, is of chondritic type, with numerous chondrules of varying structure, and consists principally of olivine and bronzite, and about 5 per cent. of nickel-iron.

CORRESPONDENCE.

THE TYGERBERG ANTICLINE.

Sir,—I recently spent a week in the country between Prince Albert village and the east end of Tygerberg in order to see the evidence for the inverted fold said to exist there by Dr. Sandberg.[1] Without troubling you with details, which will be published in the Ann. Rep. Geol. Com. of Cape Colony for 1908, may I state briefly the results of my observations, as the question of the existence of

[1] See Geol. Mag., 1908, p. 311.

the fold has been raised in your pages? There seemed to me to be no room for doubt as to the anticlinal structure of Tygerberg; as Professor Schwarz points out,[1] such a structure is clearly seen, even in the section of which a photograph is given by Dr. Sandberg in support of his views. There are many sections through the range where clear evidence of the existence of the anticline is seen, and one can walk along the axis of the anticline with the beds dipping away on either side.

I could find no trace of the Witteberg Beds *in sitû* in the Sand River Valley as required on Dr. Sandberg's view, and as inserted in his sections. On the other hand, the few outcrops there are of Ecca Beds, and the character of the valley is such as to make it extremely unlikely that the Witteberg Beds ever existed there above the present surface.

The masses of quartzite in the Dwyka area belong to the Dwyka Series itself; they are lenticular beds of quartzite such as have been described from that formation in other places on the south and west sides of the Karroo. ARTHUR W. ROGERS.

GEOLOGICAL COMMISSION,
SOUTH AFRICAN MUSEUM, CAPE TOWN.
November 17, 1908.

BURNING CLIFFS.

SIR,—I recollect the burning cliff at Holworth. As a little boy I used to ride my pony often from Osmington to visit it. The fire was in the face of a part of the cliff that had slipped so as to form a pond at the back of it. It seems that a disturbance which admits some air and water to favour decomposition is the promoting cause of these occurrences. I have picked up pebbles of baked shale and cellular slag on the beach some twenty years after all traces of the fire had disappeared from the face of the cliff at Holworth.

O. FISHER.

GRAVELEY, HUNTINGDON.
December 3, 1908.

FLINTS IN DENMARK.

SIR,—It is incredible that any Danish geologist can have intended to inform Mr. Sheppard that there was no flint in Denmark (see GEOL. MAG., December, 1908, p. 575). Visitors to Copenhagen may have observed the English Church of St. Alban at the entrance to the well-known promenade, Lang Linie. The late Sir Arthur Blomfield told me that, when he was commissioned to build this church, he had some difficulty in finding a suitable stone, till it occurred to him to enquire, "Have you no flints in your Danish Chalk?" "Plenty," was the reply. Whereupon he adopted this local stone, almost unused before in that country, and raised a building that recalls to English visitors many a familiar church of Sussex, Hampshire, and Norfolk. F. A. BATHER.

December 2, 1908.

[1] See GEOL. MAG., 1907, "The Tygerberg Anticline," by Professor E. H. L. Schwarz, pp. 487–90, Pl. XXII; and 1908, p. 479.

JUBILEE MEETING OF THE GLASGOW GEOLOGICAL SOCIETY.

Sir,—The Geological Society of Glasgow, instituted in 1858, has now entered the fifty-first year of its existence. The Council have made arrangements to celebrate the event by holding a Jubilee meeting in Glasgow University on January 28, 1909. Sir Archibald Geikie, P.R.S., the senior member of the Society, has promised to be present and deliver an address. Sir Donald MacAlister, Dr. Teall (Director of the Geological Survey of Great Britain), Dr. Horne, Dr. Peach, and other eminent men of science will take part in the proceedings. A history of the work of the Society, with biographical notices of prominent members, is being prepared under the editorship of the Secretaries, Messrs. Peter Macnair, F.R.S.E., F.G.S., and Frederick Mort, M.A., B.Sc., F.G.S., F.R.S.G.S., who hope to issue the book by the end of the year.

Frederick Mort, Hon. Sec.

OBITUARY.

PROFESSOR ALBERT JEAN GAUDRY,

Memb. Inst. France; For. Memb. R. S.; For. Memb. Geol. Soc.

Born 1827. Died November 27, 1908.

We regret to record the decease of the eminent Professor of Palæontology, Professor Albert J. Gaudry, who for fifty years had been connected with the Museum of Natural History in the Jardin des Plantes, and whose life, accompanied by his portrait, we published in the Geological Magazine for February, 1903, pp. 49–53, on the occasion of his retirement from office. We learn from his successor, Professor Marcellin Boule, that Professor Gaudry had been in failing health for some time, but up to the last his mental activity had never deserted him, and he had just lately published his "Fossiles de Patagonie. De l'économie dans la Nature" (Ext. de Annales de Paléontologie, t. iii, pp. 44–60, 71 figures, Paris, 1908). His memory will long be cherished by a very large circle of fellow-workers and personal friends, to whom he was endeared by his many acts of kindness and by the natural amiability of his disposition to all with whom he came in contact.

JOSEPH LOMAS, F.G.S.

We deeply regret to have to record the death of Mr. Joseph Lomas, F.G.S., who perished in a railway accident near Biskra, Algeria, on December 18, 1908. Mr. Lomas was visiting Algeria to study desert conditions for a Committee of the British Association appointed at Dublin last September. We hope to give some account of his life-work next month.

No. 536. Decade V.—Vol. VI.—No. II. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. II.—FEBRUARY, 1909.

ORIGINAL ARTICLES.

I.—On the Geologic Conditions affecting the Coasts of England and Wales, with special reference to the Coast-line from Lynn to Wells (Norfolk) and from Yarmouth to Eastbourne (Suffolk, Essex, Kent, and Sussex).

By W. Whitaker, B.A., F.R.S.

Written for the Royal Commission on Coast Erosion and the Reclamation of Tidal Lands, and printed in its Report, 1907, vol. i, pt. ii, Appendices, pp. 141–5.

In reprinting this article some slight changes and corrections have been made, but it remains substantially the same, perhaps with trifling improvements. [Any notable addition is included in brackets of this kind.]

During a long series of years I have examined a large amount of the English coast, either in the course of my work on the Geological Survey or in my holidays. This includes walking along the whole or nearly the whole coast of the following counties:—Norfolk, Suffolk, Essex, Kent, Sussex, Hants, Dorset, Devon, and Cornwall; a continuous series from the east to the south-west. To these may be added the small amount of coast possessed by Cheshire. I have also examined a considerable part of the coasts of Durham and Yorkshire as well as parts of the coasts of Somersetshire, Glamorganshire, Lancashire, and Northumberland. Generally speaking, every chance of seeing our coast has been taken. In some cases my walks were along the foot of the cliffs, in others along the top, often along both, and to many parts repeated visits have been paid. These facts are noticed in order to show that I have some experience of the subject.

General Statement as to the Sea-bord Counties.

It is clear that the form of a coast must depend on its geologic structure, and therefore so also must the rapidity of coast-erosion. Hard and firm rocks will resist the various eroding powers, whether from above or at the sea-level; soft and loose rocks will yield more readily.

It is not, however, altogether a question of mere hardness or firmness; many rocks of good character in that respect are seriously affected by structural planes, by which they are more or less readily split up into large masses or even into small blocks. Faults, or planes along which the rocks have been displaced, are sometimes effective in this way; but far less so on the whole than the far more common planes of division (but not of displacement) known as joints. These are vertical or highly inclined to the bedding-planes (when the rocks are of sedimentary origin); there is often one dominant set, running in one general direction and therefore approximately parallel; but these master-joints are generally crossed by others at various angles.

The whole arrangement, therefore, of these divisional planes, which sometimes form narrow fissures, is one that favours the separation of the rocks into blocks, which may be more or less readily displaced.

In the case of sedimentary rocks the bedding-planes, that is the planes of deposition, may greatly assist in the destruction of even the hardest rocks.

It is not, however, the nature and structure of a rock that alone determine its rate of erosion. Its relation to other rocks is equally important; for instance, if a harder rock is overlain by a softer one, the resultant form of cliff will be what is known as slope over wall; the hard rock will resist the action of the sea at the foot and will form a more or less vertical cliff, whilst the soft rock will yield readily to the atmospheric agencies that are constantly in action above, parts of it being washed over or slipping over the cliff beneath, until the angle of rest is reached and a condition of comparative stability is gained. This form of cliff then is of the stable kind, depending on the resistance of a firm rock to the sea.

Where a harder rock is underlain by a softer one we get the form of wall over slope. The lower beds cannot stand with anything like a vertical face, but weather down to the angle of rest, modified as this may be by the softer bed having to support the harder one above. This form, therefore, is of an unstable kind, as the sea can readily wash away the yielding bed and so bring about the destruction of the hard overlying mass, from want of support. This, however, is one of those cases in which nature provides a check on her own destructive power; the blocks of hard rock that fall down the slope form a natural breakwater, hindering the sea from attacking the softer rock until they have been removed. There may, of course, be more than one slope or wall, in the case of alternation of harder and softer rocks, and the result will be a broken slope of considerable extent.

Another kind of alternation, that of permeable and impermeable rocks, is also important, as causing springs or general outflow of water along definite lines, thus adding to the slippery nature of the impermeable beds and facilitating the sliding down of the permeable beds above, which are often in themselves firm and resisting. Our great landslips are largely owing to this cause.

The direction of the dip in sedimentary beds is also a powerful factor in coast-erosion. Should that direction be in any way seaward, of course it favours the seaward slipping of the beds, hard or soft; but should it be landward it opposes an obstacle to such slipping, even in yielding beds, and delays the loss of land.

The kingdom of England and Wales is noted for the great variety of rocks that occurs on its coast and for the frequent changes from one class of rock to another; both of which, of course, add to the complexity of the question of coastal waste. We have massive limestones, as the Carboniferous and Magnesian Limestones; alternations of shales or clays with sandstones, as the Upper Carboniferous; thick clays, with but little intervention of other rock, as those of the Jurassic Series and the London Clay; sands and sandstones, as parts of the Old Red Sandstone and of the Trias and the Upper Greensand; conglomerates, as that of the Permian; hard shales and slates, as those of the Devonian, Silurian, and Cambrian; alternations of clays, loams, sands, and gravels, as the Drift; the softer silts, peat, etc., of the Alluvial beds; and great sheets or long strips of shingle, deposited by the sea itself, together with tracts of sand, blown up by the wind from the shore, sometimes to a considerable height. Besides the above sedimentary deposits we have also granite and other hard igneous rocks.

Of all the geologic formations the chief cliff-formers are the Carboniferous Limestone, the Magnesian Limestone, the Jurassic beds (of various characters), the Chalk, the Drift (in Norfolk), the various Cretaceous beds below the Chalk, with the Wealden beds (on the southern coast), the Trias (Sandstones and Marls), the various Devonian beds and the Old Red Sandstone, the Granite of the far west, the Carboniferous beds of the west, and the hard Silurian, Cambrian, and Pre-Cambrian rocks of Wales.

We have also every variation in dip, from horizontal to vertical, and a great variety in the relations of the various beds; here a conformable orderly arrangement, there an irregular or a disturbed one; at one place a gradual change, at another a rapid or sudden one.

From the geologic standpoint alone, therefore, it is clear that the study of our coast is far from being a simple one.

Accretion of Land.

It is well known that there are various tracts where the land is gaining on the sea, and these are often instanced as if they more or less balanced the loss of land in other places. That they do this in the matter of area cannot be questioned; but I venture to say that this is all; that is to say, they do not, as a rule, in any way assist in the protection of the higher land against the destructive coastal actions. The fact is that almost all the gained land is below high water mark, and is largely protected artificially by banks. Moreover, it is largely in more or less sheltered positions. Exceptions to this will be duly noted; they occur where the sea has formed a large shingle-bank, sometimes accompanied by blown sand.

Perhaps the best example of gained land is that of the great flat bordering the Wash, which flat consists in part of the deposit of the rivers of the Fenland, and in part of silt brought in by the sea. Many hundreds of years ago this low land was far more flooded than now, when persistent effort during some centuries has gradually drained off the waters that once spread over great tracts and has defended those tracts by earthen walls. Moreover, the seaward face of this land has been gradually pushed forward by careful processes of enclosure, and the various old sea-walls can be identified from Roman times onward. This gained land, however, does not aid in protecting the open coast; it is merely the infilling of a great hollow, and this infilling can never be carried beyond the coast-line, even if it ever reaches up to that. It is certainly valuable land, more so than much of that which is lost along the coast.

Another variety of accretion of land is where the sea piles up a mass of shingle, well above high water mark. This may form a strip along the coast (as in ordinary beaches); or may extend as a long slip between a river and the sea (as near Aldeburgh); or may form a broader tract, brought about by successive piling up of fulls or bars of beach to a considerable extent, so that the sea gradually forces itself outward from the land (as at Dungeness). [There is yet another rare mode of occurrence, where a beach (as the Chesil Beach) joins what would otherwise be an island to the mainland.]

Such tracts of shingle are, of course, of no value as ordinary land, but they have a great influence on the coast.

Crustal Movements that may be going on or which have occurred in late Geologic Time.

I can only say on this question that I know of no good evidence of movements now going on. But *there is clear evidence of such movements having taken place in late geologic times.* Thus the common occurrence of what have been called submerged forests shows that the land, at a very late geologic period, must have been a little higher than now. I object to the name given to these occurrences, as it seems to me misleading; there are no large forests, but only the occasional roots of trees and other remains of wood (see *post*). These, moreover, do not occur continuously along a great line of coast; so far as I know, they occur only in the neighbourhood of river-mouths. They are, in fact, nothing but a part of the alluvial flats of river-valleys, valleys that have been cut back by the advance of the sea, so that their latest deposits are shown at low water, where the valleys now end, that is, at the coast. These peaty beds really have no connection with the coast; they occur up the valleys also, and we have a notable instance of this in the Valley of the Thames, from London downward, where these beds have been laid open in the large excavations for docks and basins which have been carried to some depth below sea-level, or in the long trenches that have been dug for main drainage.

One of the most marked occurrences of such beds along a fair extent of coast is in the peninsula of Wirral, between the estuaries of the Dee and of the Mersey and on the other side of the latter, where the peat, crowded with roots of trees in the position of growth, can be well seen. The trees in these beds are of the same kind as those now growing in the country, and it is clear that they could not have grown in their present position, some feet below high-water mark: they must have lived when the land was at a slightly higher level than now. It is important to remember that they have nothing to do with the coast, but only with the river-valleys and their former extension. They occur in the case of small streams as well as in that of large rivers, and have been observed and described wherever large dock-works have been made in the lower parts of river-valleys: elsewhere it is comparatively rare to find sections in Alluvium, the beds as a rule being not worth digging for economic purposes and moreover being dug into with difficulty, from their low position and consequent water-logged state.

Movement of upheaval, of rather earlier date, is shown by the occurrence of sea-beaches or terraces at levels approximately parallel with the present shore-line, but sometimes considerably above it. These often yield shells of like kind to those of the present coast, and so clearly prove a former difference in the relation between sea and land. Naturally such occurrences are confined to the harder rocks, the softer ones having been so cut back by the sea that all such remains have been carried away. In the South East of England there is no evidence of these beds, and, generally speaking, they occur only at a number of detached sites.

There is one point of caution, I fear not always attended to, in taking the evidence (as to rise of land) of a recent marine deposit above the present range of the tide. In heavy storms the waves can force up beach some way above the level of the water, and therefore it is possible that, on a coast being cut back, isolated masses of such piled up beach may be left perched on the top of a very low cliff, and may be thought to show rise of land, whereas in truth they do not, their isolated position being due to the gentle incline, which once reached from them to the beach, having been cut away, so that its higher inland end now alone remains.

I have seen, too, in the low part of the coast of Sussex (by Selsea) shingle that at one place shows a continuous slope up from the beach to the land, whilst some yards off a few feet of cliff separates this higher shingle from that at the base. In this case the shingle had been driven up through a farmyard, and therefore was distinctly modern.

Special Parts of the Coast.

As the parts to which I have been asked to give special attention have all been described in Geological Survey Memoirs, and the coastal changes noticed in those publications or in the Reports of the British Association Committee (some years ago), there is no need to go into great detail. Some parts, moreover, I have not seen for several years, and therefore have had to depend on information from other people as regards later changes. There is need indeed of resident observers in all districts where much change is going on.

From Lynn to Wells, Norfolk.

From Lynn northward to Hunstanton we are dealing with the eastern border of the Wash, and therefore for the most part with a district of accretion. During the three years of my residence at the former place, which ended in 1884, I got a detailed knowledge of this district and was able to record a large reclamation of land, since the publication of the old Ordnance map and partly made, near Lynn, whilst I was there. The Lower Greensand and the Drift beds that fringe it in parts are here separated from the Wash by a strip of low alluvial land, down to the neighbourhood of Hunstanton Station, and along the northern part of this the Alluvium, in its turn, is bordered and protected by a strip of shingle, my few notes on which seem to have escaped publication.

At New Hunstanton, the watering-place on our eastern coast which faces westward, we have a cliff, for about 1½ miles, with Boulder Clay at the southern end, but mainly of Chalk underlain by the ferruginous carstone of the Lower Greensand, which last dips down out of sight at the northern end. The carstone makes a firm base and runs out along the foreshore as a rocky mass, separated into blocks along the planes of jointing. The Chalk, too, is fairly hard, and I saw nothing but very slight falls from the cliff.

From Hunstanton eastward there are no cliffs. The Chalk slopes gently northward and then, along the line of villages to beyond Burnham Deepdale, is covered by Drift (Boulder Clay and Gravel). This Drift must extend further north under the marshes, the outer parts of which are to some extent protected by bars of Shingle and Blown Sand. Further eastward, to and beyond Wells, the Chalk often reaches down to the Alluvium, though sometimes there is Drift between.

Along this somewhat peculiar coast there have probably been many changes in the shore-deposits, as may be seen by a comparison of the old Ordnance map with the new one. This also shows great shifting in the courses of the streams that flow through the low alluvial ground to the sea.

[The tract between Wells and Yarmouth was described by Mr. C. Reid, with much other matter, in pp. 163–172 of the Appendices to the Report.]

From Yarmouth to Eastbourne.

The long stretch of sea-bord now to be noticed gives some of the best examples that we have of the loss of land by coast-erosion, and it will be well to start with a short account of its geologic features.

Beginning at Yarmouth with the most recent beds (Blown Sand over Alluvium), for many miles southward we have nothing but Drift and Crag (which for our purpose may be grouped together). These consist here of Boulder Clay above (as far as Kessingland) with gravels and sands below, the thin clayey beds of the Upper Crag showing in places at or near the base.

From Gorleston to Kessingland the low cliff is breached only by the narrow valley of Lake Lothing, at Lowestoft; but southward of Kessingland the Alluvium of the many valleys reaches down to the beach to a considerable extent, so that we have but short lines of low cliff, attaining a length of about 2 miles southward from Dunwich (where too the cliff is higher than elsewhere) and of about 2½ miles from Sizewell to Thorpe.

Southward from Aldeburgh there is a change. We come to one of our great shingle-tracts, and for nearly 11 miles (measuring on the Geological Survey map) we have a strip of beach with the sea on one side and the River Alde on the other, a tract of slight accretion. A little beyond this the London Clay appears for the first time in the cliffs, from beneath the Crag; and the Felixstowe cliffs also consist of Crag over London Clay. On crossing Orwell Haven to Harwich we have more than a mile of cliff of London Clay alone (Dovercourt). Thence marshes and tidal creeks set in, and alluvial clay comes down to the shore and also forms the foreshore to the Naze, which consists of London Clay, partly capped by Crag and Drift.

From Walton to Frinton we have more than 2 miles of London Clay cliff, and then, after an alluvial gap of a mile, some 4 miles of London Clay capped by gravel.

Westward and southward from this we have no cliff for many a mile. The marshes reach down to the beach as far as the estuary of the Colne. Mersea, between the Colne and the Blackwater, is a cliffless island. Between the Blackwater and the Crouch (more than 8 miles) we have generally a broad tract of marshes, the London Clay reaching to the coast only at one spot, on the north, the site of a Roman station (Ithanchester), and then not forming a cliff. From the Crouch to Shoeburyness there is again a tract of marshland, which is of considerable extent and mostly in the form of islands, owing to the River Roach and its attached creeks cutting through from side to side.

Westward from Shoeburyness, up the estuary of the Thames, there is at first a low-lying mass of gravel and loam, forming only a very small cliff in parts, with London Clay at the base sometimes. At Southend the ground rises and there are cliffs of London Clay to Leigh, where the marshes of the Thames begin.

Crossing the Thames there are again marshes, gravel and London Clay reaching the shore only north of Allhallows, and the latter again at the eastern end of the Isle of Grain.

Crossing the Medway to Sheppey, at and near Sheerness the marshes reach to the shore; but the London Clay soon rises up and forms cliffs of fair height along the greater part of the island, the highest parts having caps of Bagshot Sand and gravel. At the eastern end the marsh is separated from the sea by a beach of shells.

On the other side of the Swale, from Whitstable to beyond Herne Bay, we have some miles of London Clay cliffs, varied here and there by their coverings of gravel or loam. Then the Lower London Tertiaries (here consisting mostly of sand, but with some clayey beds in the lower part) rise up and at length reach the cliff-top three quarters of a mile westward of Reculvers.

The rise of the Chalk from beneath the Tertiary beds is hidden by the 2½ mile wide marshes of the Wantsum; but passing these we come to the Isle of Thanet, which is bounded almost wholly by chalk cliffs, there being a very few small gaps of Alluvium or Valley Drift; the thin cappings of loam in places are of no moment in this enquiry. In the lower ground westward of Ramsgate the Thanet Beds (sand and marly beds) come on over the Chalk somewhat suddenly and form a cliff for a short way.

Then southward, across the valley of the Stour, is a broad tract of marshland, bordered, from the river nearly to Deal, by a strip of Blown Sand (at one part over half a mile broad) with an outer margin of shingle, which latter indeed is not covered by the sand at the northern end. Narrow here, this shingle widens at Deal and then reaches southward for 4 miles further, to Hope Point. Deal itself is partly on the shingle, partly on Alluvium, and partly on low-lying loam.

At Walmer the Chalk again comes to the coast and forms a line of cliffs nearly to Folkestone, these cliffs on the whole gradually increasing in height south-westward and being breached midway by the valley of the Dour.

We now pass to lower and lower beds. The Gault (clay) rises to the surface just north of Folkestone and forms a cliff for a short way. Then the sand of the topmost division of the Lower Greensand rises up at the harbour and forms the base of the cliffs, thence westward to Shorncliffe, beyond which there is no cliff for many miles.

The peculiar district now reached, that of Romney Marsh, etc., consists of a broad tract of alluvial beds, largely below high water mark and generally bordered by beach. The only parts rising above the ordinary level are formed of shingle, which here reaches far inland in places, Dunge Beach being, I believe, the largest area of shingle in the kingdom.

By reason of this great spread of Recent beds the formation that next underlies the Lower Greensand, namely, the thick mass of the Weald Clay, never shows at the coast here, being wholly hidden, and we have, therefore, no cliff-section to show us the details of its structure.

It is not till we get westward, nearly to Fairlight, that higher land is found. There we have the lowest beds of the Wealden Series (the Ashdown Sand) and the Fairlight Clays beneath, classed with the Purbeck Beds. These, with some overlying Wadhurst Clay, form the fine cliffs on to Hastings, and the like is the case with the cliffs of the Bexhill district, separated only by the Alluvium of the Catsfield stream.

Next comes the broad alluvial tract of Pevensey Levels, with its border of beach, the latter swelling out to a breadth of seven-eighths of a mile at Langney Point and then again decreasing in breadth to Eastbourne, where the Upper Cretaceous beds rise up, the Weald Clay being here again cut off from the coast and mostly hidden under the Alluvium, as also is the Lower Greensand, which, however, is here much thinner than on the Kentish coast.

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

II.—The Hill of Beath, a Volcanic Neck in Fife.

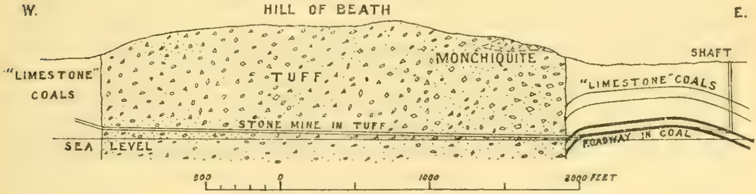
By J. S. Grant Wilson [1] & H. Brantwood Muff.

THE Hill of Beath, which lies 3 miles to the north-east of Dunfermline, Fife, is an isolated hill with steep, but rounded, contours, and rises fully 250 feet above the surrounding plateau. Whilst the hill itself consists of dark grey tuff, the rocks forming the

[1] On January 2, 1909, the Editor received the sad intelligence of the sudden death of Mr. J. S. Grant Wilson, who had only a few days previously communicated his MS. for publication in the Geological Magazine (see his Obituary, p. 91).

plateau belong to the Coal-measures of the Carboniferous Limestone series. The latter are thrown into gentle anticlines and synclines, the dip on the limbs of the folds usually lying between 10 and 15 degrees. The outcrop of the tuff has the form of an ellipse, the long axis of which trends east and west and measures nearly 1,000 yards, whilst the breadth of the ellipse is rather more than 500 yards. The distribution of the outcrops of the Carboniferous rocks around the hill and the evidence from the coal workings show that the tuff is not interbedded with the sediments, but that it breaks through them somewhat like an intrusive rock. Sir Archibald Geikie[1] recognized that the Hill of Beath was a volcanic neck, and this view has been confirmed by recent mining operations in a conclusive manner.

The Dunfermline Splint and Five Foot coals on the east side of the hill are worked in the Hill of Beath Colliery belonging to the Fife Coal Company. In order to reach the same seams on the north-west side of the hill a 'stone-mine' was driven in a westerly direction beneath the summit of the hill and almost along its greatest diameter. The stone-mine commenced at the foot of a roadway, which is partly cross-cut and partly 'dook' in the Dunfermline Splint coal, as shown



Section across the Hill of Beath near Dunfermline, Fife.

in the section, at a depth of 500 feet beneath the pit-mouth, or a little above Ordnance Datum. After driving a short distance the tuff was entered, and on plotting the underground position of the junction on to the 6 inch map it was found to be more than 550 feet vertically below the junction at the surface. The stone-mine was driven through compact tuff quite similar to that at the surface for about half a mile, and finally emerged into sedimentary rocks, the junction being vertical and almost perpendicularly beneath the margin of the neck as seen at the surface. The mine passed beneath the summit of the hill and at a depth of 700 feet beneath it, so that these mining operations have proved a vertical column of tuff piercing the Lower Carboniferous rocks and at least 700 feet high.

The eastern margin of the tuff against the sedimentary rocks is a typical neck junction, i.e. the beds as they approach the contact bend down sharply towards it. Whilst the general dip of the beds in the mine is about 10°, near the junction of the roadway with the stone-mine through the tuff the dip is 22° towards the neck. Eighteen yards further on it has increased to 50°, and 14 yards further it is 65°, and close to the contact with the tuff a dip of 74° was measured. This great increase in the angles of

[1] *Ancient Volcanoes of Great Britain*, vol. i, p. 425, footnote.

dip close to the tuff was also proved in the 'levels' in the Five Foot coal on both sides of the roadway. At the actual contact the shales are much crushed, dragged out, and slickensided, and the sandstones are shattered, but there is no sign of contact alteration, which sometimes occurs at the edge of other necks. On the western side the stone-mine has penetrated a massive white sandstone, which shows no signs of bedding, so that it is not yet possible to say whether the usual downward flexure of the beds takes place here also.

Further evidence of the behaviour of the tuff is afforded by the now closed down Halbeath Colliery, in which the coals were worked close up to the south wall of the neck, until they began to dip down towards it at an angle of 24°. At the south-east corner of the hill the coals were worked for a short distance vertically beneath the surface crop of the tuff, thus showing that the wall of the neck was here not vertical but inclined inwards. The angle of inclination, however, is not large. Thus the neck has not only been pierced from side to side and found to consist of volcanic tuff, but it is known to possess approximately vertical walls around more than half its periphery.

The cause of the characteristic downward flexure of the strata surrounding necks is not perfectly clear. The deformation must often have taken place very slowly, for massive beds of sandstone, etc., are in many cases bent without being broken, though in other instances the beds are fractured and displaced. Slickensides are frequently found on the walls of necks, and the clearest exposures closely resemble sections of a fault in which the strata on the upthrow side have been dragged downwards and the weaker beds crushed and drawn out. In the case of a neck the fault must be a circular one, the whole mass of material filling the neck having subsided bodily. If the subsidence were due merely to the consolidation and consequent contraction of the infilling volcanic rock, the amount of the flexure should decrease with the depth. This is not corroborated by the examination of neck-junctions underground. Sir Archibald Geikie points out that "after copious eruptions, large cavernous spaces may conceivably be left at the roots of volcanoes, and the materials that have filled the vents, losing support underneath, will tend to gravitate downwards, and if firmly welded to their surrounding walls may drag these irregularly down with them".[1] The phenomena at the margin of the Hill of Beath neck are very much what might be expected if such a subsidence had taken place. Though the surrounding sediments are dragged downwards, the tuff shows no signs of disturbance except near the margin, where it is cracked and the fissures occupied by calcite.

The material filling the neck is a palagonite tuff quite uniform in character throughout. It is composed of greenish vesicular lapilli scattered through a dull bluish-grey matrix, in which sand-grains can be made out. The lapilli vary in size from particles only just visible to the naked eye to fragments an inch or more across. The tuff is not stratified, strictly speaking, but it exhibits in the mine a broad striping due to bands containing large lapilli alternating with others made up only of smaller ones.

[1] Loc. cit., vol. i, p. 73.

A thin slice of a specimen from the mine shows under the microscope that the lapilli are irregularly rounded masses of greenish-brown palagonite, charged with cumulites and longulites, and without action on polarized light. Pseudomorphs in calcite after olivine are enclosed in some of the lapilli. The abundant, minute vesicles, which have oval shapes and are not often cut by the margins of the lapilli, are filled by zeolites or sometimes by chlorite. In some parts, however, the brown palagonitic substance shows faint aggregate polarization under crossed nicols, whilst the walls of the vesicles and of cracks show a fibrous structure, the very short fibres being arranged perpendicular to the walls.[1] This alteration is probably a secondary devitrification, and the vesicles in these altered parts are frequently occupied by calcite. In the dark matrix chips of quartz and felspar and minute particles of palagonite may be discerned, but the structure is in most parts quite obscure.

The numerous sand-grains in the tuff consist of angular and rounded particles of quartz, with some of microcline and plagioclase. These minerals are the chief constituents of the surrounding Carboniferous sandstones, and the grains in the tuff may have been derived from them, the concave curves bounding many of the angular quartz-grains being readily explained as the trace of fresh conchoidal fractures produced during the volcanic explosions which blew out the strata. But if the grains were really derived from the disruption of the Carboniferous sandstones, the absence of blocks of sandstone and shale is remarkable, unless it may be assumed that the rocks were not thoroughly consolidated at the period of vulcanicity. We refer later to the probability that the neck belongs to the age of the Upper Limestones, and supposing the volcano to have been a subaqueous one, the sand-grains may have been derived from the same source as the other Carboniferous sediments and deposited in the neck along with the truly volcanic material.

The lenticular mass of basic rock, which crops out on the eastern side of the neck, was not met with in the mine. The rock is decomposed at the outcrop, and its junction with the tuff is not well exposed, but probably it is intrusive into the tuff. It is a very fine-grained black rock, showing to the eye small, scattered phenocrysts of idiomorphic olivine altered to serpentine. Under the microscope an abundant second generation of idiomorphic olivine phenocrysts replaced by serpentine, reddish-brown strongly pleochroic biotite hexagonal in cross-section, and two or three small phenocrysts of pale green augite lie in a groundmass, which is charged almost to opacity by dusty magnetite, and is further obscured by spots of secondary calcite. In the thinner parts of the slide, however, one can see that the groundmass consists of minute prisms of augite, apparently pale green in colour, embedded in a clear, colourless, isotropic substance, which has a very low refractive index and is probably analcime. Recognizable analcime occurs in certain clear areas to be referred to below, and from these areas it appears to be

[1] Zirkel noted a somewhat similar alteration in palagonite tuff from Nevada. *Micro. Petro. Fortieth Parallel*, 1876, p. 274.

continuous with the base of the rock. There is no felspar. The rock has some affinities with the biotite-bearing limburgite of Carboniferous age from Whitelaw Hill, East Lothian, described by Dr. F. H. Hatch,[1] but it resembles more closely certain monchiquites of the same age from East Lothian to be described by Mr. E. B. Bailey in the forthcoming memoir on that district, and probably it is best termed an augite-monchiquite. Though evidently very basic in composition, it is too decomposed for the determination of the specific gravity to have any value, and further it contains numerous small, irregular vesicles filled with zeolites or calcite. There are also small but less well-defined spots free from magnetite. They are occupied by minute prisms of pale green augite embedded in analcime or calcite. Often the augite prisms form a distinct border on the periphery of the spot, the centre of which is occupied by calcite or analcime or both these minerals, whilst the biotite scales are sometimes very abundant in a narrow rim immediately outside the augite border. Though somewhat resembling the reaction-rims of augite, which surround xenocrysts of quartz in some basic rocks, these spots cannot be explained in that manner. Neither is there any sign of the regular crystallization of the augite in spherulitic fashion from a centre, or from points on the wall of the cavity. It is difficult to discriminate between two possible explanations. The spots might be due to an attempt on the part of the analcime to form definite crystals, which have succeeded in pushing away the magnetite and biotite, but the augite has only been collected on the borders. It is possible, however, that they are early-formed steam cavities, into which still unconsolidated parts of the magma have soaked and there crystallized out. There would be nothing surprising in the early formation of steam cavities in a rock containing a considerable quantity of analcime.

The age of the neck cannot be determined with absolute certainty. It must be younger than the rocks which it pierces, viz. the lower part of the Coal-measures of the Carboniferous Limestone series, but the higher limit of its age is indefinite. There are no bedded volcanic rocks in the neighbourhood with which it can be connected, but in the Saline Hills some 6 miles away in a west-north-westerly direction, similar tuff-necks are associated with bedded tuffs lying on the position of the Upper Limestones above the coal-bearing group, and Sir Archibald Geikie has classed the Hill of Beath neck with this group of Carboniferous puys.[2] The petrological evidence given above is in conformity with this correlation, for the monchiquite clearly belongs to the Carboniferous and not to the Tertiary igneous magma.

Amongst the many volcanic necks, between two and three hundred in number, which pierce the Old Red Sandstone and Carboniferous formations in the south of Scotland, several have had their subterranean extension proved by mining operations. Perhaps the best known cases are those in the Ayrshire Coalfield.[3] An instance in which a mine was driven from side to side of a neck, situated about 2 miles south-west of Muirkirk in Lanarkshire, is given in the "Explanation of

[1] Trans. Roy. Soc. Edin., 1892, vol. xxxvii, p. 116. [2] Loc. cit.

[3] Memoirs of Geol. Surv. Scotland, Explanation of Sheet 22, p. 25, and Explanation of Sheet 14, p. 22.

Sheet 23 (Scotland)", p. 39. Dr. Peach mapped a neck near East Grange, 5½ miles west of Dunfermline, the cross-section of which was ascertained in underground workings.[1] A somewhat similar case is that of Knock Hill in the Saline Hills.[2] The vertical extension of necks piercing the Calciferous Sandstone series has also been proved in the shale mines in the oil-shale field west of Edinburgh. Mr. H. M. Cadell[3] has described a remarkably good instance from the Broxburn oil-shale workings near Philipstoun (West Lothian). At a depth of 120 feet below the surface a mine was driven from a level in the Broxburn Oil-shale through the tuff of the neck into the oil-shale on the other side. The neck was 360 feet broad on this line of section, and the oil-shale on approaching the tuff dipped steeply towards it on each side. The walls of the neck were quite perpendicular and somewhat slickensided, like the face of a fault.

For information, and for giving us all facilities to examine the stone-mine through the neck, we are indebted to Mr. Henry Rowan, general manager of the Fife Coal Company.

III.—New Species of Cretaceous Bryozoa.

By Professor J. W. Gregory, D.Sc., F.R.S., F.G.S., University of Glasgow.

THE second volume of the Catalogue of Cretaceous Bryozoa in the British Museum, of which the manuscript has been completed, contains the description of various new Cretaceous species. Such a catalogue inevitably takes some months in passing through the press, during which it might happen that the species were anticipated by description elsewhere. To avoid the risk of reduplication of the names it is most convenient to publish the diagnoses. Fuller accounts of the species, with illustrations, will be given in the Catalogue.

Multitubigera, d'Orbigny, 1853.

Multitubigera sulcata,[4] n.sp.

Diagnosis.—Zoarium massive and thick. Radial ridges of each zoœcial sub-colony short, thick, and wedge-shaped. Apertures triserial to multiserial at the ends of the radii. The zoœcial colonies are elliptical, and usually separated by valleys or depressed porous areas, and not by definite regular laminæ.

Distribution.—Senonian—Maastrichtian: Maastricht.

Discofascigera, d'Orbigny, 1853.

Discofascigera vinei, n.sp.

Diagnosis.—Zoarium small, with a short, pointed base, covered by epizoarium. The upper surface is flat, with small raised marginal projections. In young zoaria the apertures are sparse and widely scattered.

Distribution.—Cambridge Greensand: Cambridge.

Fasciculipora, d'Orbigny, 1846.

Fasciculipora spicata, n.sp.

Diagnosis.—Zoarium with a narrow stem, widening into a thick horizontal expansion, from which rise numerous short, blunt fasciculi. The zoarium seen from

[1] *Ancient Volcanoes*, vol. i, p. 426. [2] Loc. cit., p. 435.

[3] "On an Ash Neck in the Broxburn Shale Workings at Philipstoun": *Trans. Edinburgh Geol. Soc.*, 1899, vol. vii, p. 477.

[4] So named on account of its furrows between the sub-colonies.

above is roughly triangular. The head includes about ten bundles of zoœcia, which rise upward in sharp spikes. The bundles are grooved longitudinally and branch dichotomously; the sides, when worn, appear punctate, but in well-preserved specimens are marked with longitudinal ridges, decorated by small points.

Distribution.—England—Chalk: South-east of England. Foreign—Senonian (Campanian): Ciply.

Retenoa,[1] nov. gen.

Diagnosis.—Theonoidæ with an erect frondose zoarium, composed of a network of dichotomous, anastomosing branches. The apertures all open on one face of the zoarium.

Type Species.—*Retenoa campicheana* (Orb.), 1853. Neocomian: Sainte-Croix, Switzerland.

Homœosolen, Lonsdale, 1850.

Homœosolen gamblei, n.sp.

Diagnosis. — Zoarium frondescent, of crowded multipinnate branches. The branching is irregular; the branchlets cross and intersect, but do not anastomose. The back of the distal parts of the branches is traversed by longitudinal, fluted, or carinate ridges, which form a strong median carina; but this structure may be replaced by transverse wrinkling in the proximal ends of the branches in old specimens. Gonœcia ovoid; attached to base of the pinnules on the obverse face.

Distribution. — Upper Chalk (zone of *Micraster coranguinum*): Gravesend; Bromley, Kent. Middle Chalk (zone of *Micraster cortestudinarium*): Chatham. Also from Chalk, zones not recorded, at Charing, Kent; Salisbury; Guildford; Arreton Down, Isle of Wight.

Homœosolen virgulosa, n.sp.

Diagnosis.—Zoarium an erect, irregular tuft, which is repeatedly branched. The branching is irregularly dichotomous. The peristomal bundles are transversely elongated, and may occur in biserial ridges with as many as five apertures in each horizontal, transverse row. Some groups of apertures are irregularly triserial. Reverse surface fluted.

Distribution.—Chalk (zone of *Micraster cortestudinarium*): Chatham.

Discocytis, d'Orbigny, 1854.

Discocytis profunda, n.sp.

Diagnosis.—Zoarium very small, solid, pointed below, and expanding gradually or rapidly upward to an irregular but horizontal upper surface. The sides are coarsely ridged. Apertures in groups on irregular blunt knobs around the margin of the upper surface; seen from above the groups are radial and separated by irregular, small zoœcia.

Distribution.—Chalk: Charing, Kent.

Desmepora, Lonsdale, 1850.

Desmepora blackmorei, n.sp.

Diagnosis.—Zoarium of flat, broad branches. The apertures open on the ends of short, ridge-like lateral processes which project along the sides of the stems; these lateral processes are irregularly elliptical; the apertures are generally biserial with about eight in each row of a process, and the series are placed horizontally. The reverse surface is covered by crowded rows of small round pores (cancelli), and the surface is slightly concave.

Distribution.—Upper Chalk (zone of *Actinocamax quadratus*): East Harnham, near Salisbury.

[1] An abbreviation of *Rete-theonoa*, the theonid with a net-shaped zoarium.

Desmepora pinnigera, n.sp.

Diagnosis.—Zoarium composed of short, thick, somewhat swollen branches, which rarely subdivided and are frequently arranged in a cross. There may be five arms. The zoarium is attached by a short peduncle and base. The sides are marked by a series of ridges, which extend across the whole width of the side. Apertures arranged along the lateral ridges; the apertures are biserial or rarely triserial, and there are usually from five to seven in each row. Obverse face of the zoarium concave. The spaces between the raised groups are marked by rows of small, round pores (cancelli) between horizontal ribs.

Distribution.—Upper Chalk: Beachy Head; Dover; Burham, Kent; Sussex. Middle Chalk (zone of *Micraster cortestudinarium*): Chatham; Rochester. Lower Chalk (zone of *Holaster planus*): Dover.

Desmepora reussi, n.sp.

Synonymy.—*Desmepora semicylindrica*, von Reuss, 1872. Bry. Unt. Pläner: Palæontogr., vol. xx, pt. i, p. 123, pl. xxx, figs. 6 and 7, *non* fig. 8.

Diagnosis.—The branches are large, thick, and irregular, and form a short, stout, bushy zoarium. The peristomal groups project as large, blunt knobs; they are usually elliptical or subcircular, and contain from thirty to fifty apertures. They are scattered irregularly over the stems, being sometimes in the middle of the stems. Surface ornamented with long ribs.

Distribution.—Cenomanian—Unter Pläner: Plauen, Saxony.

TREPOSTOMATA.

Reptomulticava, d'Orbigny, 1853.

Reptomulticava canui, nov. nom.

Synonymy.

Reptomulticava tuberosa, d'Orbigny, 1854. Bry. Crét., p. 1036, pl. 791, figs. 13, 14.

non Alveolites tuberosa, Römer, 1839. Verst. norddeut. Ool. Nachtrag, p. 14, pl. xvii, fig. 9.

Diagnosis.—Zoarium massive, tuberous, with small, irregular tuberosities on the upper surface. Zoœcia with circular or elliptical apertures, and walls varying in width from one-fifth to occasionally one-half the diameter of the apertures.

Distribution.—Neocomian: St. Dizier and Vassy, Haute Marne.

Reptomulticava fungiformis, n.sp.

Diagnosis.—Zoarium fungiform with broad, short stalk, which may be hidden by the overgrowth of the broad upper surface of the zoarium. The side looks ringed by the overlap of the expanding upper layers. Zoœcia small; the apertures in well-preserved specimens are circular. About twelve apertures per sq. mm.

Distribution.—Lower Greensand: Farringdon; Upware.

Defranciopora, Hamm, 1881.

Defranciopora libiformis, n.sp.

Diagnosis.—Zoarium of saucer-shaped or cup-shaped sub-colonies, with the base of one resting in the cavity of the sub-colony below. The rims are well rounded and wide. Apertures often in oblique series of three or four in a row, but in some parts of the zoarium the arrangement is irregular. The sides of the sub-colonies, except on the rim, are smooth and imperforate.

Distribution.—Senonian—Maastrichtian: Maastricht.

Ceriopora, Goldfuss, 1827.

Ceriopora farringdonensis, n.sp.

Diagnosis.—Zoarium nodular with tuberous upper surface, and may be sub-pedunculate below. The tubercles, which are sparse and low, pass into short, finger-shaped lobes. Surface smooth, but weathered specimens may look variolated owing to the formation of depressions. Surface, when well preserved, covered in places by a thin calcareous epizoarium, which closes most of the apertures. Zoœcia of above average size; from twelve to twenty apertures per sq. mm. Walls thick and distinctly moniliform in longitudinal section. Diameter of zoœcia about ·2 mm.

Distribution.—Lower Greensand: Farringdon, Berks.

Heteropora, de Blainville, 1830.

Heteropora keepingi, n.sp.

Synonymy.

Heteropora (*Multicrescis*) *michelini*, Keeping, 1883. Foss. Neoc. Upware, p. 141.
non Ceriopora michelini, d'Orbigny, 1850. Prod. Pal., vol. ii, p. 143.

Diagnosis.—Zoarium tufted, rising from a thick base, giving off above thick, finger-shaped, simple branches, or knobby branches, which may divide irregularly; branches end bluntly. Mesopores uniserial, or sometimes biserial.

Distribution. — England — Lower Greensand: Brickhill, Upware? (*fide* Keeping); Coxwell and Farringdon, Berkshire; ? Isle of Wight. Foreign—Albian: Grandpré, Ardennes.

Heteropora clavata, Kade, 1852.[1]

Synonymy.—*Heteropora clavata*, Kade, 1852. Los. Verst. Schanzenb., p. 32.

Diagnosis.—Zoarium clavate, of a short stem which expands regularly upward into a pear-shaped mass. Transverse section irregularly elliptical, flattened on the side. Most of the surface is smooth, but the type-specimen is irregularly pitted. Zoœcia large, irregularly scattered. Mesopores large, a circle of five to seven around each aperture; and the circles of mesopores are confluent, so that but one mesopore or line of mesopores occurs between adjacent zoœcia.

Distribution. — England — Lower Greensand: Farringdon (Workhouse Pit), Berkshire. Foreign—Remanié in Drift: Schanzenberg, near Meseritz.

Heteropora subæquiporosa,[2] n.sp.

Diagnosis.—Zoarium funnel-shaped, composed of a thick layer around a hollow axis. Surface pustular, with irregular, indefinite tubercles or knobs. Mesopores large; in single lines between the apertures, but not well marked off from the zoœcia.

Distribution.—Upper Greensand: Warminster.

Zonatula, Hamm, 1881.

Zonatula brydonei, n.sp.

Diagnosis.—Zoarium club-shaped, with a short, narrow stem and an egg-shaped head. The apertures of the zoœcia are circular or subcircular. They are divided into groups by alternate horizontal laminæ, which extend half-way across the apertures into alternate groups.

Distribution.—Lower Greensand: Farringdon, Berkshire.

Discocavea, d'Orbigny, 1853.

Discocavea reussi, n.sp.

Synonymy. — *Heteroporella collis* (*non* d'Orb.), von Reuss, 1872. Bry. unt. Quad. Elbthalg.: Palæontogr., vol. xx, pt. i, p. 133, pl. xxxiii, fig. 6.

Diagnosis.—Zoarium small, circular, convex, with a small central depression, on the floor of which are about fifteen apertures. Radial series of apertures numerous

[1] Kade's name is practically a list name, and the description is therefore included in this paper.

[2] Named from the comparatively slight difference in size between the zoœcia and mesopores.

and crowded, separated by only very narrow inter-radial furrows. About seven apertures in each ray. Apertures large.

Distribution. — Cenomanian—Lower Quader: Gamighügel, near Dresden; Kahlebusch, near Dohna, Saxony.

Discocavea longiradiata, n.sp.

Diagnosis.—Zoarium large, thin, circular. Zoœcia very numerous and apertures occurring in many (about forty) long rays, which each contain from about ten to sixteen apertures. No selvage. Inter-radii very narrow.

Distribution.—Lower Chalk: Southeram Pit, near Lewes.

Bimulticavea, d'Orbigny, 1853.

(Bry. Crét., p. 982.)

Bimulticavea simonowitschi, nov. nom.

Synonymy.

Ceriopora stellata, *pars*, Goldfuss, 1829. Petref. Germ., p. 85, pl. xxxi, fig. 1*c* (*non* figs. 1*a*, *b*).

Semimulticava goldfussi (*non* von Reuss, 1866), Simonowitsch, 1871. Bry. Essen Grüns.: Verh. nat. Ver. preuss. Rheinl., vol. xxviii, pp. 34–6, pl. i, figs. 3*a–d*.

Diagnosis.—Zoarium large, massive; Goldfuss' type is 45 mm. long by 18 mm. wide, with radial groups up to 6 mm. across. Each group has about eight spindle-shaped raised radial groups with biserial apertures.

Distribution.—Cenomanian—Grünsand: Essen.

Trochiliopora, nov. gen.

Diagnosis.—Radioporidæ with a simple top-shaped or capitate zoarium, composed of a constricted stem and expanded head. Apertures in vertical series on the margin of the head.

Type Species.—*Trochiliopora humei*, n.sp. Upper Chalk: Gravesend.

Trochiliopora humei, n.sp.

Diagnosis.—Zoarium fungiform, composed of a thick disc and stout, blunt stem. The diameter of the stem is nearly half that of the head. The lower end of the stem is longitudinally grooved, with linear pores. In the upper part of the stem the pores are irregularly arranged, and the intervening walls are reticular. Base of stem discoid. The upper surface of the disc is flat; its central portion is large, with numerous irregularly arranged apertures of young zoœcia. Margins vertical or well rounded, and marked by radial series of large apertures; there are three to four apertures in each series, and the series are separated by lines of cancelli.

Distribution. — Upper Chalk (zone of *Micraster coranguinum*): Gravesend.

Domopora, d'Orbigny, 1849.

Domopora colligata, n.sp.

Diagnosis.—Zoarium large and irregular; from the upper side it appears tubercular and massive. On a side view it is seen to be composed of numerous columns which are often attached, giving the zoarium a massive aspect like a *Radiopora*. The sub-colonies are distinct and thick. Apertures irregular in the centres of the sub-colonies, but become radial and vertical on the sides. In the lower sub-colonies the regular arrangement of the apertures is obscure, as most of the apertures in the vertical series are covered by the overgrowth of the upper sub-colony.

Distribution.—Lower Greensand: Farringdon, Berkshire.

Domopora vinei, n.sp.

SYNONYMY.
Domopora polytaxis?, *non* (Hag.), Vine, 1885. Cambr. Grnsd.: Proc. Yorks Geol. Soc., vol. ix, p. 21.
,, ,, ? ,, Vine, 1889. Further on Cambr. Grnsd., pt. ii: ibid., vol. xi, pt. ii, pp. 258, 270.
,, ,, ? ,, Vine, 1891. Rep. Cret. Polyz.: Rep. Brit. Assoc., 1890, p. 389.

Diagnosis.—Zoarium small, of two or more stems arising from a circular base. The stems are sharply divided by transverse annular constrictions into several segments, which decrease in diameter towards the blunt apex. Apertures in vertical series, containing from two to five in each series. The apertures in the series are in places well raised above the general surface of the stem. Mesopores scarce.

Distribution.—Cambridge Greensand: Cambridge.

Domopora virgulosa, nov. nom.

SYNONYMY.—*Ceriopora stellata*, *pars*, Goldfuss, 1829. Petref. Germ., p. 85, pl. xxx, fig. 12, *non* pp. 39 and 85, pl. xi, fig. 11; pl. xxxi, figs. 1*a–c*.

Diagnosis.—Zoarium sub-dendroid or tufted; it grows either in numerous short branches from a broad base, with the branches bifurcating occasionally, or as cylindrical branches, which may either give off above many sub-branches or expand distally into irregular lobes, or the main stem may expand into a thickened body giving off above small cylindrical stems. Sides marked by annular constrictions. The end consists of a group of crowded, irregularly arranged zoœcia, surrounded by the radial series, which pass into the vertical marginal series.

Distribution.—England—Upper Greensand: Warminster, and Chute Farm, near Warminster, Wilts. Zone of *Schlœnbachia rostrata*; the Cutting, Black Ven, Charmouth. Foreign—Cenomanian: Essen. Lower Quader: Plauen, Saxony.

Domopora novaki, n.sp.

Diagnosis.—Zoarium usually clavate, with a large lobed head and annular peduncle, tapering towards the base; but also found massive, with numerous stems rising from a broad encrusting base. Zoarium of many layers, up to about ten in number. Mesopores scarce, about as many or slightly more numerous than the zoœcia. Apertures, about six in each vertical series.

Distribution.—Cenomanian—Korycaner Schichten: Kamajk, Zbislav, Kolin, Kank, and Jiné, Bohemia.

Domopora cantiana, n.sp.

Diagnosis.—Zoarium small, of stems which are circular in section and marked by numerous horizontal annular constrictions. The upper segments gradually decrease in diameter, and the zoarium ends in a blunt point. Apertures in short vertical series, including from two to six apertures in a series. Mesopores scanty.

Distribution.—Upper Chalk (zone of *Micraster coranguinum*): Bromley, Kent. Middle Chalk (zone of *Micraster cortestudinarium*): Chatham.

IV.—CONTRIBUTION TO THE FAUNA OF THE CHALK ROCK.

By CHARLES P. CHATWIN & THOMAS H. WITHERS.

(PLATE II.)

ALTHOUGH small examples of Ammonites are fairly common in the Chalk Rock (Turonian) of this country, large examples are decidedly rare. The only species of Ammonites as yet recorded from this bed are *Prionocyclus neptuni*, Geinitz, sp., and *Pachydiscus peramplus*, Mantell, sp. The former species is always of a small size and is not at all common, but small examples of the latter species, averaging $1\frac{1}{2}$ inches in diameter, are often found, and one large example measuring 8 inches across has been recorded by Mr. H. Woods.[1]

We have lately collected in the Chalk Rock at the Waterworks Quarry, Marlow, Bucks, two completely septate portions of a fairly large Ammonite which cannot be referred to either of the above-mentioned species.

In 1878 Bayle[2] instituted the genus *Puzosia*, but he gave no diagnosis of the genus, and although he refers to it the three species *Puzosia latidorsata*, Michelin, sp., *P. mayoriana*, d'Orbigny, sp., and *P. planulata*, J. de C. Sowerby, sp., he does not fix on either as the type of his genus, a fact which has given rise to much misunderstanding and confusion. The question has been discussed in a work by Mr. G. C. Crick,[3] who gave a diagnosis of the genus *Puzosia*, which is quoted below, and which we here follow.

Our specimens agree well with this diagnosis, and are therefore referred to the genus *Puzosia*.

Genus PUZOSIA, Bayle.

"Shell more or less umbilicated, with whorls more or less elevated; ornamented with forwardly inclined ribs which are continued over the rounded ventral area but are absent near the umbilicus, also with several forwardly-bent usually rather strong constrictions or varices. Suture-line similar to that of *Desmoceras* but more reduced; first lateral lobe longer than the ventral lobe, lobes trifid and relatively a little narrower than in *Desmoceras*, saddles almost alike, divided by a rather deep lobule into two parts, each of which is subdivided as in *Desmoceras*, several auxiliary lobes present, umbilical portion of suture-line dependent."[4]

The two specimens to be described are closely allied to the group of *Puzosia planulata*, J. de C. Sowerby, sp.,[5] the affinities of which are fully discussed by F. Kossmat.[6] He considers *P. planulata* as characteristic of the Cenomanian, from which horizon Sowerby's type from Hamsey in Sussex came. He, however, does not incline to the opinion that it has an extensive vertical range, and considers that the forms from the higher horizons belong not to the same but to allied species.

Our two specimens come from a much higher horizon than Sowerby's type, and although they are closely allied to *Puzosia planulata*, differ in some respects from that species. We therefore propose for these specimens, which in all probability belong to the same individual, the name of *Puzosia curvatisulcata*.

[1] H. Woods, "Mollusca of the Chalk Rock": Quart. Journ. Geol. Soc., 1896, vol. lii, p. 80.

[2] E. Bayle, "Explication de la carte géologique de la France," 1878, iv, Atlas, pls. xlv, xlvi.

[3] G. C. Crick, "Cretaceous Fossils of Natal.—I. The Cephalopoda from the Deposit at the North End of False Bay, Zululand": Third and Final Report Geol. Surv. of Natal and Zululand, 1907, pp. 209, 213.

[4] "That is, directed backwards, the lobes pointing across the whorl."

[5] J. de C. Sowerby, Min. Conch., 1827, vi, p. 136, pl. DLXX, fig. 5.

[6] F. Kossmat, "Untersuchungen über die Südindische Kreideformation": Beitr. zur Pal. und Geol. Österr.-Ungarns und des Orients, 1898, Bd. xi, Heft iii, p. 112.

Puzosia curvatisulcata, sp. nov. (Plate II, Figs. 1–4.)

Description.—Whorl very slowly increasing, laterally-compressed oval in transverse section, width three-quarters the height, indented to about a quarter of its height by preceding whorl, inner half of sides somewhat flattened, the outer half sloping gradually towards the periphery, periphery broadly convex, umbilical margin not very clearly defined, umbilical zone feebly convex, steeply inclined towards the umbilicus. There are no indications of the test, but on the anterior portion of the larger specimen (Fig. 1) are seen distinct indications of broad, feebly-convex ribs which are disposed in a forwardly-directed curve and which seem to disappear at about the middle of the sides. On both pieces a pronounced constriction is seen, being deeply, but not sharply, incised at the umbilical margin, whence it extends radially to about the middle of the side, where it becomes more shallow and assumes a forwardly-directed curve towards and over the periphery. The suture-line is well seen in the smaller specimen (Fig. 3), and is reproduced in Fig. 4. In the larger specimen only part of the external saddle, the first lateral saddle, and the intervening first lateral lobe are seen.

Dimensions.—Larger fragment is 64 mm. in length measured along the centre of the periphery. Height of whorl 55 mm. Height above preceding whorl 42 mm.; thickness 43 mm. Smaller fragment 46 mm. in length measured along the centre of the periphery. Height of whorl 36 mm. Height above preceding whorl 28 mm.; thickness 29 mm.

Affinities.—The species differs from *Puzosia planulata* in the curvature of the constrictions not being sigmoidal, and in the less prominent and more distantly disposed ribs. The flattening of the sides of the whorls in *P. planulata* extends nearer the periphery than in this species, and the slope of the umbilical zone is more steep.

In the Cretaceous of India several species of *Puzosia* occur, and Stoliczka [1] has recognized two varieties of *P. planulata*—(1) a strongly compressed form with fine ribs, (2) a thicker sub-species with stronger and less numerous ribs. Our specimens come nearer the former, which was separated by F. Kossmat [2] and referred to *P. gaudama*, Forbes, which is the only species found as high up as the Turonian. Compared with *P. gaudama*, the whorls in our specimens are much stouter and much more rounded on the periphery. The ribs are farther apart and less forwardly directed, while the constrictions assume a forwardly directed curve much nearer the umbilical zone.

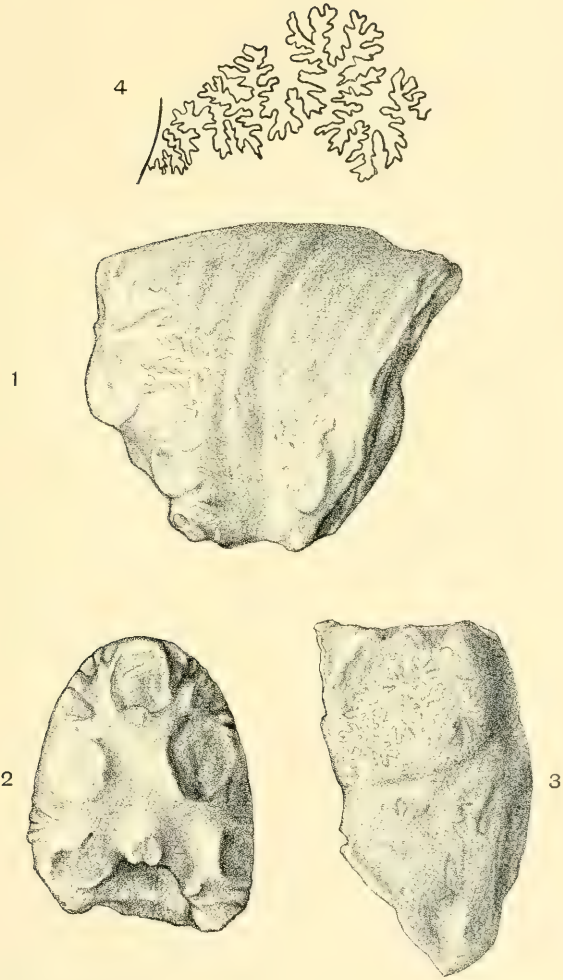
Our best thanks are due to Mr. G. C. Crick for the advice which he has kindly given us in the preparation of this paper.

EXPLANATION OF PLATE II.

Puzosia curvatisulcata, sp. nov.

Fig. 1.—Part of a whorl, showing constriction and faint ribbing.
,, 2.—End view of same.
,, 3.—Part of a smaller whorl, showing constriction.
(These figures are $\frac{2}{3}$ natural size.)
,, 4.—Suture-line (natural size) traced from the original specimen.
Horizon.—Turonian—zone of *Holaster planus*: Waterworks Quarry, Marlow, Bucks.

[1] F. Stoliczka, *Cretaceous Fauna of Southern India* (Pal. Indica), 1865, vol. i, p. 134.
[2] F. Kossmat, op. cit., p. 116.



G. M. Woodward del.

Puzosia curvatisulcata, sp. nov. Turonian—zone of *Holaster planus*: Waterworks Quarry, Marlow, Bucks. Figs. 1–3, $\frac{2}{3}$ nat. size. Fig. 4, suture-line, drawn nat. size.

V.—Notes on *Phacops Weaveri*, Salter.

By F. R. Cowper Reed, M.A., F.G.S., Sedgwick Museum, Cambridge.

A RE-EXAMINATION of the type-specimens of *Phacops Weaveri*, Salter,[1] in the Museum of Practical Geology, Jermyn Street, was recently rendered necessary in connection with my palæontological work on the Tortworth Silurian area, the results of which have been published in the November number of the Quarterly Journal of the Geological Society, 1908 (vol. lxiv, pp. 512–545), in a joint paper by Professor S. H. Reynolds and myself. A question had arisen in the course of our work as to the occurrence of this species above the Llandovery Beds, for Salter had stated that some of his figured specimens of pygidia (Mon. Brit. Trilob., pl. iii, figs. 2, 3) came from doubtful Ludlow rocks at Horse-shoe Farm, Tortworth. The species had, however, been founded by him previously on specimens from so-called 'Caradoc' [= Llandovery] rocks from Long's Quarry, Tortworth,[2] and an outline figure of the pygidium, apparently a restoration based on the three specimens in Jermyn Street (Nos. 19220, 19221, 19222), had then been given. Subsequently a head-shield from the same quarry was figured in his monograph (pl. iii, fig. 1). It is clear that Salter based the species mainly on the pygidial characters, for the head-shield is dismissed with a few inadequate remarks, its resemblance to *Ph. caudatus* being considered to be very close. The original description given by Salter in 1849 runs as follows:—"P. laevis, capite quam in *P. caudato*, nisi lobis glabellae tumidioribus;—caudâ triangulari, ferè aequilatera, convexa, apice acuto haud mucronato, axi 13–16 annulato, costis lateralibus 10–12, simplicibus, vix curvatis, ad marginem aequalem angustum abruptè terminatis." In the diagrammatic figure of the pygidium which accompanied this description only 12 or 13 rings are indicated on the axis and 10 or 11 ribs on the lateral lobes, which might incline us to think that an immature individual was chosen for the figure, since Salter in his remarks on the species says (op. cit.) that "young specimens have not the full number of ribs", but no mention that this is the case is found in the explanation of the plate. In Salter's subsequent work (Mon. Brit. Trilob., p. 58) the tail is described as "broad-triangular, wider than long; the sides a little convex; the apex short-mucronate; the axis narrow, conical, ribbed by about sixteen rings; the sides very convex with *nine to ten* arched simple ribs scarcely at all interlined; the margin [=border] narrow, smooth". The italics in this quotation are mine, as the number of ribs is fewer than that given in his earlier definition of the species. It may here be remarked that Salter in his monograph reproduces verbatim the definition of the species published in the decades, with the addition of the word *trigono* with reference to the head before the word *nisi*, and with the insertion of the epithet *multicostata* after the word *æquilatera* in the description of the pygidium.

[1] Salter, Mem. Geol. Surv., 1849, dec. II, art. 1, p. 7, pl. i, fig. 16; Mon. Brit. Trilob., 1864, p. 57, pl. iii, figs. 1–3; pl. iv, figs. 6–9.

[2] The site of this quarry in the Llandovery rocks has been fixed with much probability by Professor Reynolds (op. cit., p. 514).

Salter at this time admitted that his knowledge of this species was but slight, and though he believed that all the specimens which he figured belonged to one species, yet expressly stated that he "would prefer to keep the name for the fossil of the May Hill Sandstone". Moreover, as the specimens from the doubtful Ludlow rocks of Horse-shoe Farm, figured in his monograph on pl. iii, figs. 2, 3, were attributed by him to a "larger form of the species", it is clear that Salter's intention was to regard the specimens from Long's Quarry (of May Hill Sandstone age) as the typical form. Accordingly, it is on the characters of these latter that the species must rest.

The pygidium is figured in the decade ii, pl. i, fig. 16, somewhat incorrectly and diagrammatically as above mentioned, but only one (No. 19221) of the three specimens in Jermyn Street seems to have been used in the much more accurate figure given in his monograph, pl. iv, fig. 7. The head-shields from the same horizon were illustrated by two figures in the monograph on pl. iii, fig. 1, and pl. iv, fig. 6.

Of the three examples of the pygidium two are internal casts (Nos. 19221, 19222) and the other (No. 19220) an external impression. The shape of these pygidia is parabolic; the length of the type (No. 19221) is about 11 mm. (but the posterior margin is rather imperfect) and its width 14–15 mm.; the length of its axis is about 10 mm. and its width at its front end 5 mm., and it tapers regularly at about 20°–25° to its bluntly pointed extremity. Though the posterior margin is not clearly preserved in this specimen, so that its mucronate or non-mucronate character cannot be decided, yet in the external impression (No. 19220) from Long's Quarry, and especially in another specimen in the Wyatt-Edgell Collection from Tortworth in precisely the same rock, it is found to be not acutely pointed nor mucronate, but obtuse and rounded, as indeed Salter rightly shows in his figure (pl. iv, fig. 7). With regard to the axis in specimen No. 19221, only the anterior two-thirds or three-fourths are distinctly annulated, being composed of 8 complete rings, but the posterior part (which is, however, somewhat abraded) shows 5–6 faint incomplete rings. In the external impression (No. 19220) 14–15 rings can be counted on the axis, but the last 3 or 4 are indistinct. The total number of axial rings, therefore, is 13–15.

The lateral lobes are gently convex, as Salter mentions, but possess only *eight* ribs. Salter's figure (Mon., pl. iv, fig. 7) shows only this number in spite of the greater number given in the description. These ribs are gently and regularly curved, and successively decrease posteriorly in length and strength, the last pair being very short and nearly parallel. All the ribs seem marked with a very faint, fine, submedian line for about three-fourths of their length, and this feature is especially well seen in the external impressions. In the internal casts the ribs are separated by interspaces (interpleural furrows) as wide as the ribs themselves, but in the external impressions it is seen that these interpleural furrows are really quite narrow. The ribs and furrows end abruptly against the border, which is smooth and narrow, but definite; and in the best preserved examples it is clear that it does not appreciably widen behind and that it is not furnished with a mucro. The eight ribs of the lateral lobes correspond with the first 8 rings of the axis, the posterior annulations of the latter thus having no corresponding ribs.

The head-shield from Long's Quarry (No. 19223 in the Jermyn Street Museum) which Salter figured in his monograph on pl. iii, fig. 1, is imperfect on the left side. Its length is about 14 mm., of which the frontal lobe of the glabella accounts for 8 mm.; this lobe is 12 mm. in width and projects a little laterally, and has a well-marked elongated pit in the median line, as Salter represented in his figure but did not mention. The first lateral lobe has a somewhat greater length along the axial furrow than Salter's figure shows. The second and third lateral lobes are of equal size. The first lateral furrow runs inward at about 50°–60°, and the second and third lateral furrows, which are parallel to each other, at about 70°–75° to the axial furrows. The eye-lobes are rather larger and longer and the eyes rather less curved and rather nearer the glabella than in typical examples of *Ph. caudatus*, but except in these details there does not appear to exist any marked difference.

With regard to the pygidia, which Salter described and figured (Mon., p. 58, pl. iii, figs. 2, 3) as the "larger form of the species", from the so-called Ludlow rocks of Horse-shoe Farm, Tortworth,[1] we may note several important points of difference from those just discussed. Both are preserved in the same matrix and are considerably larger than the others; one of them (op. cit., fig. 2), though imperfect, possesses a length of about 25 mm., and is estimated to have had a length originally of 38–40 mm. with a rather less width; the other (op. cit., fig. 3), which is also broken, now measures 35 mm., but when perfect its length must have been at least 50 mm. Moreover, from the contour of the margin near the posterior extremity of each specimen there is every indication that the border was produced behind into a mucro, though the length of the latter cannot be determined.

From the specimen represented in Salter's fig. 2 the shell is missing, except near the right margin, where its surface is seen to be minutely and regularly granulated. This is not shown in the figure or mentioned in the text. Only the right half of the pygidium is present; the axis tapers very gradually so far as can be seen, and shows 15 distinctly marked rings with traces of a 16th, followed by a non-annulated piece extending to the tip of the axis, and equal in length to about the last four rings. The transverse furrows between the rings are weak in the centre but deeply impressed at the sides. There are 13 ribs on the lateral lobe, counting the anterior marginal one, and the first 11 ribs correspond with axial rings; the ribs are gently curved back and are somewhat flattened on the surface, and are rather broader than the wide interspaces or furrows between them. The anterior face of each rib is obliquely bevelled, but the posterior face is nearly vertical. The 2nd to 4th ribs have a very faint median impressed line traceable along three-fourths of their length. The last lateral rib is very short and weak, and lies nearly parallel to the axis.

[1] Reed & Reynolds, op. cit., p. 524.

In the case of the second figured example (fig. 3) from Horse-shoe Farm, Salter's figure does not correctly represent nor do justice to it. The shell is missing from the whole specimen. The axis is very long and narrow, tapering very gradually, but owing to the loss by fracture of a part of its anterior end, its length cannot be measured accurately, and its left side also is hidden in matrix. The first two rings, corresponding to the first (marginal) and second ribs of the lateral lobe, are broken off, but there are 13 rings behind and traces of a fourteenth, making 15 or 16 in all. There are 11 ribs preserved on the lateral lobes, and these ribs are not sickle-shaped as Salter's figure represents, but are simply and gently curved back; the first 10 correspond with axial rings, the 11th starting apparently from the level of the 14th axial ring. That there were more ribs behind is probable but uncertain, as this posterior portion of the pygidium is imperfect. The interspaces or furrows between the ribs are rather wider than in the other specimen, and each furrow expands somewhat at its outer end into a blunt, rounded termination, but does not thin out as Salter's figure incorrectly shows. Near the outer ends of the 2nd to 9th ribs there is a trace of a faint median impressed line, but this "interlineation" does not show so plainly or extend so far as Salter indicates. The border of the pygidium is very slightly swollen, but not raised above the general level of the ribs, which pass into it without any demarcation. The width of the lateral lobe preserved is 21 mm.; the outer half is gently arched down, but the inner portion is flattened and nearly horizontal.

These two specimens may be referred to one and the same species; but this species must be considered distinct from the other form which occurs in the Llandovery of Long's Quarry. They are both separable from *Ph. caudatus*, as Salter pointed out (Dec. ii, art. 1, p. 7), by the more numerous ribs (*Ph. caudatus* having only 6–8) and by the ribs not being duplicate. Salter, moreover, remarks that the fact that "the margin is equal all round and not expanded or mucronate at the end" is another point of difference from *Ph. caudatus*, but this non-mucronate character is only found apparently in the Long's Quarry figured specimens, as we have seen that there is reason to believe that the Horse-shoe Farm "larger form" was furnished with a mucro. Indeed, from his attempt to combine in his definition the characters of these two types of pygidia it results that Salter's description is strictly applicable to neither in every detail, and confusion has thus ensued.

The differences between the typical Llandovery form of Long's Quarry and the Ludlow (?) larger form of Horse-shoe Farm are that the pygidium of the latter is relatively more elongate and pointed, the posterior end is probably mucronate, the axis tapers more gradually and has more numerous annulations, and the lateral lobes are flatter and have more numerous (11–13) ribs upon them. It scarcely seems possible to regard these differences as of less than specific value, and the name *Ph. Weaveri* must be restricted to those specimens agreeing with the type from the Llandovery of Long's Quarry.

In his monograph (pl. iv, figs. 8, 9) Salter attributes to *Ph. Weaveri* certain specimens from Marloes Bay. They are in a completely different state of preservation to those from the Tortworth district and are somewhat crushed, distorted, and imperfect, so that their identity with *Ph. Weaveri* must be regarded as doubtful. The larger specimen of the pygidium (op. cit., fig. 8) shows 10 complete and distinct rings on the axis followed by 4 or 5 small and very weak rings; the lateral lobes possess 9 distinct ribs, of which the first 8 correspond with axial rings; the margin is not preserved and the border is broken. The smaller specimen (fig. 9), except for the presence of a short mucronate extremity, has practically all the characters of the Tortworth typical form. Probably these Marloes Bay specimens may be regarded as a local variety, but the material is too indifferent and scanty for the satisfactory decision of this point.

From the above detailed re-examination of all Salter's figured specimens which he referred to one species, *Ph. Weaveri*, we find that his definition of this species requires emendation, and though we cannot give a precise and full description of the head-shield, yet with regard to the pygidium on which the species was founded the following summary of its characters may be substituted:—Shape parabolic, wider than long, rounded behind, not mucronate; border smooth, of subequal width all round, not produced into a point. Axis conical, tapering regularly at about 20°–25° to obtuse tip, annulated for whole length, with 8 complete strong rings corresponding to the ribs, followed by 4–7 much narrower weaker rings. Lateral lobes gently convex and arched down, composed of 8 slightly curved ribs, successively decreasing in size posteriorly and the last pair subparallel, marked by fine submedian furrow for greater part of length, separated by narrow interpleural furrows, ribs and furrows ending abruptly inside border. (Figured by Salter, Mon. Brit. Trilob., pl. iv, fig. 7.)

This is the common species of *Phacops* in the Llandovery rocks of the Tortworth area. I have examined a large series of specimens collected by Professor S. H. Reynolds from the Llandovery Beds of this area in the course of his stratigraphical work, and they are all of the type of *Phacops Weaveri* as here defined. Excellent pygidia from Damery Bridge, Daniel's Wood, and the site of Long's Quarry agree precisely with those from Long's Quarry used by Salter in drawing up his inaccurate diagnosis, and with the specimen accurately figured in his monograph (pl. iv, fig. 7). There is, therefore, not the least doubt now as to the true characters of the pygidium, and it has been above shown that it is on this member of the body that the species rests. The new and emended definition which I have here given must accordingly be in future regarded as expressing the specific characters of *Ph. Weaveri*. As regards its systematic position, it must be placed in the subgenus or section *Dalmanitina* proposed by the author in 1905[1] for certain members of the genus *Dalmanites*, if we separate the latter generically from *Phacops*, as seems justifiable and natural, though this practice has been rarely adopted by European palæontologists.

[1] Reed, Geol. Mag., Dec. V, Vol. II, 1905, pp. 172–178, 224–228.

VI.—Notes on the Graptolite-bearing Rocks of New Zealand.[1]

By E. Douglass Isaacson, F.G.S.

THE series of beds containing graptolites in New Zealand occur in the Whakamarama district, which is situated in almost the extreme north-west of the South Island. They consist of intercalated bands of quartzite and carbonaceous argillites, with a north and south strike and dipping at a low angle to the west. As a result of the natural erosion of the land surface taking place more rapidly in the slaty layers than in the harder quartzites, the ridges and stream valleys exhibit a noticeable parallelism, those streams which enter the sea on the western coast usually taking a very sharp bend to the west, and with a somewhat gorgy channel to the sea. The valleys are for the most part densely clothed with forest trees, while the ridges of quartzite are barren, with the exception of a stunted growth of *manuka* (*Leptospermum scoparium* and *L. ericoides*), and in places a covering of peat to a depth of a few inches.

The deposition of the sediments has been characterized by somewhat sharp changes, due no doubt to the alternate elevations and depressions of the ocean bed, which appear to have succeeded each other somewhat rapidly about this period. Neither the beds of quartzite nor the argillites are of any great thickness, and have an approximately equal development.

In the argillites fossils have hitherto been found only in the neighbourhood of the auriferous reefs of the Golden Ridge, Whakamarama, and are restricted to a band of carbonaceous argillite which constitutes the walls of the reef in this locality. As at Bendigo, Victoria, the graptolite beds are in intimate association with the auriferous reefs, and, moreover, the prospecting for fresh reefs in this locality seems to point to the fact that their intimate association is necessary for a payable reef to be discovered. The argillite bed is some hundred feet thick, and includes a band more highly graphitic than the remainder from which the fossils are obtained. Owing to the inaccessibility of the country and the absence of outcrops, the fossiliferous beds have not yet been by any means fully investigated, and it is highly probable that further work may yet lead to important discoveries. The argillites have a somewhat schistose appearance from the parallel plates of graphite, the other component being fine silica in a cement medium.

Though not hitherto discovered *in situ*, an interesting rock-specimen obtained in this locality by the author was a spotted slate, which under the microscope was observed to contain excellent crystals of chiastolite with carbon inclusions arranged in a cruciform manner. This rock probably was a result of thermal metamorphism, caused by the intrusion of a granite boss to the southward, and is a rare instance of this change in the country. The quartzites, variously also termed chert and grauwacke by different authors, consist almost entirely of a mosaic of subangular quartz-grains. As mentioned above, the graptolites have up to the present only been

[1] See paper by Mrs. E. M. R. Shakespear, D.Sc., "On some New Zealand Graptolites," Geol. Mag., Dec. V, Vol. V, April, 1908, pp. 145–8.

obtained from Slaty Creek and its branches, where they occur in a carbonaceous argillite, the outcrop bending round on itself in a horse-shoe form of which the longer or westerly limb has hitherto been unexplored. Nor have any fossils been as yet obtained from the extreme southward extension of this limb. In some parts the replacement of the chitin of the fossils by pyrite is somewhat common, rendering the structure obscure.

Dr. Bell[1] evidently considers that the New Zealand graptolites occur at one horizon, which view, however, is not upheld by Dr. Shakespear (loc. cit., 1908), who points out that there are two zones which are both lithologically and palæontologically distinct. The specimens examined by Dr. Shakespear were obtained from three points extending along a valley for some half-mile. The most southerly of these supplied only the coarse-grained argillite called the *a* type, while the other two localities supplied both types *a* and *b*. In this half-mile or so of valley the dip of the stratum changes considerably, being some 60° at the southern locality to 30° at the northern, the bed becoming almost flat as the summit of the syncline is reached.

The fossiliferous bed is itself but a few inches thick, and is characterised by being more graphitic than the accompanying slate; and though the bed cannot be traced from one fossiliferous locality to another, yet considering together the change in the strike and the elevation of the places above the level of the creek, the weight of evidence seems to point to the bed being continuous from one place to another, and that only the one bed is present.

Again, since both types are present in a band but a few inches thick, and if each type is considered representative of a different zone, then between the period of each zone the deposition of the sediments has been almost, if not altogether, suspended. Of this there is a total lack of local evidence.

It seems highly probable, then, that the horizons have succeeded each other so rapidly that the remains of the two are almost in juxtaposition.

VII.—The Mechanics of Overthrusts.

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

Mr. OSMOND FISHER, in an article in the January number of this Magazine, entitled "Convection Currents in the Earth's Interior", speaks of my views in a way that may give a false conception of what they are on the subject of overthrusts. He appears (inadvertently, no doubt) to credit me with a disbelief in the thrust-planes occurring in the North-West Highlands. I may say at once that I am one of those who admire the way in which a band of enthusiastic geologists have worked out the structure of this most difficult tract of country, and thoroughly believe in the correctness of their conclusions.[2] The principal object of my little paper in the

[1] Bull. N.Z. Geol. Survey, 1907, No. 3.

[2] Memoirs of Geological Survey of Great Britain: "The Geological Structure of the North-West Highlands."

November number of this Magazine (1908) was to caution geologists not to push their new-born views too far in trying to account for structural difficulties by overthrusts. It must be remembered that the Moine thrust-plane has been proved to no more than 10 miles overlap, but may, of course, be much more. Incidentally, I thought the paper likely to elicit a correspondence helping the interpretation of the phenomena of overthrusts.

Perhaps the following considerations may be helpful to those geologists interested in the subject.

It may be contended that the Alps, having been compressed, according to Heim, 78 miles, have been moved that distance over the underlying rocks, and that therefore the power exerted to obtain that effect is even greater than is required to create a thrust-plane such as I have postulated, viz. 100 × 100 miles. Mountain building, I contend, is not a parallel phenomenon, the building going on in sections, and the mountain range being as it were modelled by the pressure applied at different times in different localities, not by one general movement. Internal variable strains are continually taking place, and it is to these that the mobility seen in mountain structure is due. The very name 'building' is suggestive of the process of addition, or brick on brick erection, Nature being both architect and builder. It may be seen from this that the repeated pressures applied in sections may have a general cumulative effect and constitute yet another of those examples so often seen in nature where enormous results arise from the repeated application of small forces. If it could be demonstrated how fracture could have arisen by the cumulative effect of small agencies, it would bring us nearer to belief in the theory that transference of enormous masses of rock has been effected by overthrusts.

Mr. Fisher has ably restated his well-known theory of convection currents in the earth's interior. It seems, however, to me to be one unlikely to provide the lateral pressure in the form and amount wanted to create a thrust-plane.

REVIEWS.

I.—Monograph on the Higher Crustacea of the Carboniferous Rocks of Scotland. By B. N. Peach, LL.D., F.R.S., A.R.S.M. Memoirs of the Geological Survey of Great Britain: Palæontology. 4to; pp. 82, 12 pls. 1908.

THERE is perhaps no group of fossil Crustacea of which the study promises more important results for morphology and phylogeny than does that of the primitive Malacostraca of the later Palæozoic periods. There is reason to hope that it may yet be possible to trace among them the differentiation of some of the existing orders from the common stock of the Malacostraca. Dr. B. N. Peach published important memoirs on the higher Crustacea of the Scottish Carboniferous rocks nearly thirty years ago,[1] and since his retirement from the service

[1] See B. N. Peach, Trans. Roy. Soc. Edinb., 1882 & 1883, vol. xxx, etc.

of the Geological Survey, in 1905, he has resumed his study of the subject, and has set forth the results in the elaborate monograph now before us. It is based on the examination of upwards of 2,000 specimens, some of which are in an exceptionally fine state of preservation, so that Dr. Peach has been able to recognize and describe structures so delicate as the gills, and even, he believes, the phosphorescent organs (photospheres) of certain species. Those who have puzzled over the almost indecipherable fragments by which these Crustacea are usually represented in the rocks will appreciate to the full the patience and skill which Dr. Peach has devoted to their interpretation, and will hesitate before they venture to dissent from his conclusions. After due hesitation, however, some dissent must be expressed.

Forty-two species and varieties are described, of which twenty-three are new, and they are referred to nine genera, of which four are here established for the first time. Among the new genera the most important perhaps is *Tealliocaris*, of which the abundant and wonderfully well-preserved material has enabled Dr. Peach to give a very detailed account.

Dr. Peach concludes that all the forms with which he deals are to be referred to the 'Schizopoda', and not, as had been supposed in the case of some of them, to the Decapoda. In doing so he makes no reference to the more recent views on the classification of the Malacostracous Crustacea, which are based on the work of Boas, Hansen, and others. According to these authorities the 'Schizopoda' form a heterogeneous and unnatural group, comprising the more primitive members of at least three widely divergent branches of the Malacostracan stock. It is quite probable that these branches were much less sharply differentiated in the Carboniferous period than they are now, and the retention of the name 'Schizopoda' as a convenient term for the unspecialized ancestral forms which cannot be included in any of the orders of living Malacostraca may perhaps be defended; but it seems to us that a consideration of the results of recent work on this question suggests caution in accepting many of Dr. Peach's conclusions. On one point at least there can hardly be any dispute; the characters assigned to several of the fossils make it quite impossible to refer them, as Dr. Peach does, to the *families* of existing Crustacea. Thus, for example, the genera *Anthracophausia* and *Crangopsis* are described as having the carapace loosely enveloping the thorax but not coalescing with more than one or two of the anterior somites on the dorsal side; yet these genera are referred to the Euphausiidæ, in all the living forms of which, as in the Decapoda, the carapace coalesces with the terga of all the thoracic somites. Ortmann has already drawn attention to this character in *Crangopsis*, and suggested that the genus should be referred to the Mysidacea, or rather should be regarded as intermediate between the existing members of that order and the more primitive Malacostraca. If Dr. Peach's identification of the male sexual appendages on the first pleopods be correct, *Crangopsis* would seem to combine characters of both the Peracaridan and Eucaridan divisions of the Malacostraca, and must be excluded from all the existing orders. It is by no means clear, however, that all the species of *Crangopsis* described in this monograph are congeneric. In certain of the fossils it is plainly seen that the pleural plates of the second abdominal somite are expanded to overlap the plates in front and behind. Now the only Crustacea which exhibit this character are the members of the tribe Caridea among the Decapoda; and while it would be rash to assert, without examination of the specimens, that these are really Caridean Decapods (not hitherto identified earlier than the Upper Jurassic), the character deserves more consideration than it has received.

Space does not permit of further discussion of the numerous points of interest contained in this very important memoir. It deserves careful study not only by palæontologists but also by students of the phylogeny and classification of recent Crustacea, and the veteran palæontologist of the Scottish Survey is to be congratulated on its production.

The way in which this memoir is issued shows little regard for the convenience of bibliographers. It has no number to correlate it with other Memoirs of the Geological Survey, past or future; it has no index; and the plates bear no legend to indicate their place of origin.

W. T. Calman.

II.—Palæozoic Strata of Charkow, Russia.

Das Palaeozoicum im Isjumer Kreise des Governements Charkow. [The Palæozoic Strata of the Isjumer District in the Province of Charkow, Russia.] By N. Yakowlew. Mém. du com. géolog., St. Pétersbourg, 1908 (pp. 1–29).

THE researches of W. Nalivkin and A. Borissiak dealt with the Palæozoic of the Isjumer district as an undivided whole. The present work attempts a subdivision of the Palæozoic of that neighbourhood, and deals especially with the salt-bearing deposits. The Upper Palæozoic strata belong to the highest beds of the Donjetz Palæozoic, and are divisible from above downwards into the following:

1. Salt-bearing group, with the salt deposits of Slawjansk, Bachmut, etc.
2. Dolomite group, with clays, dolomite, limestone, and gypsum.
3. Group of sandstones (occasionally containing copper) and "Schiefer-Kupfersandstein-Complex [Group]".
4. Araucariten group, sandstones and slates with intercalated grey, clayey, and unfossiliferous limestones.
5. Unproductive Carboniferous.
6. Productive Carboniferous, the top beds only being probably exposed.

Beds 1 to 4 are placed in the Permo-Carboniferous, while 5 and 6 are included in the Upper Carboniferous. The author differs from the previous investigators in some of the explanations offered for the tectonic features. The theory given for the formation of the rock-salt deposits in a narrow arm of the sea corresponds to that put forward by Ochsenius. An explanatory map of the locality accompanies the paper.

I. T.

III.—Geology of Egypt.

IN an essay on "The South-western Desert of Egypt", published in the *Cairo Scientific Journal* (vol. ii, August and September, 1908), Dr. W. F. Hume gives some account of the progress of the Geological Survey of Egypt since its establishment in October, 1896, and of the problems that remain to be solved. Already it has been possible to prepare a general geological map of the country, despite the fact that there have never been more than five workers in any one year, and that in many cases they have had to construct their own topographic maps. Naturally there is much yet to be done before even the general picture of the geology can be satisfactorily completed.

Among areas at present unsurveyed in detail is the great South-western Desert, beyond Dush in the Kharga Oasis, and in the present essay Dr. Hume gives the results of an expedition undertaken with the object of ascertaining the nature and trend of the rocks, the movements by which they have been affected, and their economic resources.

The Fundamental Strata comprise granites seamed by dykes of dolerite and felsite, gneisses, and schists, and these are overlaid by thick beds of Nubian Sandstone, which contain materials derived from the destruction of the older crystalline rocks, in the shape of coarse pebbles of quartz and felspar in the lower portions and white sands in the upper. The still newer strata comprise the Campanian and Danian of the Upper Cretaceous and the Libyan Beds of the Lower Eocene, the succession agreeing with that observed elsewhere in Egypt.

Attention is drawn to evidence of considerable movements resulting in almost symmetrical oval basins or centroclinal folds. The Fundamental Strata which are at or very near the surface "have very definite relationships, both to the centroclinal basins of the sedimentary strata and to the bends in the cliff-wall of the plateau, these all lying along definite lines, trending east and west". Thus "it will be noted that the rectangular bends of the plateau, the granitic masses, and the centroclinal basins of Eocene and Cretaceous rocks tend to fall in definite lines, the granitic masses surrounded by the dipping sandstone being the domes, and the Eocene-Cretaceous exposures being the basins due to the double movement".

Referring to these movements of upheaval, Dr. Hume remarks that "when such folds take place the convex portions or anticlines first become subject to erosion by the sea as they tend to rise above the waves, the elevation and denudation being probably simultaneous". In this way the origin of the depressions through subsequent erosion of the softer strata, and their influence on the formation of oases, are discussed. The smaller oases occur, in the main, at the junction of the hard and practically impermeable limestone of the Campanian with the white limestone of the Danian; while the greater oases are found in the underlying Nubian Sandstone, the water being upheld by clayey layers which are intercalated in the strata.

IV.—The Geology and Scenery of the Grampians and the Valley of Strathmore. By Peter Macnair, F.R.S.E., F.G.S., Curator of the Natural History Collections in the Glasgow Museums, etc. 2 vols. pp. xiv + 195 and xii + 199, with 163 plates and 10 folded and coloured maps and diagrams. 8vo. James MacLehose & Sons, Glasgow.

(*Concluded from January Number, p. 35.*)

IN the fifth chapter, on the schistose igneous rocks, the sill-like forms of basic rock, which occur amongst the schists of sedimentary origin, are dealt with first. There is much reference to ancient views on the origin of these rocks, but the author fails to give a satisfactory account of their present structure, of the changes that they are thought to have gone through, or of their original constitution. The account of the general distribution of the sills is apparently taken from the publications of the Geological Survey, and Cunningham-Craig's description of the sill on Ben Vrackie is wrongly ascribed to Barrow. The description of the so-called 'older' granite of Ben Vuroch and of neighbouring masses is apparently drawn from the same source.

Chapter vi is devoted to a discussion of the structure of the southern Grampians. The author adopts the well-known theory of mountain building, which assumes a sinking geosynclinal area in which a thick mass of sediments is deposited. Through tangential earth-pressure the sediments are converted into a geanticlinal, compressed further and ultimately rucked up into a series of isoclinal folds, arranged in anticlinoria and synclinoria.

Applying this theory to the Highlands, the author finds that the main axis of upheaval of the range passes through the Ben Lawers ridge, and can be traced in a south-westerly direction into the district of Loch Awe. Along this line the axial planes of the folds are vertical, and on each side of it they dip in towards it. The dip of the limbs of the folds decreases as one recedes from the central line. It is noticeable that in this 'fan' the youngest beds lie in the central line, where, according to the theoretical 'fan,' the oldest beds should crop out.

The author describes in some detail numerous sections taken from the central 'fan' right across country to the southern border of the Highlands. These are thought to prove the existence of another great 'fan' named the "marginal *fächer*." A part only of this fan is preserved to us along the Firth of Clyde, since the Highland boundary fault runs obliquely across its northern limb and cuts it out completely in Perthshire. The axis of the intervening synclinorium is described as running up through Cowal, and after bending sharply eastward is thought to enter the boundary fault near Ben Venue. Along this axis the author believes that the beds are arranged in a synclinal double fold, and considers the anticline of bedding of the older geologists and the anticline of foliation described by Clough in the memoir on the Geology of Cowal to be entirely deceptive. We have failed, however, to find the double synclinal fold in the sections provided. The structure there represented is on a large scale a gentle anticline of bedding.

In a short chapter concluding the first volume the author returns to a description of the narrow belt of cherts and black shales which crop out along the Highland border. Although the exact relation of these supposed Arenig rocks is left as an open question, he can find no justification for separating these rocks, at any rate as seen in Perthshire, from the crystalline schists of the Highlands.

The second volume opens with an interesting description of the Lower Old Red Sandstone of Strathmore, the stratigraphy and structure being written up mainly from the papers of Jack & Etheridge and Du Toit. The plant and fish remains are also described and illustrated. The Upper Old Red Sandstone, which rests with a violent unconformity on the Lower, occurs only in small patches, sometimes preserved between trough-faults. The interesting outlier of Lower Carboniferous rocks near Dron, proving the former extension of the Carboniferous rocks north of the Ochil Hills, is also noticed.

In the following chapter the author attempts to prove that the Old Red Sandstone was laid down in the sea. In this few geologists will agree with him, though it be not difficult to find objections to the generally accepted lacustrine theory. His chief argument is that if the Lower Old Red Sandstone were to be replaced in the position it occupied before the faulting along the Highland border took place, it would pass completely over the Highland hills even though they were four times their present height. Further, that the position of outlying masses upon the dividing ridge makes it difficult to believe that the lake basins were separate and yet contemporaneous. The argument that the 'Orcadian' and 'Caledonian' cannot be contemporaneous, because the former does not contain a volcanic horizon, is one which is difficult to follow. Other reasons given are, to say the least, curious. Thus, nothing will persuade the author that the Lorne basin is other than an outlier, because the boulders in its conglomerates are so large as to preclude the possibility of its being formed in a basin only a few miles wide (p. 29). The chemical difficulty in the precipitation of red oxides of iron in the ocean is ignored, and the attempt to bolster up his theory by an appeal to the palæontological evidence is altogether unconvincing. After the study which terrestrial accumulations have received in recent years, those geologists who find difficulties in accepting the lacustrine theory will be ready to admit that much of the Old Red Sandstone may have been formed under certain continental conditions, but few, if any, will find satisfaction in the marine theory.

Chapter x contains a description of the unfoliated plutonic rocks and dykes intruded into the Highland schists. These include the well-known igneous complex of Garabal Hill, the plutonic rocks of Carn Chois, and a small intrusion situated on the eastern shore of Loch Tay. Short notices follow on various sills and dykes of quartz-porphyry, felsite, and lamprophyre.

The following chapter treats of the volcanic rocks of Lower Old Red Sandstone age, which form the Sidlaw and Ochil Hills. These ranges form respectively the northern and southern limbs of a faulted and denuded anticline. The lavas are also associated with the Lower Old Red conglomerates, which rest on the Highland schists.

Chapter xii, on the dolerite dykes, which traverse the rocks of Highlands and Lowlands alike, is illustrated by a number of good photographs of these intrusions. The author is inclined to think that the large dolerite dykes of Perthshire, trending nearly east and west, are of late Carboniferous age, whilst those with a north-westerly trend, occurring mainly in the western districts, are undoubtedly a continuation of the Tertiary dykes of the Western Isles.

The succeeding chapter is devoted to a sketch of the glaciation of the whole region. The ordinary phenomena—rock striations, boulder-clay, erratic blocks, moraines, rock-basins, raised beaches, and forest beds—are taken up seriatim and local examples cited. On the question of interglacial periods we find the indefiniteness, coupled with more or less contradictory statements, which we have had to remark on previously. First, we read that there are at least two great phases, an older period of general glaciation and a later period of valley glaciers. Further on (p. 111) beds of sand, gravel, fine clay, and layers of peat intercalated in the boulder-clay, are quoted as evidence of the great changes of climate, and proof that the boulder-clay is not one continuous deposit. "In the one case we have a state of matters where no life is possible, away down in the depths of the ice, where there is no sound but the sound of the river of ice and rock, an incessant, hollow, monotonous grind; in the other we have light and heat, the brightness of sunshine with all the cheerfulness and beauty which it brings, the flutter of forest leaves, the song of birds, the hum of the busy insect's wing, and even, perchance, in the later of these periods, suggestions of the presence of man." How many interglacial periods are represented between the bottom and top of the boulder-clay? The localities where the layers of peat in the boulder-clay are found are not mentioned. We could understand the author arguing for the existence of an interglacial period between the deposition of the boulder-clay and the accumulation of the moraines at the mouths of the Highland glens, yet he states (p. 117) that "after the great ice-sheet passed away, local glaciers still continued to occupy the valleys", indicating therefore a continuity of glacial conditions. A remarkable confusion of personalities is caused by a large perched block near Callendar being called "Samson's putting stone" in the text and "The Deil's Puttin' Stane" in the photograph. The chapter finishes with some notes on the distribution of the so-called Alpine flora of the hill-tops. The author concludes that the strain-slip-cleavage of the Ben Lawers schist "has been a most important factor in determining the present existence of Alpine plants on these mountains".

A long description of the river-terraces of the Tay and Tummel, and a discussion of their origin, occupies the greater part of chapter xiv. It concludes with some notes on the silting up of lochs, on soils, and on peat.

In the final chapter, on the relation of the scenery to the geological structure, a summary of the geological history of the region is given first. From this the author concludes that towards the close of the Carboniferous period a platform of highly convoluted Highland schists lay buried beneath a thick mantle of Old Red Sandstone and Carboniferous rocks, which rested upon the schists with a gentle slope to the south-east. The contorted Lower Palæozoic rocks of the Southern Uplands were hidden under a similar cover, whilst gently folded Upper Palæozoic rocks were faulted down between the Highland and Southern Upland boundary faults. The plane had a slope to the south-east which gave the initial direction to the primitive rivers. These rivers cut down into the schists beneath, and carved out the transverse valleys of the Southern Highlands, whilst the longitudinal valleys were formed by tributary streams eroding courses in the belts of softer rock. The initiation of the river-system is thus thrown back into late Palæozoic times, but further on the author uses the old argument from the disposition of the Tertiary dykes that the erosion of the Highland glens has been accomplished since Miocene times. What, then, was happening between late Carboniferous and the end of Miocene times? There is only the cutting through of the cover of Carboniferous and Old Red Sandstone rocks to fill up this vast interval. It would be much more plausible to assume that the river-system was initiated on a former cover of Mesozoic rocks. The origin ascribed to the longitudinal section of the Tay between Ballinluig and the head of Glen Dochart will probably give most readers the impression that this portion of the river originated as a strike stream of its present length, and merely cut down through the cover of Upper Palæozoic rocks and the weak schists of the Garnetiferous Schist zone, whereas an inspection of a good map shows that it must have cut back from the trunk stream and captured the head-waters of several transverse streams. The whole treatment of river development leaves much to be desired. The many interesting problems which this district offers for solution are barely indicated. Although the path of the Tay is followed in detail, the relation of this river to its tributary streams and to neighbouring river-systems is not touched upon. The other rivers are treated very briefly.

The author then proceeds to a long description of the ruggedness or smoothness of the hill-slopes in the various schist 'zones', and notes the scarped features of the Ochil and Sidlaw Hills. Defiles are mentioned as intersecting the former chain, but no explanation of them is offered. Except to claim the lake basins as the work of the ice-sheet, the influence of the glaciers of the Ice Age on the river-systems receives no consideration.

The work concludes with a short bibliography and an index. The text has been carefully corrected in the press and is practically free from typographical error. The label "Upper O.R.S." in fig. 10, vol. ii, is misplaced.

V.—Hints for Crystal Drawing. By Margaret Reeks. Longmans, Green, & Co. 3*s*. 6*d*.

THIS little book will prove a very welcome addition to the sources of information available to those beginning the study of crystallography. It is intended to show the student how to make for himself drawings of crystals in clinographic projection, such as he sees—but does not always understand—in textbooks of mineralogy. The author uses graphical methods to solve the problems that arise in the pictorial representation of crystals, some of which are very ingenious and cannot fail to appeal to those numerous students who are not blessed with the mathematical faculty. In each system the mode of drawing the areas, in the conventional positions adopted by crystallographers, is first described, and then the methods of drawing around these the various simple forms either alone or in combination. The book is well illustrated by original drawings made by the author herself, and the text is written in a simple, clear, and refreshingly unacademic style. Anyone to whom the subject is new, who desires to obtain a clear idea of the geometrical side of crystallography, will find Miss Reeks's book most helpful.

C. G. C.

VI.—On the Evidence of the Origin, Age, and Alteration of the Rocks near Heathcote, Victoria. By Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S. Proc. Roy. Soc. Victoria, vol. xxi (new series), pt. i, August, 1908.

THE area in question lies about 75 miles north of Melbourne. It consists of Silurian and Ordovician sediments, the former to the east, the latter to the west. (A part has even been regarded as Cambrian, by Etheridge.) Between these two areas of unaltered sedimentary rocks there occurs a zone of igneous rocks and associated "cherts and jasperoids", forming a linear outcrop some half a mile in width running roughly north and south across the district. The igneous materials are mainly diabases and diorites, but "microgranites, granophyres, and felspar porphyrites" also occur, especially in the immediate neighbourhood of Heathcote. The exact age of these igneous rocks and their relation to the adjacent sediments, and the true nature and mode of origin of the cherts and jasperoids, are controversial questions of long standing in Victorian geology. Professor Skeats's paper is a notable addition to those already contributed on the subject by Dunn, Lidgey, Howitt, Gregory, etc.

By some the diabases have been regarded as of intrusive, by others as of effusive origin, by some as of pre-Silurian, by others as of post-Silurian or even pre-Ordovician age. Professor Skeats gives his reasons for considering them to be effusive rocks of Lower Ordovician age. The paper, besides recording the results of the author's own field and laboratory work, includes also a review and discussion of the previous literature on the district. The following extract best expresses the author's views:—

"With regard to the conclusions at which I have arrived in this paper, I find myself only in partial agreement with previous workers.

"I am in agreement with Mr. Dunn in regarding the diabases as mainly effusive. With Professor Gregory I agree that the diabase is pre-Silurian, and with Dr. Howitt that the Ordovicians are altered along the contact with the diabase, and that the black cherts are altered Ordovician rocks. On the other hand, I disagree with

Dr. Howitt, who regarded the diabase as a rock intrusive in Devonian times. I regard it as mainly effusive in origin and probably of Lower Ordovician age. With Professor Gregory I am unable to agree in the interpretation of some of the field evidence, and I differ from him in regarding the cherts as altered Ordovicians and the diabase as being probably Lower Ordovician in age, and in his interpretation of the relation of land and sea in Lower Ordovician times." A geological sketch-map illustrates the paper.

C. G. C.

REPORTS AND PROCEEDINGS.

Geological Society of London.

December 16, 1908.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communication was read:—

"On the Igneous and Associated Sedimentary Rocks of the Tourmakeady District (County Mayo)." By Charles Irving Gardiner, M.A., F.G.S., and Professor Sidney Hugh Reynolds, M.A., F.G.S. With a Palæontological Appendix by F. R. Cowper Reed, M.A., F.G.S.

The general succession of the Ordovician Rocks of the district appears to be as follows:—

(4) ? Bala Beds.—Coarse conglomerate and sandstone containing pebbles, mainly of granite and felsite.
(3) Llandeilo Beds.
  (*c*) Shangort Beds.—Grits and tuffs, coarse and fine, the prevalent type being a calcareous gritty tuff, in which is a series of limestone breccias, having a maximum thickness of about 40 feet and largely formed of disrupted fragments of the underlying limestone.
  (*b*) Tourmakeady Beds.—Compact pink, grey, or white limestones, sometimes in beds with a maximum thickness of about 30 feet, but usually represented by blocks in the Shangort Beds.
  (*a*) Red felsite or rhyolite.—A series of flows varying much in thickness.
(2) Arenig Beds—Mount Partry Beds.
  (*d*) Variable tuffs, grits, and cherts, the tuffs being seen only in the southern half of the area.
  (*c*) Coarse quartzose and felspathic grits.
  (*b*) Grits, graptolitic black slates, and radiolarian cherts.
  (*a*) Coarse conglomerates, the pebbles of which consist almost entirely of grit.

A considerable series of graptolites, collected from the Mount Partry Beds, has been examined by Miss G. L. Elles, D.Sc., and they prove to be of Upper Arenig age—about the zone of *Didymograptus hirundo*. The radiolaria from the same series of rocks have been studied by Dr. G. J. Hinde, F.R.S.

The most interesting and puzzling beds of the district are those of Llandeilo age. Although the limestones (Tourmakeady Beds) occur in the main as disrupted blocks in the gritty tuffs (Shangort Beds), the fossils indicate that there is no material difference in the age of these two deposits; and the authors believe that, after the deposition and consolidation of the limestone, but during the prevalence of the same faunal types as those which characterize that deposit, the limestone was broken up by volcanic explosions, and its fragments, mingled with bits of felsite and other material, were deposited as the peculiar limestone breccias. This view regarding their formation is held to afford an adequate explanation of the patchy development of these rocks.

The intrusive rocks are of considerable interest. They are, in the main, felsites with large quartz-crystals, and not infrequently contain augite. Some of them are certainly intrusive in the coarse Bala (?) conglomerate. A number of small but interesting intrusions of olivine dolerite, hornblende lamprophyre, and fine-grained oligoclase bearing rocks are scattered throughout the district.

The appendix embodies a critical review of the fauna of the Llandeilo Beds of the district, and a description of several new species of brachiopods and trilobites.

CORRESPONDENCE.

POST-GLACIAL CONDITIONS OF THE BRITISH ISLES, AND PRESENT GLACIAL PHENOMENA OBSERVED IN ANTARCTIC LANDS.

Sir,—Ever since the publication by Captain R. F. Scott of *The Voyage of the Discovery*, in which he gives his impressions of the Great Barrier discovered by Sir James Ross, we have been asked to suspend our judgment concerning its actual physical features. It is not quite clear what is now the uncertain feature in the minds of those who ask us to delay; but it would appear that this counsel results from a fear that if the conditions of the barrier are as stated it cannot be maintained that a similar ice-sheet did not once fill the area now occupied by the North Sea during the Ice Age.

To those who consider that the glacial phenomena of the British Isles prove that an ice-sheet did move from Scandinavia over the North Sea area and invade the east of England, the facts concerning the Great Barrier are of the highest importance.

Although there is abundant matter for further investigation in the Antarctic area, the facts put on record by Sir James Ross and Captain Scott are sufficient, I think, to warrant my calling attention to their great interest to the glacial geologist.

From about 71° S. lat. to about 83° S. lat. and 167° E. long. a range of snow- and ice-covered mountains runs in the direction of the South Pole. Some of the summits exceed 15,000 feet in height, and the range forms, for at least 800 miles, the eastern boundary of South Victoria Land. It rises abruptly from the ice-covered sea. About the centre of the known portion of this great mountain range is the active volcanic cone of Mount Erebus. It is not, however, actually a portion of the range, for it stands on an island close to the shore.

From Erebus stretches the Great Barrier in an easterly direction. This 'wall of ice', which faces the open sea, varies in height from 50 to 240 feet and extends as far as King Edward VII Land, a distance of about 390 miles. The depth of the sea along its edge, according to

Ross and Scott, varies from 1,500 to 2,700 feet. If the submerged ice is six times the thickness of the portion above the sea-level, the depth of the barrier in the sea must vary from 300 to 1,440 feet. There is, therefore, in many places more than 1,000 feet of water between the sea-bottom, for the thin ice is frequently above the deep water. The ice of the barrier, except at its ends, is floating along its whole front. On this matter Sir James Ross says: "Whilst waiting we obtained soundings in two hundred and thirty fathoms, the deep sea clamms bringing up some green mud intermixed with small volcanic stones. This depth of water would seem to prove that the outer edge of the barrier was not resting upon the ground; for by various measurements of its highest part it was found to be one hundred and seven feet above the sea, from which point it gradually diminished for about ten miles to the eastward, where it could not have been more than eighty feet." Here there was, therefore, about 1,100 feet of water under the ice. Captain Scott found that the edge of the ice when he sailed along it was about 30 miles further south and the sea quite as deep. The statement made by Ross that the barrier was floating must, consequently, have been quite correct. At Balcon Inlet, near the eastern edge of the barrier, Captain Scott noticed that a small "berg, as well as the pack ice which had been driven in by the current, took its way out to sea again, clearly showing that there is a regular tidal stream in this region, and as, in spite of this, we and the barrier ice about us rose and fell together, there was no doubt that at least this part of the barrier was afloat".

But Scott travelled south over the barrier ice until he was about 300 miles from its face, and his observations showed that he had travelled over a comparatively level plain all the way, the ice being of nearly uniform thickness, his opinion being that the "Great Barrier ice-sheet is afloat at least as far south as we travelled". He also remarks: "I still hold that the greater part of it is afloat; and strange as it is to imagine that the sea should run beneath such a solid sheet for so many hundreds of miles, I have yet to learn any reasonable argument against such an idea." I am here in complete accord with Captain Scott, and think that his reasoning is quite unanswerable. Ice behaves as a very viscous liquid, and may rest upon and slowly spread over water, a tendency to spread resulting from the fact that a portion of it stands above the sea-level.

As it is possible for an ice-sheet such as that which Ross and Scott described to maintain itself when exposed to the open Pacific, it is also possible for a similar ice-sheet to maintain itself in the North Sea during a glacial epoch, this sea facing the cold north instead of the open warm sea.

It is argued without any clear reason being given that an ice-sheet could not cross the deep channel near the Scandinavian Peninsula. I do not think that this is a real difficulty. In the first place, the moderately thick ice lobes would float across the channel, and when they touched the sea-bottom on the opposite side the ice over the channel would thicken. This thickening and consequent rise above the sea-level would furnish the necessary gradient to force the ice towards Great Britain. The distance the ice would travel would depend upon the supply of snow, and eventually the deep channel might be filled with ice to the bottom.—Yours truly,

R. M. Deeley.

Melbourne House, Osmaston Road, Derby.
January 11, 1909.

PEARL FROM THE CHALK.

Sir,—The interesting notice of Mr. Newton's paper on Chalk Pearls in your January number recalled to my memory that I still possessed the original pearl from which Mr. B. B. Woodward's section was cut. Singularly enough the circumstance had entirely escaped the memory of both of us until your notice referred me to Mr. Newton's figure and allowed me to recognize the section and the pearl as one and the same specimen. Following Mr. Woodward's example I have had the pleasure of presenting the larger half of the pearl to the British Museum (Natural History), so they can in future be inspected in the Geological Department.

G. E. Dibley.

46, Burghill Road, Sydenham, S.E.
January 13, 1909.

FLINTS IN THE DRIFT.

Sir,—I am delighted to learn from Dr. Bather's note in your January issue (p. 47) that flints are as abundant in Denmark as in East Anglia, and doubtless the prehistoric Danes made their implements from their own chalk-flints. If the word 'pink' is inserted before the word 'flint' in line 9 of my previous letter (see Geol. Mag., 1908, p. 575), it will, I think, be in order. In the Trans. Hull Geol. Soc., 1902 (vol. v, pt. ii, p. 31), Mr. J. W. Stather writes:—"Following Mr. C. Reid's surmise in the Holderness Memoir, we have become accustomed to regard Denmark as the source of the *pink* flints, common in the Boulder clays of Holderness. This is an error, as Mr. A. Jessen, of the Danish Geological Survey, recently informed the secretary that *pink* flints do not occur either in the Cretaceous Rocks or the drifts of Denmark, and are quite unknown there."

T. Sheppard.

THE DISCUSSIONS AT THE GEOLOGICAL SOCIETY.

Sir,—Though I have never had the pleasure of hearing a discussion at the Geological Society, and do not know how closely the views expressed there in full agree with the brief report subsequently given, I should be glad if I might be allowed to make a suggestion.

The publication of the discussion in the proceedings adds considerably to the interest of papers to Fellows who, like myself, are unable to attend the meetings. But the question I wish to ask is whether their usefulness does not stop at this point? There are, of course, cases when a paper deals with a subject closely studied by those present, and when even criticisms that are hastily composed may have a value. There are other cases when the subject-matter is less familiar and a paper may suffer harm from unstudied remarks. Indeed, the value of the Quarterly Journal may be lessened by the insertion of such criticisms, which the Editor can hardly in fairness eliminate.

My suggestion is that the publication of the discussions should be limited to the Proceedings. The papers published in the Journal, usually the result of years of work, would not then suffer by juxtaposition with remarks composed at a few minutes' notice, and the Proceedings would have a more lasting value. Personally, I should like to see their interest and value still further increased (and the bulk of the Journal diminished) by the inclusion in the Proceedings of the President's address, the Report of the Council, etc.

Charles Davison.

16, Manor Road, Edgbaston, Birmingham.

THE PAST PRESIDENTS OF THE GEOLOGICAL SOCIETY.

Sir,—My attention has been called to an error in the printed report of an address I delivered to the Geologists' Association last February on "The Centenary of the Geological Society", which I shall be glad if you will allow me to correct. On p. 369 of the Proceedings of the Geologists' Association, vol. xx, the statement occurs: "Since Forbes's day no President has been elected under 50, with the exception of Dr. Marr, who was 47." This should read as follows: "Since Forbes's day no President has been elected under 40, and during the last twenty years none under 50, with the exception of Dr. Marr, who was 47." The mistake arose through a line being dropped in transcribing my notes, and it escaped attention while passing through the press. As a matter of fact, there were seven Presidents of the Society under 50 between Forbes and Dr. Marr, viz., Hamilton (first term), Sharpe, Ramsay, Smyth, Huxley, the Duke of Argyll, and Professor Judd. While on this subject I may note that the oldest President was Leonard Horner, who when elected for his second term was 75.

Perhaps I may also be allowed to remind your readers that the recent election of Sir Archibald Geikie to the Presidential Chair of the Royal Society adds a third name to those I have mentioned on the above-quoted page of my address (Lord Northampton and Huxley) who have served as Presidents both of the Royal and Geological Societies.

R. S. Herries.

5, New Street Square, E.C.

THE BURNING CLIFF NEAR LYME REGIS.

Sir,—Now that the spontaneous combustion at the Lyme Regis end of Black Ven has been mentioned in your pages, I beg to be allowed to point out a possible source of misconception to visitant geologists as to the extent of the burning. But first let me make it clear that my statement is only hearsay, and may be mere gossip; for being otherwise busied at the time, I was unable to investigate the matter. Its bearing, however, on the magnitude of the effect in this instance of what is an established natural phenomenon is obvious and for that reason considerable.

The cliff took fire early in 1908. Notices, descriptions, and explanations appeared in various papers, local and otherwise, and enterprising shopkeepers in Lyme took photos and exhibited them as picture postcards, which they sold as mementos of 'the volcano'. The advertisement attracted visitors to Lyme, and evidently the burning cliff was a source of profit to the Lyme folk. In Charmouth, during April, 1908, it was common talk that when the 'volcanic' activity appeared to be subsiding, disappointed Lyme people poured paraffin on the cliff and relighted it. It is probable that, saturated with enough paraffin, any clay cliff would burn when lighted, and the effect would be commensurate with the amount of oil used. If paraffin was poured on the burning part of Black Ven, it has made it impossible to judge the extent of the natural combustion and of its effects. Last April a beautiful specimen of burnt red shale was in the Coach and Horses Hotel at Charmouth, but the interest it would naturally have evoked was spoiled by the suspicion that it was the result not of the heated behaviour of Black Ven, but of the commercial ardour of Lyme speculators. It would be interesting if a future Lyme visitor would investigate the report and establish the truth. In August last the Charmouth world said that the Lyme people had over-reached themselves, and had made so much of the 'volcano' that intending visitors stayed away through fear. This sounds so unlikely that one is inclined to doubt the truth of the paraffin statement.

With apologies for much gossip, even though it contains a warning,

Passer Vennensis.

OBITUARY.

JOSEPH LOMAS, F.G.S.

Born November 18, 1860. Died December 17, 1908.

Mr. Joseph Lomas, whose sad and premature death we recorded last month, was born at Bugsworth, on the borders of the Derbyshire Peak district, on November 18, 1860. He received his scientific education at the Royal College of Science under Professors Huxley, Judd, and others. In 1885 he was appointed to organize and conduct the teaching of science in the elementary public schools of Liverpool under the School Board, and he was professionally occupied with that work until the end. During his later years he was also a successful "Special Lecturer" in Geology in the University of Liverpool, which still has no professor of this important branch of science.

Though equally well trained as a zoologist and as a geologist, Lomas was inclined chiefly towards researches of a geological nature. His most important early work related to questions of Glacial Geology, which he attempted to solve by visits to Switzerland and the Faröe

Islands. He also wrote petrological papers. He joined the Liverpool Marine Biology Committee, and reported on the deposits found on the bed of the Irish Sea, comparing these with older geological formations. During later years, under the auspices of the British Association, most of his leisure was devoted to the study of the British Trias and a comparison of it with modern deserts. In 1905 he visited some of the desert regions in South Africa and Egypt, and when he met his death by accident in December last he was extending his researches to the region round Biskra in Algeria.

For many years Lomas was a well-known leader of field excursions, and he organized the excursion of the Geologists' Association to the Berwyn district of Wales last summer. He was also an active member of the British Association, and had been for several years Recorder of Section C (Geology). His personal charm and good nature and his enthusiastic cheerful manner endeared him to a large circle of friends, who mourn his unexpectedly early loss. The Geological Society of London acknowledged his scientific worth by the award to him of part of the Lyell Fund in 1897; while the Geological Society of Liverpool honoured him by election for two terms to its Presidential chair.

Mr. Lomas was a frequent writer on geological subjects. His separately published papers amount to seventy-two in number, thirty-one being read before the Liverpool Geological Society, twenty-four before the British Association, nine in the Geological Magazine, and the rest read before various local scientific societies, that on existing Deserts compared with the British Trias (see Geol. Mag., 1907, pp. 511 and 554) being one of the most important.

J. S. GRANT WILSON.

Born June 2, 1855. Died December 29, 1908.

We regret to record the death of Mr. J. S. Grant Wilson on December 29 after thirty-two years' service on the Scottish Staff of the Geological Survey. After completing his education at St. Andrews University, where he carried out a series of analyses of minerals in the chemical laboratory under the supervision of the late Professor Heddle, he joined the Geological Survey in 1876. He received his first instruction in field mapping under Dr. B. N. Peach and Dr. Logan Jack when they were engaged in surveying the Silurian, Old Red Sandstone, and Carboniferous Rocks of the border territory in Eskdale and Liddesdale.

During his official career it fell to his lot to map large areas of crystalline schists in Banffshire, the north-east of Aberdeenshire, Central Perthshire, the fascinating region on either side of Ben Nevis, and part of the Knapdale plateau in Argyllshire.

While prosecuting his operations in the field in Perthshire he made a careful series of soundings in Lochs Tay, Earn, and Tummel, the results of which were published in *The Scottish Geographical Magazine* for May, 1888. His results agree very closely with those obtained subsequently by the Scottish Lake Survey.

But his bent lay clearly towards the economic side of geology, and especially towards the important industry of the Scottish Coalfields. Hence, in anticipation of the new editions of the one-inch maps of the Fife Coalfield, he was entrusted with the task of revising parts of these Coalfield areas and obtaining information regarding mining and boring operations since the date of the original survey. His services in this connection were acknowledged by Sir Archibald Geikie in the two official memoirs which he wrote on the Geology of East and Central Fife. Since then he endeavoured to acquire an intimate knowledge of the development of the Fife Coalfield by gaining access to the journals of recent bores. Indeed, he obtained in a remarkable degree the confidence of those specially interested in this industry, in proof of which it may be mentioned that his opinion regarding the sites of new bores and the interpretation of geological horizons was much sought after in recent years. More recently Mr. Wilson re-examined the Carboniferous area of the Lothians and gave a concise description of the geology of the oil-shale fields, since published in a Survey Memoir.

His early chemical training was of service to the Geological Survey, for at intervals he carried out a series of chemical analyses of volcanic and plutonic rocks, of crystalline gneisses and schists, some of which have been published in *Ancient Volcanoes of Great Britain* by Sir Archibald Geikie, and in the recent memoir on "The Geological Structure of the North-West Highlands of Scotland". Since the institution of a chemical laboratory in the new office of the Scottish Survey, he has made a series of analyses of Carboniferous limestones from the midland valley of Scotland.

J. H.

SIR THOMAS WARDLE, J.P., F.G.S., F.C.S.

BORN JANUARY 26, 1831. DIED JANUARY 3, 1909.

SIR THOMAS WARDLE, who was a silk dyer and calico printer at Leek, and for many years President of the Silk Association of Great Britain and Ireland, was also an active member of the North Staffordshire Field Club, to which he had contributed geological papers. He was best known to geologists as author of *The Geology of the Neighbourhood of Leek, Staffordshire*, 1863. In 1890 he acted as one of the directors on the excursion of the Geologists' Association to North Staffordshire, and conducted the party to the Yoredale Rocks of Butterton Moor, where attention was called to the hard calciferous gritstones, which he regarded as "theoretically the best road-forming rocks" (Proc. Geol. Assoc., vol. xi, p. cxxxii).

HENRY MEYNERS BERNARD, M.A., F.L.S., F.Z.S.

BORN NOVEMBER 29, 1853. DIED JANUARY 4, 1909.

THE death of Henry M. Bernard removes from our midst a friend and fellow-worker who will be greatly missed by a large circle of men of science. Mr. Bernard took mathematical honours at Cambridge as B.A. in 1876, and entered the Church, his last charge being a Chaplaincy at

Moscow, which he left in 1888 in order to study Biology under Haeckel at Jena. In 1892 Mr. Bernard published an important monograph on "The Apodidæ", his study of these forms leading to papers in the GEOLOGICAL MAGAZINE in 1894 and 1895 on the systematic position of the Trilobites, and on 'the Sandblast' as a method of developing these organisms from the rocks in which they are embedded. In 1894 he began the study of the Recent and Fossil Corals at the British Museum (Natural History), continuing the quarto illustrated Catalogue of the Madreporaria (published by order of the Trustees) originally commenced by the late Mr. George Brook. In this work Mr. Bernard paid much attention to the fossil forms. He continued to work at the corals in the British Museum until 1907. During these thirteen years he prepared five volumes, namely :—

Vol. II of the Catalogue (begun by Mr. Brook) on the *Turbinaria* and *Astræopora*.
,, III, on the *Montiporinæ*.
,, IV, ,, *Goniopora*.
,, V, ,, *Porites* (Indo-Pacific).
,, VI, ,, *Porites* (West Indies) and *Goniopora*.

OTHER GEOLOGICAL PAPERS BY H. M. BERNARD.

1893. Trilobites with Antennæ at last. (*Nature*.)
1894. Systematic Position of the Trilobites. (GEOL. MAG., 1894, p. 230; 1895, p. 280.)
Systematic Position of the Trilobites. (Quart. Journ. Geol. Soc., vol. l, p. 411.)
Trilobites developed by the Sandblast. (GEOL. MAG., 1894, p. 553.)
1895. The Zoological Position of the Trilobites. (*Science Progress*.)
1897. Fossil Apodidæ. (*Natural Science*.)
On the Affinities of the Madreporarian genus *Alveopora* with the Palæozoic Favositidæ. (Journ. Linnean Soc., Zool.)

He died at 109, West End Lane, London, N.W., on January 4.

PROFESSOR H. G. SEELEY, F.R.S., F.L.S., F.G.S., F.Z.S., F.R.G.S., FELLOW OF KING'S COLLEGE, LONDON.

BORN FEBRUARY 18, 1839. DIED JANUARY 8, 1909.

WE regret to announce the death of Harry Govier Seeley, Professor of Geology, Geography, and Mineralogy in King's College, London, and member of the Athenæum Club, which occurred early on January 8 at his residence, 3, Holland Park Court, Holland Park Gardens, W. In June, 1907, we published a life of this able and distinguished worker in the GEOLOGICAL MAGAZINE, in our series of "Eminent Living Geologists" (pp. 241–53), accompanied by a portrait and a list of his numerous publications.

In addition to his arduous labours as a professor in King's College, Queen's College, and the Royal Indian Engineering College at Cooper's Hill, he will be best remembered, perhaps, for the wonderful collections he made in the Karroo Beds of South Africa and the resulting exhibition in the Natural History branch of the British Museum of the remarkable skeleton of *Pariasaurus* and numerous other Anomodont reptiles, which occupied years of patient work in their development (under Professor Seeley's almost daily superintendence) by Mr. Richard Hall's and the Barlows' unwearied labours. These are a monument alone to his memory which can never be forgotten.

MISCELLANEOUS.

The Messina Earthquake.

The earthquake which at the close of last year devastated Messina in Sicily and Reggio in Calabria, on the opposite shores of the Straits in Southern Italy, is one of the most terrible and disastrous on record. We gather the following particulars from the *Times* (Weekly Edition, January 1, 1909) :—

"The actual time of the earthquake seems to have been 5.20 on Monday morning, December 28. The first intimation, according to reports from Catanzaro and by fugitives from other places, was a prolonged, thunderous noise followed by a vivid flash of lightning and at the same time by a series of violent shocks which seemed interminable. Heavy torrential rain then fell.

"The second shock was at 9.30 in the evening of the same day, but it was less violent in character.

"There was a violent shock at San Marco Argentino on Tuesday night, accompanied by prolonged subterranean thunder. Many houses were damaged.

"A slight shock was felt at Palermo on Wednesday morning.

"Messina has been almost totally destroyed by the earthquake and the following upheaval of the sea. The worst damage was done by a vast wave, which has left the whole front of the town facing the sea in ruins. Fires broke out in many parts of the city and added to the difficulty of saving the innumerable persons who had been buried alive.

"Reggio, on the Italian side of the Strait, has also practically perished, and the whole shape of the coastline at that point has been altered. The sea front has been completely swept away, while the water in shore was blocked with sunken débris, foundered vessels, and every imaginable sort of obstruction. For a radius of 11 miles the country had a torn and twisted appearance, roads, bridges, footpaths, and railway lines being uprooted.

"The whole area of the ground below Reggio seemed to have turned over, and a great part of the city was in ruins, covered by the sea. In many places deep chasms appeared in the streets. Of all the villages looking towards Reggio on the coast, not one has been left standing.

"Most of the coast towns on both sides of the Strait of Messina have been wholly or partially destroyed.

"A rough estimate of the number of lives lost places it as more than 100,000 in Messina alone, while the destruction of property has been enormous."

Lyell, in his graphic account of the Calabrian Earthquake of 1783, stated that "The shocks began in February [of that year], and lasted for nearly four years, to the end of 1786".[1] These remarks and the subsequent history of the affected area do not lend encouragement to future enterprise.

Suess has observed in reference to the area of disturbance that "the crust of the earth has sunk down in the form of a dish, and thus radial fractures have been produced, which converge to the Lipari Isles. These converging lines are beset with volcanos near their

[1] *Principles of Geology*, 11th ed., vol. ii, pp. 113–44.

centre of origin. Any disturbance in the equilibrium of the several fragments of the crust gives rise to increased volcanic activity on the islands, and to earthquakes on the mainland or in Sicily".[1]

Further subsidence in the future is not improbable. At present there are symptoms of activity in Stromboli.

The Royal Society.—On November 30, St. Andrew's Day, 1908, Sir Archibald Geikie, K.C.B., was elected President of the Royal Society. It is satisfactory to find that Geology as a distinct science has been recognized in this way, although it appears surprising that Lyell, in his time, had never been chosen. Of previous Presidents Wollaston had been a Vice-President of the Geological Society and he founded its Wollaston Medal, Sir Humphry Davy had been a Founder of the Society and Vice-President, Davies Gilbert had been a Vice-President, the second Marquis of Northampton (then Earl Compton) and Huxley had been Presidents of the Geological Society.

Appointment of a Keeper of Zoology in the British Museum (Natural History), Cromwell Road, London.—This office, which since the retirement of Dr. A. Günther, F.R.S., in 1895, was *temporarily* attached (*without salary*) to the post of Director of the Museum, first under Sir William H. Flower, K.C.B., from 1895–8, and afterwards under Professor (now Sir) E. Ray Lankester, K.C.B., from 1898–1907, has at length been filled by the appointment of Dr. Sidney F. Harmer, M.A., F.R.S., Fellow of King's College, Cambridge, and Superintendent of the University Museum of Zoology. Dr. Harmer has already done excellent work in Zoology, and being now only in his 46th year, if his health and courage do not fail him, may look forward to twenty years' service under the Trustees in the National Museum.

We regret to learn that the important post of Director, created by Parliament in 1856, and held successively by Owen (1856–84), Flower (1884–98), Lankester (1898–1907) for a period of fifty-one years, has now remained vacant for two years. Surely the Trustees need not be at a loss to find an able Biologist in this country to fill the office, or is it to be abolished on economic grounds?

The New Director of the Welsh National Museum, Cardiff.—At a meeting at Cardiff on Saturday, December 5, 1908, of the Welsh National Museum Council, Sir Alfred Thomas, M.P., presiding, Dr. W. E. Hoyle, Director of the Manchester Museum and lecturer in the University of Manchester, was appointed Director of the National Museum of Wales at a salary of £700 per annum. Dr. Hoyle will commence his duties not later than March 25, 1909.—*Daily News*, December 7, 1908.

Micrasters.—Many workers in the Chalk having expressed a desire to examine critically the series of Micrasters shown in the Science Gallery of the Franco-British Exhibition, the owners have, with the

[1] *The Face of the Earth* (English edition), 1904, vol. i, pp. 85, 86, 175.

kind permission of Dr. Smith Woodward, Keeper of the Geological Department, agreed to allow them to remain in his charge for six months. Dr. Smith Woodward will therefore arrange for any serious student to have access to them on any week-day between the hours of 10 and 4 at the British Museum (Natural History), Cromwell Road, S.W.

Dew-ponds.—Mr. E. A. Martin, who has given great attention to the subject, summarizes our knowledge in an article "Some Considerations concerning Dew-ponds" (reprinted from the Trans. of the S.E. Union of Scientific Societies, 1908). The methods of construction of dew-ponds, their position, and other circumstances attending them are pointed out. As the author has previously maintained, the supply of water cannot be attributed wholly nor even principally to the deposition of dew; mist appears to be the most important source, and deposition of moisture is also favoured in some situations by trees and other forms of vegetation.

Geologists' Association.—The jubilee of this Society occurred on Sunday, November 29, and arrangements were made to celebrate it by a Conversazione at University College, Gower Street, on Friday, November 27, the nearest appropriate date; and by visits to the British Museum of Natural History and to the Museum of Practical Geology, followed by a dinner, on the Saturday. To mark the completion of their fiftieth year the Association have arranged to issue a volume dealing with the Geology of the Districts of England and Wales visited by them since 1858, the subjects to be treated from the standpoint of our present knowledge.

Geological Survey. — Dr. Aubrey Strahan, F.R.S., has been appointed Assistant Director (for England and Wales) in the room of Mr. H. B. Woodward, who retired on December 31, 1908. Mr. George Barrow, F.G.S., has been promoted to the rank of District Geologist.

Awards of Medals and Funds, Geological Society. — The Geological Society of London will this year award its medals and funds as follows:—Wollaston Medal to Mr. Horace B. Woodward, F.R.S.; Wollaston Fund to Mr. Arthur J. C. Molyneux (Rhodesia); Murchison Medal to Professor Grenville A. J. Cole; Murchison Fund to Mr. James V. Elsden, B.Sc.; Lyell Medal to Professor Percy F. Kendall; Lyell Fund to Mr. R. G. Carruthers and Mr. Herbert Brantwood Muff; Bigsby Medal to Dr. John Smith Flett; Prestwich Medal to Lady Evans.

Death of Lady Warington Smyth.—We regret to record the death of Lady Smyth.—On the 24th January, at her residence, West Cliff, Marazion, in the 82nd year of her age, Anna Maria Antonia, widow of the late Sir Warington W. Smyth, F.R.S., and daughter of the late Anthony M. R. Story-Maskelyne, F.R.S., of Basset Down, Wilts.—*Morning Post*, January 26, 1909.

No. 537. Decade V.—Vol. VI.—No. III. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journ... of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

MARCH, 1909.

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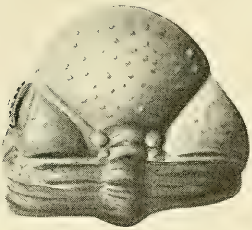

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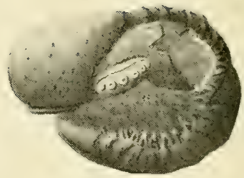

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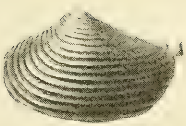

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Figs. 1–4.—*Phacops* (*Trimerocephalus*) *pentops*, sp. nov.
,, 5, 6.—*Allorisma concinna*, sp. nov.

Devonian : Portquin Harbour, Cornwall.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. III.—MARCH, 1909.

ORIGINAL ARTICLES.

I.—A New Devonian Trilobite and Lamellibranch from Cornwall.

By Ivor Thomas, Ph.D., B.Sc., F.G.S.

(By permission of the Director of the Geological Survey.)

(PLATE III.)

DURING the present survey of Cornwall Mr. Clement Reid has discovered several interesting fossils which provide a substantial addition to the previously recorded Devonian fauna of that part of the country. The forms described below were found by Mrs. Clement Reid, to whose patience and skill I am also indebted for the developing of the best parts of the specimens. My best thanks are due to my colleague Mr. H. H. Thomas for the accompanying drawings of the two forms.

Phacops (*Trimerocephalus*) *pentops*, sp. nov. (Pl. III, Figs. 1–4.)

Description.—The *cephalon* is obtusely round in front, with gentle lateral curvature, slightly indented where the dorsal furrows bounding the glabella reach the margin. The surface is covered with fine granules of fairly equal distribution. The sub-marginal sulcus is well marked, broader towards the front, and gradually diminishes in width as it follows the narrow marginal border towards the genal extremities. The length to breadth = 2 : 3.

The *glabella* (Pl. III, Fig. 2) is pentagonal in general outline, tumid, protuberant, and overhanging at an angle of about 70° to the plane of the dorsal surface. The length of the frontal lobe to breadth = 3 : 4. The first pair of lateral furrows is not discernible; the second pair is seen faintly by strong magnification; the third lateral furrows are deep, and bound a well-defined basal lobe with a small tubercle at each extremity. There are indications of a groove across this lobe. The deep dorsal furrows separating the glabella from the cheeks form an angle of about 81° with each other. The occipital furrow is narrow and deep, with a fairly conspicuous and elevated occipital ring, adorned by a tubercle at each end.

The *cheek-areas* are triangular, slightly tumid, and bounded towards the margin of the head-shield by a narrow border, which is continued under the overhanging frontal lobe of the glabella.

The *eyes* (Pl. III, Figs. 1, 2, 4), of which only the left one is preserved in the specimen, are placed upon narrow free cheeks, roughly rectangular in shape and lying at the anterior extremity of the fixed cheeks. The facets, which are fully developed, are arranged in a single row on a narrow sub-crescentic ridge, making a small angle with the border. They are five in number, circular, and slightly diminishing in size in either direction from the central facet. There is a possible trace of a terminal rudimentary sixth facet.

Thorax.—The *axis* is well defined, convex, with sub-parallel margins, and slightly tapering towards the pygidium. The bounding dorsal furrows are broadly deep. The segments, some of which are not preserved, are slightly tuberculate at the sides. The *pleura* are flattened and abruptly deflected backwards and downwards at the fulcrum about two-thirds their width from the axial furrows, and are grooved from the axis outwards, the anterior segment overlapping at the deflected portion.

The *pygidium* (Pl. III, Fig. 3) is small in proportion to thorax. The length to breadth = 2 : 5. The *axis* is prominent, convex, and gradually tapering to a blunt end posteriorly. The number of annulations is about six, and they become more weakly marked and obsolete towards the posterior extremity. The *pleura* are slightly flattened. The annulations are broadly rounded, faintly grooved, and curved slightly backwards. A marginal border is not developed.

Dimensions.—The length of the head-shield = 2·2 mm.; the breadth of the head-shield = 3·3 mm.; the greatest breadth of the thorax = 3·1 mm.; the length of the pygidium = 0·8 mm.; the breadth of the pygidium = 2·0 mm.

Locality and horizon.—One very small rolled-up specimen of this Trilobite was found in a band of highly fossiliferous grey slates, probably under 20 feet in thickness, exposed between the tide-marks on the east side of Portquin Harbour and not far from the beach. It is preserved in iron pyrites, and occurs together with a good assemblage of small mollusca, similarly preserved: *Tornoceras simplex* ? (v. Buch), *Torn. verneuili* (Münst.), *Torn.* cf. *subundulatum*, Frech, forms near to *Torn. globosum* (Münst.) and *Torn. planilobum* (G. & F. Sandb.), *Orthoceras* sp.; small Gasteropods, *Naticopsis* spp., *Platyostoma* sp., *Bellerophon* (*Ptomatis* ?) sp.; a few Lamellibranchs, *Buchiola retrostriata* ? (v. Buch), and *Allorisma concinna*, sp. nov. A fragment of a Trilobite showing a part of the thorax and pygidium occurs also in the material; it probably belongs to the same species as the one described.

The assemblage of Cephalopods points to an undoubted Upper Devonian age, while the occurrence of forms near to *Tornoceras planilobum*, *Torn. verneuili*, and *Torn. globosum*, which, with others, have been placed by Professor Frech (6,[1] p. 125; 7*a*, p. 67) under a new genus, *Cheiloceras*, appears to support a middle Upper Devonian horizon. This *Cheiloceras* horizon was first noticed near Brilon by Professor Kayser (11,[1] pp. 602 ff.), who named the beds "Nehdener Schiefer". They lie at the base of the Clymenien-Kalk and are rich in Goniatites preserved in iron pyrites. The same definite horizon has been recognized by various investigators at Elsterburg in Thuringia,

[1] These figures refer to Bibliography at end of paper.

Langenaubach near Haiger, Germany, Kielce in Poland, Rostellec near Brest, Cabrières in south of France, and apparently also in the Ural District (10, pp. 155, 156; 16*a*, p. 184). Dr. R. Wedekind has recently discussed and subdivided this horizon in an interesting contribution entitled "Die Cephalopodenfauna des höheren Oberdevon am Enkeberge" (17, pp. 565–634).

Remarks.—The employment of the name *Trimerocephalus* in the above description is in accordance with the usual interpretation. Professor Gürich would base the distinction between the typical *Phacops* and *Trimerocephalus* on the size of the angle made by the dorsal furrows bounding the glabella, which in the case of *Trimerocephalus* would be about 50° and *Phacops* 80°–90° (9, p. 362). I agree with Mr. Cowper Reed that this distinction is quite insufficient (15, p. 226). The subgenus was originally founded by M'Coy (12, p. 404) upon *Trinucleus ? lævis*, Münst. (13, p. 116, pl. x, fig. 6), a form in which he considered the eyes to be absent. Gümbel (8, pl. A, figs. 7–9) refigured Münster's original, and identified it with *Phacops cryptophthalmus*, Emmrich (2, pp. 27, 61). Münster's figure is too poor to be of use, while Emmrich's rather scanty description is unaccompanied by illustrations.

The poor state of preservation of thorax and pygidium prevents as clear a discrimination of certain parts of our species as could be desired. In the general shape of the head-shield it resembles *Phacops cæcus*, Gürich (9, pp. 362, 363, pl. xv, fig. 4), from the middle part of the Upper Devonian of the north-east border of Kadzielnia, Poland, a form which has also been described by Dr. Drevermann from the Clymenien-Kalk of Langenaubach (1*c*, pp. 114, 115, pl. xiii, fig. 4). *Phacops cæcus* differs, however, among other respects, in the absence of eyes, in the presence of a broader border and a broader occipital ring, in the possession of more extended postero-lateral margins of the head-shield, a greater angle between the dorsal furrows bounding the glabella, and a less tumid frontal margin of the glabella.

Phacops (*Trimerocephalus ?*) *lotzi*, Drevermann (1*c*, pp. 117, 118, pl. xiii, fig. 7), also bears a superficial resemblance to the form described. The eye in Dr. Drevermann's species differs in the possession of eight facets arranged in two rows, while the marginal border is broader, the postero-lateral margin of the head-shield more extended posteriorly, the frontal margin of the glabella more angular, and the angle of the dorsal furrows bounding the glabella smaller.

The Portquin species differs from Gümbel's figure of *Phacops cryptophthalmus*, Emmrich (= *T. ? lævis* of Münster), in the relative proportions of the length and breadth of the head-shield, in the narrower occipital ring and marginal border, and the different arrangement and smaller number of eye facets.

In describing *Phacops* (*Trimerocephalus*) *lævis* (Münst.), as a synonym with which both he, M'Coy, and Gümbel place *Calymene lævis* of Phillips (14, pp. 129, 130, pl. lv, fig. 250), Salter states that the "eyes are absent in our English specimens but probably present in perfect individuals" (16, p. 17). It is possible that in many cases the apparent absence of eyes is accounted for by the poor state of preservation.

Phillips has recorded *Phacops* (*Trimerocephalus*) *lævis* (Münst.) under the name *Calymene lævis* from Brushford (North Devon), Mudstone Bay, Durlstone, Knowle Quarry near Newton Bushel (South Devon) (14, p. 130). Salter questions, however, the occurrence at Mudstone Bay and Durlstone (16, p. 17).

Mr. Howard Fox has collected the same species from Trevone Bay, Cornwall (4, p. 543), and forms doubtfully referred to *lævis* from Cant Hill, St. Minver, Cornwall (3, p. 52; 18, p. 154), and near Porthmissen beach, Cornwall (5, p. 6).

A poorly preserved specimen of a form which somewhat resembles *Phacops* (*Trimerocephalus*) *anophthalmus*, Frech (7, p. 270), has been found by Mr. H. Dewey at Daymer Bay, Cornwall (H. D. 111, Geol. Surv. Coll.), while *Ph.* (*Trim.*) cf. *anophthalmus* was collected by Mr. J. Pringle at the same locality and horizon (Pr. 4733, Geol. Surv. Coll.). Specimens collected by Mr. W. A. E. Ussher at Whiteway Farm, Devonshire, in 1888, were then determined as *Phacops cryptophthalmus*, Emmrich. A re-examination of one of these specimens (22884) justifies its determination as a form closely related to that figured by Gümbel.

Allorisma concinna, sp. nov. (Pl. III, Figs. 5 and 6.)

Description.—This shell is fairly globose, equivalve, very inequilateral, and is much produced posteriorly, the posterior portion, measured from the intersection of the axes, being about twice the length of the anterior. The angular umbones lie far forward, and bend over prominently above the hinge-line. The hinge-line is straight posteriorly, but curves slightly downwards in front of the umbones. Behind and under the umbones lies a small, elongated, narrow ligamental area, gradually tapering posteriorly. A low keel runs from behind the umbo towards the posterior margin of the valve, and is separated from the hinge-line by a narrow, almost smooth, groove, gradually flattening and widening posteriorly. A very obtuse and indistinct keel or fold passes forward from the umbo to the anteroventral margin. The ornamentation consists of prominent, subconcentric, regular ridges, lessening in number and lying further apart towards the ventral margin. The ridges commence indistinctly anteriorly to the umbo, and after a regular curvature round the obtuse anterior fold run in shallow curves towards the posterior hinge-line. They become indistinct at the low posterior heel. Under a strong lens the best preserved portions of the shell exhibit finer reticulate ornamentation, the components of which are respectively concurrent with and approximately at right angles to the stronger ridges. No traces of internal parts are to be seen.

Dimensions.—Length, 13·5 mm. approx.
Height, measured at the umbo, 7·5 mm.

Locality and horizon.—The same as for the above-described species.

Remarks.—Some little variation is exhibited in the specimens obtained, though these points do not seem to suffice for specific distinction. Thus, two examples [C.R. 1521, 1672] show irregularity in their ornamentation, one ridge occasionally dividing locally into two parts. One of these specimens [C.R. 1521] also possesses more ridges within the same space than the typical form.

I do not know any Upper Devonian *Allorisma* which suggests close relationship to this species. The nearest resemblance is afforded by *Allorisma münsteri* (d'Arch. & de Vern.) as figured by Professor Beushausen from the Middle Devonian of Germany (1*b*, p. 255, pl. xxv, figs. 4, 5). Our form differs, however, from this in being considerably smaller, in the valves being less globose, in the more gradual fall from the umbo posteriorly and the less prominence of the umbo above the hinge-line, in the narrower shape of the posterior ligamental area, the straightness of the hinge-line posterior to the umbones, and the presence of the fainter reticulate ornamentation.

Professor Beushausen's figures differ from those given by d'Archiac and de Verneuil (1*a*, p. 376, pl. xxxvii, figs. 3, 3*a*) in the sharper fall of the shell anteriorly to the umbones, as well as in the less elongated shape.

After examination of a poor specimen from Breiniger Berg, doubtfully referred to *Allorisma münsteri*, Beushausen suggests the possibility of this form ranging into the Upper Devonian (1*b*, p. 256).

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EXPLANATION OF PLATE III.

Phacops (Trimerocephalus) pentops, sp. nov.

Devonian: Portquin Harbour, Cornwall.

Fig. 1.—Head-shield (× 10).
,, 2.—Side view showing the fall of the frontal portion of the glabella and the position of the eye (× 10).
,, 3.—Pygidium and part of thorax (× 10).
,, 4.—An enlarged view of the left eye showing the arrangement of the facets (× 20).

The original is in the Geological Survey Collection [23068].

Allorisma concinna, sp. nov.

Fig. 5.—Side view (× 2).
,, 6.—Dorsal view (× 2).

The original is in the Geological Survey Collection [23078].

II.—The 'Trias' of Moray.

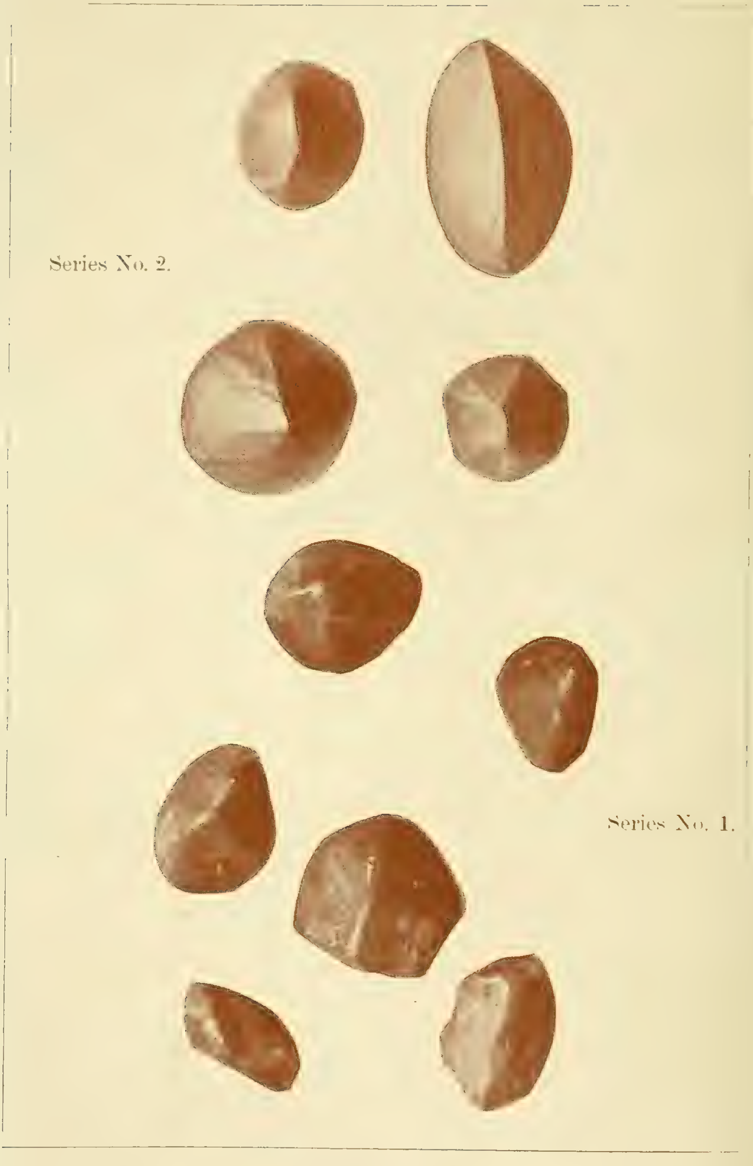
By D. M. S. Watson, B.Sc., Beyer Fellow of the Manchester University.

(PLATE IV.)

THE Reptiliferous Sandstone of Moray first attracted attention in 1851, on the discovery in it by Patrick Duff of a skeleton of *Telerpeton elginense* at Spynie. This was described by Mantell (17),[1] but did not raise any doubts as to the age of the bed in which it was found, which was at that time universally regarded as Upper Old Red Sandstone. This opinion was not disturbed until Huxley showed that *Stagonolepis Robertsoni*, Ag., was a crocodilian, the allies of which were of Triassic age (9); when Huxley showed that *Hyperodapedon* occurred in the undoubted Trias of Coton End, near Warwick (11), the point was generally regarded as settled. Meanwhile some footprints had been found by Captain Brickenden (6) at Cummingstone, near Elgin, which were recognized by Huxley to be similar to those described by Sir William Jardine from Annandale. The discovery by C. Moore (19) that the well-known quarry at Linksfield, formerly supposed to be in rocks of Wealden age, was really opened in beds of Rhætic age appeared to be a strong argument in favour of the Triassic age of the reptile-bearing beds. It had, however, already been shown by Hugh Miller (18) that this mass was really a boulder resting on an ice-scratched surface of the subjacent rocks, hence the evidence drawn from the occurrence of this mass is quite inconclusive. The discovery by Professor Judd (15) that a small patch of a rock identical in physical characters with the cherty rock of Stotfield existed on the north side of the Moray Firth, which was conformably covered by an unfossiliferous series of beds which graded up into the Lower Lias, afforded further evidence of the correctness of Huxley's conclusions as to the age of these beds.

Meanwhile another series of reptiles had been found at Cutties Hillock Quarry, and in a trial pit below them the Upper or Rosebrae Beds of the Upper Old Red Sandstone were proved and yielded a specimen of *Holoptychius nobilissimus*, Ag., now in the Elgin

[1] These numbers in parenthesis refer to the Bibliography at end of paper.



Series 1.—Six wind-cut pebbles from Permian of Quarry Wood, Elgin, Moray.

Series 2.—Four wind-cut pebbles from North Island, New Zealand, for comparison with the Elgin series.

Museum. An inconsiderable bed of pebbles was regarded by Professor Judd as marking the base of the reptile-bearing beds (16).

The Cutties Hillock reptiles were fully described by E. T. Newton (20), who showed that they represented a fauna entirely different to that of the ordinary *Stagonolepis* Sandstone of the district. He, however, continued to regard the beds as Triassic.

More reptiles have been since described by Newton and Smith Woodward from the quarries of Lossiemouth and Spynie (21, 23).

The Reptiliferous Sandstone of Moray occupies three quite distinct areas, which do not touch and whose relative ages can hence never be determined by stratigraphy. These patches are—

1. The Cutties Hillock area. This occupies the top of Quarry Wood Hill to the east of the town of Elgin; this area is about three-quarters of a square mile in extent, and is exposed in several quarries, of which only that of Cutties Hillock has yielded any fossils. The rock is a coarse sandstone often containing inconstant bands of pebbles, usually not more than 8 inches in thickness. They are much false-bedded; the real bedding is probably nearly horizontal, although in one quarry the apparent dip is about 30° to the south-west.

The resemblance between these beds and the Upper Old Red on which they rest is fairly close, but the latter is usually much finer and seldom, if at all, contains pebble bands; this account only refers to the Rosebrae Beds which form the base of the Quarry Wood Hill. The pebbles in the Cutties Hillock Beds are all of characteristically wind-cut shapes, and good 'Dreikanters' are quite common (see Plate IV, series 1). The sand grains are rounded and the whole deposit is pretty obviously of desert origin; judging from the appearances presented by the whole series of quarries, the surface on which the reptile-bearing sandstone was deposited was an irregular one, although I have not seen a really satisfactory exposure of the junction. This area is entirely surrounded by Upper Old Red Sandstone and lies practically entirely above the 300 feet contour.

2. The Lossiemouth area. This forms a large patch east of 321 Q extending from the coast at Lossiemouth towards Elgin and eastward for about 3 miles. It is exposed in the quarries at Spynie, Lossiemouth, and Findrassie Wood. Its base is nowhere seen, but at the East Quarry at Lossiemouth there is a small exposure of soft, fine-grained, yellow sandstone, which greatly resembles some types of the Rosebrae Beds of the Upper Old Red. It has, however, yielded no determinable fossils. At the Little Skerries at Branderburgh a dark-red rock comes to the surface which is quite distinct from the Reptiliferous Sandstone, and in which it is stated that scales of *Holoptychius* have been found. The relation of this mass to the Trias is not, however, clear, and it is very probably brought up by faulting.

The typical character of this series of beds is that of a fine, fairly soft sandstone, nearly white in colour, with no pebbles and no distinct bedding; it is, however, very strongly jointed. This rock is said to be overlaid at Stotfield by "the Cherty rock of Stotfield," a curious, apparently chemical, deposit, the origin of which it is not easy to ascertain. The real relations of the cherty rock and the Lossiemouth Sandstone are, however, not easy to establish. At the upper quarry at Spynie there occurs a very hard white quartzite, which appears to be an altered portion of the ordinary Reptiliferous Sandstone which is worked in the quarry just below. This rock yielded one of the skeletons of *Scleromochlus Taylori*, recently described by Dr. Smith Woodward. It has, however, been confused with the Stotfield rock, with which, I believe, it has nothing whatever to do. At Findrassie Wood Quarry this type of Reptiliferous Sandstone approaches to within 1½ miles of the Cutties Hillock type, but is only 80 feet above sea-level.

3. The Cummingstone area. This extends along the shore from Burghead to Coversea, and is very well exposed in the cliffs as well as the quarries at Cummingstone. The rock is a moderately coarse, false-bedded sandstone, with occasional thin beds of small pebbles, which appear to be of the ordinary water-worn type. The deposit is very false-bedded; there is apparently a steady dip of about 40° to the south-west for about 3 miles of coast, whereas the real dip is quite small and probably variable in direction. The beds are sometimes flaggy, and in that case contain considerable numbers of tracks of reptiles. At Coversea this type of rock comes to within 2 miles of that of the Spynie type.

The Cutties Hillock Quarry has yielded the following reptiles:—

Gordonia Juddiana, E. T. Newton, and four other species of the genus.
Geikia Elginense, E. T. Newton.
Elginia mirabilis, E. T. Newton.

None of these reptiles have ever been found elsewhere, but their allies are known in the Karroo of South Africa (the age of which is also uncertain), in India in beds of uncertain age, and in Texas and Russia in beds that are undoubtedly Permian (1, 2, 3, and 7).

Elginia is allied to *Pariasaurus*, which has been found by Professor Amalitzky in the Permian of Russia, and of the Cotylosauria found by Professor Cope in the Permian of Texas and other North American localities. *Gordonia* is a close ally of *Dicynodon*, which also occurs in the Permian of Russia. *Geikia* is allied to *Ptychognathus* of the Karroo, which occurs there with *Dicynodon*.

The Lossiemouth Beds yield a completely different fauna, of which fairly numerous examples have now been found. These are as follows:—

Dasygnathus longidens, Hux.	*Stagonolepis Robertsoni*, Ag.
Telerpeton Elginense, Mantell.	*Erpetosuchus Granti*, E. T. Newton.
Hyperodapedon Gordoni, Hux.	*Ornithosuchus Woodwardi*, E. T. Newton.
Stenometopon Taylori, Boulenger.	*Scleromochlus Taylori*, A. S. Woodward.

The affinities of *Dasygnathus* are uncertain; it appears to me, however, to be a Labyrinthodont, and large examples of this group are common in the Trias.

Telerpeton is a small Anomodont allied to *Procolophon* of the Karroo.

Hyperodapedon Gordoni has been found in the undoubted Trias of Coton End, near Warwick; it occurs in the Spynie and East Lossiemouth Quarries.

Stenometopon is a Rhynchocephalian so far only found in the West Quarry at Lossiemouth; it is obviously fairly closely allied to *Hyperodapedon*.

Stagonolepis and *Erpetosuchus* belong to the exclusively Triassic group of the Parasuchia, which is of very wide distribution, being well represented in Germany and the United States.

Stagonolepis has occurred at Findrassie Wood Quarry at Spynie and East Lossiemouth.

Erpetosuchus has been found at West Lossiemouth and probably also at Spynie.

Ornithosuchus and *Scleromochlus* are by some regarded as Dinosaurs, and by another important group of palæontologists as belonging to Owen's group, the Thecodontia, which is nearly the same as Huxley's Parasuchia. Neither group, however, is known to occur in rocks older than the Trias.

In addition, at least three undescribed genera of reptiles occur at West Lossiemouth. These appear to me to be either Dinosaurs or Thecodonts, of one of which there is a somewhat obscure skeleton in the Manchester Museum, presenting resemblances to *Aetosaurus*.

Taken as a whole, this fauna is undoubtedly Triassic in its affinities, and the fact that most of its members have now been found in at least two localities suggests that we now have a reliable knowledge of the general character of the fauna.

The Cummingstone area has not yet yielded any fossils except footprints. During my visit I saw tracks of four or five types, all agreeing, however, in general character. They are double tracks, the right and left feet being widely separated when compared with the stride. The manus and pes are of approximately the same size, and are impressed to about the same extent. I was seldom able to count the number of toes; in those cases where I did so they were five in number. The feet are short and brachydigitous, and in certain cases, at any rate, were provided with claws, which the animal sometimes dragged along, producing a pronounced scratch before the actual print. These tracks differ entirely in type from all Triassic ones with which I am acquainted, but they resemble entirely the tracks in the Permian Sandstone of Mansfield, Nottinghamshire, one of which was recently described by Mr. G. Hickling, in whose company I saw in the quarry at that place some four or five other species of tracks. Similar types of footprints have been found in the Permian of Thuringia, and it seems that such tracks are always of Permian age. The track that Huxley described (14), which is now in the Jermyn Street Museum, seems to be identical with one from the Permian of Mansfield, of which I possess a specimen. This track was regarded by Huxley as possibly belonging to *Stagonolepis*, an idea which must be given up, for the metapodial subsequently described by Huxley indicates an elongated foot. Of the Lossiemouth reptiles *Hyperodapedon* alone remains for examination. Its foot seems more suitable, but examination of a well-preserved foot in the Elgin Museum seems to show that it even is too long to produce the Moray tracks. It is unfortunate that amongst the Cutties Hillock fossils no complete foot is known, but the fragments known in *Gordonia Traquarii* (?), consisting of short and stout metacarpals and phalanges, suggest that the foot was similar to that of the allied *Dicynodon*, of which a specimen was figured by Owen in his Catalogue of Fossil Reptiles from South

Africa, and later in the Quarterly Journal of the Geological Society (22); this foot seems quite competent to produce the prints in question, and the characters of the humerus of *Gordonia* seem to indicate great breadth of track, one of the most characteristic features of the prints under consideration. The known *Dicynodon* foot is pentadactyl, so that no objection can arise on that score. It seems, therefore, that the Cummingstone rocks are to be associated with the Cutties Hillock group rather than with the Lossiemouth Trias, and that both are really Permian.

In the field one gains the impression that the New Red Sandstone rocks of Moray are not of great thickness, but on account of their constant false-bedding and isolated exposure (except in the case of the Cummingstone group) it is impossible to give actual measurements. I believe that 200 feet will cover the thickness of the Lossiemouth group, 120 feet more the Cutties Hillock rocks, and probably 400 or 500 feet the Cummingstone Beds.

The present relationships of the beds are easiest accounted for by faults, and Judd has already pointed out that evidence of faulting exists in the neighbourhood. One fault of considerable throw must run easterly and westerly through the village of Quarrywood to throw the Permian Cutties Hillock Beds up to a height of some 200 feet above the Triassic Lossiemouth Beds of Findrassie Wood Quarry, and another with general north and south direction of similar throw must be invoked to separate the Permian Cummingstone Beds at Coversea from the Lossiemouth Beds at Stotfield.

It appears to me that the footprint-bearing beds of Annandale must also be regarded as Permian, as the tracks from that locality described by Sir W. Jardine are of the well-defined type which occurs at Mansfield; some of the tracks, in fact, seem to be identical.

Summary.—It is pointed out that there are three types of Reptiliferous Sandstone in the neighbourhood of Elgin—the Lossiemouth Beds, the Cutties Hillock Beds, and the Cummingstone Beds, and that there is no stratigraphical evidence of their mutual relations. It is pointed out that whilst the Lossiemouth Beds contain an undeniably Triassic fauna, the Cutties Hillock Beds contain a completely different assemblage of reptiles, much akin to the Permian fauna of Texas and Russia. The Cummingstone Beds have yielded only footprints, but these are of the well-defined type occurring in the Permian of Mansfield and Thuringia. It is shown that these tracks could not have been made by *Stagonolepis* or *Hyperodapedon*, the two possible reptiles of the Lossiemouth Beds, but that they agree well enough with the foot of *Dicynodon*, an ally of *Gordonia*, one of the Cutties Hillock reptiles, whose foot, judging from the fragmentary remains alone known, must have greatly resembled it.

It is suggested that the Cutties Hillock Beds and the Cummingstone Beds are of the same age, and that they are really Permian and not Trias, as has formerly been supposed.

I wish to express my indebtedness to William Taylor, Esq., J.P., of Lhanbryde, on whose list of the localities of Lossiemouth Bed fossils (5) my own is largely founded, and to Dr. W. Mackie, of Elgin, the first to call attention to the desert evidences in the Cutties Hillock Beds.

To Mr. G. Hickling I am indebted for much information with regard to Permian footprints.

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EXPLANATION OF PLATE IV.

Series 1.—Six pebbles from the Permian of the Quarry Wood group. They exhibit characteristically wind-cut shapes, despite the rounding off of their angles. From a quarry 150 yards to the east of Cutties Hillock. In the Manchester Museum.

Series 2.—Four pebbles from the surface, Waitotara Grand Flats, North Island, New Zealand. These should be compared with those from the Elgin rocks represented below. In the Manchester Museum.

III.—Fossil Representatives of the Lithodomous Worm *Polydora*.

By Dr. F. A. Bather, M.A., F.G.S., Brit. Mus. (Nat. Hist.).

THE borings of the Polychæt Annelid *Polydora ciliata* (Johnston)[1] are familiar in limestone pebbles and the stouter mollusc-shells on our coasts, but shales and occasionally other rocks are not free from their attacks. They may be recognized by the double aperture, often loosely described as keyhole-shaped, leading to a U-shaped cylindrical tube. The union of the two apertures in a single depression, by the loss of the organically formed septum between them, produces a more slit-like opening, whereas if the surface of the pebble be further worn the two round holes are more clearly distinguished. The differences between the burrows of *Polydora* and those of other lithodomous Annelids, especially the associated *Dodecaceria*, were clearly stated by Dr. W. C. M'Intosh in a very full paper "On the Boring of certain Annelids" (1868, Ann. Mag. Nat. Hist. [4], ii, pp. 276–95, pls. xviii–xx).

The disintegrating action of these worms has been emphasized and its geological importance pointed out by several writers, among whom may be mentioned the Abbé Dicquemare (1781, Rozier's Obs. et Mém. Phys., Paris, pp. 222–4, xviii); Mr. (now Sir) E. Ray Lankester (1868, Ann. Mag. Nat. Hist. [4], i, pp. 233–8, pl. xi); and Professor L. Vaillant (1891, Ann. Sci. Nat. [7], xii, pp. 39–50). It would, therefore, be of some interest to trace the palæontological history of this lithodomous Annelid. According to the revisions by Dr. D. Carazzi (1893, Mitt. Zool. Stat. Neapel, xi, pp. 4–45, pl. ii) and by Mr. M. P. Mesnil (C. R. Acad. Sci., Paris, cxvii, pp. 643–5), there are from ten to fifteen species now living, but that which is of most importance as a borer, at least in north-western Europe, appears to be *P. ciliata*. This lives in the lower half of the littoral or, more strictly speaking, inter-tidal region, and its forsaken burrows may therefore throw light on the elevation or depression of the land. The existence of other species must, however, guard us against rashly referring to this species fossil borings of similar character.

Though, so far as I can ascertain, this genus has not hitherto been recorded in a fossil state, the collection of fossil Annelids in the British Museum enables us to carry the history of *P. ciliata* or an allied species back to the middle of the Pliocene. The following examples may be mentioned:—Borings in a valve of *Volsella modiolus* (Linn.), from the Glacial beds of the Clyde series; the borings fringe an area from which the outer layers of the shell have been broken [A 235].[2] A phosphatic nodule from the Red Crag of Suffolk, cut and polished and showing numerous tubes; in this the two limbs of the U are in many cases cut across, and each pair is enclosed by concentric layers of the concretion, forming a sort of figure of 8 [58197]. A similar nodule from Woodbridge, Suffolk [58220].

Samuel Woodward, on p. 20 of his "Outline of the Geology of

[1] I have to thank my colleague, Dr. W. T. Calman, for kindly referring me to this species and some recent papers on it.

[2] The relations of *Polydora* to recent oysters have been fully discussed by Professor M'Intosh (1902, Ann. Mag. Nat. Hist. [7], ix, pp. 299–308).

Norfolk" (1833), describes the denuded surface of the Chalk on which the Norwich Crag was laid down. He refers particularly to "a chalk-pit near Postwick church, the plateau of which, in its whole extent, is perforated by an animal of the Tubicolæ family, as the rocks of our present coasts are". Specimens of this old sea-floor collected at Postwick by Samuel Woodward himself show that the borings are similar to those of *Polydora*, though rather coarser than those of *P. ciliata*. In one specimen [A 275] the planed surface of the chalk is clearly seen, but the borings are concentrated so thickly in places as to have given rise to irregular cavities about a centimetre across; in another specimen [A 279] the chalk is so riddled that the planed surface is no longer to be detected. From the same locality comes a pebble formed from a Chalk fossil *Echinocorys*, and richly pierced with similar tubes [A 274]. These borings must have been made before the sea-shore was covered with the shell-beaches that now form the Norwich Crag. They may, therefore, be regarded as of Plaisancian rather than Astian age.

Since these borings can only be expected in strictly littoral deposits, such as are rarely preserved through a long period of geological time, it is natural that traces of the genus should not have been observed in the older Tertiary and the Mesozoic rocks of Britain. I cannot detect them, as I had hoped, in our specimens of *Ostrea bellovacina*, or in any of our *Serpula*-covered Cretaceous and Jurassic shells, except perhaps one. This is a *Gryphæa incurva* from the Sinemurian zone of *Arnioceras semicostatum* near Dorsington, Gloucestershire. [A 1183, R. F. Tomes Colln.] The surface of both valves is covered with numerous tubes of a small *Serpula*, and on the large valve are also several oval pits each apparently leading to a double tube. The length of the oval pit is only ·4 or ·5 mm., as compared with 1·5 to 2 mm. in *Polydora ciliata*, and the burrows are perhaps more likely to be those of a *Dodecaceria*. The specimen is merely mentioned here as affording the nearest approach to *Polydora* burrows that I have been able to find. All other specimens that are bored seem to have been attacked by anything rather than *Polydora*.

In view of this lack of evidence it was the more interesting to receive from Mr. Linsdall Richardson an enquiry regarding a bored pebble that he had extracted from the basal conglomerate of the Rhætic series at Hapsford Mill, Vallis, near Frome, Somerset. This is a grey limestone pebble of irregular shape, with extreme measurements 76 mm., 46 mm., and *circâ* 50 mm. Its exposed surface is almost entirely covered with borings which Mr. Richardson had already recognized as similar to those in a pebble of chalk from the sea-shore at Flamborough. The worm that made these may well have been a *Polydora*, but it was not *P. ciliata*, for the tubes are plainly larger and their openings seem to have been further apart. The diameter of the tubes in a recent specimen of *P. ciliata* is ·5 to ·6 mm.; in the Rhætic fossil, ·8 to ·9 mm. Until the need arises for discriminating between these Rhætic borings and others that may be found in rocks of approximately the same age, it scarcely seems advisable to invest them with the dignity of a new specific name.

Whether as a disintegrator of rocks or as an index to the former relations of land and sea, *Polydora* has, it appears, sufficient importance to warrant the publication of this brief note, to the end that other field-geologists and collectors may keep their eyes open for such occurrences as the very interesting one made known by Mr. Richardson.

IV.—Hamster Remains from the Norfolk Forest Bed.

By E. T. Newton, F.R.S., F.G S.

Mr. A. SAVIN, of Cromer, has been kind enough to send me for examination a large number of small vertebrate remains which he has recently collected from the Upper Freshwater Bed of the Norfolk Forest Bed Series at West Runton. Among these there is one little specimen which deserves to be recorded, as it represents a genus not hitherto recognized in the 'Forest Bed'. The specimen is a right maxilla with three grinders in place, indubitably belonging to the genus *Cricetus*; in size it is distinctly larger than the common Hamster *Cricetus vulgaris* (= *C. frumentarius*), which is the largest species of the genus living at the present day. Only once before has *Cricetus* been recognized in Britain, W. A. Sanford[1] having identified from the Hutton Cave, Mendip Hills, remains of a small mouse-like species which he referred to *Cricetus songarus.*

Mr. Savin's specimen is a right maxilla, which, in its present condition, measures 14·5 mm. in length; it has the three molars in place and in an excellent state of preservation. Towards the front of the bone, on the outer side, is seen the base of the jugal process, and on the inner side the palatal plate, which, though not quite perfect, shows much of its oral surface and the floor of the right nasal passage. The greatest length of the crowns of the three teeth is 9·3 mm., the alveoli measuring a little more (10·3 mm.). The grinding surfaces of the teeth are just sufficiently worn to show their patterns in a remarkably clear manner (see Figure), and when examined with a strong lens, or, better still, with a low power under the microscope, the series of islands formed by the enamel, which extend along the middle of each tooth, form a very striking feature. One's attention is also attracted to the deep and sharply defined pits, which are seen between the cusps, both on the inner and outer sides of the crown. The outer cusps are more prominent than the inner ones, and this feature is most marked on the anterior tooth and least on the posterior one. The anterior tooth has evidently had the usual six cusps, but the greater part of the anterior inner one is wanting. The anterior and outer cusp is somewhat larger than either of the others (or those on the other teeth), and this causes an outward projection of the front of the crown unlike what is seen in the living Hamster. The second tooth has four cusps approximately equal in size, and the third tooth has four cusps, the hindermost pair of which are markedly smaller than the others, and consequently this tooth is reduced in width posteriorly. The inner cusps are all a little in advance of the outer ones, so that on the worn surface they seem to

[1] W. A. Sanford, Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 128, and Proc. Somersets. Nat. Hist. Soc., 1870, vol. xv, p. 56.

form oblique transverse ridges, which are, however, interrupted in the middle by a deep depression, which is in part due to wearing away by the attrition of the lower grinders, and which runs from front to back along the middle of the three teeth. The anterior molar has a distinct cingulum running along the inner side of the crown, and a similar cingulum, but much less distinct, is also to be seen on the second and third molars.

Cricetus vulgaris Runtonensis, n.subsp. From the Norfolk Forest Bed at West Runton. Grinding surfaces of three molars of right maxilla, enlarged six times. The specimen is in the possession of A. C. Savin, Esq., of Cromer.

A comparison of this little maxilla with a number of recent specimens in the British Museum at South Kensington and in the Museum of the Royal College of Surgeons, Lincolns Inn Fields,[1] leaves no doubt as to its generic identity with the common Hamster *Cricetus vulgaris* (= *frumentarius*). The main characters of the teeth are the same; but in none of the recent specimens is the anterior outer cusp of the first molar larger than the others, and there is no outward expansion of this region which would correspond with a larger anterior cusp. The teeth of the 'Forest Bed' specimen are likewise larger than those of any of the recent specimens examined, in which the length of the series of three upper crowns varied from 7·4 to 7·7 mm. Dr. Nehring[2] in his paper on Pleistocene Hamsters gives the extreme measurements of the three upper teeth in recent Hamsters as 7·4 and 8·0 mm.

The large size and difference in structure of these 'Forest Bed' teeth, as well as the age of the beds from which our fossil was obtained, make it highly probable that it represents a form specifically distinct

[1] I am pleased to have this opportunity of thanking the officers in charge at both these institutions for the courteous assistance so kindly rendered on this as on many other occasions.

[2] "Ueber pleistocäne Hamster-Reste aus Mittel- und Westeuropa": Jahrb. k.k. geol. Reichsanst., 1893, Band xliii, Heft ii, p. 179.

from the living *Cricetus vulgaris*. M. C. Depéret[1] has described two lower jaw rami of a *Cricetus* from the Pliocene of Perpignan under the name of *Cricetus angustidens*.[2] These are said to agree as nearly as possible with the living *C. vulgaris*, but the species is distinguished by the narrowness of the anterior molar tooth and by the obliquity of the tubercles, which are compressed and directed forwards so as to join the external tubercle of the pair next in front; also the two anterior tubercles are small. It is obvious that the structure of these teeth is unlike what obtains in the 'Forest Bed' specimen.

Dr. Nehring,[3] in the paper above referred to, discusses the affinities of the larger and smaller species of *Cricetus* found in the Pleistocene deposits of various localities in Middle and Western Europe, and draws special attention to the large jaws described and named by Dr. Woldřich[4] *Cricetus frumentarius major*. These large specimens seem to agree very closely in size with our 'Forest Bed' form, but the series of upper grinders are not quite so large. Dr. Woldřich gives the alveolar measurements of his two largest specimens as 8·8 and 9·5 mm. The same measurement of the 'Forest Bed' specimen is 10·3 mm. The description of these large Hamsters is not sufficiently detailed to allow of a close comparison with the peculiarities observed in the 'Forest Bed' example, and the figures of the teeth are not large enough to give the smaller details of structure; it seems, however, from Dr. Woldřich's figure (loc. cit., pl. ii, fig. 23), that the anterior tubercles of the front tooth are somewhat narrower than the others.

Dr. Nehring (loc. cit., p. 185) seems to think Dr. Woldřich hardly justified in giving the subspecific title *C. frumentarius major* to these fossil forms, as he says there is much variation in size among living Hamsters; but, according to Dr. Nehring's own measurements, no recent Hamster has attained to the size of Dr. Woldřich's fossils, and Dr. Nehring himself includes them under his own subspecies *C. vulgaris fossilis*. If a third name is to be used, that of Dr. Woldřich should be adopted.

During the last few years several living forms of *Cricetus* have been described and provided with subspecific or race names, but for the most part these are distinguished by external characters, and make no nearer approach to our fossil than does the common Hamster itself. I am not aware that any fossil Hamsters have been described other than those already alluded to; but there are two or three papers [5, 6, 7]

[1] "Les Animaux pliocènes du Roussillon": Mém. Soc. Géol. France, 1890, vol. i, Mém. No. 3, p. 54.

[2] See also Dr. Woldřich, "Uebersicht der Wirblethierefauna des Böhmischen Massivs während der anthropozoischen Epoche": Jahrb. k.k. geol. Reichsanst., 1897, Band xlvii, p. 393.

[3] See note 2, p. 111.

[4] "Diluviale Fauna von Zuzlawitz bei Winterberg im Böhmerwalde": Sitzb. d. k. Akad. d. Wiss. in Wien, 1880, Band lxxxii, p. 30.

[5] J. Kafke, "Recente und Fossile Nagethiere Böhems": Arch. Landesdf. Böhem, 1893, vol. viii, No. 5.

[6] J. Nüesch, "Das Schweizersbild, eine Niederlassung aus paläolithischer und neolithischer Zeit": Denkschr. schweiz. Gesellsch. Naturw., 1896, Band xxxv, pp. 1–334.

[7] Dr. A. Nehring, "Ueber die pleistocäne Fauna der Belgischen Hölen": Sitz. Gesellsch. Naturf. Freunde, Berlin, 1897, p. 74.

on fossil rodents, including the genus *Cricetus*, to which reference may profitably be made, that by H. J. Nüesch having an account of the small mammals by Dr. A. Nehring.

If the 'Forest Bed' specimen were of the same age as those described by Dr. Woldřich, one would have had little hesitation in referring them provisionally to the same subspecies; but the evidence in favour of these Norfolk deposits being of Pliocene age is becoming stronger. Dr. Forsyth Major's[1] study of the Forest Bed Voles has led him to think that most of the 'Forest Bed' mammals now referred to living species will eventually prove to be extinct forms, and recent investigations seem to lend strength to his opinions.

A name is needed by which this unique Hamster from the 'Forest Bed' may be known, and under the circumstances it would scarcely be wise to adopt the name of a Pleistocene form, as this would seem to imply affinities for which we have no grounds. It is very unlikely that additional evidence will be obtained for a long time to come, and I suggest that we regard this fossil as representing a peculiar race and call it *Cricetus vulgaris Runtonensis.*

V.—On the Geologic Conditions affecting the Coasts of England and Wales, with special reference to the Coast-line from Lynn to Wells (Norfolk) and from Yarmouth to Eastbourne (Suffolk, Essex, Kent, and Sussex).

By W. Whitaker, B.A., F.R.S.

(*Concluded from the February Number*, p. 56.)

HAVING now given a short account of the geology of the long line of coast from Yarmouth to Eastbourne, one may say of the first part of it, north of the Thames, that it is, so to speak, most favourably constructed for coast-erosion. Without a single hard or firm rock, such as the Chalk; without anything that can form a nearly perpendicular cliff of any height, no cliff indeed being high enough to give rise to a respectable landslip; composed of loose sand and gravels, loams and clays (the last partly strengthened by thin layers of soft stone), there is really nothing to withstand either the assaults of atmospheric action from above or of the sea below. Such parts as are of special interest or have been subject to special observation will now be noticed.

Along this coast the general movement of the shingle is southward, or toward the Thames. Owing to this the most easterly point of this island, Lowestoft Ness, consists of low flat land gained from the sea, a tract of Blown Sand and Shingle about 2½ miles long and nowhere half a mile broad. The seaward extension of the harbour has helped to arrest the progress of the shingle and to pile it up on the northern side. Naturally this has led to a decrease of shingle on the other side of the harbour, and on my last visit, in 1902, the defences of the southern part of the town, by Pakefield, had been overcome and the cliff cut back so as to endanger some of the houses. [Since the above was written further loss of land has taken place here.] Curiously enough, however, at Kessingland, the southern end of this long line of

[1] "The Mammalian Fauna of the Forest Bed": Geol. Mag., 1908, p. 329.

cliff, a little Blown Sand had accumulated at the foot and had been artificially helped to form a protection, so that here erosion was checked, whereas when I was first there, many years ago, it was going on markedly. At Covehithe I have measured the greatest loss of land that has come under my notice, namely, about 60 feet in a year. In nine years (1878–87) the loss was at the rate of something over 18 feet a year.

Easton Bavent (a place now gone) is also a case of continuous marked loss, and I was able to take measurements from 1878 to 1882. Others taken before and since are noticed in the Geological Survey Memoir on the district (1887). At a later visit, however, I found a change in the course of things; what had been a fairly clear cliff, showing a long and good section of shelly Crag below gravel, had changed to a weathered-down slope, with no sign of the Crag except where rabbits had obligingly made holes at one part. Erosion therefore had been checked here. On the other hand, whilst I was living at Southwold (1878, etc.) there was practically no change there, but since then erosion has occurred to a considerable extent, and has been duly recorded by Mr. Spiller.[1]

At Dunwich again, one of the most noted places in the matter of coast-loss, there was practically no change while I was first in that neighbourhood, and apparently there had been very little for some years, there being a good deal of talus at the base of the cliff, so that none of the shelly Crag was to be seen. Up to 1897, indeed, there were but two or three geologists who had seen that bed in the southern part of this cliff, and they had seen but little of it. But then the base of the cliffs having been swept bare, good sections of shelly Crag were seen by many observers (including myself) in 1898, and the cliffs were again cut back. From Easton Bavent to Dunwich, therefore, in the course of less than thirty years there has been a good deal of vacillation in the process of erosion.

The growth of the shingle-spit southward from Aldeburgh is remarkable. The Alde must have once flowed direct to the sea just south of that town, whereas now it has been doubled back south-westward for several miles, not joining the sea until past Hollesley. Some day perhaps the river may be able to force a passage through a narrow part of the shingle, either by Aldeburgh or by Havergate Island. This sort of thing has happened in the past, as also, to my knowledge, near Christchurch, in Hants.

Some miles further on the shorter shingle-spit of Landguard Common seems to have slightly deflected the combined channel of the Orwell and Stour. The shingle can hardly cross this broad and fairly deep water, and the London Clay cliff of Dovercourt has, therefore, little protection from the sea, the foreshore consisting of that clay, with layers of cement-stone. These stones make a sort of pavement where they have not been removed, as they once were, for the manufacture of Roman cement; that removal probably facilitated the cutting back of the cliff.

At the Naze slips occur, water being thrown out at the junction of

[1] Geol. Mag., 1896, pp. 23–27.

the Crag (shelly sand) with the London Clay. Here and along the stretch of London Clay cliffs to Clacton there is no great protection of the base of the cliff by beach, and the foreshore consists largely of the clay.

The marshes that form the coast of southern Essex are protected by earthern sea-walls and are areas of accretion rather than of destruction. In the midst of these marshes there are small tracts of shingle, the long broken line in the marshes between the Blackwater and the Crouch pointing to a former shore-line, of which the smaller patches of shingle in Foulness may be an extension.

Crossing the Thames the general movement of the shingle is in a reverse direction to what we have hitherto had, that is to say, westward and northward, but still toward the Thames. The cliffs of Sheppey are a noted instance of continuous loss of land, Warden Church and churchyard having gone in late years. The clay coast of the mainland eastward also wastes steadily, and at the highest cliffs, east of Herne Bay, there are often good examples of what are not inaptly termed mud-glaciers, streams of moist broken-up clay that flow down the slopes and are crevassed as ice-flows are. At Reculvers the Roman station has been destroyed to the extent of a half, and it is only by careful protective work that the twin towers of the old church within the walls have been kept.

The Chalk of the Isle of Thanet forms a huge natural breakwater, without which there would have been great destruction of the softer Tertiary beds to the west and south. This tract is a good example of the effect of joint-planes on the erosion of cliffs. There is a dominant set of these planes, roughly from N.W. to S.E., and these have led to the cutting out of projecting masses and sometimes of isolated stacks. The line of cliff from Foreness to White Ness, at the north-eastern part, is cut along such joint-planes. In the neighbourhood of Ramsgate sets of small faults, some too small to be shown on the map, have a marked effect.

On reaching the marshes of the Stour we find a point of some interest in regard to changes in coastal conditions. In Kent, as has been said above, the general movement of the shingle is toward the Thames, which in this case means northward from Deal toward Thanet. In accordance with this the shingle of the coast and its accompanying Blown Sand form a ridge with a northerly extension, ending at the Stour; but a little way in from the shore of Thanet we have evidence that once it was otherwise. We have there a short shingle-bank running from the higher land at Cliffs End over the marshes south-westward, and then another and longer bank from the rising land at Half Way House southward across the marshes to Stonar, where it ends in a broader mass. These shingle-banks, which show old shores, must have been formed from the north to the south, or in the reverse direction to the later shingle of the present coast.

Here, too, we have another good example of the deflection of a river by the gradual lengthening of a beach. The Stour must once have flowed direct to the sea; but by the extension of the old beach it has been driven down southward to Sandwich, when it returns northward (getting close to its course on the other side of the beach at Stonar

Cut) and then, after some 6 miles of wandering, again takes its regular easterly route to the sea.

Northward from Deal there has been considerable loss of land from the travelling of the shingle northward. When I was a boy Sandown Castle (dating from Henry VIII) was in sound condition and inhabited: now it has been destroyed, and the batteries farther north have shared a like fate. Deal itself is protected by groynes, and the stopping of the shingle here has probably aided in the destruction of Sandown. From Deal southward the breadth of the shingle has increased much since the time of the old Ordnance map (Sheet 3, published 1819). [This increase was duly noted on the Geological Survey Map years ago, as well as other changes of a like sort.]

There are sometimes large falls at places along the Chalk coast, but the loss here is not to be compared to that of the coasts of Norfolk, Suffolk, and Essex. The former extension of the land is well shown, as in other like coasts, by the cutting back of dry valleys and combes, the bottoms of which are sometimes at a considerable height above the shore.

The Admiralty Pier at Dover has caused a small accumulation of shingle on its western side, and has probably hindered the passage of shingle along the coast north-eastward, thus leaving the base of the cliffs unprotected and aiding their erosion. The great extension of the harbour-works here will probably increase this aid.

West of Abbotscliff we come to the Undercliff (a good example of coastal landslip), due partly perhaps to the clayey character of the Chalk Marl at the base of the formation, but still more to the underlying Gault clay, which forms a damp slippery yielding bed to the Chalk above. The Gault itself, in East Wear Bay, is of course readily eroded. [At Sandgate landslips have occurred through the clayey Sandgate Beds holding up the water in the overlying permeable Folkestone Beds, and forming a good slide.]

The great alluvial flat of Romney Marsh, below high water of spring-tides, is an area of deposit, and is protected either artificially by sea-walls or naturally by great spreads or banks of shingle. The gradual growth of this latter and its extension outward, from the west to Dungeness, is well shown on the Geological Survey Map (Sheet 4).

The way in which many of the successive fulls of Dunge Beach tail off inland into narrow strips, divided by Alluvium, is notable, and at the heads of the little valleys thus formed there are often small springs or outflows of fresh water. The bare shingle probably absorbs rain more quickly and in greater quantity than any other gathering ground in the kingdom, so that some way inland from the shore there is no room for infiltration of sea-water.

The bay marked on the old map eastward of New Romney is now filled up. An old shore-line seems to be shown by the shingle on which that town stands and by that of Lydd.

At Fairlight the broken cliffs consist of permeable sand above, with clay beneath, and the result is a considerable landslip, which ceases westward where the clays do not come to the surface, the massive sand, about 150 feet thick, then forming a nearly vertical cliff with clay above at the higher parts, which therefore give way.

At and beyond Hastings the coast is more or less protected, and the Pevensey Levels, like Romney Marsh, have either sea-wall or shingle-bank to keep the sea from the marshes.

To give details of the amount of waste of land along those parts of the coast treated of would involve much work of compilation: the facts are to be found in Geological Survey Memoirs, in British Association Reports, and in other publications, which are duly noted in the Bibliographic List in the Report of the Royal Commission.

In the above notes I have simply tried to give information as to the various coastal conditions, with a general account of what is happening or has happened of late years.

General Conclusions.

As regards what can be done to decrease the waste of land along our coasts, it is clear that this must vary greatly in various places. I do not speak of *stopping* that waste, as I believe this to be impossible. The actions of atmospheric weathering are always going on everywhere, especially perhaps along a coast, where a free margin is provided for the loss of wasted material: we cannot stop them, though we may greatly delay their proceedings. There are two things, however, that surely could be done quickly and could not fail to have effect in many places.

Nature has so generally put a limit to her work by the piling up of shingle: surely it should be an easy matter to prevent the taking away of that shingle, taken as it is for the small gain of comparatively few persons at the great loss of many.

A stop should be put to the taking away of shingle from protective beaches, that is, in the great majority of places. There may be tracts where the taking of shingle is practically harmless, as in the inland reaches. For instance, one cannot see how the loss of some of the shingle of Dungeness can in any way affect the coast, of course on the understanding that nothing is touched within some distance of the shore. At the same time there remains the question whether, in some future change in the action of coastal eroding forces, these inland masses may not be attacked by the sea and their material shifted on elsewhere, in which case, of course, the stronger they are the better their power of resistance.

The second point is also a very simple one. It is inadvisable that land should be ploughed up almost to the edge of cliffs, as is often the case. By keeping a broad border of unbroken ground, under grass or other growth, along a coast, the destructive atmospheric actions may be checked, whereas on ploughed land there is every facility for rain to sink through and for cracks to occur. On poor porous land there can be practically no loss in giving up such a strip.

Another matter is the prevention of small isolated attempts at protection, often badly planned and badly carried out, and which commonly result in little else than waste of money, and now and then in damage to neighbouring land. It is pitiful sometimes to see these feeble, useless efforts, with their waste of work. Owners of land along the coast and those otherwise interested in checking coastal waste should be led to understand that useful protective work can only be rightly done on a comparatively large scale, with a large amount of combination between landowners, local authorities, and perhaps some more central body. I do not see, however, that the last point can be pushed to what may seem its logical end, that is, universal protection, for reasons now to be given.

In the first place, the land of much of our sea-bord is of little value, as land; often, indeed, the cost of effective protection would be many times that value. In such a case, of course, it would be a losing game to make such protective works as would be needed, unless by so doing the protection of some far more valuable or important parts in the neighbourhood could be aided by the protection of the comparatively valueless land, as far as is possible. On the other hand, it is equally possible that the protection of the less important part might add to the difficulty of dealing with the more important. It is not always that a coast-town can do all the work needed for its security within its own boundary, neither has such a town power to stop or to control work, beyond its boundary, that may be harmful.

Again, were protection practically universal, if it could be for a time, what would happen? Clearly no fresh material for the formation of beach would be brought to the shore from the cliffs, and there would be nothing to replace wear and tear of the constantly moving beach. Moreover, the steady movement of beach along the shore, in given directions, would result in its being swept away from certain parts, which would then be left in a state more fully open to the action of the sea, so that their defences might be overstrained and broken, when rapid erosion would probably set in.

As regards those parts of the coast which are composed of hard rocks, generally speaking, protection is needless, and moreover would often be impossible. Sometimes there is little or no shore, the cliffs being in places reached by the sea at all states of the tide, or nearly so; so that protective works could hardly be made. Moreover, it is from the comparatively slight waste of the cliffs of hard rock that some material is provided for the natural protection, by beach, of other and more attackable parts of the coast.

I think, therefore, that in the first place efforts should be directed to the protection of the more important parts of the coast, such as where there are towns and villages. The towns, of course, have done much work in this way and often with great success; but it seems to have become essential to extend the work far beyond their boundaries, and the spirit of parochialism should be exorcised in this matter. Harbours and the mouths of rivers naturally fall into this class.

There are parts of the coast where, as a rule, little interference is needed, that is, in the large low alluvial tracts. In such cases as the Wash it has paid in the past to do large works of enclosure (so as to reclaim land) and to make seaward defences for that land. Presumably, therefore, it will pay in the future to keep those defences in order, and in some cases also to extend the work of reclamation. Land so gained is of value and can pay for itself; but here, too, there may be need of concerted action. Well thought out large schemes will be better and cheaper than patchwork.

In the original Report (Appendices, pp. 146–158) this Memorandum is followed by a "Chronological List of Works relating to Coast-erosion, Coast-accretion, and Coast-deposits of England and Wales", dating from 1675 to 1907. A few further entries may be made in a later Report.

The Appendix by Mr. Reid, already referred to, is followed by Appendices by Professor Lebour and Mr. R. H. Worth (Northumberland, Durham, and South Devon, pp. 175–184), a map of the Wash by Mr. W. H. Wheeler, and a statement by Mr. T. M. Reade (Rhyl to Gosforth, pp. 209–211).

VI.—Notes on a Well-sinking in the Great Oolite of Lansdown, Bath.

By the Rev. H. H. Winwood, M.A., F.G.S.

The following particulars were obtained with the assistance of Mr. Isaac Sumsion, jun., Hon. Sec. of the Golf Club:—

Section of Well in Great Oolite

at the Lansdown Golf Club, north of the Blathwait Arms, Lansdown, on the 750 ft. Contour, 1908.

		Thickness.		Depth.	
		ft.	in.	ft.	in.
	Turf and mould	1	0	1	0
Great Oolite.	Brown, fissile, shelly, oolitic limestones, coarse and crystalline; the organic remains very fragmentary	6	6	7	6
	Yellow, more solid beds of oolite, lighter in colour than beds above and finer in grain	7	6	15	0
	Very fossiliferous bed, one portion composed entirely of well-preserved shells of *Rhynchonella concinna*, *R. obsoleta*, and *Terebratula*	0	5	15	5
	Close-grained tough beds of finer oolite, in part crystalline. So-called 'Bastard Oolite', used for walling	4	1	19	6
	Thin seam of yellow clay	0	0	0	0
	Blue limestone, non-oolitic	0	8	20	2
	Blue clay	1	0	21	2
	Yellow clay	0	1½	21	3½
	Yellow, compact, oolitic rock	1	6	22	9½
	Thick yellow oolite	1	0	23	9½
	Yellow clay parting	—		—	
	Thick, yellow, drusy, oolitic limestone	0	9	24	6½
	Coarse-grained, tough, yellow, oolitic limestone	5	9	30	3½
	Thin oolitic band, moist	0	1	30	4½
	Yellow clay	—		—	
	Blue limestone, banded with yellow	0	9	31	1½
	Blue clay	0	6	31	7½
	Blue limestone, partially oolitic	1	0½	32	8
Fuller's Earth.	Light-blue greasy clay, with hard, fossiliferous, shaly, limestone bands, fossil wood, and 'cone-in-cone'; Ostracoda, *Cythere oscillum*, *C. sphærulata*, *Cytheridea Bradiana*, etc., and some Lamellibranchs	25	4	58	0

Mr. Sumsion states that there is a good supply of water, and the result of the examination by the City Analyst shows it to be of excellent quality—

Chlorine as chlorides	·84 grain per gallon
Free ammonia	none
Albuminoid ammonia	·0014 grain per gallon
Total solids	16 grains ,,
Oxygen required to oxydize decomposing matter	none
Nitric acid as nitrates	none

The water was perfectly clear and without sediment.

Mr. L. Richardson, who kindly examined the fossils from the Fuller's Earth, informs me that "the hard grey shale from a depth of 36 ft. 6 in. contains an *Ostrea* of the *O. Sowerbyi*-type; and that from a depth of 54 ft. contains numerous specimens of *Trigonia clapensis*, Terquem & Gourdy, and a *Placunopsis* near to *P. sociale*, M. & L. There were also present internal casts of *Pleuromya*, *Placunopsis detrita* (Terq. & Gourdy), *Tancredia*? *brevis*, M. & L., *Leda lachryma* (Sow.), and Ostracods".

The Great Oolite, which is nearly 33 feet thick, represents only the lower portion of the formation, or the "Lower Rag beds", which occur beneath the main freestones of Box and Corsham. The Lower Rags are seldom exposed, but we have records of 15 to 20 feet at Odd Down, 17 to 40 feet at Box, 45 feet at Corsham, and 43 feet at Murrel, near Winsley.[1] The beds evidently vary a good deal in detail within short distances, and the freestones occur on somewhat different horizons in the series above the Lower Rags.

The Rev. Joseph Townsend, in 1813, remarked that "Lansdown has the bottom beds, which terminate on the Northern hanging of the hill, and it is curious to observe numerous pits remaining near the monument, to remind us of the ignorance which prevailed in former times; because from these very pits, at the distance of four miles from Bath, all the free-stone was taken for building the city and cathedral [Abbey], although the same kind of stone was immediately at hand, but concealed, till Mr. Allen opened his quarries behind Prior Park".[2] This probably is not quite correct, as the view now generally accepted is that the stone for the Abbey came from a disused quarry near Entry Hill, on the south side of Bath, and that the old pits on Lansdown were opened to obtain flaggy beds mainly for roofing purposes.

VII.—Note on the Shore Sand of St. Ives Bay, Cornwall.

By T. Crook, F.G.S., & G. M. Davies.

THE shore and dune sand of St. Ives Bay is typically light-coloured owing to the predominance of calcareous matter in the form of shell fragments, etc. But the actual proportion of the platy shell

[1] See Lonsdale, Trans. Geol. Soc., ser. II, vol. iii, p. 253; H. B. Woodward, "The Jurassic Rocks of Britain," Mem. Geol. Surv., vol. iv, pp. 261–7; and H. H. Winwood, Proc. Geol. Assoc., 1896, vol. xiv, p. 347.

[2] "The Character of Moses," 4to, Bath, p. 150; see also p. 192.

fragments to the heavier and more granular ingredients of the sand varies considerably, especially within the limits of high- and low-water marks, as is usually the case. Some of the heavier ingredients are dark-coloured, and may be observed to have been streaked out in bands or aggregated in patches at the surface, where they have been concentrated by the action of the waves. Where heavy minerals abound, tidal action can be seen to have effected a persistent concentration about the mean high-water mark, where the heavier ingredients predominate for at least a foot beneath the surface. Such a band can be easily traced for a considerable distance in the vicinity of the Red River.

A specimen collected from this band at a point about midway between Red River and Hayle River was found to contain about 30 per cent. of shelly matter, etc. The residue left after dissolving this calcareous portion of the sand in cold, weak acid was found to have approximately the following mineral composition:—

			Per cent.	
Strongly magnetic	Magnetic iron oxide		1	Dark-coloured portion.
Weakly magnetic	Killas fragments Tourmaline Impure quartz Brown biotite Chlorite Siderite		74	
Non-magnetic	Quartz Felspar Killas fragments	s.g. < 2·84 (bromoform)	10	Light-coloured portion.
	Fluorspar Andalusite	s.g. > 2·84 < 3·32	15 (almost wholly fluorspar)	
	Topaz Free tinstone Killas fragments impregnated with tinstone Zircon Spinel	s.g. > 3·32 (methylene iodide)		

The constituent referred to as magnetic iron oxide is complex. It appears to be partially hydrated, and probably consists of a mixture of magnetite, hæmatite, and hydrated iron oxide, the magnetite predominating. With the exception of a slight amount of hæmatite, it is opaque even in the smallest particles. It is apparently non-titaniferous.

The killas fragments show a very compact structure; they are for the most part weakly magnetic, owing to the presence of magnetic enclosures, many of which are black, and consist, in part at least, of magnetic iron oxide. The non-magnetic killas fragments are either free from dark enclosures or are impregnated with granules of tinstone; in the former case they float in bromoform, in the latter they may sink even in methylene iodide.

The tourmalines are chiefly brown; but some are blue, while others are almost colourless in ordinary light.

The impure and weakly magnetic quartz is in part rusty and in part impregnated with fine needles of tourmaline. The non-magnetic quartz is very dusty in appearance, due to the abundance of liquid inclusions, with numerous gas bubbles.

The non-magnetic portion heavier than bromoform consists almost wholly of fluorspar, with only small amounts of the other constituents, including andalusite, topaz, killas fragments impregnated with tinstone granules, and a few small free grains of tinstone.

The fluorspar fragments are mainly colourless, but many of them show a well-marked violet colour. They are isotropic. They exhibit the characteristic octahedral cleavage, yielding numerous triangular plates with bevelled edges. Their very low refractive index is a striking feature.

The andalusite fragments are partly irregular in shape, but some of them are elongated prisms, with definite limiting edges; these latter show straight extinction. They have a refractive index about 1·64, and are optically negative. They exhibit the characteristic pleochroism, showing the rose tint when the short diagonal of the polarizer is along the length.

The topaz fragments are partly granular and partly in the form of good basal cleavage plates. These latter show the normal emergence of the acute bisectrix, which is positive; and they also show the feeble birefringence characteristic of basal flakes of topaz, with a refractive index near 1·61.

Siderite in rhombohedral cleavage plates, pale spinel in irregular grains or octahedra, zircon crystals, ilmenite, epidote, muscovite, free grains of tinstone, and probably also rutile and blue corundum are seen occasionally in the sand.

A lighter-coloured sand from near low-water mark at the same locality, and another from near Lelant about half a mile to the west of Hayle River, both contained about 70 per cent. of shell fragments, etc. Their insoluble residues contained the same ingredients as the specimen already described, but in different proportions; and the heavier minerals were present only in small amounts.

It seems, therefore, that fluorspar, andalusite, topaz, and tinstone are probably distributed throughout the sands of St. Ives Bay. The amount of fluorspar is considerable, that of andalusite and topaz small, whereas the amount of tinstone is very small, the mineral being mostly present as fine granules disseminated in killas fragments. The presence of these minerals is not surprising, considering their abundance in the granite and killas of Cornwall; but it is perhaps rather remarkable that one can pick up sands so rich in fluorspar.

There can be little doubt that the non-calcareous portion of these sands consists chiefly of the products of mining activity brought down to the coast by the Red River. It appears to be practically identical in its general character with the Red River sand described by the officers of the Geological Survey (see Memoirs, "Geology of Falmouth and Camborne," 1906, p. 273). The total amount of stamp-battery products and other mining refuse brought down by the

Red River to the coast must have been enormous, and has obviously contributed to the building up of the aggressive dune sands of this district.

The mineral composition of the sand of St. Ives Bay thus affords a good example of the influence of the human factor in geological processes.

VIII.—On the Chalk Section at the Waterworks Quarry, Marlow.

By Charles P. Chatwin & Thomas H. Withers.

Having had occasion to work at the Chalk Rock in this quarry, we took advantage of the opportunity to examine the whole of the Chalk exposed above that bed, which, owing to the inaccessibility of the upper half of the quarry, had not been examined in detail. The floor of the quarry coincides in part with the top of the Chalk Rock, and as there is a vertical face of nearly 50 feet of Chalk above it, the junction of the zones of *Holaster planus* and *Micraster cor-testudinarium* was to be expected in the upper portion of the section, and it was with the object of defining the junction of these two zones that we paid attention to the higher beds.

It was found possible, with the aid of a ladder, to collect from the upper half of the quarry and to determine the zonal junction, and owing to the interest attached to the finding of the Ammonite described in the preceding paper (see February Number, p. 66), this seems a fitting opportunity to give a complete description of the section. The first description was given in the Survey Memoir,[1] in which the Chalk was assigned to the lower part of the *Micraster cor-testudinarium* zone. In a later publication [2] the beds were described as belonging to the upper part of the same zone. Later, Messrs. L. Treacher & H. J. Osborne White [3] correctly referred the lower part of the quarry to the zone of *Holaster planus*, and the higher beds to that of *Micraster cor-testudinarium*, but were unable to obtain sufficient evidence to fix the junction of the two zones. They further state that the floor in part coincides with the top of the Chalk Rock, but record no fossils from that bed. A long stretch of Chalk is exposed in the quarry, and it is probable that the descriptions by the Geological Survey were based on the Chalk at the south-western end, which is now railed off and has not been worked for some considerable time. The beds dip to the south-west, thus allowing slightly higher Chalk to come in at that end of the section, and this would account for some difference in the horizons given. The present description is based on the vertical section seen a few yards to the right of the railings which divide the old from the new working.

To the north-east of the pit the floor is formed by the Chalk Rock, which is grass-covered; consequently the soil has to be removed to obtain an exposure. Several fossils representative of the *Reussianum*-zone fauna were obtained from this bed, as well as the two fragments

[1] "Geology of London": Mem. Geol. Surv., 1889, vol. i, p. 76.
[2] "Cretaceous Rocks of Britain": ibid., 1904, vol. iii, p. 217.
[3] "Excursion to Marlow": Proc. Geol. Assoc., 1905, vol. xix, pp. 157–8.

of *Puzosia* described,[1] which were found in the weathered rock immediately beneath the soil. About 10 feet above the level of the Chalk Rock there is a prominent band of tabular flint which shows step-faulting, the total downthrow being 2 feet to the north-east. There are no well-marked lithological features above the tabular flint band, so that either this band or the Chalk Rock can be used as a datum-line. The interporiferous areas of the examples of *Micraster præcursor* collected below the tabular band vary from sutured to feebly inflated. Those from this point up to 4 feet above the tabular band, have feebly to moderately inflated 'areas' and belong to the upper *Holaster planus*-zone type. Above this horizon the 'areas' of the Micrasters gradually become more strongly inflated, and not until the height of 16 feet above the tabular band do they exhibit the features of the *Micraster cor-testudinarium*-zone type. At this horizon occurs a band of nodular flints, and this may be regarded as marking the junction between the two zones. The thickness of the *Holaster planus* zone, if we estimate the thickness of the Chalk Rock at 6 feet, is therefore 32 feet.

The following is the section seen, with the fossils collected from the various beds:—

		Feet.
Micraster cor-testudinarium zone.	Firm white chalk with many bands of nodular and tabular flint	23
	Micraster præcursor, *Cardiaster cotteauanus*.	
Holaster planus zone.	Greyish, lumpy chalk with tabular flint lines and small scattered flints. One conspicuous band occurs about 10 feet from the floor	26
	Micraster præcursor, *M. cor-testudinarium*, *Echinocorys scutatus*, var. *gibbus*, *Holaster placenta*, *Cidaris serrifera*, *Dimyodon nilssoni*, *Inoceramus* sp., *Ostrea* sp., *Spondylus latus*, *S. spinosus*, *Crania egnabergensis*, *Rhynchonella reedensis*, *Terebratula carnea*, *T. semiglobosa*, *Serpula ampullacea*, *S. fluctuata*, *S. plana*, *Terebella lewesiensis*, *Coscinopora* sp.	
	Floor of pit.	
	Chalk Rock. Massive cream-coloured limestone, with layers of green-coated nodules . . . seen for	3
	Micraster leskei, *M. præcursor*, *Inoceramus* sp., *Arca* (*Barbatia*) sp., cf. *geinitzi*, ? *Solariella gemmata*, *Trochus schlüteri*, *Turbo geinitzi*, *Nautilus* sp., *Scaphites geinitzi*, *Pachydiscus peramplus*, *Puzosia curvatisulcata*, sp. nov., *Terebratula semiglobosa*, ? *Parasmilia granulata*, *P.* aff. *serpentina*.	

In a previous paper[2] we commented on the connection between the thickness of the zone of *Holaster planus* and the development of the rock bed at its upper limit, and stated that where this rock bed was developed the thickness of the zone was considerably decreased. It is interesting to note that the present section confirms our views on this point. A comparison between three sections in the zone of *Holaster planus* in this part of the country will make our point clear.

[1] See Geol. Mag., February, 1909, pp. 66–9, Pl. II.

[2] "The Zones of the Chalk in the Thames Valley between Goring and Shiplake": Proc. Geol. Assoc., 1908, vol. xx, pp. 412–13.

In the section at Aston Rowant,[1] Oxon, a compact yellowish limestone band 1 foot in thickness marks the upper limit of the zone, and here we measured 19 feet for the thickness of the zone. At Hart's Lock Wood,[2] near Whitchurch, Oxon, a band of yellowish lumpy and nodular chalk (hard and soft mixed), much less compact than at Aston Rowant, is developed at the top of the zone, but this to a thickness of 3 feet, and at this place the thickness of the zone is 24 feet. In the present section, where there is no definite rock development at the top of the zone, the thickness, as already stated, is 32 feet. We can therefore surmise that the development of a hard rock band at this horizon indicates a period of arrested or diminished sedimentation, and in connection with this it is interesting to note that in this section, where no rock bed is present, the transition between the upper *Holaster planus*-zone type of Micraster with moderately inflated 'areas' to the definite *M. cortestudinarium*-zone type with strongly inflated 'areas' occupies a more extensive vertical range.

NOTICES OF MEMOIRS.

I.—Geological Cycles in the Maritime Provinces of Canada. By G. F. Matthew, D.Sc., LL.D. Trans. Roy. Soc. Canada, 1908–9, ser. iii, sect. iv, vol. ii, pp. 121–43.

THE object of this paper is to show briefly the succession and age of the several formations that were accumulated in the eastern provinces of Canada, from the earliest that can be recognized to the end of the Trias (or Jura-Trias).

As the Cambrian is well represented in these provinces by a formation that contains many characteristic faunas, it forms a basis to which the older and later formations can be co-related. The writer upon this basis affirms the presence of several formations, or systems, older than the Cambrian, and indicates the physical characteristic by which they are separable from each other (there being no fossils in these earlier groups of strata by which they can be distinguished). One of these groups is the gold-bearing or Maguma series of Nova Scotia, having the enormous thickness of 5 miles of sandstones (quartzites) and slates, the chief gold-bearing zone being near the middle of the succession. Older than this is a group containing much limestone, which the author compares to the Grenville Limestones of the Laurentian system. Younger than the Maguma series, but older than the Cambrian, are other groups of strata, many of which consist largely of effusive rocks.

Above the Cambrian (which includes also the Lower Ordovician) there is a break in the succession; the Upper Ordovician is wanting, and the Upper Silurian begins in many districts with effusive rocks and elsewhere with sandstones; these are succeeded by fine dark-grey shales, and these by paler shales and sandstones, which are also more

[1] Mem. Geol. Surv. (Expl. Sheet 254), Henley-on-Thames, 1908, pp. 39, 40.
[2] Proc. Geol. Assoc., 1908, vol. xx, p. 396.

calcareous. These are seen by their faunas, as shown at Arisaig, etc., to range from the Llandovery to the Ludlow or higher. A peculiar phase of this formation is the plant-bearing beds near St. John, N.B., which contain many types of plants that reappeared in the Carboniferous, with others that are special to this locality.

Following this formation there is a break in the succession, the Middle Devonian being absent, or at least not recognized by its marine fossils, and the next formation (Upper Devonian) by its plant remains shows a close relation with the Lower Carboniferous, yet it has many typical Devonian genera and species of plants. The Carboniferous Age began with a widely extended deposit of marine limestones spreading through nearly the whole length of the eastern provinces in a belt across their centre, but not known in their northern part. The Millstone Grit and Coal-measures followed in a widely extended tract to and under the Gulf of St. Lawrence. In a northerly direction they were covered by the Permo-Carboniferous found along the borders of the gulf and extending into the province of Prince Edward's Island.

The final geological system of this part of Canada was the Trias (or Jura-Trias), which occupied a large area in the Bay of Fundy and the Basin of Mines, and is also found in the islands of the Gulf of St. Lawrence. In the Bay of Fundy area and the Basin of Mines the system is characterized by extensive eruptions of dolerite and volcanic-ash deposits that have left a strong imprint on the topography of the country as it now appears. Subsequent to the Jura-Trias there were no great geological systems laid down in this region, and it is supposed that it remained for long ages above the sea. Only in post-Pliocene time did the sea again invade these provinces, and lay down a marine fauna closely related to and mostly of species living at the present time.

II.—Brief Notices.

Fluorspar.—An important paper on "The Fluorspar Deposits of Derbyshire" has been contributed by Mr. C. B. Wedd, F.G.S., and Mr. G. Cooper Drabble to the Transactions of the Institution of Mining Engineers (1908, vol. xxxv, pp. 501, etc.). The authors give a general account of the structure of the Carboniferous Limestone area and of the associated igneous rocks. The limestone is from 1,500 to 1,700 feet thick, and forms the southern end of the Pennine anticline. The fluorspar appears to be confined to the upper 600 feet of the limestone, and is chiefly concentrated within 300 or 400 feet of the top. The upper beds of the limestone contain a good deal of chert, also secondary quartz; they are often dolomitic, are more fossiliferous than the lower strata, and contain bituminous products. Moreover, all the known sheets of igneous rock are found in the upper half of the great mass of Derbyshire Limestone. The mineral deposits occur in joints and cracks, in pockets and pipes, and in independent 'flats'. The fluorspar is remarkably free from silica; 1 per cent. is an exceptional quantity. The authors believe that local circumstances agree best with the hypothesis of deposition in fissures and to a small extent as a metasomatic replacement of the country-rock, from a heated aqueous solution containing gases and forced up from a great depth, possibly in connection with the later phase of igneous activity. They hold that deposition, consequent on diminution of pressure and temperature, was precluded in the case of fluorspar from taking place in the lower parts of the vein-fissures, owing to the fact, pointed out to them by Dr. W. Pollard, that superheated steam decomposes calcium fluoride. The relatively low specific gravity of the mineral probably had some further influence in determining the limitation of the mineral to the upper parts of the fissures. The economic uses of fluorspar are discussed from an historic and practical point of view, and the paper concludes with a bibliography.

III.—Geological Hand-Map of the British Isles.—Mr. Edward Stanford, of 12, Long Acre, has sent us a copy of a neat colour-printed map with the above title, which he has published at the price of 6*d*. The size of the sheet on which the map is printed is about 7½ by 10 inches, and it should prove useful for handy reference in classes.

REVIEWS.

I.—Records of the Geological Survey of India: General Report for 1907. By Sir T. H. Holland, K.C.I.E., D.Sc., F.R.S., Director.[1]

THE Director observes in his introduction that there has been satisfactory progress in mineral production during 1907, and an extraordinary increase in the activity of prospectors, "mainly inspired by the phenomenal success of those who were already prepared to meet the increased demand for manganese-ore and coal." The statement of mineral concessions during the year is indeed most remarkable, and the details of the 600 licences granted fill thirty-one pages of the report. Clearly the prospectors are in an optimistic mood.

The Director in his obituary notice calls attention to the value and importance of Mr. Griesbach's work.[2]

Mineralogy.—The jadeite deposits in Upper Burma have been carefully investigated, and the recent conclusions, both as to the origin and age of this mineral, differ materially from the views formerly advanced.[3] It was known previously that the jadeite formed a light-coloured layer in the midst of a dark-green serpentine, and it was conjectured that the jadeite must have separated as a primary segregation from the magma. There seemed some difficulty in understanding how a soda-alumina silicate could have segregated from a magnesian rock, but recent observations tend to show that the jadeite occurs in a metamorphosed igneous dyke intruded into the serpentine. It is concluded that the jadeite is the result of the

[1] [This review was written by our late friend and co-editor, Mr. W. H. Hudleston, and sent to us on January 20, 1909, nine days before he passed away from his active, useful life, without any illness or suffering, happily engaged up to the last moment (see Obituary).—H. W.]

[2] See Geol. Mag. for 1907, p. 240.

[3] Geol. Mag., 1907, p. 328.

metamorphism of an albite-nepheline rock originally forming the dyke, since both these minerals are found in conjunction with the jadeite. The region is one where crystalline schists have been invaded by granite. The previous view that the serpentine-jadeite complex is of Tertiary age is also rendered improbable by the fact that these old eruptives, including the jadeite, are prominently represented among the boulders in the Tertiary conglomerate, which is worked expressly for that mineral. The amount raised in 1907 was 3,590 cwts., valued locally at £18,998, and mostly sent to China.

Palæontology.—Amongst items of general interest under this heading the discovery of inter-trappean fossils in the Cretaceous of Baluchistan may be noted. *Physa Prinsepii*, for instance, so characteristic of the fresh-water beds intercalated in the Deccan Trap, is found to occur in marine beds containing Upper Cretaceous (Maestrichtian) ammonites. These fresh-water shells must have been carried out to sea from the land on which the inter-trappean fossils were laid down, and in this way evidence is obtained fixing the age of the great Deccan Trap eruptions with greater precision than previously.

Some curious facts are recorded with reference to the so-called 'exotic blocks' of the Kumaon Himalaya, where the later Mesozoic beds are capped in places by massive limestone blocks (*Klippen*), which either appear to rest conformably on the soft Jurassic shales or else are imbedded in them. These blocks are partly of Palæozoic and partly of Mesozoic age, and their anomalous position among younger strata has given rise to a considerable amount of controversy. It is assumed that the exotic blocks of Kumaon were brought from somewhere further north in the Tibetan region at present unrecognized; and if so, they must represent the result of one of the most gigantic overthrusts known to geologists. The interest from a palæontological view lies in the fact that there is a remarkable agreement between the fossils of these 'Tibetan' masses and Alpine Carnic and Liassic fossils, whilst the facies is different from that of the beds of corresponding age in the normal sections within the area in question. Clearly, this is a palæontological puzzle by no means easy of interpretation.

The examination of the Cambrian fossils from Spiti, collected 1898–1901, leads to equally surprising results. The fauna comprises ten genera of Trilobites, five genera of Brachiopods, one genus of Pteropod, one Echinoderm, and one Zoophyte. Six horizons have been recognized in the region whence most of the fossils have been derived, and the fauna of each horizon is peculiar to it, no single species having been found in any two horizons. The only Trilobite that has been identified with a known species is *Redlichia Noetlingi*, and the presence of this Salt Range species is of interest as the only form known to be common to the two areas. The remaining Trilobites, with the exception of those found in the *Olenus*-horizon, as also the other fossils, are remarkable for their dissimilarity to either Salt Range or European types. The general conclusion is that the main mass of the beds must be referred to the Middle Cambrian, and that the palæontological affinities of the fossils in these beds are with the Rocky Mountain province of America. Once more, then, we find a palæontological puzzle in the disagreement of these Himalayan fossils (Cambrian) with those of their nearest neighbours of approximately the same age. It is thought that the investigation of these Spiti Cambrians will have an important bearing on the classification adopted for the oldest Palæozoic systems of the Himalaya.

Economics.—Several pages are devoted to this subject under the heading of "Enquiries" and "Surveys". Manganese-ore, with the exception of gold, the only heavy metal of any importance as a product in India, attracts some attention. The chief object of the surveyors latterly has been to institute a comparison between the deposits in South India and those of the Central Provinces. In the latter area the ore-bodies as now constituted appear to be an integral part of the crystalline complex, although it is probable that they have attained their present character of clean oxides by alteration of manganese silicates. In South India, on the other hand, the ore deposits are more superficial, and appear to be residual products from the surface alteration of the "various lithological elements that constitute the Dharwar system of schists". The manganese-ores of this class occur irregularly associated with lithomarges, ochres, and wads. A comparison is then instituted between these shallow or surface ore-bodies and those of the crystalline complex. As regards these latter it is hinted that they may be found in depth to pass down into manganese silicates unsuitable for the requirements of the metallurgist.

In connection with the subject of petroleum in Burma "a survey of the Minbu Hills" may be taken as in some sense typical of the region in the neighbourhood of the oilfield. "This anticline of Miocene and Pliocene beds is one of great interest from a scientific point of view. Slightly asymmetric and sharply folded, it has been very extensively denuded and its deeper structure laid bare. There are many comparatively large faults, one of which appears to coincide with the line of mud volcanoes near the town of Minbu." The results of boring for oil in this particular district are not very encouraging.

As a further contribution to the economic geology of Burma, there is a note on the occurrence of tin-ore in the Mergui district. The only ore worked is cassiterite, and this occurs as a somewhat scarce constituent in a decomposed pegmatite rich in tourmaline and muscovite, in fact under conditions not dissimilar from those at home. The industry is a small one, the output in 1907 being valued at £11,882.

Geological Surveys.—In Central India the major portion of the area surveyed in 1907 is occupied by the Deccan Trap, and three thin beds of what appear to be fragmental volcanic ejectamenta were found intercalated with the normal basalts. The lowermost bed of the Deccan Trap occupies the flat plains for several miles before the upper beds composing the scarp make their appearance. The scarped edge of the Malwa plateau rises more than 1,000 feet in softer and harder beds of trap, some of which are columnar, and some contain the usual geodes, full of siliceous or zeolitic material.

The Northern Shan States of Burma are described with considerable detail, and a graptolite band (Pangh-sapýe) in the Upper Ordovician was found to be of considerable service in working out the stratigraphy. The following are the European equivalents of the beds identified:—

Late Pliocene or Pleistocene.
Jurassic (exact horizon not yet known).
Rhætic.
Permo-Carboniferous.
Carboniferous and Devonian.
Silurian.
Ordovician.
? Cambrian.

"It is somewhat surprising that igneous rocks are of extremely rare occurrence over the whole of this area. The ancient rocks near Mogok (Ruby-Mines) are traversed by great bands of granite, and there are indications of volcanic conditions, consisting of rhyolites and rhyolitic tuffs, along the borders of the Ordovician land-surface; but throughout the whole sequence of Palæozoic and Mesozoic strata there are no traces whatever of volcanic activity. In late Tertiary times there was, however, a feeble manifestation of these agencies, for in one locality the silts were found to be traversed by dykes of basalt, resembling that of the sub-recent volcano of Hawshuenshan in south-west Yunnan."

Mineral Production of India during 1907.—The total value of minerals, as ascertained, was £7,071,868, being an increase of £759,047 (= 12 per cent.) over the previous year. For the first time the value of coal exceeds that of gold, but part of this increase may be due to the high prices of coal prevailing in 1907. Out of 11,147,339 tons raised, the Gondwana Coalfields account for 10,720,245 tons; the output of the Jherria Coalfield now exceeds that of Raniganj, which for so many years has been the leading producer. After coal and gold the next largest figures are shown by petroleum and manganese-ore; other heavy metals are insignificant in amount. Gems, including ruby, sapphire, and spinel, account for £98,258.

Striated Boulders in the Blaini Formation of Simla.—This is a special contribution by the Director to an interesting and much debated question. The writer alludes to the early notices of the so-called 'conglomerate', an inappropriate term, since the "fine-grained slaty matrix in which the boulders lie is often in excess of the volume of the pebbles". These have usually been regarded as of glacial origin, and at length a boulder (represented on plate 1 of the report) has been found "which shows the essential signs of glaciation to an unmistakable degree". It should be observed that there are two distinct boulder-beds separated by about 200 feet of thin-bedded shales, and the boulders under notice were obtained from the lower bed at Simla.

The story of the Talchir boulder-bed in Orissa, and its correlation with beds at the base of the Karroo system in South Africa and the coal-bearing beds of New South Wales, is well known. It gradually came to be assumed that the two boulder-beds in the Blaini formation were also of Upper Palæozoic age and equivalent to the Talchir boulder-bed. Furthermore, the Blaini boulder-bed having been accepted as a reliable horizon of known age, "the sequence of strata below and above it in the Simla region became distributed accordingly along the standard stratigraphical scale; those below the Blaini-beds were regarded as Permian or older, and those above as Permian or younger."

This inference for a time seemed natural, but its acceptance was the cause of much difficulty, arising from the attempt to correlate the fossiliferous strata of Mesozoic and Tertiary age on the northern or Tibetan side of the crystalline axis with their presumed unfossiliferous equivalents on the south. It may be noted that more than one Indian geologist has had an eye to the possibility of finding in the Himalaya the counterpart of the great mass of unfossiliferous sedimentaries, so largely developed in Peninsular India, known as the *Purana*-group. As regards the beds above the Blaini boulders at Simla, any such correlation was impossible so long as these boulder-beds were held to synchronize with the Talchir boulder-bed.

The Director thinks that he sees a way out of the difficulty in the presumption that there has been more than one period of glaciation in times preceding the formation of the Talchir boulder-bed and its equivalents in South Africa and Australia. To prove this point he quotes the glacial boulder-beds held to exist below the Cambrian in South Australia, and he also believes that in South Africa there were two periods, preceding the Dwyka, where glacial phenomena are indicated. Moreover, on the coast of the Varanger Fjord, in Norway, glacial phenomena have been described by Reusch and Strahan in a formation which is presumably pre-Cambrian. Thus pre-Talchir boulder-beds are recognized in many quarters, and, whatever may be the value of this recognition as a proof of true glacial conditions in the respective periods, such recognition affords an alternative to the prevailing theory that the Blaini beds must be of Upper Carboniferous age. Hence the geologist will have a free hand in dealing with the unfossiliferous series above the Blaini formation at Simla.

W. H. H.

II.—The Geology of the Country between Newark and Nottingham. By G. W. Lamplugh, F.R.S., W. Gibson, D.Sc., R. L. Sherlock, B.Sc., and W. B. Wright, B.A. pp. vi, 126, with six text-illustrations and one plate of sections. 1908. Price 2*s*. 3*d*. Colour-printed map, Sheet 126; price 1*s*. 6*d*.

THE eastern side of the area described in this memoir consists of a belt of Lower Lias, with a gentle escarpment between Newark and Barnstone, along which the Rhætic beds outcrop. The central portion, occupied mainly by the Keuper marls, is traversed by the River Trent, which on its right impinges against the marls at Radcliffe and along the Trent Hills. To the west the ground is formed of Keuper waterstones and Bunter pebble-beds and sandstone, which extend from Nottingham northwards into Sherwood Forest. On the western margin there are fringes of Permian marls and Magnesian Limestone, which rest with marked unconformity on the Coal-measures.

Many points of considerable interest are dealt with in the memoir. Although the Coal-measures occupy a tiny and inconspicuous area at the surface, the question of their underground extent is of great importance; and Dr. Gibson, who deals with this subject, is able to bring the experience he has gained in Derbyshire and North Staffordshire to bear on the records of trial-borings. It is satisfactory to learn that the divisions established in those districts hold good in Nottinghamshire, and that the successive strata can be readily distinguished by their lithological and palæontological characters. Thus four marine bands in the chief coal-bearing series are found to maintain definite positions in the sequence. The divisions are shown in a useful table which gives particulars of the thicknesses of the strata and of the depths at which the chief coals occur. Borings have proved that Coal-measures occur beneath the Trias and Permian as far east as Thurgarton, where at a depth of 850½ feet the higher and unprofitable measures were reached, and they were penetrated to a total depth of 2,237½ feet without reaching the Top Hard Coal. That seam was, however, proved to the west, at Oxton at a depth of 2,026 feet and at Gedling at a depth of 1,375 feet; while the results of other borings to the south of Nottingham indicate that to the south and south-west of Thurgarton there is "a buried coalfield of great potentiality".

Mr. Sherlock's observations tend to show how closely linked are the Permian and Triassic deposits, as the Permian marl "appears to pass upward gradually into the Bunter by the intercalation of sandy material".

Deposits of economic importance are duly noted. The lower mottled sandstone of the Bunter yields moulding sand. The Permian and Keuper marls and the Lias Clay yield materials for brickmaking, while the Keuper marl has been used for the preparation of a top-dressing for cricket pitches and lawns. It furnishes also the important beds of gypsum worked at Newark and Orston.

The Lower Lias is noted for its hydraulic limestone which is worked in the basal beds at Barnstone. At a higher level, in the zone of *Ammonites semicostatus*, occur layers of ferruginous limestone of no economic importance, but on the horizon of the valuable iron-ore of Frodingham, in Lincolnshire.

Although the map accompanying this memoir is a Drift edition, the area covered by superficial deposits is remarkably small. There are a few patches of stony loam and gravel that are grouped by Mr. Lamplugh as glacial drift, the stony loam being coloured as Boulder-clay. This contains Bunter pebbles and occasional erratics, and part of it, west of Cotgrave, may be a direct product of glacial action; but other accumulations give the impression that they are rearranged relics of once existing glacial deposits.

Some of the older gravels along the Trent Valley may, in Mr. Lamplugh's opinion, belong to the closing stages of the Glacial period, but he finds no satisfactory evidence that the river was in existence prior to the great glaciation.

III.—CYANIDE PROCESSES. By E. B. WILSON. Fourth edition. pp. vii, 249, and 26 figures. New York, John Wiley and Sons; London, Chapman & Hall, 1908. Price 6*s.* 6*d.* net.

THE development of the cyanide process for the extraction of the precious metal when present in minute particles has had a most important bearing upon the gold industry. Without its aid many mines now profitably worked would have long since been abandoned. That gold was soluble in cyanide of potassium solutions has been known for more than a century past, but it is only within comparatively recent years that the method has assumed such a prominent position in mining practice. Although in simple cases the process is so exceedingly successful that the amount of gold which escapes is trivial, it cannot be applied blindly because certain minerals may be present in the ore which would hinder, if not entirely prevent, the extraction of gold. It is therefore necessary that the nature of the ore should first be studied and a suitable treatment devised to remove or render innocuous the cyanicides, as they may be termed.

In preparing this edition of his valuable manual, Mr. Wilson has taken the opportunity to add a chapter on the latest treatment of slimes, and has generally brought the information well up to date. It may safely be stated that the book is one which should be in the hands of anyone interested in the running of a cyanide plant. The procedure and the chemical reactions underlying it are fully explained, and the difficulties which may be encountered in the several processes receive ample discussion. Mr. Wilson keeps strictly to the point, and has wisely refrained from marring the usefulness of the book by overlading it with matter which concerns only the constructor of the plant and the engineer who erected it. In a future edition a few patent errors in the chemical equations call for amendment.

Mr. J. C. Jenkins gives in an appendix the treatment to be followed in a case of cyanide poisoning. Medical assistance may not be immediately forthcoming, and so rapid and fatal is this poison that the only hope lies in effective measures being promptly taken.

IV.—DEVONIAN FOSSILS.

MR. J. G. HAMLING (*Trans. Devon Assoc.*, 1908, vol. xl, pp. 276–80) writes on "Recently-discovered Fossils from the Lower and Upper Devonian Beds of North Devon". He refers to the eastern side of Lynmouth Harbour, where fish-remains have been said to occur in abundance. After verifying the fact of their occurrence he subsequently obtained, in company with Mr. Upfield Green, a specimen identified as *Pteraspis* by Dr. A. Smith Woodward. Other important discoveries have also been made. On the eastern side of Lee Bay, west of Lynton, Mr. Hamling and Mr. Green obtained fish-remains; and also *Spirifer primævus*, *S. sub-cuspidatus*, *S. speciosus*, and *Orthotetes umbraculum*, Brachiopods not previously recorded from the locality. It is noted that "the discovery of *Spirifer primævus* (a Taunusian form) in the Lynton Beds is an unexpected corroboration of Mr. W. A. E. Ussher's homotaxial correlation of these beds with those of the Meadfoot group, in which the Taunusian is included". Again, as "the

Dartmouth slates are homotaxially correlated with the Foreland grits, the discovery of *Pteraspis* materially strengthens this correlation, as Mr. Ussher has shown that these remains are not restricted to the Dartmouth slates proper, but range up into dark slates presumably belonging to the Meadfoot group". Our attention was called some time ago by Mr. Upfield Green to the title of a paper read before the Geological Society on November 23, 1870, "On the Discovery of a 'Bone Bed' in the lowest of the 'Lynton Grey Beds', North Devon," by F. Royston Fairbank, M.D. The title only was printed in the Quarterly Journal (1871, vol. xxvii, p. 33), the paper having been withdrawn. The abstract, however, with the discussion, appeared in the Geological Magazine for January, 1871, p. 38. Mr. R. H. Valpy then stated that he had recognized similar beds along the coast of North Devon, an account of which had already been published at Ilfracombe. (See his *Notes on the Geology of Ilfracombe*, printed by Twiss & Sons, Ilfracombe, no date.)—H. B. W.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—*January* 13, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council, at its meeting that afternoon, had passed the following resolution:—

"The Council of the Geological Society desires to express to the relatives of Professor H. G. Seeley, F.R.S., its profound sorrow in the death of one who had been a Fellow for nearly half a century, had frequently served on the Council of the Society, and for so many years continued to enrich the literature of Geology and Palæontology by numerous original researches in these Sciences."

The following communications were read:—

1. "On Labradorite-Norite with Porphyritic Labradorite." By Professor Johan H. L. Vogt, F.M.G.S.

This paper deals with a rock occurring at Napp Farm, on Flakstadö, off the northern coast of Norway. It contains 23 per cent. of labradorite-phenocrysts, in a crystalline groundmass made up of a more acid plagioclase, hypersthene, diallage, and titano-magnetite, with small quantities of biotite, and very little spinel, apatite, and pyrite. A little secondary hornblende and some garnet are present, but few other secondary products. Olivine is conspicuously absent.

The plagioclase-phenocrysts are more acid in their outer zones, and the groundmass plagioclase is still more acid as determined optically and by specific gravity and analysis. Analyses are tabulated of the bulk of the rock and the groundmass and of the separated plagioclases and the magnetite. From these the relative proportions of the constituents are calculated and the formula of the felspars determined; also the titano-magnetite proves to be a mixture of magnetite with ilmenite.

The order of crystallization is found to be: (1) Phenocryst plagioclase; (2) plagioclase with magnetite; and (3) plagioclase, magnetite, pyroxenes. The plagioclase-phenocrysts started to form at points from 8 to 18 centimetres apart, and when they had grown to some size a second crop of smaller crystals grew at nearer points; the magnetite was much aggregated round the plagioclase-phenocrysts, growing together with the plagioclase of the groundmass; and finally the remaining magma crystallized. The order of crystallization is found to be consonant with the physico-chemical laws applying to the phase liquid-solid. Graphic representations are given to illustrate the order of crystallization of a ternary system of plagioclase, magnetite, and pyroxene; and it is shown that the separation of such a system would yield first the formation of plagioclase-phenocrysts; secondly, the solidification of a magnetite-plagioclase eutectic; and finally an eutectic of plagioclase, magnetite, and pyroxene. In considering the equilibrium between the solid and the liquid albite-anorthite phase, it is found that equilibrium must have been maintained sufficiently long for the phenocrysts to acquire a composition different from the first-formed crystals, but that eventually the equilibrium broke down, a matter possibly connected with the size of the phenocrysts in relation to the viscosity of the solution. The history of events in connection with the pyroxenes was probably similar to that in the case of the plagioclases, but this portion of the subject is not fully worked out. The temperature interval of crystallization is estimated to have been between about 1400° and 1000°.

The author considers that this investigation establishes that the processes of crystallization in a magma may be explained in all details according to physico-chemical laws.

2. "On the Genus *Loxonema*, with Descriptions of New Proterozoic Species." By Mrs. Jane Longstaff (*née* Donald), F.L.S. (Communicated by Dr. G. B. Longstaff, M.A., F.G.S.)

There is some confusion with regard to the type of the genus *Loxonema*, which has arisen from the confounding of the Silurian *Terebra* (?) *sinuosa* of Sowerby with the Devonian form which Phillips called *L. sinuosum*. This matter is discussed, and the author, following Lindström, Koken, and Perner, takes *L. sinuosum*, Sowerby, as the type in the absence of sufficient reasons to the contrary. If this be done, the other two types mentioned by Phillips cannot remain in the genus, one belonging to the genus *Macrocheilina* and the other to *Zygopleura*. This paper deals simply with Ordovician and Silurian species, therefore only a few subgenera are referred to—*Rhabdostropha*, Don., and *Stylonema*, Perner.

The diagnosis of *Loxonema* is amended, and a note given as to the true range and the geographical distribution of the genus. Descriptions are given of *L. sinuosum*, Sow., of *L. intumescens*, Lindstr., and of *L. striatissimum*, Salt. MS., and six new species and one new variety are described of this genus. *R. pseudofasciatum*, Don., and *R. Grindrodi* and a new species of this subgenus from Stoke Wold in the Lower Ludlow Beds are next described. This is followed by a description of two new species of the subgenus *Stylonema*, one from the Chair of Kildare and the second from Mulloch Hill. In conclusion, a new species of *Hormotoma* from the Llandeilo Flags of Builth Bridge is described.

2.—*January* 27, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Conway Succession." By Miss Gertrude L. Elles, D.Sc. (Communicated by Dr. J. E. Marr, F.R.S., F.G.S.)

In this area the author has found a complete succession of strata, from Llandeilian up to Salopian date. The divisions proposed are as follows:—

		Zone of
SALOPIAN.	Benarth Flags and Grits . .	*Cyrtograptus symmetricus.* *Monograptus riccartonensis.* *Cyrtograptus murchisoni.*
VALENTIAN.	Gyffin Shales. (300 feet.) . .	*Monograptus crenulatus.* *Monograptus crispus.* *Rastrites maximus.* *Monograptus sedgwicki.* *Monograptus gregarius.* *Mesograptus modestus.*
	Conway Castle Grits. (150 feet.)	
ASHGILLIAN.	Deganŵy Mudstones. (30 feet.) .	*Phacops mucronatus* and *Dicellograptus anceps.*
	Bodeidda Mudstones. (350 feet.)	*Trinucleus* Beds.
CARADOCIAN.	Cadnant Slates (Upper) . . .	*Dicranograptus clingani.* *Climacograptus wilsoni.*
LLANDEILIAN.	Cadnant Slates (Lower). (310 feet.)	*Dicranograptus brevicaulis* and *Mesograptus multidens.* *Climacograptus peltifer.*
CONWAY MOUNTAIN VOLCANIC SERIES.	Upper or Coetmor Ash Group. Upper Brecciated Lava Group. (710 feet.) Lower or Bodlondeb Ash Group. (60 feet.) Lower Banded Lava Group. (1,400 feet.)	

After references to the literature and an account of the landscape and structure of the district, the beds are described in ascending order, lists of fossils being given from the more important exposures. The sections show that there is no break whatever in the sequence between the Ordovician and the Silurian rocks in the district. Petrological notes on the chief igneous rocks are given, and then a detailed comparison is established between the rocks of this area and those of South Wales, the Rhayader and Tarannon districts, Lakeland, the South of Scotland, and Pomeroy. The Conway Mountain Volcanic Series appears to be equivalent to the Borrowdale volcanic rocks of the Lake District, and the Cadnant Slates and Bodeidda Mudstones equivalent to the Upper *Dicranograptus* Shales, *Trinucleus* Beds, and Sholeshook Limestone of South Wales, the Sleddale and Roman Fell Groups of Lakeland, and the Upper Glenkiln and Lower Hartfell of the South of Scotland. The Deganŵy Mudstones are paralleled with the Redhill Beds and the Ashgill Shales. Close comparison is possible between the graptolitic zones of the Gyffin Shales and corresponding beds at Rhayader, Tarannon, in the Lake District, and the South of Scotland. Finally, the Benarth Flags are compared with the Brathay Flags, the Riccarton Beds, and beds above and including *Cyrtograptus murchisoni* in the Tarannon district.

2. "The Depth and Succession of the Bovey Deposits." By Alfred John Jukes-Browne, B.A., F.G.S.

The total thickness of the Tertiary Beds in the Bovey Basin has never yet been ascertained, because no boring has yet reached the bottom of the basin in which they lie; and no one has yet attempted to make out a stratigraphical succession from the sections exposed in the numerous clay-pits.

Some years ago, however, Messrs. Candy & Co., of the Heathfield Potteries, put down a boring which reached a depth of 526 feet from the surface. Having obtained some particulars concerning the beds traversed by this boring, the author is able to discuss the succession of the Bovey deposits, so far as they have been explored. The following is a generalized description of the strata seen in the Heathfield pit, and penetrated by the boring from the bottom of that excavation:—

	Thickness in feet.
Superficial deposits	about 20
Beds of clay and sand, with occasional beds of lignite	250
Beds of lignite and clay, with one of sand	36
Beds of lignite, with thin layers of clay	220½
	526½

The author confirms the conclusion arrived at by Pengelly in 1861, with regard to the relative age of the beds exposed in the 'old coal-pit' south-east of Bovey Tracey and those proved in a boring to the east of it. From all the data mentioned, and assuming the actual base of the Tertiary deposits to be not more than 30 feet below the bottom of the Heathfield boring, he estimates the total thickness of the 'Eocene' beds to be about 613 feet.

The Bovey Basin itself is regarded as a tectonic basin or post-Eocene pericline, and not as a lake-basin; although, during the deposition of the higher part of the series, it may have formed part of a large lacustrine or lagoon area, extending over the greater part of East Devon.

The author dissents from Heer's view of the manner in which the lignites were formed, discusses the identification of some of the plants, and concludes that the lignites which form the mass of the lower beds represent the growth and decay of successive swamp-forests, similar to that of the Great Dismal Swamp of Virginia at the present day.

Assuming that these lower beds are of Eocene age, and contemporaneous with the Bournemouth Beds of the Hampshire Basin, the author points out that nothing has yet been proved with regard to the higher beds, which may be of Bartonian or even of Oligocene age.

3.—*February* 10, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The President announced that the Council, at its meeting that afternoon, had passed the following resolution:—

"The Council of the Geological Society records its sense of the very great loss which the Society sustains from the death of Mr. W. H. Hudleston, F.R.S. By his distinguished services as President and as Secretary, by the constant interest which he took in the Society's affairs, and by the distinction of his high scientific reputation, he had laid the Society under a deep obligation. The Council desires to express to Mrs. Hudleston the sincere sympathy of the Society in her bereavement."

The following communications were read:—

1. "Note on some Geological Features observable at the Carpalla China Clay Pit in the Parish of St. Stephen's (Cornwall)." By Joseph Henry Collins, F.G.S.

An east-and-west fault traverses this pit near its southern wall, with a downthrow to the south of more than 50 feet. North of the fault there is china clay rock or 'carclazyte', at one point underlying granite not sufficiently altered to yield china clay, and sometimes containing embedded lenticles or irregular masses of partly kaolinized granite. The carclazyte is often traversed by veins of secondary quartz, in most instances associated with schorl. It also contains lepidotite, gilbertite, topaz, fluor, and schorl. South of the fault there is nearly horizontal tourmaline schist, at one point 50 feet thick, and thinning off southwards and eastwards. This, like the rock of the north side, is overlain by subsoil or 'growan', covered in turn by soil or 'meat-earth'. Underlying the schist there occurs also china clay rock to a distance of many fathoms from the fault. This occurrence of china clay under a thick schistose overburden is unique in Cornwall, although the other features of the pit are reproduced elsewhere. The author considers that this example is strongly in favour of the pneumatolytic origin of carclazyte, the gases producing the change being possibly in part carbonic acid, but probably to a more important degree chlorine, fluorine, and boron.

2. "Some Recent Observations on the Brighton Cliff Formation." By Edward Alfred Martin, F.G.S.

The author records in his paper certain features presented by the face of the cliffs between successive falls at Black Rock, Brighton, during the past eighteen years. As the cliffs have worn back, the base-platform of Chalk grows in height, and the layer of sand which Prestwich found above the Chalk grew thinner and thinner until finally it completely disappeared. At the same time the raised beach has grown in thickness from 1½ to 12 feet. In 1890 there were 6 feet of sand, with a foot and a half of beach above it. There was practically no protection at this date in the shape of groynes. In 1892 the sand had decreased to between 3 and 4 feet, but the beach remained as in 1890. Many falls of cliff took place between 1892 and 1895, and at the latter date the beach had increased to between 4 and 5 feet. The eastern limit of the beds had become more clearly defined, the trough in the Chalk in which they had been defined taking an upward direction about 300 yards east of the Abergavenny Inn. Many blocks of red sandstone had become dislodged, and were lying on the modern beach. In 1897, 10 feet of chalk formed the lower portion of the cliff, with 8 feet of raised beach above it in places, but there was a mere trace of sand left. The rubble drift above was seen to be distinctly stratified. Many masses of red sandstone had fallen out of the cliff, the largest measuring 5 feet in its greatest dimension. In 1899 the raised beach had reached a thickness of 10 feet. Great masses of moved and reconstructed chalk were observed on the eastern boundary embedded in the beach. Two rounded lumps of granite were extracted from the beach. In 1903 the beach was but a little over 8 feet thick in the exposed parts, but the platform of chalk was 14 feet thick. The upper portions of the beach, which were the least consolidated, had fallen away in such a manner as to leave cave-like gaps beneath the rubble. The number of red sandstone blocks which lay on the modern beach was remarkable, forty such blocks being counted in a space of 50 yards square. In 1906 the raised beach had increased from 15 to 20 feet; farther west, however, the thickness was not so great. In 1908 there were 17 feet of chalk, 12 feet of beach. It is noteworthy that as the degradation of the cliff proceeds, the material is rapidly carried away by the sea. No talus remains for any length of time, and if the material is to be prevented from disappearing into deep water, some such contrivance as chain-cable groynes seems to be demanded, fixed somewhere between low and high tide-marks. The only organic remains observed in the cliffs were some fragments of shells, found at the top of the raised beach.

At a Special General Meeting held at 7.45 p.m. before the Ordinary Meeting, the following resolution was proposed by Dr. A. Smith Woodward, F.R.S., and seconded by Dr. R. D. Roberts:—

"That it is desirable, under the existing Charter, to admit Women to candidature for the Fellowship of the Society, on the same terms as men."

A ballot having been asked for, the resolution was rejected by 50 votes to 40.

II.—Mineralogical Society.

Tuesday, January 26.—Dr. A. E. H. Tutton, F.R.S., Vice-President, in the Chair.

(1) On the identity of poonahlite with mesolite; by Dr. H. L. Bowman. Small colourless prisms, associated with stilbite and pale-green apophyllite from Poonah, which appear to be identical with the mineral described by H. J. Brooke in 1831 as poonahlite, are shown by analysis to be mesolite having a composition corresponding to a mixture of two molecules of scolecite with one of natrolite. The optical characters are similar to those recently observed by Görgay in mesolite from the Faroe Islands.—(2) Cross-planes in twin-crystals; by Dr. J. W. Evans. A twin-plane is composed of two equivalent planes, one from each component crystal, and every line in it is composed of two equivalent lines. A cross-plane is also composed of two equivalent planes, but there are only two, four, or six lines (at right angles in pairs) composed of equivalent lines. A plane of composition is always a twin-plane or a cross-plane. In the former molecular distances are the same in all directions in the plane; in the latter in two, four, or six directions only.—(3) Comparison of the refractive indices of adjoining crystals in a rock slice which have their directions of vibration oblique to one another; by Dr. J. W. Evans. The nicols are placed with their directions of vibration parallel and bisecting the angle θ between the directions of the vibrations whose refractive indices are to be compared. The light received from these directions will (apart from interference) be proportional to $\cos^2 \frac{\theta}{2}$, and that from

those at right angles to them to $\sin^2 \frac{\theta}{2}$, so that the former will bear to the latter the ratio $\cot^2 \frac{\theta}{2}$. If θ be less than 35°, this will be greater than 10, and the light from the directions at right angles may be neglected both in respect of its direct effects on the Becke phenomena and its indirect action in producing interference.—(4) Note on the spontaneous crystallization of solutions as spherulites; by Mr. J. Chevalier. Experiments on solutions of potash-alum, sodium, ammonium, and lithium sulphates, etc., made at the suggestion of Professor Miers in the Oxford Mineralogical Laboratory, show that spherulites and sphero-crystals are characteristic of the spontaneous crystallization of many solutions in thin drops. When other crystals grow first, it is probably because they have been introduced, the drop in that case appearing to be metastable. The spherulites mark the passage of the solution to the labile state.—(5) On a method for studying the optical properties of crystals; by the late Dr. H. C. Sorby. The author gives complete details of his work on the determination of refractive indices in thin plates, of which preliminary accounts have been published in the first two volumes of the *Mineralogical Magazine*. The method he describes in the case of doubly refractive minerals is identical in principle (though devised quite independently) with that given by the Duc de Chaulnes for singly refractive substances, but is worked out in far greater detail.—(6) Some additional localities for idocrase in Cornwall; by Messrs. G. Barrow and H. H. Thomas. During the mapping of the metamorphic area round the Bodmin Moor granite further occurrences of idocrase have been found in the altered limestones. Well-shaped crystals of the mineral, up to 6 mm. in length, are fairly common in drusy cavities. They are perfectly uniaxial, but show in thin sections considerable variation in the double refraction, especially in the outer layers of the crystals. The idocrase is associated with pale-pink to pinkish-brown garnet (often in regular intergrowth with the idocrase), pale-green diopside, and epidote approximating to clinozoisite in its low extinction and birefringence.—(7) Detrital andalusite in Tertiary and post-Tertiary sands; by Mr. H. H. Thomas. Occurrences of detrital andalusite are described in sands from various localities in West Wales. In no sedimentary rock of greater antiquity than the Pliocene has detrital andalusite been found. In the sands of West Wales the mineral occurs as slightly elongated, somewhat angular grains, often showing very intense pleochroism from blood-red to pale greenish blue. It is associated in these sands with pink garnet, greenish-brown augite, cyanite, zircon, rutile, tabular anatase, staurolite, brown and more rarely blue tourmaline, green hornblende, bright-green epidote, cordierite, iron-ores, and in some cases glaucophane.—(8) The energy of twin-crystals; by Mr. H. Hilton. The author determines in a simple case the conditions according to which a twin-crystal may be a more stable form, or in other words may have less surface energy, than a simple crystal of the same volume.—Mr. Hutchinson exhibited a new protractor devised by Dr. V. Goldschmidt.

CORRESPONDENCE.

SOLUTION THEORY OF VALLEY FORMATION.

SIR,—In the December number of the GEOLOGICAL MAGAZINE there appeared a short article by Mr. Jukes-Browne on the subject of the solution theory of valley formation as applied by the Rev. E. C. Spicer to the area of the Glyme and Dorne. It seems to me that there are several points in this paper that demand some attention.

It is said that Mr. Spicer's proposition "assumes that the rocks of the district are traversed by a double set of joints which coincide approximately with the winding 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 Evenlode are so irregular that they cannot be reduced to the intersection of two sets of lines. This map is reproduced, so that the reader can judge for himself". I have studied the map in question, and also traversed the ground several times, twice under the guidance of Mr. Spicer. Though the map was not drawn with that intention, it seems to me to show very clearly the tendency of the Evenlode, Dorne, and Glyme to twist in right angles, and so indicate a set of lines which may well coincide with joints. It is a very suggestive fact that where the Evenlode runs across the Lias this tendency appears to vanish.

No one who looked at the question impartially would expect to find a network of joints accurately indicated by valleys in such an 'advanced' stage as those of the Evenlode, Dorne, or Glyme. The right angles are practically gone from the Cherwell Valley, but are very characteristic of many of the valleys in the area under discussion which are still dry, and are shown by such 'embryo' solution valleys as may be seen near Wooton and (outside the area) at Cuddesdon.

A little further on we read that "on this [Mr. Jukes-Browne's] 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'". We do find traces of such a system. The most noticeable instance is described by Mr. Pocock in the Geological Survey Memoir on the country round Oxford, under the name of the 'Wilcote Valley' (p. 92). While the covering of Oxford Clay was still nearly continuous over the area, the Windrush joined the Evenlode near Ashford Mill, a fact which is of great importance in considering the 'misfit' of the Evenlode. As the clay was removed a solution valley was developed which finally broke into the Windrush Valley and led it into the present course past Witney. But the pre-solution mechanically formed valley between Wilcote and Northleigh remains, flanked on the south by the outliers of Oxford Clay alluded to by Mr. Jukes-Browne.

The part played by landslips in the formation of valleys has certainly received little attention. That many of the chalk valleys are frequently widened by small slips no one who knows them will deny; it is possible, too, that slips may occasionally serve to lengthen such valleys, but for obvious reasons they can neither initiate nor deepen them.

Mr. Jukes-Browne has pointed out that the solution theory requires (1) a previous series of valleys formed in the clay, which has now largely disappeared, by mechanical surface action, of which series we might expect to find traces; (2) that there should be some indication in the present valleys, supposed to be due to solution, of two sets of joints in the limestones.

I have endeavoured to point out that we find both of these requirements in the Evenlode–Glyme area. C. N. Bromehead.

University Museum, Oxford.
January 19, 1909.

OBITUARY.

GEORGE HENRY KINAHAN, M.R.I.A.

Born December 19, 1829. Died December 5, 1908.

(PLATE V.)

We regret to record the death at Fairview, Dublin, in his 79th year, of G. H. Kinahan, one of the most distinguished of Irish geologists. The son of Daniel Kinahan, M.A., Barrister-at-Law, he was educated at Trinity College, Dublin, and having qualified as a civil engineer, in 1853 he had conferred on him the Diploma in Engineering of the University. His first professional engagement was on the staff employed on the viaduct which spans the Valley of the Boyne at the harbour of Drogheda, on behalf of the Dublin and Belfast Junction Railway Company, now merged in the Great Northern Railway. Sir John Macneill and James Barton were the chief engineers. This lattice-bridge was the second of its kind built in Ireland. In 1854 Kinahan was appointed to the Irish Branch of the Geological Survey of the United Kingdom, under Sir Roderick I. Murchison, K.C.B., Director-General, Professor J. Beete Jukes being then the Local Director for Ireland. He was promoted Senior Geologist in 1861, District Surveyor in 1869, and retired after thirty-six years service in 1890. His official work extended to almost every county in Ireland, and his name appears on twenty-six of the official "Memoirs of the Geological Survey of Ireland". He was a voluminous writer from the time he joined the Survey. His contributions to the Journal of the Geological Society of Dublin (afterwards the Royal Geological Society of Ireland) extend from 1859 to 1889, articles from his pen appearing in every volume during these years; and he delivered as President the Anniversary Addresses in 1880 and 1881 before that Society. He was a member of the Council of the Royal Irish Academy and a contributor to its Proceedings.

As an archæologist he contributed many papers on Crannoges, Megalithic monuments, and other cognate subjects to the Kilkenny and South-East of Ireland Archæological Society and to the Royal Historical and Archæological Association of Ireland. Other papers by him were published by the Geological Societies in Edinburgh, Manchester, Liverpool, and Glasgow; by the Institute of Civil Engineers, Ireland, and the North of England Institute of Mining and Mechanical Engineers. The British Association, of which for many years he was one of the General Committee, received his last written article for the 1908 meeting in Dublin, on the "Raised Beaches of the

G. H. KINAHAN, M.R.I.A.

late of the Geological Survey of Ireland.

Born December 19, 1829. Died December 5, 1908.

Liffey Valley". He frequently wrote in the *Irish Naturalist*; and to the Geological Magazine, from the first volume in 1864 to 1888, he contributed no fewer than 85 papers. Besides his numerous articles, many hundreds in number, his principal separate publications were *Manual of the Geology of Ireland* (1878); *Valleys, and their relation to Fissures, Fractures, and Faults* (1875); *Handy Book of Rock Names* (1873); *A Handy Book on the Reclamation of Waste Lands in Ireland*; and *Superficial and Agricultural Geology, Ireland* (1908).

No one had so extensive a knowledge of Irish geology as Kinahan, and he was especially acquainted with the practical side of the science, as shown in the important papers he communicated to the Scientific Proceedings of the Royal Dublin Society on the Economic Geology of Ireland.

He is to be regarded as one of the last of that brilliant band of pioneers in the Irish School of Geology that included Griffith and Portlock, Jukes, Haughton, and Maxwell Close, whose meetings attracted hundreds of Dublin citizens to learn the story of the building of their island, and to ponder upon the interesting problems which they could so conveniently study near their city.

His remains were interred in the quiet country churchyard on the hillside near the meeting of the waters in the Vale of Avoca, a district which was one of his latest stations when on active service on the Geological Survey.

H. Leonard and R. Clark.

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

Born June 2, 1828. Died January 29, 1909.

Among the numerous fellow-workers in science lost to us in the closing months of the old and the opening of the new year, the death of none has been more keenly felt than that of Mr. Hudleston, our friend and co-editor in this Magazine since 1886.

Educated at Uppingham School he subsequently entered St. John's College, Cambridge, where he graduated B.A. in 1850. Although attracted by Professor Sedgwick's lectures he did not take up geology in earnest until he came under the influence of Professor Morris in 1866. His earlier years were devoted to the study of the Law, and he was called to the Bar in 1853, but never practised. Attracted by Professor Alfred Newton, of Cambridge, and Mr. John Woolley, Hudleston (who at that time was Wilfrid Simpson) took up the pursuit of ornithology, visiting Lapland in 1855, and subsequently exploring the Eastern Atlas range and Algeria in company with Canon Tristram and Mr. Osbert Salvin. Afterwards he spent a year travelling and collecting in Greece and Turkey. From 1866 to 1886 he devoted close attention to the study of geology with John Morris. In 1867 (having taken the name of Hudleston) he was elected a Fellow of the Geological Society. From 1886 to 1890 he served the office of Secretary, and from 1892 to 1894 he occupied the Presidential Chair, receiving the award of the Wollaston Medal in 1897. Mr. Hudleston was President of the Geologists' Association 1881–3, and both by his writings and his conduct of many of its excursions he won the lasting gratitude of the Association. Mr. Hudleston's papers and memoirs are numerous,[1] not only in the Geological Magazine, but also in the Proceedings of the Geologists' Association, the Quarterly Journal of the Geological Society, the Proceedings of the Dorset Field Club, the Transactions of the Devonshire Association, etc.

His greatest undertaking was the preparation of a Monograph on the Inferior Oolite Gasteropoda, issued by the Palæontographical Society 1887–96, which comprises no less than 514 quarto pages of letterpress and 44 quarto plates of fossils. This work, and the systematic collection of the materials for its production, occupied much of the author's time, assisted by A. H. Bloomfield, Henry Keeping, B. Reynolds, Peter Cullen, and others, over a period of twenty years. He also acquired the Gasteropoda from the private collections of Mr. S. S. Buckman, Mr. Darrel Stephens, and others, in order to complete his work.

So lately as December last he received the gold medal at the hands of the President of the British Ornithological Union in recognition of his early contributions to ornithology.

His paper on the "Halolimnic Fauna of Lake Tanganyika" appeared as a supplement to the Geological Magazine for July, 1904 (pp. 337–82, with two plates); in the September number of that year is a biographical notice of Mr. Hudleston's life and works, with an excellent portrait (op. cit., pp. 431–8). In 1908 he published an important paper "On some Recent Wells in Dorset" (see Geol. Mag., 1908, pp. 212, 243).

Mr. Hudleston's life was marked by untiring energy, directed with a steady purpose throughout. Besides his numerous scientific interests he was a keen sportsman and fisherman. He administered the affairs of his landed properties in Dorset, Yorkshire, Northumberland, etc., with great skill and judgment, and left his estates in good order for his administrators. Quite lately he provided a site and advanced capital for erecting a Marine Biological Laboratory at Cullercoats, Northumberland, to be named the "Dove Laboratory" (after a great ancestor of his family), the completed building having been handed over to the authorities last year at a meeting under the presidency of His Grace the Duke of Northumberland.

Mr. Hudleston took a warm interest in many local scientific societies in Dorset, Devon, and Yorkshire. He was a Vice-President of the Dorset Natural History and Antiquarian Field Club, and contributed some valuable papers to its proceedings on the geology of that county. He had quite lately been busily engaged in rearranging the fossils in the Dorset County Museum, to which he had also largely contributed from his own cabinets.

Ever active up to the last, he had planned (in pencil) the speech he intended to deliver at the Special General Meeting of the Geological Society on February 10, and on January 20 he posted to his friend the Editor of the Geological Magazine the able review which appears in the present number on the Geology of India (see pp. 127–31).

So terminates a life devoted to scientific work, happily ending without pain or illness, from heart failure, at his country residence, West Holme, Wareham.

[1] A list of fifty-eight is given in the Geol. Mag., 1904, pp. 436–8.

No. 538. Decade V.—Vol. VI.—No. IV. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

APRIL, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. IV.—APRIL, 1909.

ORIGINAL ARTICLES.

I.—Secular Earth-Creep.

By Professor E. H. L. Schwarz, A.R.C.S., F.G.S., Rhodes University College, Grahamstown.

DR. J. R. SUTTON has recently read a most important paper to the Royal Society of South Africa on the diurnal variation of level at Kimberley. The paper gave the preliminary results of observations made during the course of three years upon the variation of the level of the ground as recorded by a large horizontal pendulum of a special design made for the author by the Cambridge Instrument Company. It appeared from the results that the movements in the surface of the ground, which set up corresponding movements in the pendulum, were very great. The maximum westerly elongation of the extremity of the pendulum occurred about 5.30 a.m., the maximum easterly about 4.15 p.m., the medium positions a little before 11 a.m. and 9.30 p.m. Geometrically these movements may be represented on the hypothesis that the hemisphere facing the sun bulges out, forming a sort of meniscus to the geosphere. The rise and fall of the surface of the ground which such a supposition would postulate is enormous, and the very magnitude has led Dr. Sutton to hesitate in giving the figures. There can, however, be very little doubt that some rise and fall in the earth's surface is occasioned by the sun's gravitational pull, although the present figures may have to be lessened by taking into consideration other causes which contribute to the disturbance of the pendulum.

The subject is not a new one; Professor Milne, in his Bakerian lecture, referred to experiments he had carried out at Shide, Isle of Wight, in which it was proved that the earth's surface bulged on a sunny day and was depressed on a cloudy or rainy day; the cause for this was the different rates of transpiration in the leaves of the trees, grass, and so forth, which led to the accumulation of water in the soil on a cloudy day sufficient to weigh down the earth. Such elevations and depressions, however, leave no permanent distortion, but when the earth is day by day pulled out towards the sun, this must in the course of geological periods cause the ridges in the earth's crust to creep westwards.

In the Devonian rocks we have in South Africa a peculiar assemblage of forms characterized by a small Brachiopod, *Leptocœlia flabellites*, Conrad. When these were first sent home by A. G. Bain, Rupert Jones at once wrote back saying that they were the same as the fossils then recently brought back from the Falkland Islands by Charles Darwin. Recent work has proved the correctness of this view, and not only in the Falkland Islands, but the Lower Devonian fossils from the Argentine, Brazil, and Bolivia in South America, and the eastern portion of North America, are remarkably alike, and, on the other hand, as remarkably distinct from the European Devonian fossils.

To make sure that our South African fossils were identical and not merely similar to the North American forms, I submitted a small series from the Bain Collection in the Albany Museum, Grahamstown, to Dr. J. M. Clarke, who very kindly examined them and replied as follows:—

"The specimens of *Leptocœlia flabellites* are entirely in accord with the usual expression of this species as it occurs in the New York Oriskany, the Gaspé sandstone of Eastern Quebec, and the Lower Devonian sandstone of Central and Southern Brazil and of the Falkland Islands. There are some variations in this species which might upon close analysis serve to exhibit definite stratigraphic or time values. We find, for example, in certain Oriskany beds in this State multitudes of more diminutive forms which seldom attain the normal average size as expressed by your South African specimens. On the other hand, in the Grand Grève limestones of Eastern Quebec the species attains quite extraordinary dimensions, and it is interesting to observe that this large size is reached in a calcareous facies, and the same effect is noticeable in other Eo-Devonian species which are most commonly known in the arenaceous sediments."

A large part of these Lower Devonian strata are sandstones with shales and limestones interbedded, and the whole aspect of the series is that of a shore deposit. I cannot speak of the direction from which the sediment was carried except in South Africa, where the sandy beds occur towards the north, and their place is taken by shale beds to the south, and there can be no question, therefore, that the land in these times lay to the north. We can, however, plot roughly the shore-line of this ancient continent on the south and western shores. In the north we know very little yet of the beds; the actual shore-line is submerged beneath the ocean in Europe, and in North Africa the exposures in the Sahara are too isolated and as yet not sufficiently explored to enable one to plot the shore-line. It is true that Professor E. Haug has described two characteristic South African fossils, including *Leptocœlia flabellites*, from Tassili in the French Soudan, which were brought back by the Foureau expedition. I have, of course, only seen the photographs published with the description of these beds, but the fossils do not to my mind resemble the South African ones. However, accepting Professor Haug's determinations, the occurrence of the *Leptocœlia flabellites* fauna in the Soudan would indicate that an inlet of the shore of the Devonian Atlantis passed somewhere in the neighbourhood. The rest of the Saharan Devonian fossils are plainly European, and suggest that there was no connection of the European Devonian ocean with the American and South African Devonian ocean such as the Tassili fossils, according to Professor Haug, should indicate.

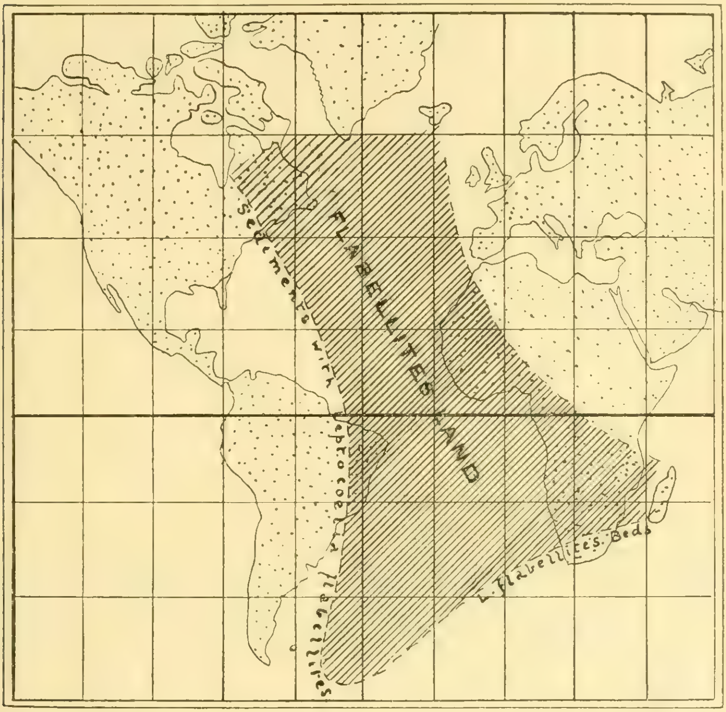


Fig. 1.—Map showing the distribution of land and water in the Atlantic region during early Devonian times; from Trans. Phil. Soc. S.A., Cape Town, 1905, vol. xvi; see also F. Katzer, Bol. d. Museu Paraense, 1895, vol. ii, map to face p. 237.

Taking only the southern and western shores into account, it is manifest that there was a land-mass occupying the area of the Atlantic in Lower Devonian times of somewhat similar dimensions to that of the Americas. Has Dr. Sutton's investigation at Kimberley any connection with this? The facts are very suggestive taken into account with the later Lemuria, which occupied the Indian Ocean closer to Africa than the earlier *Flabellites* land did to America. I do not wish to strain the point at present as it is a new one, but I wish to draw attention to Dr. Sutton's work, which appears to me pregnant with important bearing on questions of earth physics. If this earth creep westwards is established, it will be the deathblow to the Tetrahedral theory, for it will provide for a continuous obliteration of earth features in the direction of the earth's revolution, and there are no forces within the earth to reproduce the tetrahedral edges, which are supposed to have originated by the collapse of the shell in the shrinking nucleus of the globe, once these have been flattened out longitudinally by this earth creep.

The subject first suggested itself to me when working on the rocks of Tristan da Cunha, and the map here reproduced is taken from my paper on "The Rocks of Tristan da Cunha brought back by H.M.S. Odin, 1904, and their bearing on the question of the Permanence of Ocean Basins".[1] Dr. Katzer, in his "A fauna devonica do rio Maecuru, e as suas relações com a fauna de outros terrenos devonicos do globo",[2] drew his "Continente atlantico-aethiopico" on more or less the same lines, but terminated it to the south by a shore running latitudinally, parallel with the southern extremity of South Africa, deriving his sediments in the Falkland Islands from a "Continente meridional". The sediments in the Falkland Islands, however, are so similar to those in the Bokkeveld Beds in South Africa that I am inclined to think they must have been derived from the same continent. The important point to notice is that Dr. Katzer, working from Brazil, arrived at the same distribution of land and water in Devonian times as I did working from the other side of the Atlantic.

II.—On the Jaw Apparatus of *Discoidea cylindrica* (Lamarck).

By Herbert L. Hawkins, B.Sc., Mark Stirrup Scholar in the University of Manchester.

(PLATE VI.)

WHILST searching through the duplicate drawers in the Manchester Museum I found recently a specimen of *Discoidea cylindrica* which contained the dental apparatus in a very good state of preservation. The softness of the matrix within the test made it possible to develop and extract the jaws, and thus to detect several new features of interest.

The jaws of *Discoidea* were described in 1892 by Lovén, who gave good figures of the maxillæ both in the text (p. 53) and on plate x (figs. 114, 115). In this paper he discusses the two distinct types of perignathic girdle that occur in *Discoidea cylindrica.* He states that in the depressed form (*forma vulgaris*) the ambulacral processes ('auricles') are low, and connected by interradial ridges ('walls') which are of almost the same height; whereas in the tall form (*forma elatior*) the processes are much more prominent than the ridges. The jaws he describes are from the form he designates as the "more normal", but it is hard to determine to which type he refers in this phrase. There is no mention of the teeth or of the epiphyses in Lovén's paper, but both these structures are preserved in the specimen about to be described.

It will, perhaps, be best to proceed with the description of the specimen, and subsequently to consider the differences from Lovén's description.

The specimen, which is one of a pair of small *Discoideæ* collected

[1] Trans. Phil. Soc. S.A., Cape Town, 1905, vol. xvi, p. 19.
[2] Boletin do Museu Paraense, 1895, vol. ii, Para, Brazil.

by the Rev. A. Dixon from the Lower Chalk of Sewell, in Cambridgeshire, is what would be usually described as a young form, the cylindrical character of the sides of the test of adult forms being scarcely perceptible. The dimensions of the test are: Breadth of base, 38·75 mm.; height of test, 22·25 mm. At one point the test was broken away, and by careful development sufficient was removed to expose the five pairs of hemi-pyramids with their teeth, all lying in the left anterior interradius (Fig. 1).

The *maxillæ* are small and lanceolate in form, with their adoral ends strongly curved inwards. The inter-pyramidal joint-face (Fig. 3) is broad, being 6·6 mm. long and 3·2 mm. wide at its greatest breadth, which extends from about 2 mm. above the oral end, almost to the aboral end of the face. Its aboral margin slopes very slightly outwards and downwards. The transverse ridges are almost parallel to the aboral margin; they are straight and very fine, being about seven to each millimetre. The *fossa arcualis* is high, and about ·75 of the breadth of the aboral margin of the inter-pyramidal face. The outer surface (Fig. 2) is slightly narrower, and strongly convex adorally. Its length is 8·1 mm. and its greatest width 3·1 mm. The external margin is sharp and elevated into a flange. The admedian outer plane is very narrow aborally, but becomes widened into an inward sloping plane, 1·0 mm. wide adorally. It crosses the marginal flange, and is continued as a strongly incurved process for about ·75 mm. beyond it. The *fovea magna externa* is narrow and deep below, with a distinct facet on the outer side of the admedian plane, but it rapidly becomes shallower upwards, and, save for a slight depression aborally, it forms a broad, somewhat concave surface. The symphysial face is narrow (·9 mm. wide near the upper end), becoming somewhat broader at the incurved adoral end. The length of the symphysis is 5·4 mm. (chord measurement), and the full height of the maxilla is 8·1 mm.; the ratio of symphysis to maxilla is therefore ·67. The internal face has a deep concavity partly divided by a carina at the aboral end. The dental slide is concave and rather deep. It extends to within ·6 mm. of the angle of the supra-alveolar process. The adoral region of the internal face is smooth.

The *epiphysis* (Fig. 6) is very minute and slender. Its horizontal length is 2·7 mm., its height at the outer end 1·5 mm. It is reduced to a narrow bar towards the inner end. The inter-pyramidal surface is horizontally ribbed, with a rounded prominence at about 1 mm. distance from the inner end. The surface of articulation with the maxilla is almost smooth.

No recognizable trace of a *rotula* or of a *compass* can be determined, but the rounded prominence on the epiphysis indicates the existence of a rotula, as this articulation is the chief one between these two pieces in most Regular Echinoidea.

The *teeth* are narrow and but slightly curved. There is a strong keel on the concave side, and a less conspicuous rounded ridge along the convex side, as in *Echinus*. The cutting edge of the tooth seems not to have been very sharp, but to terminate in a blunt chisel edge rather than in a point. The tooth is, however, a far more effective cutting instrument than the short stumps of the Clypeastroid jaws.

The length of the tooth extracted for examination is 6·2 mm. (measured along the chord), and the breadth from side to side is uniformly ·9 mm.

The relative length of the symphysis as compared with the maxilla in Lovén's specimen was ·74, whereas it is ·67 in the present example. That this proportion increases with the age of the individual seems certain; thus, in a series of measurements I have taken of these lengths in small specimens of *Echinus miliaris*, the proportion varied from ·52 (in a very minute specimen, the total length of the maxilla of which was only 2·3 mm.) to ·61 in a specimen with a maxilla 3·1 mm. long. But the two specimens of *Discoidea* now under comparison have maxillæ of precisely equal length, namely, 8·1 mm., so that the difference in the relative length of the symphyses (·07) is not of necessity due to difference in the age of the individuals. The general proportions of the maxillæ in the new specimen are considerably more slender than those of Lovén's specimen.

The method of articulation with the perignathic girdle is comparable to that of the Clypeastroids. The narrow adoral end of the *forea magna externa* is deeply depressed, and articulates perfectly with a radial process of the perignathic girdle. Interradially the pyramid seems to have leaned against two somewhat approximated radial auriculæ, and to have had very small possibilities of movement.

As has been previously mentioned, Lovén points out the striking differences between the two types of perignathic girdle in *Discoidea cylindrica*, and assigns the type with prominent auricles to the cylindrical *forma elatior*. His two figures ("Echinologica," pp. 48, 49) exhibit the characters of the girdle in both types very clearly. He shows that the tall form not only has more prominent auricles than the depressed form, but that in it the characteristic interradial ridges that radiate from the peristome to the sides of the test are more strongly pronounced.

The specimen of *D. cylindrica* here described is undoubtedly one of the low or depressed forms. A comparison of the outline in Fig. 1 with that in Wright's monograph of the Cretaceous Echinoids referred to by Lovén (Wright, Pal. Soc., Cret. Ech., 1874, pl. xlvi, fig. 2*a*) shows it to be almost identical in form with that typically depressed specimen. But the characters of the perignathic girdle in my specimen (and also in the companion specimen, which is identical with it in shape and size) conform more or less completely to those ascribed by Lovén to the elevated form. Except for the fact that the auricles are not quite so prominent in the case of the example from Sewell, the drawing in "Echinologica" (p. 49) would serve as a representation of this specimen. This correspondence in the perignathic features of the high and low forms of *D. cylindrica* tends to break down the distinction between them.

It has usually been stated (see Wright, 1874, p. 206) that the hemispherical form of *D. cylindrica* is the young stage of the true cylindrical form, but Lovén suggests that there may be a specific difference between the two forms. The present example seems to me to lessen the probability of the existence of any fundamental distinction between the two forms, and to give confirmation to the older belief. Lovén does not give the sizes of the specimens he describes, so that it is impossible to judge certainly as to the relative ages of the specimens, but the fact that the auricles in my example are not quite so fully developed as in the original of Lovén's figure on p. 49 seems to indicate that my specimen is the younger of the two. Assuming that the jaws described by Lovén are those of the tall form, then the smaller symphysial proportion in the present specimen lends confirmation to this belief.

Perhaps the most striking feature of the 'lantern' of *D. cylindrica* is its strongly 'regular' character. In many respects the structures closely resemble those in *Cidaris papillata.* The slightly less elevation of the outer faces of the pyramids, the internal keel of the tooth, and the slanting position on the perignathic girdle, are the only obvious differences, save for a slight tendency in the epiphyses of *Cidaris* to converge to form an arch. The epiphyses of *Discoidea* are very like those of the Diademine genus *Asthenosoma*, but in that form again the tooth is grooved on the concave side.

The great similarity between the dental structures in *Discoidea* and the regular Echinoids tends to confirm the belief that the Discoidiidæ are very primitive among irregular Gnathostomata. In the structure of the jaws, at least, these forms might well be regarded as intermediate between the Regularia and the Clypeastrina, for the pyramids bear a strong regular facies, whilst their method of articulation with the perignathic girdle, and the slight modifications that they do present, all seem to tend towards a typical Clypeastrine character.

Summary.—The maxillæ of a specimen of *Discoidea cylindrica* are described, and found to differ somewhat from those described by Lovén in "Echinologica". The epiphyses and teeth of *D. cylindrica* are described for the first time, and are shown to resemble those of several Regular Echinoids.

The differing characters of the perignathic girdle, which were considered by Lovén to be of almost specific importance, are not found to be confined to the different forms of test, and are regarded as differences due to the age of the specimens.

The intermediate character of the family of the Discoidiidæ between Regular and Clypeastrine Echinoids is emphasized.

In conclusion, I wish to express my thanks to Dr. Hoyle, of the Manchester Museum, for permission to develop and describe the specimen; also to Dr. Bather for his help and encouragement, and especially for lending me the proof-sheets of his forthcoming memoir.

LITERATURE REFERRED TO.

1874. T. Wright. Monogr. Brit. Foss. Echinodermata.—Cretaceous: I. Echinoidea; pt. vi, Echinoconidæ, pp. 198–213, pls. xlv–xlvii. (Presence of jaws asserted without proof.)

1886. P. M. Duncan. "On the Perignathic Girdle of the Echinoidea": Journ. Linn. Soc. Zool., vol. xix, pp. 179–212, pls. xxx, xxxi. (Terminology of perignathic girdle.)

1888. Sven Lovén. "On a recent form of the Echinoconidæ": Bihang Kongl. Svenska Vet. Akad. Handl., Bande xiii, Afd. iv, No. x, Stockholm. (Describes one form of girdle in *D. cylindrica.*)

1889. P. M. Duncan & W. P. Sladen. "Note on Perignathic Girdle of *D. cylindrica*": Ann. Mag. Nat. Hist., ser. vi, vol. iii. (Expresses disbelief in the existence of jaws in this genus.)

1890. P. M. Duncan & W. P. Sladen. "On the Anatomy of the Perignathic Girdle of *D. cylindrica*": Journ. Linn. Soc. Zool., vol. xx, p. 48.
1892. Sven Lovén. "Echinologica": Bihang Kongl. Svenska Vet. Akad. Handl., Bande xviii, Afd. iv, No. i, Stockholm. (Describes jaws of *D. cylindrica*.)
1909. F. A. Bather. "The Triassic Echinoderms of Bakony." (Terminology of Echinoid jaws discussed.)

EXPLANATION OF PLATE VI.

Fig. 1.—Side view of the specimen of *Discoidea cylindrica* in Manchester Museum (L. 8806), with the jaw apparatus *in situ*. × 1½.
,, 2.—Outer surface of a pyramid, A in Fig. 1, the two halves separated along the symphysis and the tooth forced between them. As found. × 8.
,, 3.—Inner (inter-pyramidal) view of a pyramid, with the incurved extensions of the halves of the admedian outer plane at the adoral ends. × 8.
,, 4.—Tooth; side view. × 8.
,, 5.—Inner (alveolar) view of a hemi-pyramid, showing the symphysial surface and half the dental slide. × 8.
,, 6.—Epiphysis, inter-pyramidal surface, showing rounded prominence for articulation with a rotula. × 15.
,, 7.—Portion of the perignathic girdle of this specimen, showing the processes. × 3.

III.—On the Composition of 'Borolanite' from Am Meallan, Ross-shire.

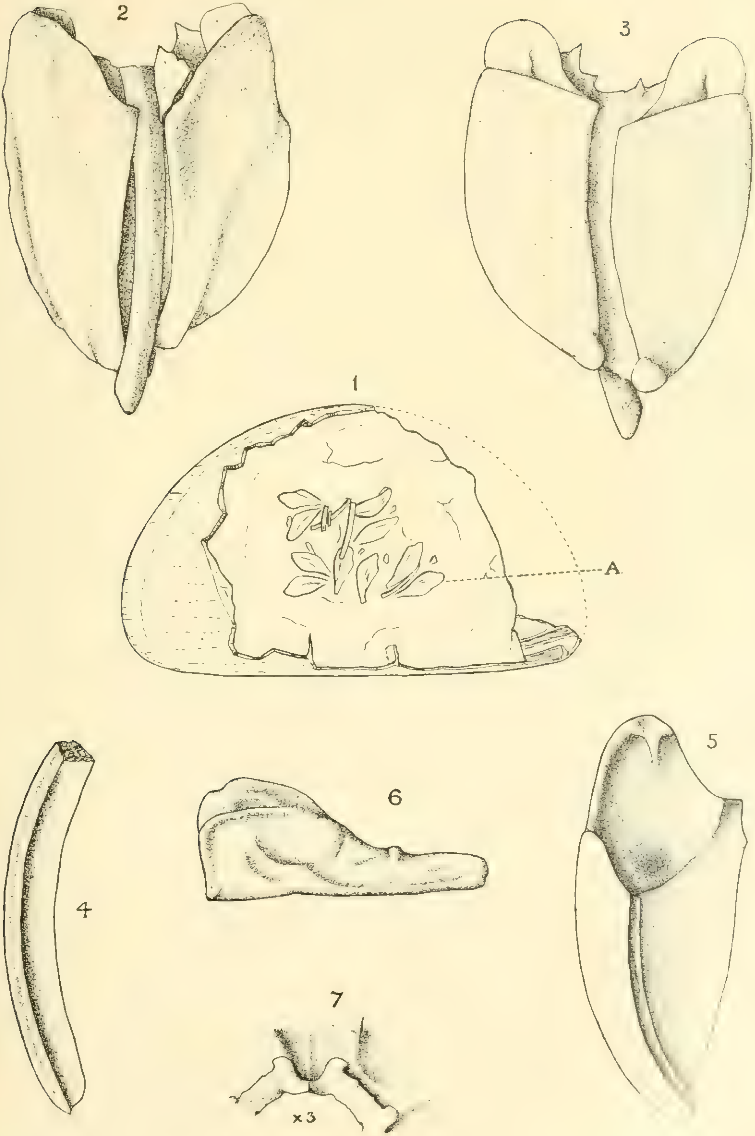
By W. Campbell Smith, Scholar of Corpus Christi College, Cambridge.

THE peculiar garnetiferous rock occurring to the east of Loch Borolan seems to have been first noted by Dr. Callaway in 1883, and is described by Dr. Bonney in an appendix to Dr. Callaway's paper.[1]

The rock was more fully described by Messrs. Horne & Teall in 1892.[2] The authors give it the name borolanite, defining the typical rock as an aggregate of orthoclase and melanite. The mineral composition is described, with special reference to the white patches, which consist of an aggregate of orthoclase and a substance which is probably an alteration product of nepheline or sodalite. The occurrence of a turbid mineral in micropegmatitic intergrowth with the felspar is noted, and it is suggested that this is an alteration product of nepheline. The theory that these white patches are pseudo-leucites was suggested by Professor Derby, who compared them to the pseudo-leucites of certain Brazilian rocks. It is also pointed out that borolanite appears to be a member of the elæolite-syenite family.

An appendix to this paper of Messrs. Horne & Teall records the discovery of much decomposed borolanite in the Eilean Dhu Limestone at Elphin, and of two vertical dykes in the Torridon Sandstone at Camas Eilean Ghlais. The dyke is of medium texture and brownish-grey colour. Hand-specimens show melanite and lath-shaped cleavage faces of felspar. Sections show the rock to be composed of an aggregate of orthoclase, nepheline (partly decomposed to a substance giving aggregate polarization), melanite, ægirine, and biotite. The melanite is either pale yellow or deep brown, a pale zone often surrounding a dark nucleus. Two bulk analyses were made, one by Mr. Hort Player and the other by Dr. Teall; the latter also analyzed the part soluble in hydrochloric acid, thereby proving the presence of nepheline.

[1] Q.J.G.S., 1883, vol. xxxix, p. 409.
[2] Trans. Roy. Soc. Edinburgh, vol. xxxvii, p. 163.



H. L. H. del.

Figs. 1–7.—Dental apparatus of *Discoidea cylindrica* (Lam .

In a later paper[1] Dr. Teall points out the similarity between the rocks of Cnoc-na-Sroine and those of Christiania. He again mentions the dyke-rock as being allied in mode of occurrence and mineral composition to the tinguaites of Rosenbusch, but differing from these in containing 5 per cent. of lime, and also in structure. Accordingly, after much hesitation, he has classed it as borolanite. He also discusses the relations between the rocks of Cnoc-na-Sroine and those of Magnet Cove, Arkansas, and regards borolanite as almost identical with the leucite-syenite of the latter locality. To support this theory he compares the analyses of the dyke-rock with that of the leucite-syenite. The quotation of this analysis in this place seems to have led to its being accepted by Rosenbusch as that of "Borolanit vom See Borolan". The same analysis has also been taken as that of "Borolanite, Borolan, Scotland" by Washington and by Osann in their collections of analyses.

In a paper,[2] "Ueber Borolanit und die Gesteine des Cnoc-na-Sroine Massivs in Nord-Schottland," Dr. J. Shand points out the above-mentioned error. In the part of this paper which deals with borolanite the author distinguishes between the typical rock (as originally defined) and the spotted variety. He has paid most careful attention to the micrographic intergrowth with orthoclase, and to the nature of the zeolite. He considers that the former consists of sodalite or analcime, and applies to the finger-print structure, which it forms with the orthoclase, the term 'dactylotype'. The exact nature of the zeolite is still rather uncertain, and, pending further results, he retains Brögger's term 'Spreustein'.

Hoping to throw light on the 'pseudo-leucite' theory raised by Professor Derby, Dr. Shand analyzed some of the white patches cut from a specimen from Allt a' Mhuilin; he also analyzed some of the black material. The figures obtained were as follows:—

	I.	II.	III.
SiO_2 . . .	44·85	56·26	55·91
TiO_2 } Al_2O_3 } . .	17·10	21·93	23·88
Fe_2O_3 . . .	10·06	·67	3·12
FeO . . .	2·71	—	—
MnO . . .	—	—	—
CaO . . .	14·00	1·46	1·22
MgO . . .	·39	—	tr.
Na_2O . . .	1·67	4·95	9·55
K_2O . . .	6·92	10·63	6·09
H_2O . . .	1·66	4·16	1·46
	99·36	100·06	101·23

I. Black material without visible pseudo-leucite.
II. Pseudo-leucite.
III. Pseudo-leucite of Serra de Tinga, Brazil.

Analysis III is quoted for the sake of comparison.

[1] Geol. Mag., 1900, Dec. IV, Vol. VII, p. 386.
[2] *Neues Jahrb. f. Min.*, etc., 1906, Beilage Band xxii, p. 413.

In the same paper Dr. Shand gives a sketch-map of the district, and a brief description of the positions of various localities mentioned above may not be irrelevant.

The main mass of rocks occupies about 5 square miles between Ledbeg and Loch Borolan, attaining its greatest height at Cnoc-na-Sroine, east of the former locality. Aultnacallagach is situated on the north-east of Loch Borolan, and the main exposures of borolanite occur in the stream Allt a' Mhuilin, to the south-east of this place. Am Meallan is on the roadside, close to Allt a' Mhuilin and slightly to the north-west. It should also be noted that Camas Eilean Ghlais, where the dyke-rock occurs, is on the coast about 18 miles west of Loch Borolan.

A summary of most of the work above mentioned is given in the Memoir of the Geological Survey of the North-West Highlands.

At the suggestion of Mr. R. H. Rastall an analysis of a borolanite from Am Meallan has been made. The specimen, kindly provided by Mr. Harker and collected by him a few years ago, was dark grey in colour, with numerous ill-defined white patches, which never exceed 1 cm. in diameter. The groundmass was fine-grained, the garnets being very small. Some lath-shaped cleavage faces of felspar were observable.

To obtain a good average sample about 400 gms. of rock was coarsely powdered and well mixed; about 100 gms. of this was then more finely powdered, and finally about 10 gms. ground down for analysis. Silica and the bases were estimated on about 1 gm. of substance, alkalies and ferrous iron being each estimated on a separate quantity of about ·5 gm. Water was determined on about 1 gm. of powder, contained in a platinum boat and heated in a quartz tube, first by a Téclu burner and finally by a strong blast. The water was collected in a weighed sulphuric acid tube. The loss in weight of the boat was in each case slightly less than the weight of water collected, owing to the presence of $Fe\,O$. For the rest the directions of Washington and Hillebrand were followed throughout. The results were as follows:—

	I.	II.	III.	Mean.
$Si\,O_2$	48·27	48·12	—	48·19
$Ti\,O_2$	1·85	1·66	—	1·75
$Al_2\,O_3$	18·52	18·52	—	18·52
$Fe_2\,O_3$	4·57	4·45	—	4·51
$Fe\,O$	1·64	1·73	1·68	1·68
$Ca\,O$	10·23	10·35	—	10·29
$Mg\,O$	1·18	1·07	—	1·12
$Na_2\,O$	3·43	3·46	—	3·44
$K_2\,O$	8·13	7·98	—	8·05
$H_2\,O$ (above 105°) .	2·99	3·01	—	3·00
$H_2\,O$ (105°) . .	·45	·45	—	·45
	101·26	100·80	—	101·00

Sp. gr. = 2·77.

Traces of $P_2\,O_5$ and $Mn\,O$ were also present.

Three sections were cut from the remains of the specimen analyzed, and these were examined with a view to getting some idea of the proportions of minerals present.

The garnets are quite typical, pale brown, and filled with inclusions of small sphenes, some biotite and a very little apatite. The larger crystals (2 mm. diam.) are very irregular and broken; the smaller (·1 mm. diam.) show excellent sections of rhombic dodecahedra. No sphene occurs outside the garnets; apatite is sparingly present, and green pleochroic ægirine was observed only as two small patches in one section. The biotite is dark green, occurring as somewhat ragged flakes in the orthoclase-melanite aggregate and to a small extent as inclusions in the garnet.

'Dactylotype' structure was well shown, the material forming it being apparently of *lower* refractive index than orthoclase. Here and there rather indefinite black crosses, shown by parts of the zeolite between crossed nicols, were observed.

Estimates of the volume-percentages of the minerals of each of the three slices were made by three independent observers, making nine in all. The mean of the nine is: Garnet, 25·3; orthoclase, 51; 'Spreustein,' 19; and biotite, 5. Taking the specific gravities of these minerals as 3·6, 2·57, 2·3, and 2·9 respectively, the percentage mineral composition becomes: Garnet (including sphene), 32·48; orthoclase, 46·75; 'Spreustein,' 15·59; and biotite, 5·17.

The specific gravity calculated from these values, assuming the minerals to have the specific gravity above given, is 2·79. The actual specific gravity was found to be 2·77.

In view of the fact that the only minerals present, whose composition is known, are orthoclase and sphene, and further that there is very little guide as to the composition of the zeolite, any definite calculation of mineral composition from the analysis is extremely difficult, and it is probable that several equally plausible arrangements might be made. The figures which seem to fit best are here given:—

	Ratios.	Melanite.	Sphene.	Thomsonite.	Biotite.	Orthoclase.
SiO_2	·803	·164	·022	·133	·049	·433
TiO_2	·022	—	·022	—	—	—
Al_2O_3	·181	·027	—	·066	·016	·072
Fe_2O_3	·028	·028	—	—	—	—
FeO	·023	·018	—	—	·005	—
MgO	·028	·008	—	—	·020	—
CaO	·184	·143	·022	·011	·008	—
Na_2O	·055	—	—	·055	—	—
K_2O	·086	—	—	—	·016	·070
H_2O	·166	—	—	·166	—	—
		26·66	4·31	21·66	7·74	38·92
Calculated		30·97		21·66	7·74	38·92—99·27
Estimated		32·48		15·59	5·17	46·75—99·99

A fair degree of approximation is observed between the calculated and estimated results.

The melanite is assumed to contain all the Fe_2O_3, and to have the composition of a melanite from the nepheline-syenite of Dungannon, Ontario (after depriving it of sphene and water). A thomsonite is selected because it is the only zeolite which will bring about the proper ratio between $Na_2O + CaO$, and water. In view, however, of the rather uncertain condition of the water in zeolites, this cannot be regarded as a strong piece of evidence that the zeolite has this composition. The biotite is purely hypothetical, and doubtless should contain some water.

The dyke-rock of Camas Eilean Ghlais seems to have very little in common with borolanite. A rough calculation of the 'mode' shows it to contain about 20 per cent. of nepheline, 15·5 per cent. melanite, 42 per cent. orthoclase, with some ægirine, nosean, and biotite. A glance at the two analyses given below shows the great difference between the two rocks—

	Am Meallan.	Camas Eilean Ghlais.
SiO_2	48·19	47·8
TiO_2	1·75	·7
Al_2O_3	18·52	20·1
Fe_2O_3	4·51	6·7
FeO	1·68	·8
MnO	tr.	·5
MgO	1·19	1·1
CaO	10·29	5·4
Na_2O	3·44	5·5
K_2O	8·05	7·1
H_2O (above 105°)	3·00	2·4
H_2O (105°)	·45	
BaO	—	·8
SO_3	—	·4
	101·00	99·3

It seems very difficult to find any rock whose composition is very near that of borolanite.

A calculation of its true position in the quantitative classification of Cross, Iddings, Washington, and Pirsson shows that it falls in Subrang 3, Rang 2 (Vulturase), Order 7 of Class II. No other analyses seem to fall in this subrang. The dyke-rock falls in a similar position in Order 6 of the same class, and therefore is in a sense nearly allied to borolanite. The 'norm' of borolanite shows very little similarity to the 'mode' or true mineral composition, orthoclase being the only mineral which occurs in both. The 'norm' is as follows: orthoclase, 30·86 per cent.; anorthite, 11·12; leucite, 13·32; nepheline, 15·62; wollastonite, 16·70.

Taking the molecular ratios of SiO_2 and alkalies as abscissæ and ordinates respectively, about a hundred analyses, mainly of plutonic rocks, were plotted on squared paper. The points fall roughly into the two well-known curves 'alkaline' and 'calc-alkaline', and it was hoped that the rocks closely allied to borolanite might be thus found. The result is somewhat disappointing. Borolanite falls on the upper curve, and occupies a position intermediate between the nepheline and leucite syenites on the one hand and the essexite group on the other. In this position it stands rather alone, its three nearest neighbours being ijolite from Umptek and augite-syenites from Hedrum (Norway) and from Yogo Peak.

The dyke-rock falls nearest to an ijolite from Iiwaara (Finland), leucite-syenite from Shonkin Creek, and amphibole-malignite from Poobah Lake, Canada.

Borolanite is more acid and more alkaline than either the nepheline-syenite, leucite-syenite, or leucite-tinguaite-porphyry of Magnet Cove.

With reference to the Christiania rocks, the alkali and silica ratios of borolanite are about half-way between those of laurdalite and the essexite of Sölvsberg. Its alkali ratio is nearly identical with that of laurvikite from Tönsberg.

In a recent paper[1] Dr. F. H. Hatch has published a new scheme of classification for the plutonic rocks. In this the basic rocks are divided into the alkali-gabbro and gabbro families; the alkali-gabbros are further divided into nepheline-gabbro, essexite, shonkinite, and kentallenite sub-families. The rock of Camas Eilean Ghlais falls in the nepheline-gabbro sub-family along with theralite and covite. Borolanite itself appears to fall in the shonkinite sub-family, as it undoubtedly belongs to the potash series. By plotting the 'rock-pictures' by Brögger's modification of Michel-Lévy's method it can readily be seen that borolanite bears affinities to the shonkinite of Poobah Lake, and also that it belongs to the same series as plauenite (potash-syenite of Plauen, Dresden).

An isolated analysis of one specimen from such an interesting locality is of very little use in determining the affinities of the rock, and it is hoped that further analyses of the Cnoc-na-Sroine complex will be made, so that it may be possible to compare these rocks with those of Magnet Cove and Christiania, and to arrive at some definite conclusions as to the origin of borolanite.

In conclusion, I have to acknowledge my great indebtedness to Mr. Rastall for his very valuable assistance, and also to Dr. Shand for useful information and suggestions. The analysis was made in the Mineralogical Laboratory at Cambridge, and I have to thank Dr. A. Hutchinson for his assistance and advice in this part of the work.

IV.—Coal Pebble in a Coal-seam.

By W. S. Gresley, Assoc.M.Inst.C.E., F.G.S.

Recorded Coal Pebbles.

LOGAN, in 1840, noted the occurrence of pebbles of cannel in the roof of a coal-bed in South Wales; also of pebbles of coal in the 'Pennant' rock (Proc. Geol. Soc., vol. iii, p. 276). De la Beche refers to coal pebbles in the Monmouth and Glamorganshire Coalfield,[2] and H. K. Jordan to similar forms of coal in the

[1] *Science Progress*, No. 10, October, 1908.

[2] [Mem. Geol. Survey, 1846, vol. i, pp. 159, 193, etc.; see also *Geology of the S. Wales Coal-field*, 1907, pt. vii, by A. Strahan and others.—Ed.]

base of the Pennant Series, and to a coal pebble the size of a hen's egg in the roof of the 'Rock Fawr' coal-seam near Bridgend (Q.J.G.S., vol. xxxiii, p. 932).[1] In the roof of the 'Nanaimo' coal, in Vancouver Island, a coal pebble in a conglomerate was recorded in 1906. Several instances of water-worn lumps of coal have been mentioned in the volumes of the second Geological Survey of Pennsylvania as having been found in the semi-bituminous and Pittsburg regions.

Pebble of Coal in Coal.

Having collected all available notices of rolled pebbles and of angular or travelled rock-fragments discovered *in* seams of coal, or in the floors and roofs of coal-beds, as well as in the Coal-measures generally, for a period of twenty-five years, the writer has just met with the only instance known to him of the occurrence of a rounded fragment of *coal* actually embedded in a seam of coal. If this specimen does happen to be unique, the circumstances of its occurrence need create no wonderment, since rounded fragments of almost every *other Coal-measure rock* would seem to have turned up either actually in or near to seams of coal in one coalfield or another.

Location, etc., of the Coal Pebble.

Found, lying flat, in about the middle of the 'Little Coal' seam, in the Donisthorpe Colliery, in Overseal, Derbyshire, in the Leicestershire and South Derbyshire Coalfield, and at a depth of about 900 feet. The seam is about 4 ft. 10 in. in height, and is believed to lie at about the middle of the Middle Coal-measures.[2] The character of the seam is what may be called ordinary house-coal, but the lower half of it is, on the whole, much harder or more 'spirey' than is the upper portion, which, for the most part, is 'dicey' or soft. Now, it was just within the bottom of the dicey layers that this coal pebble was discovered, the discovery being made in this way: A workman on the 'screens' at the surface, in order to separate an ordinary lump composed of part soft and part hard coal, split the same with a pick and thus exposed the pebble. The specimen was handed to the foreman, who presented it to the writer a few days afterwards.

Parenthetically it may be stated that a few years ago the Manager of this colliery (Mr. J. Armson) gave the writer a well-rounded pebble of pale-brown, fine-grained quartzite, which had been found in the clay floor of this same 'Little Coal' at this same colliery; also that, some thirty-five years ago now, a much larger quartzite boulder occurred in the same horizon (in the underclay) at a colliery about 3 miles north of Donisthorpe. For a description of this, as well as of other smaller erratics in these Coal-measures, see the author's paper on "The occurrence of Boulders and Pebbles in the Coal-measures" (Trans. Manchester Geol. Soc., 1888).

[1] [See also remarks by W. Sanders and H. Cossham on pebbles of coal in the Bristol Coalfield. The pebbles found in the Upper Measures were stated to be anthracitic, proving their derivation from the Lower Measures. (GEOL. MAG., 1865, p. 134.)—ED.]

[2] There are, approximately, 1,000 feet of Coal-measures above and 1,000 feet beneath this seam.

Description of the Pebble.

Fairly well-rounded, but bearing decided traces of vertical joints belonging to the layer or bed from which it was doubtless derived. In form flattish subangular, being rather suggestive of a flattened pear. The grain or laminæ of the material lie parallel with the flatter sides. Thickness about $\frac{5}{16}$ inch, but quite uneven; not unlikely the thickness of the pebble approximates that of the individual band from which it was derived. Longer diameter $3\frac{1}{2}$ inches; maximum width about 2 inches. The surface all over may be described as rough and uneven, considerably pitted, and quite concave on part of one of its vertical sides, the rest being very convex. The roughness of surface is about similar to that of a Brazil nut. The pittings, etc., upon the horizontal or flatter parallel surfaces are mainly due to the wearing away of little patches of fossil charcoal. A few shallow and parallel striæ run approximately parallel with the longest diameter, and occur mainly on one flat side only. They are just such scratches that a fragment of coarsish sandstone makes when rubbed across similar coal. The material is very hard, compact, dull, heavy coal, and contains, besides numerous wee specks, streaks or shred-like bits of lustrous hydro-carbonaceous materials, very many macrospores or spore cases measuring about $\frac{1}{30}$ inch across. These fossils show up quite conspicuously on the pebble's surface.[1] In short, the coal is not at all unlike that of some of the spirey layers belonging to the 'Main Coal' seam of the same field, nor of similar hard layers found in the 'Roaster' coal some 10 miles to the east, and in the 'Slate' seam near Nuneaton, in Warwickshire, 15 miles distant. It is extremely probable that the matrix of this pebble consists mainly of spores, because Mr. Edward Wethered, F.G.S., found that a micro-slide of coal, to all appearance, so far as the author can see, resembling this, was so composed. The pebble weighs about $2\frac{1}{2}$ oz.

History of the Pebble.

From its position in the coal-seam the best explanation is that it got there by flotation, in all probability was dropped from the roots of a tree, in which it had become entangled in some way, floating in water over the site. Thus the inference is that this seam of coal was deposited below water. The pebble, to become such as described, has presumably travelled a considerable distance—has, at all events, been swirled about in water, and by attrition and pressure with rock débris become worn down to its present shape and size. Now, such subjection to rough treatment must of course have taken place before it got into the soil, or, say, *pebbly deposit*, in which the tree-ferns, etc., would seem to have grown. This 'soil', in part at any rate, was formed of Coal-measure débris, so that Coal-measures actually containing perfectly formed coal must have been elevated and undergoing denudation at this very time, i.e. shortly before the forming of the Little Coal seam. Granting this, it is evident that the coal-bed containing the spirey layer of which our pebble is a part was an older seam than the Little Coal. There is no evidence that I know of in the present coalfield that

[1] The pebble takes a high polish similar to spirey coal.

upheaval and denudation of coal-beds were going on *pari passu* with the deposition of the workable coals, a condition of things required, as it seems to me, to account for this coal pebble.

Perhaps the most interesting and instructive point in the story of this coal pebble lies in the fact that whilst the central seams of coal of the Middle Coal-measures were being laid down in a quietly subsiding bay or flat, underlying or older beds of completely formed coal, etc., not so very far away, were, by the waves, being reduced to mud, sand, and gravel, on flats composed of which grew trees, etc., at about sea-level.

Lithology.

Now, this is *not* a water-worn or rounded *piece of wood or fragment of a tree*, but a *bonâ-fide pebble* of that puzzling compound we know as coal *in* coal. It furnishes still another instance of what has always to the author been a conundrum, a seeming paradox in lithology, which is this: How is it that pebbles or fragments of rocks in the shape of inclusions or individual bits composing a conglomeratic or brecciated mass enclosed in a stratum of normal rock, are, to all appearances, not dissimilar from the enclosing bed in its normal or undisturbed condition? e.g., you get pebbles and fragments of Carboniferous Limestone in the shape of a conglomerate in what to all outward appearances seems to be a normal stratum—iron-ore fragments in iron-ore beds; bits of slate in a slaty massif; rounded sandstone in sandstone beds, and so on—in short, rocks calcareous, arenaceous, siliceous, argillaceous, carbonaceous, etc. The question that puzzles me is, *why is not now the coal pebble* of ordinary coal, in a seam of the same, *farther advanced towards a condition of anthracite*, since it must have been exposed for vast ages to *further mineralizing influences* since burial—its *second burial*—in the seam? And it is just as hard to explain why or how the substance of such a pebble had arrived at maturity as to its condition *as coal* during the Middle Coal-measure period, for the very aspect and nature of the pebble speaks for itself; it was just as much coal *then* as it is to-day, apparently neither more nor less so! That is just where the *inexplicable* seems to come in! 'Inclusions' *seem* to have been incapable of receiving further metamorphism on becoming inclusions. The facts seem to point to solidification of sediments, coupled with hardening, shrinkage, jointing, and other rock-forming processes as having operated to the completion of the *normal* stage—the strata as we now have them—*very rapidly indeed* after burial. Is not this a phase of our science not yet much understood, and certainly a difficult but most interesting problem for observers to help solve?

V.—The Probable Source of the Limestone Pebbles in the Bunter Conglomerate of West Somerset.

By Edgar C. Martin, B.Sc., A.I.C.

(WITH A MAP.)

When the Budleigh Salterton Pebble-bed is traced northward into Somerset it loses its unconsolidated character and passes into a calcareous conglomerate. The change takes place north of Burlescombe, and is complete at Thorne St. Margaret; thence to

Combe Florey this division of the New Red Sandstone Series is generally represented by a conglomerate composed of pebbles of limestone, quartz, and grit, more massive in its lower part.[1] For some distance north of Combe Florey the upper beds of the division are faulted out and the lower beds are represented by a loose, rubbly gravel of subangular fragments of Devonian grit in an earthy or sandy matrix. The conglomerate reappears at Yellow, near Stogumber, and is found in several places in the Williton district, whilst in other places it is represented by gravels, sands, and sandstones.

The influx of limestone and grit pebbles which takes place north of Burlescombe has usually been referred to the degradation of the Culm limestones and Devonian rocks.[2] The study of the distribution of the minerals in the matrix of the Pebble-bed and conglomerate between Budleigh Salterton and Milverton lent support to this view, and led Mr. H. H. Thomas to deduce the existence in the Bunter period of a main sediment-bearing current from the south, joined by a minor current from the west in the neighbourhood of Burlescombe.[3] It is difficult to believe, however, that the large quantity of limestone in the conglomerate between Thorne St. Margaret and Combe Florey has all been derived from the comparatively small inliers of Culm limestones near Burlescombe, or from the thin and impersistent limestones occurring to the west of the district, especially in view of the fact that the Culm inliers are surrounded by Lower New Red deposits, and they cannot, therefore, have occupied a larger area in Bunter times than they do now.

In the case of the massive conglomerates of the Williton district the difficulty of referring the limestone pebbles contained in them to the Devonian rocks of the surrounding area seems to have been felt by De la Beche, who suggested that "compact grey limestones probably occur beneath the red sandstone series near Sampford Brett and Stogumber, for red conglomerates there worked for lime abound in rounded stones and pebbles of a grey compact limestone".[4]

The Carboniferous Limestone to the north and north-east appears to be a much more probable source for the limestone pebbles in the conglomerate. Neglecting the Cannington Park inlier, which lies on the east side of the Quantock Hills, the nearest exposure of Carboniferous Limestone is about 15 miles north-east of Williton, or no further than the Culm limestones on the south. In the south of Glamorgan Keuper, Rhætic, and Liassic deposits successively overlap one another and rest directly on the Carboniferous Limestone, each of the newer deposits assuming a peculiar 'littoral' facies in the vicinity of the older rock.[5] During the Bunter period South Glamorgan was evidently a land area formed chiefly of Carboniferous

[1] Memoirs of the Geological Survey: "Geology of the Quantock Hills, etc.," 1908, p. 46.

[2] Ibid.: "Geology of the Country between Wellington and Chard," 1906, p. 14.

[3] H. H. Thomas, B.A., F.G.S., "The Mineralogical Constitution of the Finer Material of the Bunter Pebble-bed in the West of England": Q.J.G.S., 1902, pp. 620–32.

[4] *Report on the Geology of Cornwall, Devon, and West Somerset*, 1839, p. 55.

[5] Memoirs of the Geological Survey: "The Geology of the Country around Bridgend," 1904, ch. v.

Limestone and probably joined to the Mendip Hills by limestone ridges, of which fragments still remain in the islands in the Bristol Channel.

In June, 1907, in a small conglomerate quarry at the south end of Langford Heathfield, I noticed several limestone pebbles with Corals and Brachiopods, which suggested Carboniferous Limestone of Mendip type rather than the Culm limestone. During two recent visits to Wiveliscombe I was able to collect fossiliferous pebbles from several localities between Thorne St. Margaret and Williton. In the following notes I have briefly described the fossils obtained (the localities being taken from south to north) and have then discussed their bearing on the origin of the conglomerate.

Description of the Fossiliferous Pebbles.

Thorne St. Margaret. — Several more or less silicified limestone pebbles with crinoid fragments and badly preserved Brachiopods were found in an old quarry north of the church by the road to Kittisford.

Langford Heathfield.—In the small quarry at the south end of the Heathfield I found a large limestone pebble with *Syringopora* (closely resembling *S. ramulosa*, Goldfuss). Another pebble of very hard limestone showed Spiriferids on the weathered surface.

Cobhay.—Fossiliferous limestone pebbles, with crinoid fragments, Spiriferids, etc., are common in an old quarry south of Cobhay Farm, near Bathealton, but the limestone is so hard that the fossils cannot be extracted, and it is only on the weathered surfaces that the fossiliferous nature of the stone becomes apparent. Amongst the fragments in this quarry I found a beautifully weathered out piece of silicified limestone with small crinoid fragments and Bryozoa (Fenestellids and *Rhabdomeson* or *Rhombopora*); its appearance strongly suggested some of the beds in the Lower Carboniferous Limestone of the Bristol area.

Owing to a fault the Bunter Conglomerate at Cobhay is brought close to the Lower Breccio-Conglomerate subdivision, which can be examined in a small quarry east of the farm. In both divisions the limestone pebbles are fairly well rounded and bear a general resemblance to one another, but are usually much smaller in the lower division.

Milverton.—In the large quarry north of Milverton railway station I found two pebbles of hard, unaltered limestone, showing sections of *Zaphrentis*. About a mile further north, in a quarry east of the road to Halse, a slightly silicified limestone pebble with a portion of a large *Productus* was found.

Wiveliscombe. — In Castle and Tipnoller Quarries, north-east of Wiveliscombe, fossiliferous limestone pebbles, more or less silicified, are common. In some cases the silicification has only extended to the fossils, which can be extracted in a more or less fragmentary condition by dissolving out the matrix with dilute hydrochloric acid. In these pebbles I found circular and pentagonal crinoid sections, Brachiopods (Spiriferids, cf. *Chonetes Hardrensis*, etc.), and a Gasteropod resembling *Capulus*. In other cases the whole pebble is silicified; one of these contained crinoid fragments and Bryozoa (*Fenestella*, *Rhabdomeson* ?).

Williton District.—In massive conglomerate, with large limestone and grit pebbles, exposed in the face of an old quarry at Yellow, near Stogumber, I noticed several unaltered limestone pebbles with *Zaphrentis* and other fossils on the weathered surface. Owing to the

Sketch-map showing the probable directions of the sediment-bearing currents in Bunter times.

hardness of the stone I was unable to extract either the pebbles or the fossils. Further north, in the large quarry on the north side of the railway at Woolston, I found several large pebbles of very hard grey limestone with Brachiopods (*Productus* and Spiriferids) and crinoid fragments.

Source of the Limestone Pebbles.

Although the fossils in the limestone pebbles do not appear to admit of exact determination, the evidence seems quite sufficient to justify the conclusion that they have been derived from Carboniferous Limestone of the Mendip or Avonian type. A few of the normal Carboniferous fossils (including Spirifers and a doubtful *Zaphrentis*) occur in the Culm limestones, but they appear to be rare exceptions,[1] whilst the usual fossils are Posidonomyæ and Goniatites, which, in the neighbourhood of Burlescombe, are much more common in the shales than in the limestone. But, on the whole, fossils, with the exception of crinoid fragments, are very rare in the Culm limestones; on the other hand, there is abundant evidence that some, at least, of the limestone in the conglomerate has been derived from a very fossiliferous rock. The difficulty of getting good specimens of the fossils is due, not to their scarcity, but to the hardness of the stone and the coating of oxide of iron which so often covers the pebbles.

The Carboniferous Limestone of South Wales contains fossils similar to those found in the conglomerate, and often silicified; moreover, a large area of this limestone was exposed to the north and north-east whilst the conglomerate was being formed. It is from this area that some, at least, of the limestone pebbles found in the conglomerate appear to have been derived.

The origin of the Bunter Pebble-beds of Budleigh Salterton and the Midland Counties has been discussed in numerous papers in the Geological Magazine and elsewhere,[2] and the view that these deposits are of fluviatile origin now appears to meet with very general acceptance. In the case of the Budleigh Salterton Bed the 'foreign' quartzite pebbles have been traced to the old Armorican land lying to the south or south-west. To the north of Budleigh Salterton the pebbles decrease in size, and Mr. H. H. Thomas has found that the percentage of heavy minerals in the matrix of the Pebble-bed falls from 75 per cent. at Budleigh Salterton to 71 per cent. at Uffculme. There is thus good evidence for the theory that the Budleigh Salterton Bed was formed by a large river from the south or south-west. In the neighbourhood of Burlescombe this river appears to have received an important tributary from the north, flowing down the valley between the Quantock and the Brendon Hills and bringing with it pebbles of Carboniferous Limestone. The united stream probably found an outlet to the east.

On the accompanying sketch-map are shown the probable directions of the sediment-bearing currents in East Devon and West Somerset during the Bunter period. The river from the north probably received tributaries from the Devonian areas on both sides of its valley; to these streams, which would have had a short but rapid course, are to be attributed the rubbly gravels of little-worn Devonian grit fragments, found between Yellow and Combe Florey, and the

[1] Rev. W. Downes, B.A., F.G.S., Transactions of the Devonshire Association, 1878–9.

[2] A useful summary and discussion of these papers is given by O. A. Shrubsole, F.G.S., in a paper "On the Probable Source of some of the Pebbles in the Triassic Pebble-beds of South Devon and of the Midland Counties": Q.J.G.S., 1903, p. 311.

similar deposits of the Williton district. The southern river was probably joined by tributaries from the west, as suggested by Mr. H. H. Thomas.

Note on the Breccio-Conglomerate.

The lowest division of the New Red Series, when traced from Devon into Somerset, undergoes a change similar to that which takes place in the Bunter division. The gravels of the Tiverton district are represented in West Somerset, partly by similar deposits and partly by a breccio-conglomerate of subangular or rounded fragments of limestone, grit, quartz, and slate. I found limestone pebbles with crinoid fragments near Escott, at Bathealton, and at Cobhay; but, in the absence of other fossils, there is not enough evidence to determine whether these pebbles represent Devonian, Culm, or normal Carboniferous Limestones: they most resemble the latter.

The fossiliferous nature of the limestone pebbles occurring in the Breccio-Conglomerate is mentioned in several places in the recently published Memoirs of the Geological Survey, and corals are stated to occur in the limestone pebbles near Escott,[1] but no species are mentioned. At Langley, near Wiveliscombe, "the limestone fragments are numerous, and mostly grey or pale grey, and sometimes oolitic; the majority resemble Carboniferous Limestone (Mendip type) rather than Devonian."[2]

In a recent paper[3] I pointed out that fragments of grit with Upper Devonian fossils can be traced in the Lower New Red gravels for a distance of 15 miles southward from the outcrop of the Upper Devonian rocks. Although it is possible that some of these fossiliferous fragments may have been derived from Upper Devonian rocks concealed beneath the New Red deposits in the Tiverton and Crediton Valleys, as suggested by Etheridge,[4] it is more probable that they have been derived from the north-east. I have not been able to detect similar fragments in the Lower New Red deposits of West Somerset, and this fact is suggestive of drifts from the north or north-east in the case of these deposits as well as in the case of the Tiverton gravels.

If this view is correct, we should expect to find the Culm limestones largely represented in the Breccio-Conglomerate of Sampford Peverell (which lies south-west of the Culm inliers near Burlescombe) and Carboniferous Limestone of the normal or Mendip type in the Breccio-Conglomerate further north. The limestone fragments in the Sampford Peverell Quarries have been referred to the Culm limestones by geologists from De la Beche onwards, and although in a short visit to these quarries I was unable to find any fossiliferous fragments which would have afforded definite evidence of their origin, there seems no reason to doubt that the limestone pebbles have been derived from the Culm limestones, which they closely resemble. Close search in the Sampford Peverell Quarries would probably reveal fragments of shale with *Posidonomya* or Goniatites.

[1] "Geology of the Quantock Hills, etc.," p. 42.

[2] Ibid., p. 43.

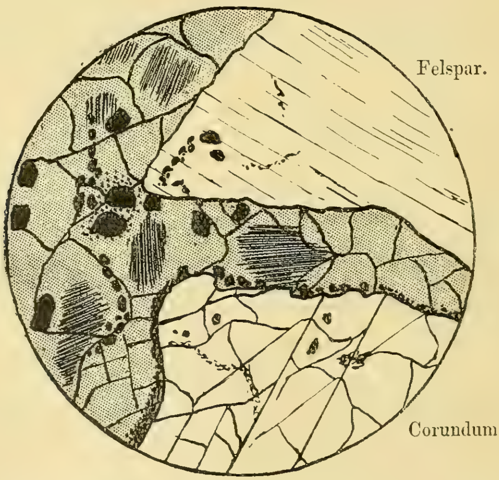
[3] Geol. Mag., 1908, pp. 150–7.

[4] See Mr. W. A. E. Ussher's paper on "The British Culm Measures": Proc. Somersetshire Arch. and Nat. Hist. Soc., 1892.

VI.—Note on an Occurrence of Corundum in Rhodesia.

By F. P. Mennell, F.G.S.

Corundum is one of those rather exceptional rock-formers whose mode of origin is not fully explained, and it is, accordingly, of interest to put on record any new localities for the mineral, together with the features they present. Fragments of it have frequently been found among the old gravels of the Limpopo River, along the Transvaal-Rhodesian and Transvaal-Bechuanaland border, but although the Transvaal Geological Survey has described an occurrence in the Pietersburg district, the source of these fragments for some time remained unknown. However, last year I received from the Rhodesian side of the border, close to Rhodes' Drift on the Limpopo, and northward from the well-known Messina copper-mine, some rocks which included large pieces of a type rich in corundum. The area is known to comprise gneissose granulites, consisting of the contact zone and marginal modifications of a granite mass, and the specimens received included large cleavage fragments of felspar and pieces of coarse granite.



Microscopic section of corundum-bearing rock. × 25 diam.

The corundum occurs in the form of irregular masses of a dull pinkish or greyish colour, up to several inches across. These show the usual well-marked rhombohedral parting, and are sometimes single crystals and sometimes aggregates. The rock in which they are embedded is a felspathic one, to which sparsely distributed hornblende crystals give a somewhat gneissic aspect. Completely encircling each mass of corundum, as if protecting it from the invasion of the felspathic matrix, is a coating of what to the unaided eye looks like magnetite. This sends out straggly offshoots among the surrounding felspar grains, but is only seen near the corundum. The general aspect of the rock is very much that of an augen-gneiss, with the corundum forming the 'eyes'.

Under the microscope the matrix is seen to consist of a coarse-grained aggregate of a much twinned felspar, at least as basic as labradorite. There is a little pale-green hornblende scattered through it irregularly. The corundum is quite colourless, shows a very rough surface, and has many irregular cracks besides the well-defined parallel partings. It is traversed by occasional veins of a brightly polarizing alteration product (? diaspore). Round the corundum is the dark substance noticed in the hand-specimen. This proves to be principally a deep-green spinel, no doubt *pleonaste*, in granular aggregates, associated with a good deal of magnetite. The grains are perfectly isotropic, and have no definite shape even where in contact with the felspar, but there are indications of rectangular cleavage traces, and in some cases the granules are darkened by close-set parallel striations like those sometimes observed in augite.

It is difficult, without having made an examination of the locality, to offer any useful suggestions regarding the origin of this interesting association of minerals.

VII.—A Note on *Phacops* (*Trimerocephalus*) *lævis* (Münst.).

By Ivor Thomas, Ph.D., B.Sc., F.G.S.[1]

THE British form recognized under this designation appears to have been first recorded and figured from this country by J. de C. Sowerby (16, pl. lvii, fig. 30), who named it *Asaphus* or *Trinucleus* (?). He remarks "that no trace of the position of the eyes remains on the cast, which is also the case with the genus *Trinucleus*, Murchison". This form was afterwards allocated by Salter to *Phacops* (*Trimerocephalus*) *lævis* (Münst.) (13, p. 16, pl. i, figs. 5–7; 14, p. 1, pl. ix, figs. 1–5). Phillips had previously named the same species *Calymene lævis*, Münst. (8, p. 129, pl. lv, fig. 250), a determination which both Salter (13, p. 16) and M'Coy (6, p. 404) showed to be at fault. This was complicated by the fact that Münster (7, pl. x, fig. 6; 7*a*, pl. v, fig. 4) had described two different forms under the same specific name, *Trinucleus* ? *lævis*] and *Calymene lævis*, the latter of which Salter (13, p. 18) correctly adjudged to be a synonym of *Phacops granulatus* (Münst.) (*Calymene* auct.) (7*a*, pl. v, fig. 3). M'Coy had previously noted the identity of *C. lævis*, Münst., with *Calymene granulata* of the same author, but assigned it to his genus *Portlockia* (6, p. 404).

Münster's figure of *T.* ? *lævis*, which gave the specific name to *Ph.* (*Trimerocephalus*) *lævis* of Salter, is very poor, and a determination by comparison with it would appear at present to be quite unsafe. A similarity certainly exists between the two forms in the absence of eyes and in the smooth character of the surface. But distinctions exist; for instance, among other details, the ratio of the length of the head-shield to its width is considerably less in Münster's figure than in the British form, while the broad marginal border seems

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

much more accentuated in the former than in the latter. The question is still further complicated by the fact that Gümbel (4, p. 495, pl. A, figs. 7–9) refigures what he expressly states is the original of *T.*? *lævis*, Münst. His figure shows the presence of well-marked eyes, together with granules over the surface of the head-shield. Other differences are easily recognizable on comparison of the two figures. Gümbel identifies the form with *Ph. cryptophthalmus*, Emmr. (2, pp. 27, 40, 61), which name he retains in preference to *lævis*, at the same time deprecating Salter's retention of the latter name. Salter, however, had expressed an opinion in two of his works (13, p. 16; 14, p. 1) that it might be found necessary to give the British form another specific name. In the later work (14, p. 1) he even suggests the use, should occasion arise, of *trinucleus* as a substitute for *lævis*.

As no traces of eyes have been noticed on any of the numerous specimens of the so-called *Ph.* (*Trimerocephalus*) *lævis* found in this country, there is strong reason to believe that eyes were never present. In this character the species would be more allied to *Ph.* (*Trim.*) *anophthalmus*, Frech (3, p. 270), and *Phacops cæcus*, Gürich (5, p. 362, pl. xv, fig. 4), in which eyes are likewise absent, than to *Ph. cryptophthalmus*, Emmr. Compared with *Ph.* (*Trim.*) *anophthalmus*, Frech, the angle made by the dorsal furrows bounding the glabella of the British form is considerably larger, the marginal border is narrower, the ratio of the length of the glabella to its width is much less, while the frontal margin of the glabella is more curved.

Compared with *Ph. cæcus*, Gürich, the head region of the British form is considerably wider in proportion to the length, and the frontal margin of the glabella is less acute. The glabella and cheeks of the Polish specimens are covered with granules, while various other differences of detail also help to distinguish the two forms. Other examples of *Trimerocephalus* without eyes have been described by various authors, but none appears to agree with the British species.

If satisfactory traces of eyes could be found in the numerous specimens from Cornwall and Devon, the form might probably be allocated near to *Ph.* (*Trim.*) *cryptophthalmus*, Emmr., as interpreted by Gümbel's figure, which is unfortunately unaccompanied by a description. *Ph.* (*Trim.*) *cryptophthalmus*, however, furnishes another instance of a confusion arising through different interpretations by different authors. Thus *Ph. cryptophthalmus*, Richter (9, p. 20, figs. 23–31), belongs, according to a later work of the same author (10, p. 116), to *Ph. granulatus* (Münst.), while a new *Ph. cryptophthalmus* of the same work (10, pl. ii, figs. 1–5) probably belongs to *Ph. brevissimus*, Drevermann (1, p. 115, pl. xiii, fig. 3). *Ph. cryptophthalmus*, F. Roemer (12, pl. xiii, figs. 6, 7), and *Ph. cryptophthalmus*, Tietze (17, pl. xxi, fig. 1), have been described by Professor Frech as *Ph.* (*Trim.*) *anophthalmus*. *Ph. cryptophthalmus*, F. Roemer (11, pl. xxxv, fig. 18), and possibly that of Sandberger (15, pl. i, fig. 6*a*), appear to belong to Frech's species. The remaining figures of Sandberger's *cryptophthalmus* represent different species. Salter's *Ph. cryptophthalmus* (13, p. 17, pl. i, fig. 8; 14, pl. ix, fig. 6), which is in the Museum of Practical Geology [6986], has since been shown by Mr. Whidborne to be *Ph. latifrons* (Bronn) (18, p. 6, pl. i, fig. 8).

Finally, in view of all the foregoing facts, it seems undoubtedly justifiable to apply a new name to the form known up to the present in this country as *Ph.* (*Trim.*) *lævis*. In accordance with Salter's suggestion I propose it be called *Phacops* (*Trimerocephalus*) *trinucleus*, nom. nov. The description and figures given by Salter, together with the above comparative remarks, make it unnecessary to add any further comments.

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VIII.—On a Well-section at Ware House, near Lyme Regis, and the Fossils obtained therefrom.

By A. C. G. Cameron.

WARE, about a mile west of Lyme Regis, is situated on the lower part of the Foxmould Sands of the Upper Greensand, and some distance above the 'West Cliffs', which are formed of Lower Lias clay and limestone.

The site of the well is 395 feet above o.d. It is 117 feet deep, and consists of a shaft sunk to a depth of 48 feet, with a borehole in the bottom 69 feet in depth. The following are particulars of the strata passed through :—

			THICKNESS. ft.	in.	DEPTH. ft.	in.
UPPER GREENSAND.	Zone of *Amm.* [*Schloenbachia*] *rostratus.*	Foxmould sand	21	0	21	0
		Cowstone	2	0	23	0
		Grey sand with small concretionary stones	5	0	28	0
		Light-green sand, with hard stone 2 ft. 5 in.: *Ammonites rostratus*	20	0	48	0
		Light-green, sticky sand	10	0	58	0
		Hard, coarse sand	3	0	61	0
		Grey sandstone concretion	0	9	61	9
		Sand	1	3	63	0
		Grey sandstone concretion	0	4	63	4
		Sand	0	8	64	0
		Sand	7	0	71	0
		Dark sandstone	1	6	72	6
GAULT.	Zone of *Amm.* [*Hoplites*] *interruptus.*	Sandy, micaceous clay	6	10	79	4
		Dark, loamy clay	9	0	88	0
		Greenish, loamy clay	10	0	98	0
		Lighter-coloured, sandy clay	15	0	113	0
		Dark, loamy clay	2	0	115	0
		Brownish, sandy clay	2	0	117	0

Water to the extent of about 2,000 gallons a day was obtained from the shaft, and no further supply was yielded by the boring. Along this range of cliffs, which extends to Whitlands and Bindon, the water is naturally drained away, and wells are not always successful.[1]

In the present record of strata all the beds classed as Upper Greensand may be referred to the zone of *Amm. rostratus*, the remaining 45½ feet to the Gault. The borers were told to look out for the pebbly basement-bed of that formation, but its presence was not detected, neither was there any evidence to indicate that Lias was reached. It is probable, therefore, that as the lowest clay was sandy, the boring did not extend to the base of the Gault, although the observations of Mr. W. D. Lang at Black Ven show that the pebbly basement-bed is there impersistent. On the face of Black Ven the actual junction of the Gault with the Lower Lias lies at a height of 315 feet above O.D., a height nearly 40 feet above that at Ware. The latest measurements taken by Mr. Lang[2] at Black Ven show that below the lowest bed of Cowstones there is about 39 feet of argillaceous strata which may be classed as Gault, while at least 46 feet seems to be the thickness at Ware.

The following Upper Greensand fossils were collected entirely from the sandstone concretions or 'doggers' which were brought up from the well during the progress of sinking. None were obtained from the boring.

Exogyra conica, Sow.
Gryphæa vesiculosa, Sow.
Inoceramus concentricus, Park.
Ostrea sp.
Avicula pectinata, Sow.
Aucellina gryphæoides, Sow.
Pecten quinquecostatus, Sow.
Pecten sp.
Lima tombeckiana, d'Orb.
Arca.
Cucullæa.
Thetis.
Trigonia vicaryana, Lyc.
Turritella.
Crioceras.
Ammonites rostratus, Sow. [*Schloenbachia*].
Serpula.
Vermicularia concava, Sow.
Necrocarcinus tricarinatus, Bell.
Hoploparia.
Plant-remains.

[1] See G. Roberts, *An Account of and Guide to the mighty Land-Slip of Dowlands and Bindon*, 1840, 5th ed., p. 13.

[2] GEOL. MAG., 1904, p. 131; 1907, p. 153.

I am indebted to Mr. H. A. Allen for naming the specimens. The list is of interest as containing several species not previously recorded from the Cowstone beds.[1] In this district Selbornian ammonites are rare, consequently the occurrence of *Amm. rostratus*, the zonal fossil, is interesting. The same can be said of *Necrocarcinus tricarinatus*, the crab, whose horizon is now fixed. *Hoploparia longimana*, Sow., had previously been found by De Rance in the Cowstone beds below the roadway between Charmouth and Lyme.[2] *Crioceras* has not hitherto been recorded amongst the local fossils.

NOTICES OF MEMOIRS.

I.—The Discovery of Trias in the Caucasus.

Translated from the Russian by Felix Oswald, D.Sc., F.G.S.

IN a preliminary communication by Dr. Th. Černyšev, Director of the Geological Committee of Russia and Foreign Correspondent of the Geological Society, in April, 1907, to the Imperial Academy of Sciences of St. Petersburg,[3] an important addition has been made to the geology of the Caucasus by the announcement of the discovery of beds of Upper Triassic age. Pending the publication of fuller details, which will be published in the Memoirs of the Geological Museum of the Imperial Academy of Sciences, the following abridged translation, which I have made from the Russian of the original article, may help to render this discovery more widely known. It is of special interest to find that on the one hand the fossils are in many cases identical with those of the Upper Trias of Balia Maden in Western Asia Minor, and that on the other hand in the nearest occurrence of Trias to that of the Caucasus, viz. that of Julfa on the Araxes in Armenia, the Upper Trias is altogether wanting, and only the lower division of the Trias is present, overlying Permian.

Dr. Černyšev stated that in 1903 W. I. Worobiev conducted an expedition into the Kuban territory of the Caucasus for the purpose of geological and mineralogical research, especially in the district between the Rivers Laba and Bielaya. Since W. I. Worobiev unfortunately lost his life on the Dzitak glacier the results of his journey have not been published. His collections, journals, and maps were, however, fortunately recovered by N. I. Worobiev in an unharmed condition, and are now in the possession of the Geological Museum of the Academy. Even a cursory examination of Worobiev's collection showed that it would cause a fundamental and essential alteration in the geological map of the Caucasus, and that in particular it would affect the composition, as hitherto known, of part of the Central Caucasus range. The most remarkable discovery, however, made by Worobiev was his finding beds of undoubted Triassic age, which are

[1] See Jukes-Browne, *Cretaceous Rocks of Britain*, 1900, vol. i, p. 187; and H. B. Woodward & W. A. E. Ussher, *Geology of the Country near Sidmouth and Lyme Regis*, 1906, p. 43.

[2] Geol. Mag., 1874, pp. 247, 253.

[3] Bull. Acad. Imp. St. Petersb., ser., vi pp. 277–80.

characteristically represented in his collection; and an entirely new contribution to the geology of the Caucasus results from that part of Worobiev's materials, which has been worked out by Dr. Černyšev, who described the Brachiopods, and by A. A. Borisiak, his colleague on the Geological Committee of Russia, who identified the Pelecypods.

The starting-point of Worobiev's expedition was from Psebai, on the Little Laba River, whence he proceeded to the source of the Khods River (a left tributary of the Little Laba), where he pitched his first camp. From this place he made a series of excursions in different directions, resulting in an interesting collection of Triassic material.

On the very first excursion, which was undertaken along the Khods River, 3 versts from the camp, in the Mietok Ravine, Worobiev found a small exposure of limestone crowded with valves of *Pseudomonotis ochotica*, Keyserling; and again lower down the gorge, in the same limestone, he observed great quantities of *Terebratula pyriformis*, Suess, *Waldheimia cubanica*, n.sp. (somewhat recalling *W. norica*, Suess), *W.* (*Cruratula*) *labensis*, n.sp. (near to but undoubtedly distinct from *W.* (*C.*) *Beyrichi*, Bittn.), and *Amphiclinodonta Katzeri*, Bittn.

The third excursion was in a southerly direction towards Mt. Tkhach; 2 versts beyond the ford across the Khods River Worobiev investigated limestones extremely rich in Brachiopods; still further on these limestones continued, but without clear exposures. In these Brachiopod limestones he found the following forms:—*Terebratula turcica*, Bittn., *T. pyriformis*, Suess (abundant), *Spiriferina* aff. *kössenensis*, Zugm., *S. Suessi*, Winkler, *Spirigera cubanica*, n.sp., *S. oxycolpos*, Emmr., *Retzia superbescens*, Bittn., *Rhynchonella fissicostata*, Suess, *R.* aff. *fissicostata*, Suess, *R.* aff. *anatolica*, Bittn., *R. labensis*, n.sp., *R. Worobieffi*, n.sp., *Amphiclinodonta Suessi*, Hofm., and other less well-preserved forms.

Subsequently his journey was directed towards the upper Sokhra River, belonging to the system of the Bielaya River. At 5 versts from Mt. Tkhach, towards the left feeder of the Sokhra, he met with a complete section of the Triassic limestone, dipping 15°–25° N.E., showing the following downward succession:—

1. Red and grey limestone, with *Pseudomonotis ochotica*, Keyserling.
2. Red, more compact limestone, with *P. ochotica*, Keyserling, and the following Brachiopods:—*T. pyriformis*, Suess, *W.* aff. *norica*, Suess, *W.* (*Aulacothyris*) aff. *frontalis*, Bittn., *W.* (*A.*) *reflexa*, Bittn., *Spiriferina Suessi*, Winkler, *Spirigera Worobieffi*, n.sp. (undoubtedly belonging to the same group as *S. oxycolpos* and *S. Manzavinii*), *S. oxycolpos*, Emmr., var. *caucasica*, n.var., *Retzia superbescens*, Bittn., *Rhynchonella levantina*, Bittn., *R. Fuggeri*, Bittn.
3. Grey limestone with Crinoid fragments,[1] and the Brachiopods *W.* (*A.*) *reflexa*, Bittn., *R. superbescens*, Bittn.

[1] With regard to this Crinoidal limestone it may be of interest to draw attention to the fact that Dr. Radde in one of his journeys in this region of the Caucasus very nearly anticipated by about thirty years Worobiev's discovery of these Triassic strata, for in the Tiflis Museum (*Die Sammlungen des kaukasischen Museums*, iii, Geologie, p. 171) there is a specimen collected by Dr. Radde from this very district, viz., from the "river-bed of the Matchubusta, a tributary of the Khod river, near Mt. Tkhach".—F. O.

4. Grey, extremely hard limestone, enclosing a bed of greenish-grey, argillaceous limestone, with well-preserved specimens of *Spirigera Manzavinii*, Bittn., and *S. oxycolpos*, Emmr., var. *caucasica*, n.sp.

In the bed of this rivulet, which flows into the Sokhra, there also occurs a dark-grey, nearly black, arenaceous slate, very micaceous, crowded with valves of *Koninckina Telleri*, Bittn., and also containing well-preserved shells of Pelecypods (*Phænodesmia* sp. and *Nucula* cf. *strigilata*, Goldf.).

Even a cursory examination of the above fauna shows that this formation must belong to the Upper Trias, for some of the forms in the foregoing list have been described by Suess and Zugmayer as typical of the Kössen and Starhemberg Beds, e.g., *T. pyriformis*, Suess, *W. norica*, Suess, *Spiriferina Suessi*, Winkler, *S. kössenensis*, Zug., *Spirigera oxycolpos*, Emmr., *R. fissicostata*, Suess, whilst others are representative of the Dachsteinkalk, e.g., *W.* (*A.*) *frontalis*, Bittn., *W.* (*A.*) *reflexa*, Bittn., *R. Fuggeri*, Bittn., thus indicating an equivalence with the Rhætic stage of the Alpine Trias. The fauna, which contains new forms peculiar to the Caucasus, also comprises some characteristic Anatolian forms, described by Bittner in Mysia, e.g., *T. turcica*, *Spirigera Manzavinii*, *R. anatolica*, *R. levantina*, corresponding to the Rhætic stage of the Alps or only slightly older. In addition to the Brachiopods particular attention may be drawn to the numerous well-preserved bivalves (occurring in the same beds), which A. A. Borisiak, after careful comparison with the original fossils in the Geological Museum of the Academy, referred to *P. ochotica*, var. *densistriata*, Teller.

A few words still remain to be said concerning the dark-grey, arenaceous slates, in which there were found abundant valves of *K. Telleri*, Bittn. Since the slates underlie the limestones, and this fossil, which occurs so abundantly, is typical of the Alpine Upper Trias, we may reasonably conclude that the Northern Caucasus possesses a nearly complete series of Upper Alpine Trias.

To judge from some indications given by W. I. Worobiev, the Upper Trias has probably a wide extension on the northern slope of the Caucasus; and a considerable area, which in the absence of palæontological evidence has hitherto been attributed to other formations, may eventually be found to belong to the Upper Trias.

II. Bibliography of Mexican Geology.

In 1898 the Instituto Geológico de México published as Bulletin No. 10, under the title "Bibliographia Geologica y Minera de la República Mexicana", a list of books and papers on Mexican geology and mining consisting of xii + 160 pages, each 13 × 9 inches and containing 1,953 items, arranged alphabetically under authors' names, with an index of localities and a subject-index, the references extending to papers published from 1556 to the end of 1896. This most useful work has now been continued in Bulletin No. 17 (dated 1908) under the same title with the addition "completada hasta el año de 1904". Bulletin No. 17 consists of xiv + 332 pages, 13 × 9 inches, and contains 4,252 items, arranged, as before, alphabetically under authors' names, with an index of localities and a subject-index, the references including such as were omitted from Bulletin No. 10, and, as far as possible, all papers and books since published up to the end of 1904. Both bulletins have been compiled by Señor Rafael Aguilar y Santillán. As showing how complete the bibliography is, it may be mentioned that the references to Popocatepetl in Bulletin No. 10 are 28 and in Bulletin No. 17 as many as 72 in number; to Meteorites 55 and 208 respectively.

B. Hobson.

REVIEWS.

I.—The Geology of the Goldfields of British Guiana. By J. B. Harrison, M.A., C.M.G. Published by the direction of the Governor of British Guiana. London: Dulau & Co., 1908.

It is nearly five and thirty years since the last Government Report on the Geology of British Guiana, that of Brown and Sawkins, saw the light. Comparing that report with Mr. Harrison's work one cannot fail to be struck with the great progress which gold-mining has made in the colony, and the still greater advance in the methods of geological science as applied to the problems of metamorphic rocks and the genesis of ore deposits. We miss, perhaps, that spice of adventure and exploration which makes the older book so readable, but in return we gain much solid knowledge of the complex geological structure presented by this vast extent of little explored country. The book, it may at once be said, is meant for the geologist and the mining engineer rather than for the prospector, though the route details and mining regulations which it includes will be of use even for the latter class of readers.

The colony is divided naturally into three regions. There is a narrow coastal belt of alluvium, much of which is below high-water mark, and was reclaimed partly by the efforts of the early Dutch settlers by means of an elaborate system of dykes. Practically all the rice, cotton, sugar, and rum, which are the staple products of the country, are raised on these flat lands. Behind them are forest-clad plains and grassy downs, where here and there the live rock peeps out from beneath a dense covering (sometimes 200 feet thick) of rotted rock and lateritic surface deposits. The great hinterland, which makes up eleven-twelfths of the area of the colony, consists of forest-covered ranges of elevated hills and flat-topped, terraced, sandstone mountains.

During the eighteenth century the Dutch were aware of the occurrence of gold in a few spots, and Sir R. Schomburg was able to confirm this by his explorations, but Brown and Sawkins saw little of it, and it was only about the year 1886 that the discovery of some rich placers on the Cuyuni and Essequibo Rivers started a temporary boom. Since then the industry has gone ahead, over seven millions of pounds worth of gold having been extracted within the last twenty years, and it is to be expected that when the latest methods of hydraulicking and dredging are brought to bear on the goldfields of the Colony there will be a long future of prosperity before them.

The gold occurs in two ways—in placers or alluvial deposits and in reefs or mineralized masses of igneous rock. The placers are not true gravels of alluvial origin, but merely the rotted surface accumulations covering the gneisses and other igneous rocks which make up the greater part of the country. This material is very thick, and often a considerable overburden covers a foot or two of pay dirt on the bed-rock. It is purely of local derivation, except that the rain-soaked clays creep slowly down slopes after the wet season. The gold is got by sluicing, so that it is a poor man's field, and is mostly very fine, though some large nuggets have been found. The river alluvia also are auriferous, but they have a much more limited distribution. Clearly, if much of the sedentary surface deposits of British Guiana contains gold in payable quantities, this will be an important goldfield, but the dense forests render exploration very difficult. The gold in these alluvia comes from the country rock, and Mr. Harrison is of opinion that it is principally derived from the greenstone or diabase. He has made a very large number of assays of the different types of rock that occur in the goldfields, and has found gold in many of them, but principally in the basic rocks. He holds that by concentration through weathering and solution the gold content of the alluvia has been increased, a proposition certainly very reasonable in itself but excessively difficult to prove in the circumstances under which the gold occurs.

The gold-reefs of the Omai, Barima, and other mines are of a different category. They are associated with pegmatites, alaskites, and albite aplites which recall many well-known auriferous deposits like those of the Alaska Treadwell. Many of them show evidence of pneumatolytic origin. But in the quartz reefs there is a tendency for the gold to occur in quantity only at the junction of diabase with gneiss or granite or other country rock, a fact which, seeing that the basic rock is the latest intruder, suggests again that it is the real ore-bringer. Mr. Harrison states all the available evidence very clearly. He admits the importance of the granites and aplites as fully proved in certain cases; but he is strongly of opinion that much of the gold came in with the basic rocks. The impartial caution with which he handles the problems of ore-genesis deserves great praise, and his wide knowledge of the country gives his opinions much weight.

Since 1890 small diamonds have been found in considerable numbers in various parts of British Guiana. They occur in gravels which may lie 70 or 80 feet above the rivers, but they have never yet been traced to their parent rock. From their distribution it seems probable that most of them have been derived from the sandstone and conglomerate which overlie the gneisses, but this can only be a mediate source. At Omai they were obtained in "a blue clay, a product of the decomposition of gabbro or diabase in situ". Mr. Harrison made experiments on some of the mica-gabbro of Mazaruni and obtained a residue of minute grains, insoluble in acids, which from their optical and other characters he believes may have been diamonds. Unfortunately they were too small and too few to yield conclusive evidence. The results are interesting, and the experiment is well worth repeating; it suggests a resemblance to the occurrence of diamonds in epidiorite in Australia.

The groundwork of the geology of the country is a complex of gneisses, amphibolites, and schists of many different kinds, but apparently all igneous. This has been reduced by erosion to a peneplain and covered by extensive deposits of sandstone, relics of which now form flat-topped mountains. Some of these, like Mount Roraima, have a considerable elevation. The sandstones are probably Cretaceous, though in British Guiana they have not yielded any fossils. The various Palæozoic rocks which are known in the Amazon Valley apparently do not occur in British Guiana. At the base of the sandstones there are dykes and sills of diabase which Mr. Harrison suggests may belong to the Tertiary Cordilleran or Pacific magmas, but opinions differ as to the relations of these rocks, and there may be two diabases, one older and one newer than the sandstones. The petrographical characters of the fundamental complex are very fully described. They have many affinities to the Lewisian rocks of North-West Scotland. The quartz diabases are excellent representatives of a type which has been repeated with identical characters at many different epochs over the whole world. Many analyses of the metamorphic and igneous rocks are given, and the excellence of Mr. Harrison's analyses is known to all petrologists. Some photomicrographs appear, unfortunately not accompanied by any descriptions. The volume also would be improved by the insertion of a map, if only as a guide to the topographical details. In spite of minor defects the work deserves high praise; it shows how much can be done, even in a country where the physical difficulties are extremely great, by the continued researches of a resident geologist. Even the most accomplished visitor can do little in such a region. No part of the British West Indies is so well described as British Guiana, and in the whole of South America there are only a few small portions so well known in a geological sense. We have reason to be thankful for the intelligent policy of the colonial administration which has made it possible for scientific work of this character to be carried to completion.

J. S. F.

II.—Text-Book of Petrology. By F. H. Hatch, Ph.D. Fifth Edition. pp. xvi + 404, with 130 figures. London: Swan, Sonnenschein, & Co., Ltd. New York: The Macmillan Co. 1909. Price 7*s*. 6*d*. net.

It is eighteen years since Dr. Hatch issued a slim volume entitled *Introduction to the Study of Petrology*. So immediate was its success, and so great the demand for it, that only two years later a second edition appeared under the more extensive title which has been retained in the subsequent editions. Although two editions have been issued during the intervening years, they are merely reprints of the second, and there has, therefore, been really no fresh edition since the second. These years have marked a period of great activity in petrological science. Important improvements have been introduced into the petrological microscope, and more subtle methods have been devised for the discrimination of the mineral species constituting a rock-section, and the resulting discoveries have led to not insignificant changes in the classification of rock species and to greater refinement in subdivision. As the years passed it became increasingly evident that a complete revision was necessary if the work was to retain its former position among petrological textbooks. This has now been done, and the present edition may confidently be recommended to the student who requires a sound, yet not too abstruse, grounding in the characteristics of the several species of igneous rocks, and in some of the simpler methods for their discrimination. Examples have been freely drawn from recent research, such as, for instance, Harker's admirable memoir upon the Tertiary igneous rocks of Skye.

While the general framework of the book remains much the same, there is scarcely a paragraph that has not undergone alteration. In the opening pages the student who is desirous of wider reading will find a list of the principal works on the subject. In Part I the author discusses the physical characters of rocks, such as their mode of occurrence, their macro- and micro-structure, and their composition. In Part II he deals with the rock-forming minerals and their characters. Some space is devoted to the phenomenon of double refraction, upon which depends the usual method of distinguishing the minerals seen in a thin section, and a list is given of the principal rock-forming minerals, arranged according to their maximum birefringence. Since petrological students generally acquire some knowledge of mineralogy and crystallography, it would have been advantageous if the refractive properties had received somewhat fuller treatment. In the description of the minerals the mean refractivity is given, and the double refraction is characterized as 'strong', 'moderate', or 'weak': it would have taken no more space to have stated the greatest and least of the refractive indices, and the information would have been fuller and more complete. In the description of the mineral species attention is, of course, chiefly paid to their appearance as seen in rock-sections. In Part III we find a clear and lucid discussion of the igneous rocks, arranged according to the plutonic, hypabyssal, and volcanic groups. The characters and distinguishing features of each family are pointed out, typical analyses are quoted, and happy use is made of Iddings' elegant diagrammatic method for representing the composition of the rocks constituting a family. The reproductions of micro-photographs, prepared by Mr. R. H. Rastall from sections in the Students' Series in the Sedgwick Museum at Cambridge, facilitate the understanding of the text. The account of the distribution of igneous rocks in the British Isles, which was previously included in this part, has now been expanded and forms Part IV. This feature of the book renders it peculiarly valuable to students in this country. A useful table, prepared by Mr. R. H. Rastall and Mr. J. Romanes, for the determination of the minerals in a thin section by means of their optical properties is appended, and a full index brings the work to a close.

Dr. Hatch has endeavoured to make the subject intelligible to any reader, even if approaching it for the first time; the language employed is as simple as possible, and the meaning and derivation of all technical terms are stated. The publishers have likewise done their part well; the printing and general appearance of the book are all that could be desired.

III.—The Geology of the Country near Oban and Dalmally (Explanation of Sheet 45, Scotland). By H. Kynaston, B.A., and J. B. Hill, R.N.; with contributions by B. N. Peach, LL.D., F.R.S., J. S. Grant Wilson, H. B. Muff, B.A., and E. B. Bailey, B.A., with Petrological Notes by J. J. H. Teall, D.Sc., F.R.S., and J. S. Flett, M.A., D.Sc. pp. vi, 184, with 2 text-illustrations and 7 plates. Ordnance Survey Office, Southampton, 1908. Price 2*s.* 6*d.*

THIS memoir deals with a very interesting and picturesque Highland district, one which (to quote Mr. Kynaston) "shows a diversity of rock type and structure, combined with a variety of scenic feature, which is seldom seen in any other area of equal extent". Visitors to Dalmally, Loch Awe, and the Pass of Brander, to Taynuilt, Connel Ferry, and Oban, who are interested in the physical features and wish to know something of the story of the rocks, will, however, find very stiff reading in this memoir. The fundamental rocks, the Highland metamorphic schists, limestones, and quartzites, with intruded epidiorites, occupy the eastern and north-western portions of the area; rugged mountain masses of granite rise in Ben Cruachan to 3,689 feet, and dominate the central and northern parts of the area; while the great series of volcanic rocks associated with the Old Red Sandstone and conglomerate of Oban and Dunstaffnage, a series consisting of andesites, rhyolitic felsites, agglomerates, and tuffs, extend over most of the western part of the area. Glacial deposits, raised beaches, and a tiny tract of Carboniferous rocks complete the list of main formations. Again quoting from Mr. Kynaston, "So varied an area can hardly fail to constitute a wide field of geological interest and inquiry, and to afford the materials of problems, metamorphic and igneous, structural and physical, of which we will now proceed to give some account in the following chapters." As a matter of fact, eight of the fourteen chapters are almost wholly petrological, and they make up about three-fourths of the volume. They contain matter of more than local interest with regard to the subjects of folding and progressive regional metamorphism, and of contact metamorphism; and in the accounts of the Kentallenite of Glen Orchy, and of the Tertiary Camptonites and Monchiquites; but they appeal essentially to the specialist.

An excellent view of the Pass of Brander with its screes is given in the frontispiece, and it is interesting to learn that the gorge corresponds with a line of fault, and that it is owing to the gradual excavation of the pass that the waters of Loch Awe are now drained through it instead of finding their way out, as they formerly did, at the south-western end of the loch.

We are told that the great granite masses of Ben Cruachan and Blackmount "have been intruded into the metamorphic series at a later date than the movements which caused their foliation"; and a fine view is given of "Coire Creachainn" (elsewhere apparently spelt Cruachan).

It is difficult, however, to find in any one place a good description of the rocks and features depicted in the above-mentioned plates, nor have we come across any discussion of the probable ages of the granites.

Around Oban, as pointed out, the Lower Old Red Sandstone rests on black schists of the Highland Series, and the basal portion consists of coarse conglomerates which pass upwards into sandstones and shales. The conglomerates are remarkable for the immense pebbles and boulders of andesite which they contain, some of the blocks weighing nearly half a ton. Hence the volcanic phenomena of Lorne did not commence with the lowest lavas of the plateau, which overlie the conglomerates and some of the sandstones, but "lava-flows must evidently have been erupted before any of the visible conglomerates began to be formed". In the sandstones immediately above the conglomerates remains of *Cephalaspis*, *Pterygotus*, and *Kampecaris* have been found.

The evidence of the presence of Carboniferous rocks at the Bridge of Awe, at the north-west end of the Pass of Brander, was established during the course of the Geological Survey. The strata, previously regarded as Old Red Sandstone, consist of conglomerates overlain by variegated marls, purple shales, and sandstones. Some fossils have been found in the shales, and they include *Asterocalamites scrobiculatus*, Schl., identified by Dr. Kidston, and a mollusc almost identical with *Modiola Macadami*, Portl., determined by Dr. Peach. The fossils favour the view that the beds are Lower Carboniferous. The superficial deposits are not extensive. Mr. Kynaston remarks that "the glens, as a rule, are narrow and the hills bold and steep, so that surface accumulations would be apt to be rapidly carried away in a climate characterised by a high rainfall".

Abundant evidence of glaciation is met with in the polished and striated surfaces of the rocks, and in the mounds of morainic material which fill the glens. The phenomena are attributed for the most part to the period of later glaciation, and this applies also to the small areas of boulder-clay in the Kilchrenan area and elsewhere. Fluvio-glacial gravels, which occur in places, have been traced into the 100 foot beach.

Raised beaches at elevations of 50 and 100 feet are noticed. The cliffs bounding the 50-foot beach are here and there hollowed out into caves, some of which "bear evidence from their contents of having been inhabited from before historic times down to the present". A little more information might perhaps have been given respecting them. We notice in the Bibliography that there are titles of papers on the caves, but there is no reference to these in the text. The same remark unfortunately applies to many other papers in the Bibliography, and we are at a loss to know to what extent others have contributed to a knowledge of the geology of the district.

Economic Geology occupies one chapter of two pages, relating to granite and other building-stones, slate, lime, road-metal, and material for pottery manufacture. Peat is dealt with in the previous chapter, but there is no mention of water-supply.

IV.—The Water Supply of Kent: with Records of Sinkings and Borings. By William Whitaker, B.A., F.R.S.; with contributions by H. F. Parsons, M.D., H. R. Mill, LL.D., and J. C. Thresh, M.D. 8vo; pp. v, 399, with rainfall map, 8vo; cloth. 8*s.* 6*d.*

The Water Supply of Bedfordshire and Northamptonshire, from underground sources: with Records of Sinkings and Borings. By Horace B. Woodward, F.R.S., and Beeby Thompson, F.G.S., F.C.S.; with contributions by H. R. Mill, LL.D. 8vo; pp. vi, 230, with two rainfall maps, 8vo; wrapper. 4*s.* 6*d.* Published at the Ordnance Survey Office, Southampton.

During the past ten years the Geological Survey has issued memoirs on the Water Supply of Sussex, Berkshire, Lincolnshire, East Yorkshire, and Suffolk; and previously in Mr. Whitaker's *Geology of London*, vol. ii (issued in 1889), there was printed a record of the strata passed through in wells and borings over a large area in and around the metropolis and in the lower part of the Thames Valley.

We have now before us the two memoirs above noted. That on Kent is probably the most complete work on local water-supply ever published. As we are reminded by the Director of the Geological Survey, the author, Mr. Whitaker, took a large share in the original geological mapping in that county, and has since added very much to our knowledge of its underground structure.

So greatly, indeed, has this knowledge been increased by the results of recent borings that the county has now perhaps a fuller list of formations than any other. At the surface there is considerable variety of Recent and Pleistocene deposits, some remnants of Pliocene, a nearly complete series of Eocene formations, and a continuous series of Upper and Lower Cretaceous rocks; below ground all the Jurassic divisions, as well as representatives of Trias, Coal-measures, Devonian, and Silurian, have now been proved.

The information which Mr. Whitaker has assiduously gathered for many a year is methodically arranged and tabulated in his volume. He gives full particulars relating to springs, swallow-holes, and the intermittent streams known as Bournes or Nailbournes—all matters that have considerable geological interest. The water-bearing capacities of the formations from the shingle of Dungeness to the Hastings Beds are duly described, and the supplies taken from springs and wells are separately indicated. Maidstone and Folkestone are the only places which take large supplies from springs, and these supplies are supplemented by well-water. The greater part of the water-supply of Kent is drawn from the Chalk; the Kent Water Company (now part of the Metropolitan Water Board) supply a population of more than 680,000 people, pumping from wells between 18 and 19 millions of gallons of water daily. As Mr. Whitaker points out, this is the largest supply in the world obtained from underground sources.

The records of the strata passed through in shafts and borings are arranged in three divisions: those for water, those for coal, and those for sundry other purposes (various trial-borings).

Of special interest are the borings for coal, and details of the Secondary strata at Ottinge, Hothfield, Penshurst, and Old Soar, contributed by Professor W. Boyd Dawkins, are now for the first time published. These borings, however, did not extend to the Palæozoic floor. We should have been glad to see details also of the Secondary strata passed through at the Ellinge, Ropersole, Waldershare, and Fredville borings, which reached Coal-measures, and of the Brabourne boring, which reached Devonian or possibly Silurian (as suggested on p. 383). Records of the Dover pits are given, summarized to some extent from accounts previously printed.

Many analyses of water have been contributed by Dr. Parsons, on behalf of the Local Government Board, and by Dr. Thresh, while the statistics of rainfall have been prepared by Dr. Mill. A Bibliography together with Miscellanea and Addenda form the concluding portions of this volume.

In the memoir on the Water Supply of Bedfordshire and Northamptonshire the Geological Survey has had the advantage of the services of Mr. Beeby Thompson, whose researches on the geology of Northamptonshire, from a practical as well as scientific point of view, are well known. He has contributed, in addition to numerous records of well-borings, a full account of the springs around Northampton, and of the various schemes for supplying the town with water from the date of the earliest record, which was in the thirteenth century. He has also written notes on the characters of the Northamptonshire waters, and supplied records of original analyses. The particulars relating to Bedfordshire have been arranged and classified by Mr. H. B. Woodward, who has written the general outline of the geology of the two counties, with notes by Mr. Thompson and Mr. Jukes-Browne. Various records of wells and borings have been contributed by Mr. Whitaker and Mr. A. C. G. Cameron, and the sections on rainfall have been drawn up by Dr. H. R. Mill. We note on p. 64 that the grouping "Alluvial Drift" is printed in mistake for Glacial Drift. The volume concludes with a Bibliography.

V.—The Geological Society of London.

THE record of "The Centenary of the Geological Society of London", prepared by Professor W. W. Watts, late senior Secretary of the Society, has been issued uniform with the Quarterly Journal (pp. vi, 166) at the price of 2*s*., and with an excellent portrait of Sir Archibald Geikie. The main features are the report of the reception of the delegates, the addresses of congratulation from individuals and institutions representing all parts of the world, and the presidential address delivered by Sir A. Geikie.

Most of the addresses are in English, but others are in Latin, French, German, and Dutch. Many of them were elaborate in design, of great beauty and artistic merit.

The oldest institution that tendered congratulations was the Royal College of Physicians, now in the 389th year of its corporate existence. It was represented by Dr. Michael C. Grabham, who also issued an independent address to the President and Fellows entitled "The First Hundred Years of the Geological Society of London". In this essay the author remarks "we may surely ask the mathematician, if his mill has to be reset, to deal gently with the geologist, and to afford him all reasonable scope for his vast meditations". He adds, however, in a side-note, "'Deal gently and without shedding of blood' was the mediæval formula for burning alive." The inference perhaps was not intended. In the numerous addresses printed in the volume before us there are many references of historic interest to the early workers in different lands, and to those who helped in the establishment of the Geological Society of London.

In his interesting Presidential Address Sir A. Geikie dealt with the history of geological research prior to the foundation of the Society, and showed that, as a recognized branch of science, geology is not much older than the Society itself.

In addition to the matters already mentioned, the Centenary volume contains a record of the dinners, conversazione, visits to museums, and of excursions made to different parts of the country. The longer trips were not popular, but the single-day excursions were for the most part well attended.

The total number of those attending the Centenary was 307; of these there were about 50 Fellows who came as delegates, and 111 other Fellows, out of a total number of between 1,251 and 1,278 (the full number of Fellows at the end of the years 1906 and 1907 respectively). Thirty ladies were present.

The volume is a valuable record of an historic gathering, most carefully prepared and edited by Professor Watts with the assistance of Mr. Belinfante.

REPORTS AND PROCEEDINGS.

Geological Society of London.

Annual General Meeting.

February 19, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The Reports having been received and adopted, the President presented the Wollaston Medal to Mr. Horace Bolingbroke Woodward, F.R.S., addressing him as follows:—

Mr. Woodward,—The Wollaston Medal is awarded to you in recognition of researches conducive to the interests of the Society in particular and to the science of Geology in general, especially in relation to the Jurassic rocks of Britain and the *History of the Geological Society*.

No one possesses a more encyclopædic knowledge of the Geology of England and Wales than yourself, and your well-known book on this subject, distinguished by its clear and orderly presentation of a vast collection of facts, is indispensable to every English student of our science.

The Jurassic System, as developed in this country, has long occupied your attention, and you have given an admirable account of it in your three great volumes on *The Jurassic Rocks of England and Wales*, a work which embodies your own personal observations, and fully and impartially records every fact of importance contributed by other investigators.

The invaluable History of the Society which you prepared for our Centenary Celebration is a mine of information, and at the same time a continuous and consistent story well told. The heroic figures and the battles of long ago are brought vividly before our eyes; and the human side of our great predecessors is faithfully touched in with many a quaint saying, odd mannerism, and witty story. As we read we are conscious of a deepening appreciation of the great and lovable nature of the men who helped to found and build up our science, and an increased pride in the Society which they have transmitted to our care.

Your retirement from the Geological Survey will doubtless be merely the introduction to a new sphere of activity; the good wishes of the Society will follow you there, and we hope that you will live long to enjoy the powers conferred upon you by your well-earned leisure.

Mr. Woodward replied in the following words:—

Mr. President,—In receiving from your hands the Wollaston Medal I feel intensely gratified that my work has been adjudged by the Council to be worthy of this great honour.

I cannot claim to be one who engaged in the "Pursuit of Knowledge Under Difficulties", as the Society in my early days, and the Geological Survey afterwards, directed my steps and made the pathways smooth. Thus, whether under command or away from official control, ambition was stirred to make as full acquaintance as possible with the Geology of this country. In almost every part of it we have the advantage of following in the footsteps of previous geological workers, and as progress could not be made without heed to the lessons which they have taught, it is natural that some of us should be led from the rocks into historical and biographical trackways. In these directions, from the field to the study, my tasks have conducted me; and, while I recognize that, as a recipient of this award, I am highly privileged, I rejoice in the weight attached to researches which indicate how much we are indebted to those who have gone before us.

I thank you, sir, for the very kind words with which you have accompanied this presentation.

The President then presented the Murchison Medal to Professor Grenville A. J. Cole, F.G.S., addressing him as follows:—

Professor Cole,—In awarding you the Murchison Medal the Council wish to express their appreciation of the value of your contributions to Geology in general and especially to Petrology.

You have combined, in the happiest manner, work in the laboratory with observations in the field; in addition, your petrological studies have been so arranged as to lead naturally to comparative results, and by visiting allied areas you have caused each in turn to throw light upon the other. The tachylytes of Scotland thus led you to the variolitic masses of the Hautes Alpes, and Hungary was thus made the basis for the description of the rhyolites of Antrim.

Impressed by the modifications suffered by igneous magmas through the absorption of foreign material, you were led to important conclusions with regard to the granite of Slieve Gallion in Londonderry; and in Tyrone and Donegal you found in the phenomena of igneous intrusion an explanation of the structure of gneisses which had been previously attributed to dynamo-metamorphic action.

Since 1905 you have been called on to direct the work of the Geological Survey of Ireland, and have endeavoured to connect the study of soils with the underlying drift and older rocks.

Not the least merit of your work is the endeavour to present your results in a pure and simple literary style.

We have made many excursions together on Irish soil, and I have had frequent opportunities to observe, not without admiration, how keen is your interest, how untiring your enthusiasm, and how ample your enjoyment when brought face to face with the knotty problems of the field.

The memory of our association in the past adds to the pleasure with which I hand you the Murchison Medal.

Professor Cole replied in the following words:—

Mr. President,—I beg to thank you and the Council of the Geological Society for the generous and unexpected award made to me to-day. In your friendly references to my work you have fully appreciated the aim of my petrological studies, although I fear that you have been unduly kind to the performance. The illustrious founder of the medal which I now receive laid stress, in common with his contemporaries, on the necessity for the comparison of geological phenomena in many lands besides our own. Travel, it was urged, was one of the first duties of a geologist, and this was never lost sight of in the training that I received from my own revered master, Professor Judd. In my far smaller way I have always endeavoured to realize that a rock-specimen is not a mineralogical curiosity, but a portion of this very vital globe on which our destinies are cast. It is an especial pleasure, Mr. President, for me to receive this encouragement from your hands, since the work so kindly recognized has been mainly done in Ireland. When, eighteen years ago, I entered that country as a stranger, you freely placed before me the results of your own enquiries, and year by year you stimulated me by your energy in research. May I venture also to think—you, sir, have opened the way for me to say it—that the Geological Survey of Ireland, which has so kindly received me as a colleague, becomes again to-day associated with the historic name of Murchison?

In presenting the Lyell Medal to Professor Percy Fry Kendall, M Sc., the President addressed him as follows:—

Professor Kendall,—The Lyell Medal has been awarded to you by the Council as a mark of honorary distinction and as an expression on the part of the Council that you have deserved well of the science, especially by your researches into the Glacial Geology of England.

The success which has attended your performance of the arduous duties connected with the Professorship of Geology in a young University has only been achieved by strenuous labour; that you have been able at the same time to accomplish so much in the field of research is a striking testimony to your indomitable energy.

Your delightful account of the Geology of Yorkshire, with its wealth of detail and breadth of view, is a model of its kind, and your report to the Royal Commission on the Concealed Coalfields of North-Eastern England is important, both from a theoretical and from a practical point of view; but to the Fellows of this Society you are probably better known by your long-continued and successful researches into Glacial phenomena, and especially by your brilliant account of the Glacial lakes of Cleveland.

I sincerely trust that the future may have in store a larger share of time and opportunity for the exercise of your original powers.

Professor Kendall replied in the following words:—

Mr. President,—I thank the Council most heartily for the honour which it has done me in the award of this valued distinction, and you, sir, for the generous terms in which you have conveyed it.

My lot as a geologist has been cast in very pleasant places. I have been trebly fortunate in my teachers, for, while my studies in early manhood were directed by such distinguished exponents of our science as my friend and master, Professor Judd, and his lieutenant, Professor Grenville Cole, I owe not a little to the fact—until this moment unknown to you—that at a still earlier period in my career I had the advantage of attending a course of lectures in the City of London delivered by you.

This inspiration fanned to a glow the fire of enthusiasm for Geology that is among my earliest recollections, and will, I doubt not, last to the end of my life.

I have found in Yorkshire a wide and varied field, replete with problems of the highest scientific interest and economic importance, which press so insistently for solution that the temptation has been great to pass on from one half-solution to another. It is most gratifying to find that my small measure of achievement has commended itself to the Council of the Geological Society.

I must not forget an acknowledgment of the debt that I owe to the many enthusiastic brother-geologists in the county of my adoption, who have helped and encouraged me in the field, and by frank and friendly criticism have saved me from not a few downright blunders.

The President then presented the Bigsby Medal to Dr. John Smith Flett, M.A., addressing him as follows:—

Dr. Flett,—In a series of masterly memoirs published during the past thirteen years, you have greatly extended our knowledge of the geology and petrography of Great Britain, particularly of Scotland and Cornwall.

The responsible post of Petrographer to the Geological Survey has brought you many opportunities, of which you have made such excellent use that you have come to be generally recognized as a worthy successor to Dr. Teall, and than this I know of no higher praise.

You have not confined your studies to these Islands, but have given us descriptions of the rocks of remote parts of the world. At the call of duty and in the pursuit of Science you visited, in company with Dr. Tempest Anderson, St. Vincent and Martinique, and gathered your facts amidst the explosions of la Montagne Pelée. From my own experience of other active, if less ferocious volcanoes, I know something of the demands which this makes on the coolness and courage of the observer. It is, therefore, with the sympathy of a comrade in arms that I hand you this Medal in the name of the Council.

Dr. Flett replied in the following words:—

Mr. President,—The honour which the Society has done me by awarding to me the Bigsby Medal is one of which I am deeply sensible. I can assure you, sir, that it will be my endeavour to see that the stimulus that it gives to scientific work, the injunction "not to rust unburnished, but to shine in use", will not pass unregarded. In the study of British rocks, principally the igneous and metamorphic, I have had exceptional advantages; for I have received the kindest assistance from my colleagues on the Geological Survey, and especially from Dr. Teall, who also by his example has placed before me the highest ideals of thoroughness and accuracy in investigation. The labour spent in research is in the best sense its own reward, but the pleasure which I have derived from it has been greatly increased by the approbation which you have expressed this afternoon in handing me this Medal.

In presenting the Prestwich Medal to Lady Evans, the President addressed her as follows:—

Lady Evans,—The Council has awarded to you the Prestwich Medal *in memoriam* of Sir John Evans.

It is now fifty years since Sir John Evans, in company with his lifelong friend Sir Joseph Prestwich, visited the scene of Boucher de Perthes's famous discoveries at Abbeville. The results of that visit in its effect upon the whole range of human thought would be difficult to estimate: one of them is apparent in the increasing growth of that new branch of Science—the Anthropology of the Pleistocene Epoch—which Sir John Evans did so much to create.

This award commemorates in some sense the joint labours of the two friends; that it was not made earlier is due to Sir John Evans's long-continued and self-denying services on the Council.

We esteem ourselves fortunate that you, Lady Evans, who shared his interests, and are yourself an antiquary, are able to be present on this occasion, and in handing you this Medal I desire to express, on the part of the Society, our deep appreciation of the unceasing devotion and affectionate solicitude with which its interests were watched over by our lost leader, whose memory we shall long preserve.

On behalf of Lady Evans, Mr. Lewis Evans replied in the following words:—

Mr. President,—Speaking on behalf of Lady Evans and my late father's family, I have to express our great appreciation of the honour which the Society has paid to his memory in awarding to her the Prestwich Medal; we also recognize the special fitness of the award because of the long, unbroken, and most intimate friendship between Sir Joseph Prestwich and my father; and, on account of his knowledge of medallic art, my father was chiefly responsible for the design of this medal.

To you, sir, I wish to tender our special thanks for your kind and sympathetic words on the occasion of this presentation, terminating in so graceful a manner the fifty-year-long connection between my father and your illustrious Society.

The President then handed the Balance of the Proceeds of the

Wollaston Donation Fund to Mr. Arthur John Charles Molyneux, F.G.S., addressing him as follows :—

Mr. Molyneux,—Thanks to the enterprise of scientific explorers, the Continent of the Sphinx is slowly yielding up its mysteries.

One of these explorers we are glad to welcome in your person on this occasion. We owe to your exertions important contributions to our knowledge of the geology of Southern Rhodesia and Bechuanaland; all of these are distinguished by carefulness of description and caution in inference.

You were the first to give a scientific account of the Victoria Falls, and to explain their origin. When the British Association visited the Falls in 1905, your work was very searchingly criticized; along with my fellow-geologists I had the satisfaction of recognizing its faithfulness to fact as well as its theoretical adequacy.

We are all glad to find that the climate of Africa has treated you leniently, and we hope that when you return you will be able to throw further light on that still mysterious continent.

In presenting the Balance of the Proceeds of the Murchison Geological Fund to Mr. James Vincent Elsden, B.Sc., the President addressed him in the following words :—

Mr. Elsden,—The balance of the Murchison Geological Fund has been awarded you by the Council on account of your work among the Igneous Rocks of Wales, and to encourage you in further research.

Since your earliest work in 1883 you have continued to make welcome additions to our knowledge, particularly in the application of geology to the arts, and you have enriched the literature of British petrography by excellent papers on the igneous rocks of the Lleyn district, Llyn Padarn, and Pembrokeshire. These contributions are distinguished by their philosophic treatment of accurately described data, in the light of the most recent advances in chemistry and physics.

We wish you health and opportunity to continue your important work of research.

The President then presented one moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Herbert Brantwood Muff, B.A., addressing him as follows :—

Mr. Muff,—A moiety of the Balance of the Proceeds of the Lyell Geological Fund has been awarded to you in recognition of your researches among the Pleistocene deposits and the ancient rocks of Scotland and Ireland.

As a result of your researches on Glacial deposits in this country, you have indicated a lower limit for the ancient snow-line, at least in the vicinity of Bradford, where it did not descend beyond 1,500 feet above the present sea-level; and in company with Mr. W. B. Wright you have established a pre-Glacial limit to the sea along the southern coast of Ireland, which corresponds in a remarkable manner with that now existing.

You have also carried your hammer into the tropics, and published a valuable report on the Geology of British East Africa.

Recently, in conjunction with Mr. Carruthers, you have investigated the West of Ireland, where you have discovered a thick series of Arenig rocks, and shown that the crystalline schists of Connemara were metamorphosed before the Arenig Epoch, and probably before the Cambrian Era.

You are now engaged in studying the perplexing problems of the Western Highlands of Scotland. May your labours be crowned with equal success!

In handing the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Robert George Carruthers, to Professor E. J. Garwood, Sec. G.S., for transmission to the recipient, the President addressed him in the following words :—

Professor Garwood,—The Council have assigned a moiety of the Balance of the Lyell Geological Fund to Mr. R. G. Carruthers in recognition of his work on the Carboniferous Corals, and to stimulate him to further research.

The task of subdividing the Carboniferous Limestone into definite zones has engaged the energies of a brilliant band of investigators, and no one has contributed more fundamental data than Mr. Carruthers. The recognition of distinctive characters among forms apparently so indefinite as the corals is a difficult problem, taxing to the utmost the judgment, skill, and patience of the observer. It is one which he has undertaken, and so far with conspicuous success.

In asking you to transmit this award to Mr. Carruthers, I would beg you to assure him of the cordial interest taken by the Council in the progress of his labours.

The President then proceeded to read his Anniversary Address, giving first of all Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including Dr. H. C. Sorby (elected a Fellow in 1850); Sir John Evans (el. 1857); W. H. Hudleston (el. 1867); Professor A. J. Gaudry (elected Foreign Member in 1874); Professor A. de Lapparent (el. F.M. 1897); Dr. F. Schmidt (el. F.M. 1895); General J. F. N. Delgado (el. F.M. 1899); Professor H. G. Seeley (el. 1862); Sir Thomas Wardle (el. 1863); and Joseph Lomas (el. 1897).

He then dealt with the question of Time, considered in relation to Geological Events and to the Development of the Organic World, referring, first of all, to recent evidence in proof of the extreme rigidity of the interior of the Earth. He remarked that Mr. Strutt's method of estimating the age of sediments by reference to their radio-active constituents was of great promise, but a long series of concordant observations would be required to inspire absolute confidence in its results. Professor Joly's method of determining the age of the Ocean, based on the ratio of the amount of sodium which it contained to that annually contributed to it by rivers, was subjected to a detailed analysis, in the course of which it was pointed out that the sodium contained in river-water existed chiefly as sulphate or chloride, though theoretically it should be in the state of carbonate. The origin of the chlorine was manifold; some was traced to salts borne by the winds from the ocean, some to supplies from ancient desert-lakes, and some to juvenile waters escaping as hot springs or impregnating the vadose waters underground. The probable limits for the age of the Ocean were 80 to 170 millions of years.

An examination of the sedimentary series, where developed to their maximum thickness, gave a period of 35 millions of years, on the assumption that deposition had proceeded at a rate of 1 foot in a century. Explanations of the discrepancy were suggested, and it was proposed to divide stratigraphical time into two moieties, each of 40 millions of years duration. The earlier or pre-Cambrian moiety was termed the Protæon, the later or post-Cambrian the Neatæon. Using the scale of 1 foot in 100 years as a rough chronological measure, it was applied to illustrate the rate of evolution in the case of the Equidæ and the chief varieties or species of man. Though relatively rapid, when considered in connection with some other groups of organisms, this was shown to be so slow, when measured in terms of years, that perceptible differences in a linear ancestral series would have required tens of thousands of years for their production.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—Council: Charles William Andrews, B.A., D.Sc., F.R.S.; George Barrow; Professor William S. Boulton, B.Sc.; Professor Samuel Herbert Cox, F.C.S., Assoc.R.S.M.; Professor Edmund Johnston Garwood, M.A.; Sir Archibald Geikie, K.C.B., D.C.L., LL.D., Sc.D., Pres.R.S.;

CORRESPONDENCE.

SCANDINAVIAN ICE-SHEETS AND BRITISH GLACIAL DRIFTS.

SIR,—I am glad to see that Mr. Deeley has applied the results of Captain Scott's Antarctic expedition to the supposed extension of a Scandinavian ice-sheet to the British coasts, because it shows that the advocates of this hypothesis are abandoning the policy of "letting severely alone" the difficulty of the Norwegian Channel. Thus I regard his letter as a real advance towards the settlement of a very complex problem. But does not his idea of a floating ice bridge also involve some serious difficulties? Let us assume the sea-level during this part of the Glacial Epoch to have been the same as its present one. We may take the depth of the channel round the southern end of Norway to be from 1,500 to 1,800 feet (see GEOL. MAG., 1899, p. 282, for the variations). But the North Sea is generally not more than 250 feet deep, and occasionally only 50 feet (id., 1901, p. 187); the breadth of the channel is about 30 miles, and the distance from the Naze of Norway to Cromer about 400 miles. Let us suppose the top of the Scandinavian ice-sheet to have been only 100 feet above sea-level at the 'bridge'; then, according to Captain Scott's estimate, its total thickness must have been at least 600 feet, or the bottom of the ice-sheet some 300 feet below the margin of the North Sea plateau. Thus it must either have been forced up and over an undulating floor for over 350 miles before it reached the English coast, or its movement have been practically restricted to the upper layers. The latter hypothesis demands a greater viscosity in ice than seems probable to me, though I always thought Forbes nearer than Tyndall to the truth in their well-known controversy. The former presents several difficulties, a full discussion of which would be impossible in the limits of a letter; so I content myself with saying that we must be cautious in resorting to the Antarctic or even to Greenland for a picture of Scandinavia in the Great Ice Age. The general level of the last country may be higher, and precipitation on it may have been greater. than in Greenland, but it is much narrower; in fact, its breadth in the part with which we are now concerned is about that of the other country in lat. 64° N., and its watershed (though the snow-parting may have been somewhat east of this) is roughly 80 miles from the west coast. In the Antarctic during that 300 miles journey southwards from Mount Erebus, Captain Scott's party was travelling almost parallel with a mountainous region (generally within a few leagues) ranging from 8,000 to 12,000 feet in height, and their view to the south when they turned back was blocked by a snowy mass nearly as high as Monte Rosa. The mean temperature also in the Antarctic is much lower than we are entitled to assume for Scandinavia in the Glacial Epoch (*Ice Work*, pt. iii, ch. i; the probable minimum limit may be inferred from the statements on p. 237). There are other difficulties, such as the relative sizes of Scandinavian and British ice-sheets, the transport and distribution of boulders, the materials of British drifts and their arrangement, which will have to be considered; but the main one for our present purpose is the inadequate 'ramming' power of the ice from the Scandinavian upland, because by far the greater part of the journey to England would have been over land, not by floating on water. Assuming a lower strand-line increases our difficulties, and a materially higher one will submerge more or less of England.

T. G. Bonney.

Cambridge.
March 15, 1909.

THE TRIMINGHAM CHALK—SOUTH BLUFF.

Sir,—I have recently been convinced that the northern part of the bluff is continuous under the sand with the southern part, and in fact offers a section of the greater part of the 'sponge beds' and of some of the succeeding beds. This was first suggested by the presence of the four-angled variety of *Serpula canteriata*, whose known range is otherwise so rigidly restricted to the 'sponge beds' and immediately succeeding beds. Following up this clue, I saw that the very ill-defined lower flint lines of the northern part could be read into accurate correspondence with the flint lines which even in the admirable horizontal section of the 'sponge beds' afforded by the foreshore are not over well defined, while one of the principal hardened beds on the foreshore could be identified in the bluff. I also saw that the main face of the northern part gave a section practically along the axis of the main fold, while the dips in the southern part, from which I argued in 1900 that if the two parts were continuous *Ostrea lunata* chalk must appear within reach in the northern part, were taken from sections parallel with the axis of the fold but some way down its side. This and a local increase in the rate at which the fold rises, which was shown by the recently cleared end of the southern part, would carry the *O. lunata* chalk of the southern part well out of reach in the northern part, but I judged from the upper flint lines that if I was correctly identifying the 'sponge beds', *O. lunata* chalk should come in at the highest point, and I was able to get near enough to the highest point to scoop away a little chalk in which I found

O. lunata. (The single specimen of *O. lunata* recorded from the lower beds in 1906 was found in a detached piece of chalk lying on a ledge about 5 feet up, which I then felt bound to assume against my own views to have been detached from the chalk against which it actually lay, but it is now obvious that it must have slipped down from above.)

I have also discovered that 4 inches above the highest flint band figured on the southern part there is a sudden but apparently conformable change from white chalk with *O. lunata* to grey chalk without *O. lunata.* Of this grey chalk a maximum of 18 inches is preserved, containing one definite line of very curious flints. It is a reasonable supposition that this grey chalk is the lowest part of that grey chalk which is the lowest member of the other main series, and that it supplies the hitherto missing link between the two series.

R. M. Brydone.

27, Twyford Mansions, W.
March 13, 1909.

THE DISCUSSIONS AT THE GEOLOGICAL SOCIETY.

Sir,—I write to strongly express the hope that the suggestion of Dr. Charles Davison, in the February Geological Magazine, that the reports of discussions of papers read before the Geological Society should be printed exclusively in the Proceedings will *not* be adopted. Personally I find it very difficult to keep track of and insure the complete collection and preservation of the Proceedings, which I regard as of an ephemeral character and do not consider worth binding. If the discussions are omitted from the Quarterly Journal the report will be incomplete, and many valuable suggestions may be either lost entirely or only preserved by those paragons of method who bind the Proceedings. I would suggest that those who take part in the discussion should be requested, when proofs of the report of their remarks are submitted to them, to eliminate from them everything except what they believe, on mature reflection, to be of value, and that as far as possible the official reporters of the Society should act on the same principle. Then the discussion may be printed in the Quarterly Journal. I think a paper which when printed *in extenso* is materially damaged by the report of the discussion cannot be worth much. I have so great a respect for the views of Dr. Davison on most subjects that I regret to differ from him in this case.

Bernard Hobson.

Thornton Didsbury, near Manchester.

OBITUARY.

PERCEVAL DE LORIOL LE FORT.

Born July 24, 1828. Died 1908.

We regret to record the death (which took place last year at Geneva) of the eminent Swiss Palæontologist, de Loriol, President of the Swiss Palæontological Society, an indefatigable worker for nearly fifty years on Mesozoic and Tertiary Invertebrata, and especially distinguished for his researches on the Jurassic echinoidea and crinoidea. As early as 1861 he published "Description des animaux invertébrés fossiles contenus dans l'étage néocomien moyen de Mont Salève". Soon afterwards he was at work with E. Pellat on the Upper Jurassic fossils of Boulogne-sur-Mer, on which they issued a series of joint monographs. He aided Pictet with his *Matériaux pour la Paléontologie Suisse*, and later (1882–9) he described the Jurassic crinoids in the continuation of d'Orbigny's *Paléontologie Française*. He was associated also in joint memoirs with other workers: Cotteau, Choffat, Desor, Ernest Favre, Gilliéron, Girardot, Royer, Schardt, and Tombeck. Of independent works may be mentioned his *Echinologie Helvétique*, *Monographie des Crinoides fossiles de la Suisse*, and descriptions of Tertiary echinoids from Egypt and Portugal. He wrote also a monograph on the fossils of the zone of *Ammonites tenuilobatus* (to which attention was drawn in the Geological Magazine for 1878, p. 354, and 1882, p. 279). Some of these memoirs were contributed to the Physical and Natural History Society of Geneva, the Society of Natural Science of Neûchatel, and the Swiss Zoological Review, while others in later years were published by the Swiss Palæontological Society. De Loriol was elected a Foreign Correspondent of the Geological Society of London in 1894.

HUGH LEONARD.

Born 1841. Died February 16, 1909.

The death of Mr. Hugh Leonard, following close upon that of Mr. G. H. Kinahan, removes another link with the Irish Geological Survey as it stood up to the time of its severance from that of Great Britain in 1905.

Mr. Leonard was appointed Assistant Geologist in August, 1867, and, under the guidance of Mr. Kinahan, surveyed large tracts of the complicated areas of Mayo and Galway in the west of Ireland, subsequently mapping a considerable portion of county Cavan, and finally revising the survey of the interesting district about Enniscorthy, in co. Wexford. His mapping, always careful and accurate, has withstood the brunt of latter-day revisions, while his accompanying memoirs are clear and explicit. Possessed of a first-class knowledge of chemistry, he made good use of this science as an aid to his geological researches. Unfortunately an accident, sustained in the course of field-duties, deprived the Survey of Mr. Leonard's services in the year 1881, when he retired on a specially granted superannuation. He was for many years a Fellow of the Geological Society, an active Member of the Royal Irish Academy, and, up to the time of its dissolution in 1889, he acted as Honorary Secretary of the Royal Geological Society of Ireland. Of a kind, helpful, and cheerful disposition, he was greatly esteemed by the many who enjoyed his friendship. He passed away after a brief illness at his residence, Blackrock, co. Dublin.

R. Clark.

JAMES PARSONS, B.Sc., F.G.S.

BORN JUNE 24, 1876. LOST IN CEYLON DECEMBER 29, 1908.

MR. PARSONS, lately Principal Mineral Surveyor of Ceylon, has apparently lost his life under very unusual and sad circumstances. He had gone up from Colombo to Muwara Eliya for the Christmas holidays, and on December 29 went out walking in the morning, saying that he would be back for lunch. He did not return, and in spite of prolonged and careful search has not been found. It is now practically certain that he must be dead, and it appears likely that the mystery of his disappearance will never be solved.

Mr. Parsons was born June 24, 1876, was the son of James St. John Gage Parsons, F.R.C.S., of Bristol, and was educated at University College, Bristol, and afterwards at University College, London, where he attended Professor Bonney's classes. Appointed in 1903 as Assistant Director of the Mineralogical Survey, temporarily established by the Ceylon Government, he did excellent work in investigating the mineral resources of Ceylon, his results being incorporated in the Annual Reports of the Survey. When in 1908 the Survey was continued for a further three years, Mr. Parsons was appointed Principal Mineral Surveyor in succession to the Director, who retired. In 1907–8 he acted in this capacity, his reports being published annually.

Mr. Parsons was the author of a paper on "Development of Brown Mica from Augite", published in these pages in 1900, and of a paper on "Quartz in Ceylon", published in *Spolia Zeylanica* for 1908. His "Administration Report" for 1907 has just been issued. He had other work in preparation. He was a close personal friend of the writer. His loss will be keenly felt, for in addition to his geological work he was greatly interested in Oriental philosophy and in Sinhalese folklore. He was fairly proficient in Sinhalese, and was on the best of terms with his staff. He was at one time Secretary of the Bristol Branch of the Theosophical Society, and had made some study of Sanskrit. He was a man who cannot be easily replaced.

Great sympathy will be felt for his wife, who was with him in Muwara Eliya at the time of his disappearance, and for his family in Bristol. It is a consolation to reflect that he now, perhaps, knows something more of that psychology and philosophy which formed his deepest interest.

A. K. COOMARASWAMY.

MISCELLANEOUS.

MINERALOGY IN OXFORD.—The vacancy in the Waynflete professorship of Mineralogy at Oxford, caused by the appointment of Professor H. A. Miers as Principal of the University of London, has been filled by the promotion of Mr. H. L. Bowman, M.A., F.G.S., who has acted for some years as demonstrator in mineralogy under Professor Miers.

No. 539. Decade V.—Vol. VI.—No. V. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

MAY, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. V.—MAY, 1909.

ORIGINAL ARTICLES.

I.—Notes on the Trilobite Fauna of Devon and Cornwall.[1]

By Ivor Thomas, Ph.D., B.Sc., F.G.S.

(PLATE VII.)

THE material upon which the following descriptions are based was obtained chiefly by Mr. Ussher, who collected the Whiteway and Hestow Farm specimens. The Daymer Bay form was collected by Mr. John Pringle. For the new species of *Proetus* I am indebted to Mr. Claude H. Peter, Town Clerk, Launceston, who, through Mr. Clement Reid, kindly lent it for description. It is evident from the examination of this limited quantity of material that the British Devonian fauna is not yet fully known. We may expect the discovery of many species hitherto unrecorded in this country, which will be of interest from the possible comparative relationship with the fauna of foreign deposits. The accompanying illustrations were drawn by my colleague, Mr. H. H. Thomas, to whom I tender my best thanks.

PHACOPIDÆ.

Phacops (Trimerocephalus) anophthalmus, Frech. Pl. VII, Fig. 1.

1866. *Phacops cryptophthalmus*, F. Roemer: Zeitschr. d. d. geol. Ges., Bd. xviii, p. 674, pl. xiii, figs. 6, 7.
1871. ,, ,, E. Tietze: Palæontographica, Bd. xix, p. 126, pl. xvi, fig. 1.
1876. ,, ,, F. Roemer: Lethæa Palæozoica, i, pl. xxxv, fig. 18.
1894. ,, (*Trimerocephalus*) *anophthalmus*, Frech: Die Karnischen Alpen, p. 270.
1896. *Trimerocephalus typhlops*, Gürich: Verhdl. d. Russ.-k. Min. Geol. zu St. Petersburg, Bd. xxxii, p. 359, pl. xv, fig. 7.
1900. *Phacops* (*Trimerocephalus*) *anophthalmus*, Drevermann: Jahrb. d. k. preuss. geol. Landesanst., Bd. xxi, p. 117.

Description.—The *cephalon* is broadly semicircular, the length being about 8 mm. and the greatest breadth about 14 mm. The posterior limit is almost straight. The marginal border is fairly broad, and extends from the rounded genal extremities to the frontal margin of the glabella, and is continued anteriorly as a narrower and less distinct rim to the overhanging frontal lobe.

[1] By permission of the Director of the Geological Survey.

The fairly tumid *glabella* is markedly pentagonal, with a low curvature on the anterior margin, and is bounded by strong dorsal furrows enclosing an angle of *circâ* 50°. Its length in our specimen is 8 mm., and the greatest breadth near the frontal extremity is approximately 7 mm. The basal furrow is rather shallow at the centre, but deepens where it joins the above-mentioned dorsal furrows. The basal ring is slightly elevated and fairly broad, while the adjacent occipital furrow is shallow where it bounds the basal ring, and becomes deeper towards the cheek margins.

The *cheek-areas* are triangular, elevated, and fall gradually towards the glabella, but steeply outwards towards the marginal border. No trace of eyes is to be seen.

Locality and Horizon.—This specimen was obtained in the Upper Devonian purple and green slates of Daymer Bay, Cornwall. Mr. Dewey informs me that these beds are much overthrust and contorted on the south side of the bay, where they are overlain by sand. On the north side they are more exposed, and have been found to be highly fossiliferous in a low reef of rock near the end of the lane leading from Trebetheric to the sands. West of this lane and by the first hedge along the cliff, a fault, east and west in direction, throws down the purple and green slates, and brings into sight black shaly slates full of pyritous casts of cephalopods and lamellibranchs. The described trilobite was found on the foreshore, 50 yards west of the above-mentioned hedge, in association with pygidia of *Phacops latifrons* (Bronn), *Tentaculites* cf. *tenuicinctus*, F. A. Roemer, and poorly preserved brachiopod remains. The black slates have yielded *Tornoceras* sp., *Orthoceras commutatum*, C. G. Giebel, *Buchiola* cf. *semiimpressa*, Drevermann, and a small form referable to *Modiella pygmæa* (Conr.).

Remarks.—Owing to long exposure to the sea the specimen is not as well preserved as could be desired. The frontal lobe of the glabella has been somewhat worn anteriorly, and parts of the marginal border are destroyed. The same specimen has been referred to in a former paper under the name *Phacops* (*Trim.*) cf. *anophthalmus* (16, p. 100).

The name *anophthalmus* was given by Professor Frech (4, p. 270) to *Phacops cryptophthalmus* of F. Roemer from the Upper Devonian of Kielce, Poland (13, p. 674, pl. xiii, figs. 6, 7), and of Tietze (18, p. 126, pl. xvi, fig. 1), from the Clymenienkalk of Ebersdorf (not *cryptophthalmus* of Emmrich). Professor Gürich described the same form under the name *Trimerocephalus typhlops*, nov. nom., from the middle Upper Devonian of Kadzielnia, Poland (6, p. 359, pl. xv, fig. 7).

PHACOPS (TRIMEROCEPHALUS) aff. CRYPTOPHTHALMUS, Emmr. (as interpreted by Gümbel). Pl. VII, Figs. 2, 3.

Description.—The general contour of the *cephalon* is semicircular, with a practically straight posterior margin and a breadth almost twice the length. The whole surface is covered with small granules.

The somewhat flattened *glabella* is pentagonal in outline, and is bounded by deep dorsal furrows enclosing an angle of *circâ* 80°. The posterior part has a deep basal furrow and a fairly elevated, convex, basal ring. The occipital ring is imperfectly preserved, but appears to have been as broad and elevated as the basal ring.

The triangular *cheek-areas* rise to the level of the glabella, and slope fairly steeply towards the latter, but more gently outwards to a narrow groove bounding the marginal border of the head-shield. This border is broad and is continued from the fairly angular genal extremities to the glabella, where its outer margin appears to be continuous, as viewed from the dorsal side, with the anterior limits of the frontal lobe.

The *eyes*, of which the left one is preserved, are each situated upon a broadly elliptical lobe at the anterior extremity of the cheek-area. Eight circular facets are present, and are arranged in two sub-crescentic rows concave to the antero-lateral margin of the head-shield; there are five facets in the outer and three in the inner row.

Locality and Horizon.—This form was found in the Upper Devonian greenish-grey slates of Whiteway Farm-yard near Ideford, Devonshire. In association with it are found *Dechenella ussheri*, sp. nov., *Phacops* (*Trim.*) *tripartitus*, sp. nov., *Proetus* spp., *Posidonomya venusta* (Münst.), *Buchiola* sp., and *Entomis serratostriata* (G. & F. Sandberger). These beds were identified by Professor Kayser some years ago as equivalent to the Cypridinen Schiefer (9, p. 185; 20, p. 513).

Remarks.—The same specimen is referred to in a previous paper (16, p. 100) as being allied to *Phacops* (*Trim.*) *cryptophthalmus*, Emmr. As *cryptophthalmus* has been variously applied by different authors (17, p. 168), it is well to emphasize that its use in this case is in accordance with Gümbel's interpretation (5, pl. A, figs. 7–9). Gümbel's figure shows a marginal border which narrows more rapidly anteriorly and a more angular antero-lateral margin of the glabella. Comparison with a figure alone is unsatisfactory, since allowance has to be made for imperfections in the drawing as well as for the different positions in which the specimen may have been held.

A resemblance also exists with *Trimerocephalus cyclophthalmus*, K. Walther (21, p. 318, pl. XV, fig. 1), from the Styliolinen Schiefer of Schaderthal. The latter has a more curved posterior margin of the head-shield, more rounded genal extremities, apparently a less elongated glabella, and more eye facets, which also differ in their arrangement.

The eye of this species is seen to consist of two sub-crescentic rows concave to the antero-lateral margin of the head-shield, while that of *Ph.* (*Trim.*) *pentops*, Ivor Thomas (16, p. 97, pl. iii, figs. 1–4), is made up of one sub-crescentic row convex to the same margin.

The question of the development of eyes in *Phacops* has been discussed by Dr. J. M. Clarke in a valuable paper on the visual area of *Phacops rana*, Green (2*a*). Among other important conclusions he finds that "a definite relationship exists between the number of lenses of the eyes and the size (i.e. the age) of the animal" (2*a*, p. 257), and that "the number of lenses increases from youth to maturity and decreases from maturity to senility" (2*a*, p. 258). The deduction that "the primary lenses probably appeared in a single or double row, a visual line parallel to the margins of the orbital node" (2*a*, p. 261), is of particular interest in the consideration of the above-mentioned forms. Dr. Clarke, in a letter calling my attention to the above paper, expresses the opinion that *Trimerocephalus* is particularly interesting "in respect to its senile decline of visual surface". In agreement with this opinion forms such as *Ph.* (*Trim.*) aff. *cryptophthalmus* and *Ph.* (*Trim.*) *pentops* may represent senile stages in the phylogeny of the genus *Phacops*. On the other hand, the small number of eye facets may be the result of specialization and not of degeneration.

PHACOPS (TRIMEROCEPHALUS) TRIPARTITUS, sp. nov. Pl. VII, Figs. 4, 5.

Description.—The smooth *cephalon* shows a general parabolic outline, and in the case of one specimen has a length of *circá* 3·3 mm. and breadth of 4 mm. approximately.

The tumid *glabella* is regularly curved anteriorly, but somewhat constricted towards the low narrow basal ring, which bears terminal tubercles, one at each extremity. Lateral furrows are not traceable on the frontal lobe. The bounding dorsal furrows are deep, and enclose an angle of about 73°. The ratio of the length to the greatest breadth = 9 : 8. The occipital furrow is fairly broad and almost equal in width to the well-marked and elevated occipital ring.

The tumid *cheek-areas* are triangular, and fall steeply towards the glabella, but more gradually outwards towards the marginal border. The latter is a fairly broad and flattened area continued from the rounded genal extremities to the antero-lateral border of the glabella. It is impossible to trace it still further anteriorly in the specimens at present at my disposal.

Eyes are preserved in one of the specimens, and are each situated upon the extreme anterior corner of the triangular cheek-areas. The facets are circular and few in number.

Locality and Horizon.—Four fairly complete heads, together with many fragments, were collected from the same locality and horizon as *Phacops* (*Trim.*) aff. *cryptophthalmus*, etc.

Remarks.—This form is closely related to *Phacops* (*Trim.*) *acuticeps*, Kayser, from the Upper Devonian limestones of Martenberge, near Adorf (10, p. 288, pl. xiii, fig. 6). It differs from that species, among other details, in the possession of a straighter posterior margin and less angular genal extremities of the head-shield, in the absence of well-marked lateral furrows on the frontal lobe of the glabella, in the less angular frontal margin, and less continuity in the curvature of the outer border of the marginal area with the frontal extremity.

A similarity also exists with *Phacops* (*Trim.*) *micromma*, F. A. Roemer, as interpreted by Dr. Karl Walther (21, p. 317, pl. xv, fig. 6). The German form, however, has well-marked lateral furrows on the frontal lobe of the glabella, and the base of the latter portion is less constricted than in our species. Roemer's figure (15, p. 81, pl. xii, fig. 25) seems very much reconstructed, and is hardly comparable with the British form.

PROETIDÆ.

Zittel (25, pp. 476, 477) divides this family into the genera *Proetus* (Silurian, Devonian, and Carboniferous), *Arethusina* (Silurian and Devonian), *Cyphaspis* (Silurian and Devonian), *Harpides*, *Carmon*, *Cyphoniscus* (Ordovician), and *Phillipsia* (Devonian, Carboniferous, and

Permian), with its subgenera *Griffithides*, *Pseudophillipsia*, *Brachymetopus* (Carboniferous), and *Dechenella* (Devonian). Oehlert (12, p. 127), however, gives a slightly different division of the group. He separates the forms into two sections: Section A, Proetidæ, with glabella tapering anteriorly and including the genera *Proetus*, *Dechenella*, and *Brachymetopus*, together with *Phæton* (Silurian), a subgenus of *Proetus*; Section B, Phillipsidæ, with the glabella widening anteriorly: these include the genera *Phillipsella* (Silurian) and *Phillipsia*, together with *Griffithides* as a subgenus of the latter. In a later note (12, p. 141) Oehlert withdraws the name *Phillipsella* in favour of Novák's *Phillipsinella*, which had priority.

PROETUS DUNHEVIDENSIS, sp. nov. Pl. VII, Fig. 6.

Description.—The general shape is elongate oval, the margins bordering the thorax longitudinally being sub-parallel. The total length is 17·5 mm. approx., the breadth at the centre of the thorax being about 11 mm. In profile there is a sharp rise from the posterior border of the pygidium to the hindmost ring of the thorax, and from this point there is a gentle downward slope to the glabella. The slope forwards along the surface of the glabella is steeper and more like that of the pygidium until the frontal margin is reached, where a somewhat sharper fall towards the marginal border occurs.

The *cephalon* is obtusely parabolic, the breadth being slightly more than twice the length. The anterior margin is regularly convex, while the posterior boundary is slightly concave to the thorax. The genal angles are produced into long, gradually tapering spines, one of which is traceable to the seventh pleuron of the thorax.

The *glabella* is elongate oval, slightly narrowing towards the rounded anterior end. The ratio of the length to the greatest breadth is about 5 : 4. Under strong magnification there is an indication of three faint furrows on either side, two of which occur close together on the margin near the anterior end of the eye, while the other runs inward and backward from a point near the middle of the eye, separating off a small indistinct basal lobe. The occipital furrow is fairly deep and narrow, and bounds a well-marked occipital ring. The latter arches forward in the centre and is slightly rounded, and approximately the same width as the thoracic axial rings. In front of the glabella and continued down to the genal spines on either side is a well-marked apparently flattened border which gradually narrows anteriorly. Owing to lateral compression, which has affected most of the left side of the specimen described, this border is imperfect to the left, but is better preserved and more of the natural width to the right of the glabella.

The *fixed cheeks* are elongated and narrow, with a triangular, roughly equilateral, anterior and a narrower, also triangular, posterior portion. The eye-lobe is comparatively low and not prominent. The *facial sutures* cut the anterior border of the head-shield at a distance from one another slightly greater than the length of the glabella. They run gradually inwards posteriorly from their anterior terminations, then curve outwards round the eye-lobe, and ultimately cut the occipital ring obliquely at a low angle, reaching the posterior margin about half-way between the axial furrows and the base of the genal spine.

The *free cheeks* are triangular, fairly elevated, and slope rather steeply outwards to the marginal border. The bounding marginal and occipital furrows meet at an angle of about 60°. The *eyes* are prominent and sub-crescentic. They are situated on the summit of the free cheeks near the glabella, extending to almost half the length and rising nearly to the height of the glabella. The facets appear to be circular, minute, and very numerous.

The *thorax* is nearly twice the length of the head-shield, and consists of nine segments, with a prominent, elevated, and rounded axis very gradually tapering posteriorly. This axis is about four-thirds the width of the pleural portion. The axial furrows are well marked. The pleura run out at first practically at right angles to the axis, and are then deflected backwards at the fulcrum, situated about two-thirds of the width of the pleural portion from the axis. Each pleuron is divided into two parts by a furrow. The anterior part is deflected backwards gradually at the fulcrum, and overlaps the posterior and less deflected portion near the margin. The state of preservation of some parts of the thorax makes it impossible to give greater details.

The *pygidium* is semicircular and about five-eighths the length of the thorax. The axis is prominent, convex, and rapidly tapers to a blunt extremity. Seven rings can be clearly seen, while one or two practically obsolete ones may also exist. The lateral lobes are too poorly preserved for clear discrimination. The marginal border is very well developed, its width at the posterior extremity being about two-fifths the length of the pygidium. A gradual narrowing of this border takes place towards the anterior terminations, and its surface retains traces of ornamentation by furrows parallel to the margin.

Locality and Horizon.—A single specimen of this trilobite was obtained in the Upper Devonian of South Petherwin, Cornwall, and was collected in an old quarry on the eastern side of the road at Landlake. This exposure seems, according to Mr. Clement Reid, to have yielded all the best of the Petherwin fossils; the quarry has now been filled up with town refuse from Launceston.

Remarks.—The two forms which show most resemblance to this species are *Proetus nevadæ*, Hall (7, p. 219, pl. xxiii, fig. 19), from the lower horizon of the Devonian limestone of Comb's Peak, Eureka District, Nevada, and *Proetus superstes*, Barr. (1, pl. xv, figs. 5–9), from étage H. Compared with the former, our species is less elongated, has a narrower border of the head-shield, possesses much longer genal spines, a less number of thoracic rings, and a considerably broader marginal border and more tapering axis of the pygidium.

Compared with *Proetus superstes*, the Cornish species appears to be more elongated, has a more curved posterior margin of the head-shield, possesses smaller eyes, much longer genal spines, slightly different facial sutures, a more elevated axial region of the thorax and pygidium, and a considerably broader marginal border and blunter axis of the pygidium.

The specific name *dunhevidensis* is derived from Dunhevid, the old British name for Launceston.

PROETUS, sp. *a*. Pl. VII, Fig. 7.

Description.—The elongated *glabella* has a length of 8 mm. and greatest breadth at its base of 5·5 mm. approx. It tapers gradually from the occipital groove to about the middle of its extension anteriorly, where a slight constriction occurs. Thence the tapering continues slowly to the rounded frontal extremity. The bounding furrows enclose an angle of about 19° anteriorly. Three pairs of lateral furrows are plainly discernible. The posterior pair curve backwards, and are continued faintly to the occipital furrow, enclosing two sub-rhomboidal basal lobes. The middle pair also curve slightly backwards, but disappear nearly half the distance to the centre of the glabella. The anterior pair are still shorter. The occipital ring, which is poorly preserved, appears to have been fairly broad and elevated with a narrow occipital groove. The head-shield terminates in a raised rim of low curvature and separated from the frontal extremity of the glabella by a fairly broad concave space. The *facial sutures*, of which the left one is best preserved, cut the margin of the head-shield at a distance from one another nearly equal to the length of the glabella. They proceed backwards and slightly inwards from the frontal margin to about the middle of the glabella, then become deflected in a short curve outwards. The further course cannot be traced in consequence of incomplete preservation. A part of the right cheek is preserved, but is too poor for description.

Locality and Horizon.—This fragment of the head-shield was collected at the same locality and horizon as *Ph.* (*Trim.*) aff. *cryptophthalmus*, *Ph.* (*Trim.*) *tripartitus*, sp. nov., etc.

Remarks.—The glabella has a general resemblance to that of *Proetus dillensis*, Drevermann, from the Upper Devonian Clymenien Kalk of Langenaubach (3, p. 119, pl. xiii, fig. 9). The British form is much larger, and differs also in the possession of the raised anterior rim and a less regularly tapering glabella.

PROETUS, sp. *b*. Pl. VII, Fig. 8.

Description.—This *pygidium* is semicircular in outline, and has a length of about 2·5 mm. and greatest breadth of 4·5 mm. approx. The axis is well marked, elevated, and tapers very gradually to a blunt end posteriorly. About six fairly broad rings can be recognized. The pleura, of which six can be seen, curve very gradually outwards and backwards from the prominent groove bounding the axis. They broaden slightly in their course to the marginal border, and are divided into two well-marked portions by a narrow furrow. The two parts appear to diverge slightly from each other as they approach the margin. A well-developed flattened border is present, and is as wide as the posterior end of the axis.

Locality and Horizon.—The same as the preceding form.

Remarks.—A certain resemblance exists with the figures of young specimens of *Proetus superstes*, Barr., from étage G (2, pl. xvi, figs. 4, 5). The axis of the latter is more tapering and the marginal border is narrower.

The above described form is probably new, but it seems inadvisable to describe it as such without specimens of the head region.

PROETUS, sp. *c*. Pl. VII, Fig. 9.

Description.—The general outline of the *pygidium* is semicircular, and has a length of about 5 mm. and greatest breadth of about 10 mm. The broadly convex axis has ten rings, and tapers very quickly from the anterior portion, where the width is nearly as great as the whole length of the axis. The flattened pleura curve slightly backwards and number at least ten. Some of the better preserved parts show indications of a subdivision of each pleuron into two portions by a narrow furrow. The marginal border is very narrow, but well defined.

Locality and Horizon.—As the preceding form.

Remarks.—Compared with *Proetus*, sp. *b*, the axis of the latter is less tapering, the segments both in the axis and pleural region are fewer, and the marginal border is much broader.

DECHENELLA USSHERI, sp. nov. Pl. VII, Fig. 10.

Description.—The *cephalon* is almost semicircular, and possesses a narrow, flattened marginal border. The straight posterior margin forms the greatest breadth, and measures approximately 6·5 mm., while the greatest length of the head-shield is about 4 mm. An angle of nearly 70° is enclosed by the genal extremity, which is not produced into a spine.

The prominent, roughly triangular, and fairly tumid *glabella* is well demarcated, and tapers considerably towards the rounded frontal margin. The angle formed by the bounding dorsal grooves anteriorly = 41° approx. Three well-marked pairs of lateral furrows are present, the anterior pair being the shortest and of least depth, while the posterior furrows are very deep and run in a low curve to the occipital groove. In this manner two tumid, triangularly shaped lobes are separated off at the posterior portion. The occipital ring is only partly preserved, but appears to have been fairly prominent and narrow.

The *facial sutures* cut the anterior border at a distance of nearly 3 mm. apart. They run gradually outwards from this point of intersection, then curve inwards posteriorly to within a short distance of the glabella, and after a slightly curved course turn outwards rather sharply, reaching the posterior margin at a low angle about two-thirds of the distance between the base of the glabella and the genal angle. The *eyes* are not preserved.

The *cheek-areas* are elevated to almost the height of the glabella, and gradually slope outwards to a flattened region adjacent to the marginal border.

Locality and Horizon.—The same as *Phacops* (*Trim.*) *tripartitus*, sp. nov., etc.

Remarks.—The name *Dechenella* was first employed by Professor Kayser (11, p. 703) for those members of the Proetidæ with very tapering and strongly lobed glabella.

The glabella of our form shows a certain resemblance to that of *Dechenella verneuili* (Barr.), as interpreted by Professor Kayser (11, p. 705, pl. xxvii, figs. 1–5). In most other respects the two forms differ considerably. Thus the British specimen has no genal spine, the general outline is semicircular and not parabolic, the cheeks do not show a sudden elevation, the facial sutures have a different course, while the posterior margin of the head-shield is straighter and the marginal border is narrower.

Compared with *Dechenella haldemanni* (Hall) (8, pl. xxi, figs. 7–9; 7, pl. xxi, figs. 7–9, pl. xxiii, figs. 13–15), from the Hamilton Beds of North America, *D. ussheri* differs, among other respects, in the more gradual tapering of the glabella, in the different course of the facial sutures, the greater breadth compared with the length, the greater prominence of the posterior pair of lateral furrows, and differently shaped basal lobes.

It differs from *Dechenella rittbergensis*, Zimmermann (24, p. 119, pl. i, fig. 4), of which only a part of the head-shield is described, in the longer and slenderer character of the glabella, as well as the different arrangement and prominence of the lateral furrows.

The glabella of *Dechenella romanovski*, Tschernyschew (19, p. 167, pl. i, figs. 4–8), is considerably broader compared with its length than that of our form.

The only other *Dechenella* described from British deposits is *D. setosa*, Whidborne (22, p. 27, pl. ii, fig. 15). *D. ussheri* has a broader head-shield relatively to the length, a straighter posterior margin, a slenderer glabella with more prominent posterior lateral furrows, and, finally, different facial sutures.

Phillipsia minor, H. Woodward, 1884. Pl. VII, Fig. 11.

1884. *Phillipsia minor*, H. Woodward. A Monogr. of the British Carbonif. Trilobites: Palæontogr. Soc., p. 68, pl. x, figs. 5, 6*a*, *b*, 7, 8*a*.

1895. ,, ,, H. Woodward, in Hinde & Fox. "On a well-marked Horizon of Radiolarian Rocks in the Lower Culm Measures of Devon, etc.": Quart. Journ. Geol. Soc., vol. li, p. 646, pl. xxviii, fig. 2.

Description.—A somewhat abraded *pygidium*, measures about 4 mm. in length and approximately 4·5 mm. in greatest breadth, and has a general parabolic contour. The rounded and elevated axis tapers fairly rapidly, and reaches a distance of 0·9 mm. from the posterior margin. Owing to the abrasion only twelve segments can be seen. The ten prominent lateral pleura are separated from the axial region by a strong furrow, and curve slightly backwards towards the lateral margins, where they bifurcate. The broad marginal border narrows gradually anteriorly, and is ornamented by grooves parallel with the outer margin.

Locality and Horizon.—This specimen was obtained in the Culm beds of Hestow Farm, near Ideford, Devonshire.

Remarks.—*Phillipsia minor* has been described by Dr. Woodward from the Lower Culm of Waddon Barton (23, p. 68, pl. x, figs. 5, 6*a*, *b*, 7, 8*a*), and Hannaford Quarry, near Barnstaple (8*a*, p. 646, pl. xxviii, fig. 2).

Phillipsia cf. minor, H. Woodward. Pl. VII, Figs. 12, 13.

Description.—The *cephalon* is parabolic in contour, and possesses a roughly oval-shaped tumid *glabella*, with sub-parallel lateral borders and rounded anterior margin. Two well-marked basal lobes are present, and minute tubercles adorn the surface especially near the base. A pre-ocular pore is seen on the left margin near the frontal border. The well-developed marginal border of the head-shield is ornamented with narrow, curved furrows approximating in direction to that of the outer margin, while the genal extremity is produced into a prominent, slightly curved spine. The *eyes* are not preserved.

A portion of the *thorax* is present, and shows four rings of the rounded and elevated axis, which is bounded by well-marked furrows and is approximately equal in width to the lateral pleural area. The broad pleura are grooved down the centre and curve slightly backwards. Numerous minute tubercles ornament the whole surface.

The *pygidium* is 4 mm. long and about 5 mm. broad, and has a convex, very gradually tapering axis with about thirteen segments. The lateral pleural area is tumid and possesses at least eight segments, which curve very slightly backwards. Indications of a faint marginal bifurcation are present in some of the rings. Both axis and pleural areas are adorned with minute tubercles. The fairly broad marginal border narrows slightly anteriorly, and is apparently without distinct ornamentation. Its extreme posterior extremity is somewhat angular.

Locality and Horizon.—The same as the preceding.

Remarks.—The preservation of the head-shield is imperfect, but judging from the parts of that region in good condition it could well be assigned to *Phillipsia minor*. Examination of the pygidium, which by its proximity and position in the hand-specimen undoubtedly belongs to the head, shows, however, that this determination would be doubtful. The pygidial axis of *Ph. minor* is considerably more tapering, while the marginal border of the same species is much more curved than in our form.

Phillipsia sp. Pl. VII, Fig. 14.

Description.—A fairly well-preserved cast of a head fragment shows an elongated tumid *glabella* with sub-parallel lateral borders and a very rounded anterior extremity. The length of the glabella is 5·5 mm., and its greatest breadth 3 mm. The triangular basal lobes are well marked and bounded by a strong pair of lateral furrows. A second pair of furrows occur anteriorly to the latter. These are directed inwards and backwards, and gradually become shallower as they approach one another posteriorly. In this manner a second pair of elongated lobes are marked off and a V-shaped sculpture given to the glabella. Anteriorly to the second pair of furrows, and about half-way between them and the frontal extremity, is a small marginal pitting on either side corresponding to the pre-ocular pores. The frontal lobe is separated from the raised anterior termination of the head-shield by a shallow depression. The facial sutures cut the curved frontal border of the shield at a distance of about 6·5 mm. apart. They run at first slightly outwards, then turn backwards and inwards, and are again deflected slightly outwards at a short distance from the second pair of glabella lobes. From this point they curve inwards and backwards near the basal lobe, finally running in a shallow curve outwards and backwards, and cutting the occipital ring at a low angle. The occipital ring is elevated and convex, and separated from the glabella by a deep furrow.

Locality and Horizon.—Same as the preceding.

Remarks.—This form appears to be quite distinct from any other known *Phillipsia* in the character of the second pair of glabella lobes. With more material it may have to be described as a new species.

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EXPLANATION OF PLATE VII.

Fig.

1. *Phacops* (*Trimerocephalus*) *anophthalmus*, Frech. Anterior margin slightly water-worn. Natural size. Daymer Bay. [23430.]
2. *Phacops* (*Trimerocephalus*) aff. *cryptophthalmus*, Emmr. (Gümbel's interpretation). × 3. Whiteway Farm. [22884.]
3. Enlarged view of the eye of the same. × 8.
4. *Phacops* (*Trimerocephalus*) *tripartitus*, sp. nov. × 3. Whiteway Farm. [22884.]
5. The same, somewhat compressed laterally. × 3. Whiteway Farm. [23431.]
6. *Proetus dunhevidensis*, sp. nov. × 2. Old quarry near Landlake, South Petherwin. Original is in the Southgate Museum, Launceston.
7. *Proetus*, sp. *a*. × 2. Whiteway Farm. [23432.]
8. *Proetus*, sp. *b*. × 3. Whiteway Farm. [22884.]
9. *Proetus*, sp. *c*. × 2. Whiteway Farm. [23433.]
10. *Dechenella ussheri*, sp. nov. × 3. Whiteway Farm. [22884.]
11. *Phillipsia minor*, H. Woodward. × 3. Hestow Farm. [23434.]
12. *Phillipsia* cf. *minor*, H. Woodward. × 3. Showing the glabella and ornamented border of head-shield. Hestow Farm. [23435.]
13. The same. × 2. Showing the pygidium and drawn from a wax cast of an impression. [23434.]
14. *Phillipsia* sp. × 2. Showing the well-sculptured glabella. Hestow Farm. [23436.]

The originals, unless otherwise stated, are in the Geological Survey Collection. The register numbers are given in brackets.

II.—Some Remarks on the Mechanics of Overthrusts.

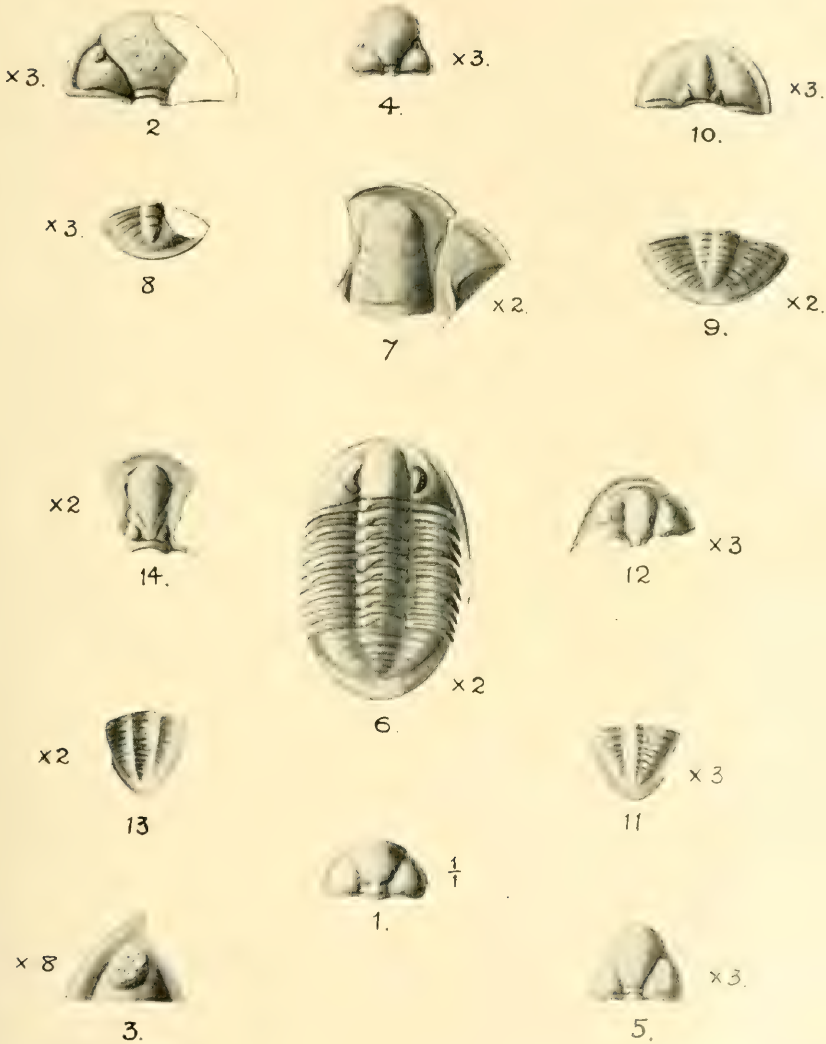
By M. S. Smoluchowski, Ph.D., LL.D., Professor of Physics at the University of Lemberg, Austria.

Mr. T. MELLARD READE evidently wished to elicit, by his note on the mechanics of overthrusts in the Geological Magazine, 1908, p. 518, a discussion on these phenomena, as he also tells us in the February Number, 1909, p. 75. May I be allowed, therefore, to contribute some remarks on his paper?

It is easy enough to calculate the force required to put a block of stone in sliding motion on a plane bed, even if its length and breadth be 100 miles, and I do not think Mr. Mellard Reade meant to use the word 'incalculable' in a literal sense. However great this force may be, it certainly will be easy to mention instances of still greater terrestrial or cosmic forces. Still, I think Mr. Mellard Reade might dispute the analogy with the piling up of the Rev. O. Fisher's broken ice-sheets, and he could defend his statement "that no force applied in any of the mechanical ways known to us in Nature would move such a mass".[1]

Let us indicate the length, breadth, and height of the block by a, b, c, its weight per unit volume by w, the coefficient of sliding friction by e; then, according to well-known physical laws, a force a, b, c, w, e will be necessary to overcome the friction and to put the block into motion. Now, the pressure exerted by this force would be distributed over the cross-section a, c; hence the pressure on unit area will be equal to the weight of a column of a height b, e. Putting $e = 0{\cdot}15$ (friction of iron on iron), $b = 100$ miles, we get a height of 15 miles, while the breaking stress of granite corresponds to a height of only about 2 miles. Thus we may press the block with whatever force we like;

[1] T. Mellard Reade, Geol. Mag., November, 1908, p. 518.



H. H. Thomas del.

Trilobites from Devon and Cornwall.

we may eventually crush it, but we cannot succeed in moving it. The conclusion is quite striking, and so far we cannot but agree with Mr. Reade's opinion.

But are we entitled, therefore, to condemn the theory of the Alpine overthrusts? I think the comparison is not quite fair. First, it may be remarked, the bed may not be horizontal but inclined; in this case the component of gravity is sufficient, at an inclination of 1 : 6·5, to put the block in sliding motion, and we need not apply any external pressure at all. And what seems still more important, nobody ever will explain Alpine overthrusts in any other way than as a phenomenon of rock-plasticity. Suppose a layer of plastic material, say pitch, interposed between the block and the underlying bed; or suppose the bed to be composed of such material: then the law of viscous liquid friction will come into play, instead of the friction of solids; therefore any force, however small, will succeed in moving the block. Its velocity may be small if the plasticity is small, but in geology we have plenty of time; there is no hurry.

Some features of these phenomena have been beautifully illustrated by Professor Sollas' pitch-experiments. Pitch is not the same as rock undoubtedly, a point which Professor Bonney lays much stress upon in the August Number, 1907, of the Quart. Journ. Geol. Soc., but, on the other side, let us realize the difference between two months (required for Professor Sollas' experiments) and hundreds of thousands or millions of years which must be allowed for the analogous process in the Alps. The analogy shows mountain-building to be a very slow, gradual process, in virtue of the smallness of plasticity, but it would be in the main a continuous process, and I do not think we are forced to assume its discontinuity, as Mr. Mellard Reade seems inclined to do.

The plasticity of rocks in greater depths is to be explained partly by elevation of temperature, partly by pressure. But whatever explanation we accept, there are too many evidences to deny the fact.

In conclusion, we must say Mr. Mellard Reade's paper is very instructive; indeed, it helps us to see, by contrast with the author's ideal example, what are the most essential features of the process as displayed in Nature.

III.—A Crinoid (*Tetracrinus* [?] *felix*, n.sp.) from the Red Crag.

By F. A. Bather, M.A., D.Sc., F.G.S., etc.

(PLATE VIII.)

Mr. P. G. H. BOSWELL, F.G.S., has kindly submitted to me a crinoid fragment found by him on August 20, 1908, in the Red Crag of Felixstowe cliffs, Suffolk. Although the specimen is somewhat obscure, it is of sufficient interest to warrant a brief note.

"The exact position of the place," writes Mr. Boswell, "was half-a-mile east of Felixstowe Church (Newbournian Zone of Red Crag). In the course of eight years' acquaintance with the Crags, having sifted for three years, I have not met with any other specimen of a crinoid, but Mr. F. W. Harmer, F.G.S., tells me he has met with several worn specimens of *Pentacrinus* during his Oakley (Waltonian Zone, Red Crag) sifting. These he believes to be derivative in the Crag. I agree with him and with Dr. Bather in thinking this new specimen to be probably derivative also."

In all British Tertiary rocks crinoids are rare, some four or five species being known from the London Clay, but none from any of the later rocks. The Red Crag is one of the last formations in which one would expect to find a stalked crinoid, but it is of course probable that the fossil is derived from some older rock. The specimen is further interesting from the fact that it does not appear to agree with the remains of any species (one might almost say any genus) hitherto described, whether from rocks of corresponding Middle Pliocene age in other parts of the world, from Tertiary rocks in general, or from those Cretaceous rocks whence it may have been derived.

The fossil, which at first sight looks like a single columnal, appears on closer examination to comprise remains of the cup. Unfortunately its upper half is somewhat worn; the sides also are disfigured, both in the upper and lower half, by a few pittings, probably due to some boring organism; and the whole is covered with the glaze or patina so common in Red Crag fossils.

The shape is roughly that of a squat, swollen barrel, the upper and lower ends being approximately circular, though not quite parallel. The greatest height is 5·5 mm.; greatest equatorial diameter, 6·9 mm.; least equatorial diameter, 6·75 mm.; diameter of the articular face at the lower end, about 4·4 mm. The upper half is separated from the lower by a slight step (not a distinct ridge) approximately corresponding with the equator, but with five slight equal curves, concave towards the worn face. Apart from this feature, which may be largely the result of weathering, the curvature of the sides is equable and their surface is smooth, except for some almost imperceptible traces of pustules, more visible on the less worn half.

More obvious pustules surround the articular face of the lower half, and seem to form an obscurely pentagonal border, having the angles of the pentagon corresponding with the cusps between the curves of the step already mentioned. The pustules are unequal in size, and the larger ones tend to be situate at the angles, an arrangement that enhances the pentagonal appearance. Within this border the articular face is concave, rising again slightly towards the centre so as to form a faint swelling round the axial canal. This canal has so irregular an outline that one cannot say whether it was slightly pentagonal, or elliptical, or merely circular. In any case there is no trace of a fulcral ridge. The greatest diameter of the axial canal is, very roughly, about 1 mm. (Fig. 3).

The five curves of the equatorial step or rebate were intensified by iron staining, but on washing this away, there became visible traces of sutures following the curves. These were more clearly seen with the aid of glycerine and alcohol, and traces of vertical sutures could also be detected rising upwards from the cusps. These sutures are very difficult to see, but they are enough to show that the upper half of this fossil consists of five elements, and this affords the only rational explanation of the peculiar weathering. These elements must have been closely anchylosed to one another and to the lower undivided half of the fossil (Fig. 2).

The upper face of the fossil, so far as its worn condition enables one to judge, is flat towards the margin, but slightly excavate towards the centre, not so excavate as the lower end. The actual centre is occupied by an axial canal, the borders of which appear to bear some radiating grooves; but these and the other markings of this face are so obscure that it is safer to attempt no description. If vertical lines be drawn upwards from the cusps, in the position of the traces of the vertical sutures, those lines seem in three or four cases to end in slight pustules or elevations. At the boundary of this face there are, however, three or four larger prominences, each coinciding with the middle of one of the five elements (Fig. 1).

The structures described have now to be interpreted. The five elements of the upper half cannot well be anything but basals or radials. That they are radials seems to result from the following considerations. Had they been basals, they would have shown some traces of a hexagonal outline, whereas they are pentagonal with flattened upper surfaces. Their size is more consistent with their being radials, since there is a tendency to the reduction of basals in all crinoids of Tertiary and later age.

If we accept the five upper elements as radials, we have to enquire what has happened to the basals. Are they fused into the single element forming the lower half of the fossil, or have they been overgrown by the radials and included in the interior of the cup, or have they possibly atrophied out of existence? I am inclined to adopt the first of these three explanations. The question may be put in another way: is the lower half of the fossil a proximale (i.e. a persistent top columnal), or is it a fused basal circlet? Now a proximale, while it has a modified upper face, for the reception of the elements it supports, generally has a lower face like the articular faces of the succeeding columnals. In the present instance those columnals are not known to us; but we do know enough about crinoids in general to be aware that a joint-face with a smooth regular concavity rarely has a pentagonal border of pustules. This pentagonal border is more readily explained as the last trace of the original pentamerism of the fused basal circlet.

Taking then, as a working hypothesis, the view that this fossil consists of a fused basal circlet supporting five closely united radials, we have to consider its systematic position.

Of the six families of recent crinoids recognized in the *Treatise on Zoology* (vol. iii, London, 1900), the Pentacrinidæ may at once be set aside by reason of their stem-articulation.

The Bourgueticrinidæ occasionally have columnals that recall the massive appearance and outline of this fossil; but in such forms the joint-face of the proximal columnals always has a distinct fulcral ridge, and the basals are distinct. The Upper Cretaceous *Mesocrinus* might otherwise have been thought to show some resemblance. *Rhizocrinus*, which still lives in the North Atlantic, is the only genus of the family recorded from Tertiary rocks, but bears no great likeness to this fossil.

The Holopodidæ, with their ancestors the Eugeniacrinidæ, have a similar massive structure, but had at an earlier period proceeded further in the union of the radials and inclusion of the basals within them.

The Apiocrinidæ, which are represented in modern seas by *Calamocrinus* of the Central Pacific, and in the Cretaceous of Europe by *Acrochordocrinus*, might possibly receive this fossil; but the joint-faces of the columnals are marked by radiating striæ or by tubercles, and there is no known genus that shows any close resemblance.

The Bathycrinidæ include only the deep-sea form *Bathycrinus*, a genus which in its possession of a fused basal circlet, followed by discoidal columnals, might seem fitted to receive our fossil. In this genus, however, the radials are very easily separated from the base.

The Hyocrinidæ are also deep-sea forms, namely, *Hyocrinus*, *Gephyrocrinus*, and probably *Ptilocrinus*. No fossil representatives are yet known, but I agree with Professor Jaekel that they are probably descended from the Plicatocrinidæ of Jurassic age. It is somewhere in this series that I incline to place our fossil. In the Plicatocrinidæ and in *Gephyrocrinus* and *Ptilocrinus* the basals are fused. The last two genera have the slender habit characteristic of deep-sea crinoids, but among the Plicatocrinidæ *Tetracrinus* has the massive habit found in crinoids that occupy a more exposed position—the reef-type of Jaekel. The pustular ornament and doliform shape of our specimen are very reminiscent of *Tetracrinus*. Remains of the ornament are seen in *Gephyrocrinus Grimaldii*, Koehler & Bather (1902, figs. 1, 2), as a ring of a dozen small conical tubercles at the proximal margin of the base, projecting beyond the joint-face. Slighter traces are also found in *Ptilocrinus antarcticus*, Bather (1908). In *Gephyrocrinus* and *Tetracrinus* the joint-face of the columnals is plane, with slight radiating grooves at the periphery; where new columnals are arising, as next the base, the adjacent joint-faces would naturally be more concave.

On the whole, then, I would suggest that this Red Crag fossil represents the patina (RR and BB) of a shallow-water Crinoid, connecting the Plicatocrinidæ with the Hyocrinidæ. It does not quite agree with any of the known genera, and in the absence of further evidence it is hard to say which of them is most closely allied. Among living forms it is perhaps nearest to *Gephyrocrinus*, but it would be absurd to suppose that it had the peculiar character of the subvective grooves that distinguish that genus, since that character is clearly connected with the deep-sea habitat. On the other hand, it is probably a long way from *Tetracrinus* in the geological scale, and its superficial resemblance is largely due no doubt to similarity of habitat. Very likely it represents an undescribed genus; but I cannot bring myself to base a new generic division and name on so obscure a specimen. Let it be enough for the present to establish a new species, which may provisionally, and as a mere matter of convenience, be referred to *Tetracrinus*.

Tetracrinus (?) *felix*, n.sp.

Diagnosis. — A *Tetracrinus* (?) with doliform patina; RR closely united to each other and to the basal circlet; proximal border of base

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TETRACRINUS (?) FELIX, sp. nov.

projecting beyond stem-facet and ornamented with small pustules forming a pentagon; traces of similar ornament on RR, especially a perradial prominence at the distal border of each.

Holotype.—The unique specimen collected by Mr. P. G. H. Boswell.

Horizon.—Newbournian zone of Red Crag (Middle Pliocene), probably derived.

Locality.—Felixstowe, Suffolk.

EXPLANATION OF PLATE VIII.

Fig. 1.—View of the holotype from above.
,, 2.—Side view of the holotype.
,, 3.—View of the holotype from below, showing stem-faces.

All figures are enlarged six diameters, and in each the right and left sides remain in the same position with regard to the beholder. Drawn by Mr. A. H. Searle.

Postscript.

Mr. F. W. Harmer, F.G.S., has kindly sent me five other fragments collected by him in the Red Crag, and presumed to be of crinoid origin.

One of these is shaped like the tapering end of a belemnite, and I can detect in it no crinoid structure. The outer crust is silica in the form of beekite; the interior, exposed at the broad, broken end, is ferruginous (? limonite) with traces of calcite.

Another is a cylindrical fragment, 6·2 by 4·8 mm., much worn, with a beekite crust, and traces of radiate striæ in the interior. If echinodermal, it might be the proximal end of an echinoid radiole or part of a crinoid stem.

Two specimens are certainly parts of Pentacrinid stems. One is 30·9 by about 5 mm., rather less in diameter at one end and swelling suddenly to a maximum of 6 mm. at the other end, which is rounded. The joint-face is not preserved; the side-faces are smooth; on the sutures are slight indentations, radial in position. This orientation is proved by the weathering of the thinner end of the fragment, where the interradial ligamentar areas have been eaten into owing to their less density. There is no trace of a cirriferous nodal. There can be scarcely any doubt that this is part of the stem of *Balanocrinus subbasaltiformis*,[1] and that it has been derived from the London Clay. The other Pentacrinid stem-fragment probably belongs to the same species; it is rounded off rather acutely at one end; at the other is an apparent hypozygal with slight traces of the markings on the joint-face. The substance of these specimens is apparently limonite, probably altered from a previous pyritized stage.

The remaining fragment is cylindrical, 11·8 mm. long, 5·3 mm. in diameter at one end, tapering to 4·6 mm. at the other end, which is more worn. The outer surface of the side-faces has been altered by partial change into beekite, so that no sutures are visible. The joint-face at the wider end is obscure, but shows some straight striæ radiating from the lumen; here are still traces of calcite. The narrower end is eaten into, and the lumen widened; this enables one to see that the fragment is composed of thin columnals, about ·5 mm.

[1] *Pentacrinus subbasaltiformis*, J. de C. Sowerby, *ex* J. S. Miller nom. nud., in N. T. Wetherell, 1840.

high, with a radiate micro-structure, and a radiately striate joint-face producing finely crenulate sutures.

I am not acquainted with any similar stem from either the Chalk or the Lower Tertiaries; but that crinoids having such a stem must have existed during those periods is rendered highly probable by the fact that this is a usual form of stem in the Jurassic Apiocrinidæ, and that we still find it in their modern representative *Calamocrinus* as well as in the Hyocrinidæ. The discovery of this fragment, imperfect though it be, leads one to expect that the missing links will ultimately be found in their correct stratigraphical position.

It is not probable that any of these crinoid fragments, the results of Mr. Harmer's long years of collecting, are related to *Tetracrinus felix*. Their sole importance in this connection lies in their bearing on the age of the derived crinoid fragments found in the Red Crag. The only direct evidence is that of *Balanocrinus subbasaltiformis*, which is common in the London Clay, and probably had a wide range, since a variety of it (var. *Pratti*) is common at Biarritz. Specimens in the British Museum [75,838] were found at Harwich. In the London Clay the substance of this fossil, as of the other echinoderms, is generally changed into iron pyrites or marcasite; and this is consistent with the present condition of Mr. Harmer's Red Crag specimens. They, however, differ in this respect from Mr. Harmer's other specimens, which agree among themselves in having a beekite crust. The silicification no doubt took place before they were redeposited in the Crag, and, taken in conjunction with the possible belemnite nature of one, it suggests the Upper Chalk as their parent rock. However this may be, no inference can be drawn as regards *Tetracrinus felix*, which retains its original calcite composition, pure and unsilicified.

IV.—Extinct Marsupials of Western Australia.

By Bernard H. Woodward, F.G.S., C.M.Z.S., Director of the Western Australian Museum.

BEFORE the beginning of this year the only records of the occurrence of fossil marsupials in Western Australia consisted of the account of the discovery of Diprotodon bones in the Kimberley district by Mr. E. T. Hardman, the Government Geologist, in 1882, and the finding of a lower jaw of this animal in 1895 in a gully near Lake Darlot in the Eastern Goldfields by Mr. Arthur, who presented it to this Institution. This jaw was so much weathered that it was valueless except for the fact of its establishing the existence of that marsupial so far inland. The Museum Committee sent an expedition to Lake Darlot in 1898, and in 1908 the Hon. Dr. Hackett sent out at his own cost Mr. Young, who was with Mr. Arthur when he found the jaw in 1895. Both these parties were unsuccessful.

In February, 1909, Mr. John Sharp, of Balladonia, Point Malcolm, on the south coast, sent to the museum a number of bones and a few teeth of *Diprotodon australis* that he had unearthed when excavating for water in a marsh on his station. These specimens are much weathered. Mr. Sharp has kindly promised to send further specimens next summer, as excavation cannot be carried on during the winter owing to the boggy nature of the ground. It may help to explain the difficulty of conducting research in this vast country when it is stated that it took more than three months for the bones to reach the museum after they were sent from Balladonia by waggon to catch the steamer at Esperance for Fremantle, thence to be conveyed by rail to Perth. Except in the closely settled districts the means of travel are difficult, slow, and costly.

The most interesting discoveries, however, are those made by Mr. Glauert during the past two months, which have resulted in the collection of about 2,000 bones and fragments of bones in the Mammoth Cave, Margaret River, about 200 miles south of Perth. These include *Diprotodon*, a new species of *Sthenurus*, and probably *Nototherium* and *Phascolonus*, associated with many specimens of wallabies still living, e.g. *Macropus brachyurus*, etc.

This proves that *Diprotodon* can only have become extinct in quite recent times.

The Mammoth Cave is one of the numerous beautiful stalactitic caves occurring in the Coastal Limestone, a group of shelly limestones and sandstones of Pleistocene age, which is found all along the western coast from Cape Leeuwin in the south-west to North-West Cape. The limestone extends in width from a few miles to 30 or 35 miles. Many of the caves which occur along this belt have been opened to the public under the management of the Caves Board. In 1904 Mr. T. Connolly, the caretaker, in cutting a pathway in the Mammoth Cave under the direction of Mr. Edgar Robinson, the superintendent of the caves, came across some fossil bones and called the attention of a visitor to them. This gentleman retained the bones for five years without publishing any description of them, and then handed them back to the Caves Board, who placed them in Mr. Glauert's hands for examination. He determined them to be a new species of *Sthenurus*, which he proposes to name *S. occidentalis*.

As long ago as August, 1905, the writer was invited by the Hon. Dr. Hackett, the chairman of the Caves Board, to accompany him to the Margaret River Caves in order to select sites for exploration, and it is at the spot then selected as the most promising that this large number of bones were found. After a lapse of three and a half years the Museum Committee were so fortunate as to secure the services of Mr. Ludwig Glauert, F.G.S., the palæontologist to the Geological Survey.

A full account of these remains shall be forwarded as soon as they are classified.

A few words with regard to the living marsupials of Western Australia may be of interest, as during my residence of nearly twenty years in this State I have succeeded in obtaining several new species, raising the number known to fifty-two, but during this period many of these forms have become nearly, if not altogether, extinct. Everywhere with the advent of civilization the indigenous fauna disappears.

Our Natural History Society induced the Government in 1894 to set aside a reserve for the preservation of the indigenous fauna and flora, containing some 25 square miles in the Darling Ranges, but this was cancelled early last year. However, Barrow Island was gazetted for this purpose in November last. It is situated about 60 miles off the north-west coast, and is about 14 miles in length with an average width of 4 miles. It is the home of four species of mammals and one bird (*Malurus edouardi*) not found on the mainland. Bernier and Dorre Islands on the north-west coast are doomed now that the Government has set aside those islands as hospitals for sick aboriginals. Vigorous efforts are being made to induce our Government to follow the enlightened policy of that of the U.S.A., otherwise the majority of the marsupials will soon become as extinct as the dodo and great auk.

V.—The Constitution of the Igneous Rocks.

By F. P. Mennell, F.G.S.

In a paper read at the 1903 meeting of the British Association and afterwards published in this Magazine,[1] the method of calculating the chemical constitution of the igneous rocks by the collation of analyses was criticized, and the results were compared with those based on actual field-work in an area where such rocks were very abundant. Mr. F. W. Clarke, whose results and those of Mr. Harker[2] had interested me in the problem, has recently published a fresh calculation of the results of the rock analyses made in the Laboratory of the United States Geological Survey. It is not proposed to discuss these results in detail, and it will suffice for my present purpose to take the question of silica percentage alone. Mr. Clarke's average for all the 1,358 rocks analyzed up to the end of 1903 works out at 60·91.[3] Mr. Clarke, however, admits that the 'salic' rocks are more abundant than the other classes,[4] and he further grants that my criticism of his previous results is entitled to some weight, though he thinks that a wider range of observation would probably modify my opinion that granite is practically the average igneous rock.

I have already insisted on the fact that to obtain trustworthy data calculations must be based on areas where plutonic rocks are abundantly exposed. It is absurd, for example, to give flows of basalt covering the surface to a limited depth the same weight in our estimates as granite masses which extend indefinitely downward. Yet this is the result to which the collation of analyses leads us. Indeed, it goes much further, for the composition of the great granite masses is so readily ascertained upon mere inspection of microscope sections, or even of hand-specimens, that they are rarely analyzed at all unless they show exceptional features. And in getting at reliable averages it is just these exceptional features that we must avoid. It is easy to

[1] Geol. Mag., 1904, Dec. V, Vol. I, pp. 263–4.
[2] Geol. Mag., 1899, Dec. IV, Vol. VI, pp. 220–2.
[3] Data of Geo. Chemistry, Bull. 330, U.S. Geol. Surv., 1908, p. 26.
[4] Loc. cit., p. 25.

show how largely exceptional types are represented by analytical data among rocks of all classes. No one is likely to dispute the enormous preponderance of felspathic rocks over those containing the so-called felspathoids, yet if we were to measure their abundance by the number of analyses that have been made we should arrive at a very different conclusion. But this is precisely the method we are asked to accept as correct. I do not know what would be thought of a mining engineer who took all his samples of a gold reef from the points where he thought it likely he would get exceptional results, and then calculated the average value on such a basis, especially if he left out of account the widths which his samples represented!

In my former paper I only gave the data from a very limited area mapped in Rhodesia, and though this is representative of the conditions throughout the whole country, it may be well to give the results arrived at from the mapping of an area ten times as great in central Matabeleland. Of 20,000 square miles, approximately 2,340 are sandstone, 5,700 Archæan schists, etc., and 11,960 granite and other igneous rocks. These last comprise portions of a number of plutonic masses, among which are two developments of syenite with about 63 per cent. of silica, covering some 40 square miles. There is also an important intrusion of a pyroxenic rock, which may be regarded as largely picrite and as containing on an average 45 per cent. of silica. It is probably a gently inclined sheet injected along a thrust plane, and its outcrop is much wider therefore than its true thickness. I have, however, taken the apparent width as the real one in order not to unduly favour my argument. Nearly all the rest of the igneous area is granite, with an average silica percentage of at least 70. It must not be thought that there are few basic rocks; on the contrary, they are well represented by dolerite dykes, basalt flows, etc. We shall nevertheless be making a generous allowance for them if we suppose there are 10,000 dykes a mile long and 5 feet thick, and 100 square miles of basalt 20 feet thick. We may further assume that they contain about 50 per cent. of silica. The volume of the dolerites may be subtracted from that of the granites, in which they are commonly intrusive. The basalts are intercalated among the sandstones that have been referred to.

Not to make too great an assumption regarding what may happen at a depth, we will suppose that each dyke and plutonic mass has vertical boundaries (though we have evidence that the latter class tends to spread out and encroach on the schists below the surface). We may then calculate the bulk of the various classes down to sea-level (i.e., nearly 5,000 feet, or, say, roughly, 1 mile) as follows:—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite	70	11,670	1 mile	11,670
Syenite	63	40	,,	240
Picrite, etc.	45	240	,,	40
Dolerite, etc.	50	nearly 10	,,	10
Basalt	50	100	20 feet	
			Total	11,960

To obtain a true average we now multiply each silica percentage by the volume of the rock represented, the products being added up and divided by the total volume. The result is a silica percentage of 69·45 for the whole. Whatever composition is assigned to the granites, their percentage will, in fact, be very near the general average, which, it will be noticed, is much higher than Clarke's figure. Granite, indeed, as previously pointed out, is not one extreme of the igneous series, but is substantially the average igneous rock.

In order not to lay too much stress on observations made in a single area, I have made similar calculations with regard to others of which I happen to have reliable data. England would evidently give very much the same result, but I do not possess a map which discriminates between the various classes of igneous rock with sufficient accuracy.

There are, however, no large masses of basic rock to set off against the granites of Cornwall, Devonshire, Cumberland, and Leicestershire. The Scottish Highlands would be an excellent area from which to draw conclusions, and it is evident that the granite masses are numerous and large as compared with other classes. My own native colony of Victoria (Australia) is perhaps not altogether typical, as the exposures of igneous rocks are much smaller than those of the sediments, and the southern portion is largely covered by flows of tertiary basalt. However, taking an area of twenty thousand square miles north of latitude 37°, i.e. between Maldon, Mansfield, and Omeo and the New South Wales border, the following rough estimate may be made regarding the 2,810 square miles of igneous rocks exposed:—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite . . .	70	2,440	1 mile	2,440
Basalt . . .	50	100	250 feet	5
Other classes	55	270	1 mile	270
			Total	2,715

In this case the silica percentage works out at 68·4. Canada is a country where the great development of igneous rocks makes the results as interesting as in the case of Tropical Africa, and I have therefore roughly worked out the data afforded by the West Kootenay (British Columbia) sheet of the Canadian Geological Survey map. Its southern boundary is the United States border, while to the north I have stopped a few miles short of the margin of the sheet at 50° N. lat. in order to avoid inconvenient calculations. The area dealt with is in round figures 5,500 square miles, of which about 4,260 show igneous rocks. Among the rocks mapped as metamorphic there are granites, but they are not coloured separately, and are therefore left out of calculation. Of the others there are three types of granite which may be grouped together as averaging 70 per cent. of silica all through. There are also three series of volcanic rocks which appear from the descriptive notes appended to the map to be in each case mainly andesitic in character. There are also exposures of serpentine, and of a 'monzonite' stated to be related to the gabbros. Tabulating these as before, we have, to a depth of a mile—

Rock.	*Silica, per cent.*	*Area, square miles.*	*Depth.*	*Volume, cubic miles.*
Granite	70	3,560	1 mile	3,560
Monzonite	50	20	,,	20
Serpentine	40	5	,,	5
Andesite, etc.	55	680	1,000 feet	130
			Total	3,715

On this basis the silica average is 69·3 per cent., almost exactly what is calculated for Rhodesia. Whether this is typical of Canada generally I cannot say, but since one reads of granite masses a thousand miles in length, it is probable that the silica percentage is not too high.

These observations may be reinforced by another line of argument. Mr. Clarke calculates the amount of quartz present in the igneous rocks as averaging 12 per cent. of the whole.[1] He also gives estimates of the average composition of the sediments, in this case, however, making an assumption as to the relative abundance of each class, and merely giving composite analyses to obtain the composition of each division taken separately. His figures for silica are: shales, 58·1 per cent.; sandstones, 78·3 per cent.; limestones, 5·19 per cent. For quartz as apart from combined silica he gives: sandstones, 66·8 per cent., and shales, 22·3, which are certainly not excessive estimates. Now let us take Van Hise's assumption that, of the sediments, 65 per cent. are shales, 30 per cent. sandstones, and 5 per cent. limestones.[2] On this basis, even assuming that the limestones contain none, they should average over 34 per cent. of the mineral. Clarke himself assumes that the sediments comprise 80 per cent. of shales, 15 per cent. of sandstones, and 5 per cent. of limestones. His figure for the shales appears altogether excessive, and as the proportions he adopts are chiefly based on his own calculations regarding the igneous rocks, we should be merely reasoning in a circle if we accepted them. On the basis of collating analysis, which he adopts for the igneous series, the figures would be very different. Now there is only one source for the sediments: they must all have been derived directly or indirectly from igneous rocks, and if the latter only contained 12 per cent. of quartz, as calculated by Clarke, how could the former contain 34 per cent.? No allowance for secondary quartz can overcome this difficulty, for the obviously detrital quartz of the sandstones alone amounts to 20 per cent. of the whole bulk of all the classes of sediment taken together. There is also another consideration which shows that Clarke's igneous average allows far too much weight to the basic division, namely, the great deficiency of magnesia in the sediments. On his estimate they should contain over 4 per cent., whereas they actually contain less than $2\frac{1}{2}$ on the most favourable assumptions. The amount of potash also evidences the same tendency.

In conclusion, I should like to pay a tribute to the value of the work of which I have ventured to criticize one of the details. Mr. Clarke's recently published volume should be of great service to geologists

[1] Loc. supra cit., p. 30.
[2] Treatise on Metamorphism: Mon. U.S.G.S., 1904, p. 940.

generally, and it is a matter for regret that the geological surveys of most other countries are so far behind that on behalf of which so much valuable material has been brought together.

VI.—The Microsauria, Ancestors of the Reptilia.

By Roy L. Moodie, the University of Kansas.

ONE of the most interesting and most vexed questions in vertebrate palæontology at the present day is the one which concerns the origin and development of the reptiles. The progress of research has shown the Reptilia to be a wonderfully diverse class, and nearly thirty orders of animals have been assigned to the group. With all this diversity of structure there is, of course, associated a great diversity of habit. We know all kinds of extinct reptiles from the semi-aquatic to the aquatic, from the flying to the fossorial, from the arboreal to the subterranean, and many are the varying degrees of structure which are associated with these various habits of life.

Recent investigations into the anatomy of the Carboniferous Microsauria of North America have led the writer to the conclusion that the Microsauria could easily have been the ancestors of all the later reptiles. The idea that the Microsauria stood ancestrally to the Reptilia is not at all new. Gadow expressed it very clearly when he placed the Microsaurians in the Prosauria. Boulenger has expressed his opinion as to this idea. Baur and others have all agreed that the Microsauria stood ancestrally to some of the reptiles, but no one has, so far as I know, claimed that they might be the ancestors of all the class. It shall be the purpose of this essay to point out briefly the main anatomical features of the Microsauria, and to show in what way they may be homologized with the structures exhibited by the reptiles. A more extended discussion of this matter and a more detailed account of the anatomy of the Microsauria are to be contained in a work to be shortly published on the Carboniferous Amphibia of North America.

It has been now a little more than half a century since the first Microsaurian was discovered and described, and during that time the additions to our knowledge of these forms have been many. Cope and Dawson have described the Microsaurian fauna of North America, Fritsch has investigated very closely the fauna of Bohemia, Huxley has given us the history of the forms from the British Isles, and Credner has studied the forms from Saxony. Taken as a whole the literature on the group is extensive though not of a monumental character. Excepting for the works of Fritsch and Credner the publications in regard to the Microsauria are widely scattered and difficult of access, some of the works having been published privately.

The Microsauria may be defined as reptile-like amphibians with limbs well developed; usually longicaudate; skull bones sometimes sculptured with pits and grooves which not infrequently take the form of lateral line canals called 'slime grooves'; skull with horns on the epiotic, supratemporal, or without horns; branchia never persistent, if present at all; sclerotic plates present; vertebræ phyllospondylous; ribs long and curved, always intercentral; usually single-headed, although there is at times an enlargement as though an incipient bicipital condition were present; sacral ribs single; dorsal vertebral series variable; tail sometimes containing over seventy-five vertebræ, the distal ones composed of the two pleurocentra; pectoral girdle invariably, in the American forms, composed of interclavicle, clavicles, and scapulæ. There is no evidence of a cleithrum in the forms from North America; pelvic girdle composed of an osseous ilium and ischium, pubis cartilaginous, sometimes calcified; articular surfaces of the limb bones well formed; carpus and tarsus cartilaginous; digits four in the hand and five in the foot; phalangeal formula 2–2–3–2 and 2–2–3–4–3; abdomen usually covered with an armature of scales, scutes, or rods; overlapping or rounded scales sometimes present over the entire body; skull stegocrotaphous with pineal foramen invariably present; supra-occipital plate and epiotics well developed. The palate so far as known has the pterygoids approximate, but the evidence is unsatisfactory. Only a fractured portion of a skull presents the palate for study. According to Jaekel the pterygoids are separated by the parasphenoid. It is unfortunate that more is not known of the palate, but the skulls are almost always preserved on their ventral surface, and only by preparation such as Jaekel has employed is it possible to obtain satisfaction as to the palatal condition. Material is not yet sufficiently abundant to admit of this.

In size the Microsauria show a wide range of structure. The known forms range from the minute *Odonterpeton triangularis*, Moodie, with a skull only 6½ millimetres in length, to *Macrerpeton huxleyi*, Cope, or *Eosaurus acadianus*, Marsh, which undoubtedly attained a length of many feet. The skull bones may be smooth or sculptured. The ribs may be long and slender or short and thick, but always curved. The limbs may be powerful or weak. If the Aistopoda are degenerate Microsaurians, as appears probable, the limbs may be entirely absent. The tail may be very short or very long with the vertebræ laterally flattened, proving the aquatic habit of the animal. The ungual phalanges are either sharp or blunt. The form is undoubtedly lizard-like, as is proven by the impressions of the bodies. The neck is very short, the pectoral girdle being closely attached to the head, but I have never seen an indication of the piscian union of pectoral girdle and skull. The body may be long and slender or short and thick. In short, there are a great variety of shapes and forms associated with a multitude of anatomical structures, which give a vast range of possibilities for development. The group is widely heterogeneous.

The differences between the earliest known reptiles and the Microsauria, so far as known, are the possession by the reptiles of osseous carpus and tarsus and the two sacral vertebræ associated with a more highly developed condition of the limb bones. These differences are not at all insurmountable. Unfortunately the skulls of neither of the two best preserved Carboniferous reptiles, *Isodectes copei*, Williston, and *Sauravus costei*, Thevenin, are preserved. They were undoubtedly stegocrotaphous. It would be of the greatest

AMPHIBAMUS GRANDICEPS, Cope.

EXPLANATION OF FIGURE.

A restoration of *Amphibamus grandiceps*, Cope, from the Mazon Creek Beds, Carboniferous of Illinois. The restoration is based on a complete specimen of the species and on Cope's drawings. The form of the body is *not* conjectural.

Skull.—Px. premaxilla; N. nasal; F. frontal; P. parietal; So. supra-occipital; E. epiotic; L. lachrymal; Pr. prefrontal; Pf. postfrontal; Po. post-orbital; Sq. squamosal; M. maxilla; J. jugal; Qj. quadrato-jugal; St. supratemporal.

Skeleton.—Ic. interclavicle; Cl. clavicle; Sc. scapula; H. humerus; R-U. radius, ulna; Ca. carpus; Pu. pubis; Il. ilium; Fe. femur; T-Fi. tibia-fibula; Ta. tarsus.

interest to know the condition of the pterygoids in these forms. In the absence of these important structures we must base our conclusions on the structures present.

In both groups, then, we find the following structures identical:—Ribs intercentral, intercentra absent, vertebræ amphicœlous with notochord persistent, pectoral and pelvic elements identical, number of dorsal vertebræ agrees in some forms, limb bones with well-developed endochondrium which becomes more pronounced in the reptiles, phalanges clawed, hand and foot broad, neural spines of the vertebræ low, rudimentary, or absent.

The absence of intercentra in the Microsauria is assured. There is not the slightest evidence that the vertebral column is composed of other than the pleurocentra and neurocentra. The intercentra probably developed late in the history of the Amphibia as in the Temnospondylia, and were transmitted by some of the Amphibia to the reptiles. I cannot believe that the intercentra are inherited from the piscian ancestors.

The only tangible differences, then, on which to base a separation of the reptiles from the Microsauria is on the reduced parasphenoid, osseous carpus and tarsus, and two sacral vertebræ. These characters serve well as class distinctions, and we must await further knowledge to unite the earliest forms which we now call reptiles and the latest forms of the so-called Amphibia. It has been suggested that the Microsauria do not furnish forms which could have given rise to the broad-headed Cotylosauria and their allies. But members of the new genus *Erpetosaurus* bear very close resemblance to these forms. The skull is closely sculptured, broad, and heavy. The members of this group and its allies might well have stood in an ancestral position to the later forms.

The Microsauria as known, however, are confined to the land and marsh dwellers, and we know nothing as yet of the inhabitants of the open seas, if there were any. It is quite possible that some members of the group such as *Œstocephalus*, which was a good swimmer, took to the sea, and from some form like this was developed the Ichthyosaurs, Mesosaurs, and the other aquatic forms. One thing which tends to militate against the Microsauria is their small size; if, however, it is taken into account that not all the Microsauria were small but that it is only the small ones which are well known, this objection can have little weight. We shall undoubtedly some day know the other forms of which we have now only faint traces, and although we may not then call them Microsauria they may nevertheless serve to bridge the gap between the Amphibia and the Reptilia. The occurrence of *Isodectes*, so similar in form and structure to the Microsauria, in the same bed with them leads one to think that they were already an old race; and the diversity of their structure would substantiate this view.

There has been some tendency among recent authors on the Microsauria, including the present writer, to class them with the Reptilia. This may, in the future, be necessary, but not in the present condition of our knowledge. Dr. R. Broom in a letter to the writer expressed very good ideas on the scheme by which to divide the reptiles and amphibians. He says: "I fancy it will be safest to keep as Amphibia the forms with two condyles, large presphenoid (vomer), and pterygoids wide apart." These characters, taken in connection with the condition of the carpus and tarsus, the sacral ribs, and the degree of ossification of the limb bones, will serve to keep the two classes separate.

In pursuance of the above scheme the following classification has been outlined for the Amphibia as we now know them, and will be used until further knowledge teaches otherwise. This scheme was read before the recent meeting of the Kansas Academy of Science.

Class AMPHIBIA, Linné, 1758. Devonian to Recent.
- Subclass I. Euamphibia, nom. nov. Carboniferous to Recent.
  - Order 1. Branchiosauria, Lydekker, 1889. Carboniferous and Permian.
  - Order 2. Apoda, Oppel, 1811 (Gymnophiona, Müller, 1832). ? Permian and Recent.
  - Order 3. Caudata, Dumeril, 1806. (? Permian) Jurassic to Recent.
    - Suborder 1. Proteida (Mudpuppies), Cope, 1868. Eocene to Recent.
    - Suborder 2. Meantes (Sirens), Linné, 1766. (In appendix to 12th ed. Syst. Nat.)
    - Suborder 3. Mutabilia (Salamanders), Merrem, 1820.
  - Order 4. Salientia, Laurenti, 1768. Eocene (? Jurassic, *Eobatrachus*) to Recent.
    - Suborder 1. Aglossa, Wiegmann, 1832.
    - Suborder 2. Linguata, Gravenhorst, 1845.
    - Suborder 3. Costata, Lataste, 1879.
- Subclass II. Holospondyli, Schwarz, 1908. Carboniferous.
  - Order 1. Microsauria, Dawson, 1863. Carboniferous to Permian.
  - Order 2. Aistopoda, Miall, 1874. Carboniferous to ? Permian.
  - Order 3.[1] Diplocaulia, nom. nov.
- Subclass III. Stegocephala, Cope, 1868. Carboniferous to Upper Triassic, ? Jurassic.
  - Order 1. Temnospondylia, Zittel, 1887. Carboniferous to Permian.
  - Order 2. Stereospondylia, Zittel, 1887. Carboniferous to Upper Triassic, ? Jurassic.

I am indebted to Dr. Leonhard Stejneger, of the United States National Museum, for the classification of the recent Amphibia.

VII.—On some Unrecorded Erratic Boulders in South Pembrokeshire.

By R. H. Chandler.

DURING the past year several igneous erratic boulders have been noticed on the cliffs of South Pembrokeshire by Mr. A. L. Leach and myself, in situations where no such erratics were previously known, so that a record of the larger ones seems advisable; five of them being dealt with in the following paper. At Mewsford Point, near St. Govan's Head, there is a well-rounded boulder measuring 4 ft. 1 in. × 2 ft. 6 in. and about 2 ft. 6 in. high, weighing approximately 32 cwt., and visible from some distance because its outline and dark colour differ markedly from the surrounding crags of Carboniferous Limestone. It appears to be the southernmost igneous erratic boulder in Pembrokeshire, and hence is of more than usual interest.

[1] The position of this new order is doubtful. It may belong to Subclass III. It is established for the genus *Diplocaulus*, Cope, from the Permian of Texas.

Mr. J. V. Elsden, B.Sc., F.G.S., kindly examined a microscopic section, and pronounced it to be "a typical enstatite-diabase, precisely like parts of the St. David's Head and Carn Llidi masses. I should say it certainly comes from there". There is a little drift containing igneous rocks in the immediate neighbourhood, capping the limestone plateau, and increasing to 6 feet at Pen-y-holt, 3 miles to the west; and a Boulder-clay 8 miles to the north-west.

By the roadside at Flimston Cottage (near Flimston Coastguard's Station) is a boulder roughly 3 ft. × 2 ft. × 2 ft. 3 in. high, weighing about 15 cwt., and having a very much weathered, rugose surface. Mr. H. H. Thomas, B.A., F.G.S., who kindly examined two slices of this boulder, regards it as "a brecciated spherulitic albite trachyte or rhyolite". He adds: "Rhyolites occur at a great number of places in Pembrokeshire, and all these rhyolites are not strikingly dissimilar from each other, but of all those that I have examined the Flimston Boulder seems to fit best with those of Roman's Castle, in the character of its spherulites and groundmass. I should think that it would be fairly safe to refer the boulder to that source."

Another large boulder occurs at Holloway Farm, Penally (used as a step to the wall of the farmyard), about 5 ft. × 1 ft. 6 in. × 1 ft. high, weighing approximately 9 cwt.; also a similar, but smaller, one on the foreshore at Lydstep Caverns, about 3 ft. × 1 ft. 6 in. × 1 ft. 6 in. and weighing about 7 cwt. Microscopic sections of each of these show ophitic structure, and are said by Mr. J. V. Elsden "to be in every respect identical with the rhombic pyroxene rocks of St. David's Head, and may be described as enstatite-gabbro or norite". The Holloway section, which is taken from the partially weathered crust, is not nearly so fresh as the one from the Lydstep shore; owing to the action of the sea on the latter the unaltered core is exposed, otherwise the two rocks are identical.

Another boulder, which occurs in the quarry on Lydstep Head, is a grit composed of angular quartz grains with some plagioclase felspar and mica, but is not distinctive enough to trace to its source; in size it measures roughly 3 × 3 × 2 feet, and would weigh about 13 cwt.

These three latter boulders (Lydstep Caverns, Lydstep Quarry, and Holloway Farm) are in an area almost devoid of drift on the cliff top, although igneous pebbles are abundant on the shore.

A glance at the map will show that the three boulders from St. David's Head have come over 30 miles from the north-west, and are separated from their parent rocks by St. Bride's Bay and Milford Haven, and by a considerable mass of fairly high ground (up to 250 feet O.D.).

The boulder from Roman's Castle is nearly 10 miles due south of its probable source, from which it is separated by Milford Haven and some high ground. Thus it is far from obvious by what route these erratics reached their present positions, although it might be by the Irish Sea Ice-sheet driving a stream from St. Davids eastwards over sea and land to deposit its boulders south-east of their sources.[1]

[1] F. W. Harmer, Quart. Journ. Geol. Soc., 1907, vol. lxiii, p. 474.

Fragments of Pembrokeshire rocks, glacially transported, have been traced as far east as Glamorganshire[1]; moreover, the shore drift contains in places abundant flint for which Ireland itself is not an impossible place of origin.

I am much indebted to Mr. J. V. Elsden and Mr. H. H. Thomas for kindly identifying the rock-sections of the boulders with their parent masses, and to Mr. A. L. Leach for chips of the Lydstep Boulders.

VIII.—Note on a Deposit of Allophane.

By R. H. Chandler.

In a denehole at Abbey Wood, near Plumstead, there is shown in the Chalk a fault of unknown extent (but probably having a throw of only a few inches), the plane of the fault roughly coinciding with one of the chamber walls. This wall has a strongly slickensided surface for some superficial yards, and extends to the roof of the chamber where the deposit of allophane is contained between the two fault faces. In some instances this mineral may be seen adhering to the fault face, and the roof of the denehole is composed of it for a length of about 7 feet by 2 feet wide; other patches are to be observed where the roof has been broken away, so that it seems evident the allophane extends horizontally some distance between the Chalk and the Thanet Sand; this latter is about 32 feet thick here. The deposit appears to be a roughly wedge-shaped mass, the greatest width being at the top of the Chalk, and from there diminishing downwards into tongues of the mineral extending between the two boundaries of the fault. Mr. J. L. Foucar, B.Sc., F.C.S., who kindly submitted a specimen to analysis for me, says: "I find the following to represent its composition:—

Moisture (loss at 100° C.)	23·19	per cent.
Loss on ignition, including some Co_2 not separately determined	20·77	,,
$Si\,O_2$	28·80	,,
$Al_2\,O_3$	23·52	,,
$Ca\,O$	2·45	,,
Loss and undetermined	1·27	,,
Fe	traces	
	100·00	,,

He adds: "The mineral is undoubtedly a variety of allophane, although its composition does not correspond with the formula $Al_2\,Si\,O_5\,5H_2\,O$. It has recently been shown[2] that the minerals of the allophane group are probably merely amorphous mixtures of hydrated oxides of silicon and aluminium, plus certain impurities. The chief impurity in this present case is calcium carbonate, and perhaps calcium silicate, the source of whose origin is obvious."

In colour the mineral is cream to buff, veined with a darker shade of brown having a waxy lustre, is rather friable, occasionally

[1] F. T. Howard & E. W. Small, Trans. Cardiff Nat. Soc., 1899, vol. xxxii; also *Geology of the South Wales Coalfield*, pt. viii, Mem. Geol. Surv., 1907.

[2] H. Stremme, Centr. Min., 1908, pp. 622–32, 661–9.

contains little pellets of ferruginous material, and the outside layer is in places crystalline.

The extent of the deposit is unknown, but there are at least 4 or 5 bushels in sight, and every evidence that the seam is much more extensive at the junction of the Thanet Sand with the Chalk, which is about 2 feet above the roof of the denehole.

Professor John Morris[1] in 1857 described the occurrence of allophane at Charlton (the first English record), and gave an account of the condition and position of deposit which seems to be essentially the same as above described. He also gives the analyses of several allied minerals, all of which differ from the analysis given here; however, the constitution of Professor Morris' allophane approximates remarkably to Mr. Foucar's analysis, the only difference being 10 per cent. more silica and 10 per cent. less alumina, the water and impurity being exactly the same. A comparison of the Charlton and Abbey Wood allophanes and a specimen from Beauvais are given below.

	Silica.	Alumina.	Water.		Analysis by
Charlton Allophane (Prof. Morris) . . .	18·89	33·52	42·73	Carb. lime 4·38	Dick.
Abbey Wood ,, (R. H. C.)	28·80	23·52	42·04	,, 4·37	J. L. Foucar
Beauvais ,, (Prof. Morris) . . .	21·90	29·20	44·20	Clay 4·7	Berthier

The above is, so far as I can ascertain, the largest deposit yet recorded, other notices speaking of 'some' allophane being reported, and although no definite quantities are stated, the implication is that the amount was small.

Since writing the above Mr. Foucar has been good enough to analyze another specimen, with the same results as given before.

REVIEWS.

I.—The Geological Society of Glasgow and its Jubilee.

History of the Geological Society of Glasgow, 1858–1908, with Biographical Notices of Prominent Members. Edited by Peter Macnair, F.R.S.E., F.G.S., and Frederick Mort, M.A., F.G.S., etc. 8vo; pp. vi, 303, with 24 portraits and 2 other illustrations. Glasgow: published by the Society, 207, Bath Street, 1908. Price 6*s*.

THIS volume was prepared to commemorate the Jubilee meeting of the Society, which was held at Glasgow on January 28. In the opening chapter a brief sketch is given of the geological features of the Clyde Valley, to which the Society has naturally given special attention; and biographical notices are inserted of some of the geological workers who had studied the rocks and fossils in earlier days. Among these were the Rev. David Ure, author of *The History of Rutherglen and East Kilbride* (1793), a work of great merit in

[1] Quart. Journ. Geol. Soc., vol. xiii, pp. 13–17.

which the fossils of the district were described, and most of them so well illustrated that the species can be easily identified; John Craig, a practical geologist and mineral surveyor, who conducted classes and gave lectures on geology; and Dr. John Scouler, for some years Professor of Mineralogy to the Royal Society of Dublin, and afterwards President of the Glasgow Geological Society from 1859 to 1862, whose name is associated with a species of *Eurypterus*.

The chapter on the Origin and Early History of the Society is reprinted from a paper by Mr. T. M. Barr (1883). It appears that as early as 1840 there was in existence a Glasgow Geological Society, of which no particulars can be obtained, further than the mention of it on a handbill announcing two lectures by Mr. John Craig on the geology and mineral resources of the west of Scotland. In 1850 a society under the same name was established by members of Mr. Craig's class, when he was chosen as president, and James Smith, of Jordan Hill, consented to be Honorary President. This society, however, ceased to exist early in the following year.

The present Society was founded at a meeting held in May, 1858; it was started by William Kirkland, Hugh Reid, Thomas M. Barr, and George M. Barr, students keenly interested in geology, and at the first meeting they were supported by Edward A. Wünsch, who was then elected Vice-President and was an active supporter until 1881, when he went to reside in Cornwall. Among those who joined at an early date were James Thomson and the Rev. H. W. Crosskey.

Various excursions were made during 1858, one to Arran, under the guidance of Dr. James Bryce, another to the Campsie District, under John Young, afterwards Assistant Keeper of the Hunterian Museum at Glasgow.

James P. Fraser, F.R.S.E., was chosen as the first President in October; but it was not until 1860 that the rules and a complete list of members (178 in number) were printed, and in the same year a lecture on "The Geology of the Campsie District", delivered by John Young in 1858, formed the first paper issued by the Society in the form of 'Transactions'.

In the course of 1859 lectures by David Page, James Bryce, Dr. Scouler, and others served to foster an interest in geology.

The Society soon became firmly established, and during its first ten years it was joined by James Smith of Jordan Hill, Dugald Bell, David Robertson, D. C. Glen, Robert Craig, James Croll, James Armstrong, Professor John Young, and Sir Archibald Geikie (as an Honorary Member). Dr. Robert Slimon, whose name is perpetuated in the genus *Slimonia*, was elected a corresponding member. In later years Sir William Thomson was chosen President and served for twenty-one years (1872–93), towards the end of which period he became President of the Royal Society, and was created Baron Kelvin.

An important section of the volume is the review of the fifty years' work comprised in the Transactions of the Society. It is divided into five chapters. That on Physical and Dynamical Geology is by Professor J. W. Gregory, who points out the large field of study open to Glasgow Geologists, their province extending from the Southern Uplands of Girvan and Moffat to the North-West Highlands, and to the Inner and Outer Hebrides. The work of Lord Kelvin on Geological Time, of Sir A. Geikie on Modern Denudation, and many other subjects are noticed, including Mr. J. G. Goodchild's solution theory of igneous intrusion. Mineralogy and Petrology are dealt with by Mr. Joseph Sommerville, and Stratigraphical Geology by Mr. Macnair, who treats with appropriate enthusiasm Professor Lapworth's researches on the Southern Uplands, and notices many papers on the Carboniferous rocks and other formations. The article on Palæontology is by Mr. James Neilson, in which further particulars are given of the older rocks and their organic remains. The labours of James Armstrong, regarded as the leading palæontologist of the Society, are specially mentioned, and a full account is given of researches relating to the Carboniferous fossils.

Discussing the zonal classification of Dr. Vaughan, Mr. Neilson points out how the range of certain species in Scotland differs from that in the British area, and observes that he has been led to consider many of the mutations of species as due to environment.

Mr. John Smith, who is stated to be the father of the Society, gives a summary of the work done on Glacial Geology. One of the earliest papers, of which brief mention is made, is that now classic essay "On the phenomena of the Glacial Drift of Scotland", by Sir A. Geikie (1863), referred to at the jubilee meeting by Professor J. W. Gregory as a paper which "at once lifted British glacial geology on to a new plane". Mr. Smith, who has dealt in detail with the Glacial Deposits of Ayrshire, expresses his belief in the marine origin of the boulder-clays.

Three chapters are occupied with Biographical Notices of Members and of some other geologists who have been associated in the work of the Society, many of the short memoirs being accompanied by portraits.

The concluding chapter deals with the present position of the Society, and it is noted that forty years ago the number of members was 231, now it is 228. It is remarked that "In most sciences the day of the amateur has departed. Palæontologists tell us that the great mammals of Tertiary times disappeared through over-specialisation. In many branches of geology the amateur, at any rate as a large contributor of original work, is being hurried to extinction by the same cause". There is, however, abundant work for geologists who have had no "highly technical training", if only they are not dismayed by modern palæontological nomenclature. The volume will be appreciated by those interested in the history and progress of geology, and it will be a valuable work of reference to those engaged in a study of the rocks and fossils of Western Scotland.

It was appropriate that Sir Archibald Geikie, who was elected an Honorary Member of the Glasgow Geological Society in 1863, and served as President from 1893 to 1896, should be invited to give an address at the jubilee meeting. The ceremony, which was held at the University buildings, took the form of a conversazione, the guests being received by the Principal, Sir Donald MacAlister, K.C.B., and Lady MacAlister, together with Sir A. Geikie, Professor J. W. Gregory (President of the Glasgow Geological Society), and Dr. B. N. Peach.

In his address Sir A. Geikie gave a picturesque outline of the geological features of the surrounding district, and referred to the work of the pioneers—Faujas de Saint-Fond, the first geologist to set foot on Staffa; James Hutton (the father of modern physical geology), whose observations in Arran demonstrated the intrusive nature of the granite and the whinstone dykes; and John Macculloch, famed for his researches on the Western Isles. Ami Boué, again, was mentioned as the author of the *Essai Géologique sur l'Écosse*, published in 1820, and A. C. Ramsay, who wrote an early account of the geology of Arran.

Among those who had conspired to raise in Glasgow an interest in geology, Sir A. Geikie was disposed to give the foremost place to James Smith, of Jordan Hill, who first called attention to the general lowering of the temperature in the Pleistocene period by his observations on the boreal mollusca of the Clyde Beds. He thus paved the way for subsequent researches on the records of the Glacial period, to which the members of the Glasgow Geological Society have so largely contributed. Indeed, on this subject they have rendered their most important services to geological science.

II.—Gold: its geological occurrence and geographical distribution. By J. Malcolm Maclaren, D.Sc., F.G.S., F.R.G.S., M.I.M.M., late Mining Specialist, Government of India, formerly Assistant Government Geologist, Queensland, etc. pp. xxiii + 687, with one coloured plate and 278 illustrations. London: *The Mining Journal*, 1908. Price 25*s.* net.

FROM the very earliest time gold has, on account of its magnificent colour and its durability, been highly prized for ornamental purposes, and as the recognized medium for the exchange of commodities throughout the civilized world it is at the present day in ever increasing demand. The literature concerning it is immense. The quest for it has carried men to the heat of the tropics and the chill of arctic regions. Prospectors are constantly searching for new fields, and the observations of individuals are supplemented by the careful studies of skilled geologists. Consequently the data relating to the occurrence of the precious metal steadily grows. Apart from the extreme importance of the matter from the economic point of view, the distribution of such well-defined minerals as gold and its compounds serves to throw light upon the origin of ore-deposits.

In the preface to the book Dr. Maclaren tenders something in the nature of an apology for adding to the literature of ore-deposits; but surely none would be demanded by the most captious of critics. It is, indeed, from the pen of one who has had occasion to visit many of the principal mining regions and who has had the knowledge and the energy to enable him to take advantage of the opportunities afforded him that a work such as this is welcome. The slight inequality that may be detected here and there in the treatment is almost inevitable in a book, the writing of which has extended over a number of years, and can well be excused.

The book is divided into two main parts. The first of them deals with the general relations of auriferous deposits. After a brief introductory chapter upon the processes which have led to ore-deposits, the author proceeds to describe carefully and fully the crystalline characters of gold and its native alloys and compounds. The text is accompanied by numerous excellent drawings of typical crystals, and good illustrations of various well-crystallized nuggets are given on plates, the frontispiece being a coloured picture, natural size, of the fine nugget—the "Latrobe"—which is treasured in the British Museum collection. The statement on p. 29 regarding the telluride of gold, calaverite, that "such crystallized specimens as have been found have been too imperfect to admit of the determination of the crystallographic system", was probably penned prior to the discovery some ten years ago of numerous brilliant many-faced crystals at Cripple Creek. The precise system is, indeed, still in doubt on account of the extraordinary complexity of the crystallization. The number of forms that have been observed on the rare mineral krennerite is considerably larger than that given on p. 33. The next chapter is concerned with the classification of auriferous deposits. Dr. Maclaren dismisses all systems which are based upon considerations of the form of the deposits and the nature of the association as useless from either a scientific or an economic point of view. Gold has often been found in the last place that might have been expected from the theoretical considerations put forward by various writers. Upon this still debatable point the author is not dogmatic, but thinks that the gold-bearing regions may conveniently, if empirically, be grouped according to a combination of geographical and geological data as follows: primary, (*a*) connected with the extrusion of intermediate or basic igneous rocks (andesites or diabases), (*b*) connected with the extrusion of acid rocks of granodioritic type; secondary, (*a*) deposits produced or modified by chemical agencies, (*b*) deposits produced by mechanical agencies. The primary group is defined to include gold which has had apparently "no prior state of combination and no former locus in space"; the metal in the secondary group is "obviously or presumably derived from sulphide or telluride ores, or from gold-quartz". Such a classification clearly cannot be considered very hard and fast, but pending further research it serves the purpose. Typical examples of the various sub-groups in different parts of the world are briefly described. Many important questions are discussed in this chapter, such as the formation of nuggets, about which there has been so much controversy, and the deposition and concentration of gold.

The second part, which occupies nearly three-quarters of the book, comprises full descriptions with great wealth of detail of all the known occurrences, arranged geographically — Europe, Asia, Australasia, Africa, America—and furnishing most fascinating reading. So far as possible, the author gives for each district the history of the mines, the geological features, the methods of working, and statistics of the output. The text is accompanied by many admirable illustrations, both plans and reproductions of photographs of various districts. Adequate discussion of this part is beyond the limits of a review; we can but commend the reading of it.

At the end of the book will be found copious and carefully compiled indices, of which the geographical index especially will be of great use for the determination of the locality of some little known mine.

The printing and appearance of the book are beyond reproach. We may safely predict that Dr. Maclaren's treatise is destined to fill a high position in the literature of gold.

III.—Brief Notices.

Vertebrate Remains in Asphalt.—Mr. J. C. Merriam, Associate Professor of Palæontology and Historical Geology in the University of California, has contributed an interesting article on the vertebrate remains obtained in an asphalt deposit a few miles west of the city of Los Angeles, in California (*Sunset*, San Francisco, October, 1908). Quite recently the occurrence of many extinct animals in this deposit has been brought to notice. Among the remains are those of gigantic wolves, the sabre-toothed tiger, camel, elephant, and large sloths. Many birds and other remains were also obtained. Of the *Machærodus* Professor Merriam remarks: "At one locality eighteen complete skulls, and at least one complete skeleton, were found within an area of less than two square yards." In other places certain layers of the asphalt proved to be nearly barren of fossil remains. The deposits appear to have been formed "from the slow accumulation of bituminous material around tar springs". In time a large pool of the material would have collected, and become more or less hardened, but in warm weather the surface would be rendered soft, and thus act "as a trap for unwary animals", which would be entombed in successive accumulations of the asphalt.

Burning Cliffs at Lyme Regis.—Since the note by Mr. Cameron was received, our attention has been called to a paper on "The Burning Cliff and the Landslip of Lyme Regis", by Mr. A. J. Jukes-Browne, published in the Proceedings of the Dorset Natural History and Antiquarian Field Club, 1908, vol. xxix, p. 153. He gives a view of the burning mound at Lyme, and has reproduced a view of the burning cliff at Holworth, Dorset, 1827.

Tsetse Fly in the Miocene.—Mr. T. D. A. Cockerell reports the discovery of another fossil tsetse fly in the Miocene shales of Florissant, Colorado. He proposes to give the name *Glossina osborni* to this new species. (*Nature*, April 1, 1909.)

The Devonian Fishes of Iowa.—These form the subject of a memoir by Mr. Charles R. Eastman, published by the Iowa Geological Survey, 1908, vol. xviii. The author gives an interesting introduction on the "Aim and general outlook of palæontological inquiry, and relations of palæichthyology to biology". He observes that detached teeth and other fragmentary fish-remains occur somewhat sparsely in the Middle Devonian of Iowa, while in the Upper Devonian they occur in remarkable abundance and locally constitute veritable fish-beds. The local strata consist of limestones and shales. The title of the memoir should have been the Devonian fishes of North

America, with special reference to the fishes of Iowa, as the author deals generally with the subject and gives a full list of the Devonian fishes of North America. Some of the species are grouped, according to Cope, in the class Agnatha, a lower grade than fishes proper; and these include the *Asterolepis*, *Bothriolepis*, and *Cephalaspis*, but none of them are recorded from Iowa. The local genera include *Conchodus*, *Dinichthys*, *Dipterus*, *Heteracanthus*, *Onychodus*, *Ptychodus*, *Rhynchodus*, and *Synthetodus*. The work is accompanied by thirteen plates of fossils and three palæogeographic maps.

Scottish 'Eenie' Coal.—Under this title Mr. C. T. Clough and Mr. James Kirkpatrick describe a variety of coal which on certain surfaces shows circular structures bearing a resemblance to 'een' (eyes). These structures, though common, are seldom so well developed as to attract attention. The authors, however, state that "A few months ago some unusually good specimens were found in Gateside colliery, Cambuslang, and these certainly are merely superficial structures, closely allied probably to conchoidal fractures, which are found on certain joint-planes. They must, however, have been formed by some natural action, perhaps by pressure acting specially on certain points, along planes which were probably also produced by pressure at some far distant period; and, since that period, thin films of spar of various kinds—calcite, a ferriferous carbonate, quartz, iron pyrites, and more rarely galena—have been deposited along many of the joint-planes, and have often taken the form of the 'een' with which they are in contact. Such spathic 'een' are, however, by no means always present". (Paper read before the Mining Institute of Scotland, Trans. Inst. Mining Engineers, 1909, xxxvii.)

The Royal School of Mines.—Mr. F. W. Rudler, I.S.O., F.G.S., presided at the thirty-sixth annual dinner of the old students of the School, which took place at the Hotel Cecil on April 30. In the course of his reply to the toast of "The Royal School of Mines", the Chairman remarked on the official ups and downs which the School has undergone, observing that "at last it has settled down under the shelter of the Imperial College of Science and Technology, but with its individuality, its name, and its associateship unimpaired". These words are reported in the *Mining Journal* for April 3, but in an article in the same journal on "Mining Education in the British Empire", we find remarks on "the threatened extinction of the diploma (A.R.S.M.). This, if it eventuates, will certainly be nothing less than a calamity. An A.R.S.M. has a market value . . . and it is a distinct injustice to demand that students, who go through a course at what is to all intents and purposes the Royal School of Mines, should in future go abroad with the mystic and unknown symbol A.I.C.S.T. after their names". We trust that this is a false alarm.

Red Granite of the Transvaal.—In his Anniversary Address to the Geological Society of South Africa, 1909 (Proc. Geol. Soc. S. Africa for 1909, pp. xxi–xxx), Mr. H. Kynaston chose as his subject "The Red Granite of the Transvaal Bushveld and its Relation to Ore Deposits". The area occupied by this granite, with its peripheral belt of basic rocks and sundry smaller intrusions of syenite—the whole usually termed the igneous complex of the Bushveld—has been estimated at about 15,000 square miles, without including some concealed portions of the granite. A great variety of rocks is met with in this complex, from peridotite to granophyre; and if the magnetite bands in the norite may be regarded as a further ultra-basic modification, there would be an extreme example of magmatic differentiation, with magnetite rock at one end of the series and quartz rock at the other. After describing the structure of the rock-masses and their general mode of intrusion, Mr. Kynaston referred to the valuable deposits of tin-ore which had been discovered in the Red Granite and in some rocks into which it has been intruded. Ores of copper, silver, lead, zinc, cobalt, nickel, and iron, and occasional gold-bearing quartz are also known; and their modes of occurrence and origin are discussed.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1.—*February* 24, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Palæolithic Implements, etc., from Hackpen Hill, Winterbourne Bassett, and Knowle Farm Pit (Wiltshire)." By the Rev. Henry George Ommanney Kendall, M.A. (Communicated by W. Whitaker, B.A., F.R.S., F.G.S.)

Implements are described from the localities mentioned in the title, which lie at heights of 885, 576, and 450 feet above O.D. respectively. Hackpen Hill forms a ridge of Chalk running north and south, capped by patches of Tertiary Clay. Trimmed stones of eolithic nature were obtained from fields ploughed in Drift gravels, together with abraded Upper Greensand chert, quartzite pebbles, and small flints. The greater number of the flaked stones were found within and near shallow pits excavated in yellow Drift clay, apparently newer than the Red Clay with Flints, exposed at the edges of the larger hollows. The implements are unabraded, abraded, and striated; some stained brown, some green, others unstained; evidently some are *in situ*, others were brought with the Drift. Implements taken from the clay are described, and a distinction is made between the palæoliths and neoliths obtained from the same surface. The similarity in the mineral condition of the former to palæoliths from Knowle Farm Pit is pointed out, and both are referred to the Chelléen period.

It is noteworthy that, while implements and flakes are numerous on the top of Hackpen Hill as compared with good, trimmed pieces, yet at this 570 foot level on the Winterbourne Bassett plain implements and flakes are very scarce, while trimmed pieces are very numerous, although the level of the Winterbourne Stones is 300 feet lower. Many of the latter, however, have been evidently re-chipped, and are therefore of later date. The author concludes that implements of at least three Palæolithic periods are found at Knowle, and these three periods may be compared with the Chelléna, Lower Acheulien, and Upper Acheulien of Professor Commont et St. Acheul. Still older implements (possibly earlier Chelléen) seem also to occur.

2. "On the Karroo System in Northern Rhodesia, and its relation to the General Geology." By Arthur John Charles Molyneux, F.G.S.

In 1903 (Quart. Journ. Geol. Soc., vol. lix) the author described the occurrence of deposits, that have since been recognized as of Karroo age, in Southern Rhodesia. The present communication traces their extension across the Zambesi, where their boundary follows the foot of the remarkable line of escarpments that divide the plateau, nearly 4,000 feet in altitude, from the low-lying (1,500 feet) regions of the Zambesi Valley. Karroo deposits also form the floor of the peculiar trench-like valleys of the Luangwa, Lukasashi, and Lusenfwa (or Luano), the walls of which are similarly steep, and of metamorphic rock gneiss, schist, and granite.

The Luano Valley is described. Its northern precipice is known as the Machinga (native meaning 'a fence'), and the Lusenfwa and Molongushi Rivers are followed in their mature courses across the flat plateau plains. They reach the Luano by waterfalls into deeply incised gorges, cutting back 15 and 8 miles respectively into the plateau. Rivers that join the Luano from the south, on the contrary, descend into open valleys of Karroo floors, that are divided one from the other by tongues from the southern highlands, and suggest 'rolled-out' folds.

Between the Kafue junction and Feira the Zambesi River also occupies a trough valley, lined by steep escarpments; that on the south side rises 2,000 feet in less than a mile, being formed of a flexure of altered sediments. The Danda flats show Karroo beds.

The Lufua River runs parallel with the strike of the gneiss of the locality, and crosses two synclinal basins of clastic deposits, separated by Archæan ridges. The Losito has also a deep strike channel.

The Karroo deposits are grouped into basal conglomerates, Coal-measures, Upper Matobola Beds, and Escarpment Series. No effusive basalts were seen, but there is an area of Forest Sandstones near the Losito-Zambesi confluence. In the Luano Valley the conglomerates are made up of resisting quartz, quartzite boulders and pebbles, all having dimpled or concave depressions on one or more sides; they possess no orientation, are unsorted, and exhibit a varying matrix. Though they form the base of the Karroo System there is no certain evidence of glaciation, but the beds seem to have originated as scree deposits on an uneven floor. The grinding of the pebbles into one another is accounted for by the soft nature of the schists and limestones, which would have been removed in the internal movement before consolidation.

In the Lukasashi and the Luano there is a general dip of the strata north-westwards, that is, towards the escarpment, and evidence of minor anticlinal and synclinal folds along east-north-east axes. By a combination of these the Karroo deposits become lowered from plateau level on the south, towards the north-west culminating in a great downthrow fault along the foot of the Machinga.

Nowhere on the plateau in the immediate vicinity of the valley walls have Karroo beds been found, and if they did once extend there it is remarkable that they should have disappeared. But it is certain that the valleys were at one time filled almost to plateau level, as the rivers pass through Archæan inliers by deep clefts, and must thus have laid out their courses before such hard masses rose from the Karroo beds by erosion of the latter. Also the comparatively late times in which the Machinga escarpment was laid bare, and the rejuvenation of the Lusenfwa River, etc., suggest a complete filling of the valleys.

It is thus possible that the Karroo beds extended over a part of the plateau, and were included in the folding and faulting movements already mentioned. Subsequently, by some continuous agency the whole surface was planed off to a plateau of remarkable monotony; and on a further radical change of conditions taking place, erosion of the softer Karroo strata set in by which the present valleys are again reaching a plane of denudation.

The facility with which atmospheric waters and acids attack the sediments is notable, and decomposition extends to 100 feet in depth over the flat regions of the plains.

The author suggests that the trough valleys of clastic rocks merely follow the axis of pre-Karroo and post-Karroo movements, trending in three directions. The Luano and part of the Zambesi course agree with that of the folds and cleavage of the complex, certain ranges of hills, and the Machinga Fault (east-north-east); a second (south-easterly) trend is that of the Kafue, Losito, Inyanga range, and Lufua, and the folds and cleavage of the complex in these regions; while the third follows the dominant direction of the great tectonic movements of South Africa (north-east). Mr. L. A. Wallace has noted that the Luangwa and mid-Zambesi are on this strike, and Mr. G. W. Lamplugh has suggested a northerly extension of his Deka Fault. A distance of 800 miles thus displays movements that commenced in pre-Karroo periods, and have repeated themselves since the Karroo time.

Fossils from the areas described support the previous allocation of the deposits to the Permo-Carboniferous and to the Karroo System of South Africa. Notable specimens are members of the *Glossopteris* flora, including pith-casts of *Schizoneura*, carapaces of *Estheria*, ostracods, and fragments of bone, fish scales, and teeth.

Palæolithic stone implements (axe-heads) were found at separate localities on the surface, about the latitude of 14° 50′ S.

3. "Plant-containing Nodules from Japan, considered structurally in their relation to the 'Coal-Balls' and 'Roof-Nodules' of the European Carboniferous." By Marie C. Stopes, D.Sc., Ph.D. (Communicated by Professor E. J. Garwood, M.A., Sec.G.S.)

These nodules are of interest because of the plant and animal fossils that they contain. The plant-petrifactions are of a type unknown from the Mesozoic, and will be described separately. The nodules are of Cretaceous age. They enclose numerous marine shells and various plant-remains, well petrified. Unlike the 'coal-balls' and 'roof-nodules', they are not contained in coal-seams or in the roof thereof, but occur in a thick series of shales below the coals, which appear to be of Tertiary age. The microscopic aspect of the matrix shows that it is highly granular, unlike the matrix of coal-balls and roof-nodules. Chemically they consist of about 60 per cent. of carbonates, both lime and magnesia being present, with 30 per cent. of silicates; the large proportion of silicates is an important point of difference from the Carboniferous nodules. In having numerous plant-fragments in a single nodule and in the type of petrifaction the nodules are like coal-balls; in having marine shells included in the matrix they are more like roof-nodules. They probably represent fragments of tangled débris, which drifted out to sea but a short distance and then were speedily petrified. The authoress acknowledges help from the Government Grant Committee of the Royal Society in carrying out the research, and also from the Japanese Government, the Imperial University, and the local Government of Hokkaido, together with the Tunko Kaisha of Hokkaido.

2.—*March* 10, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Some Notes on the Neighbourhood of the Victoria Falls, (Rhodesia)." By Thomas Codrington, M.Inst.C.E., F.G.S.

The author gives an account of the way in which the basalt lies in the valley of the Zambesi below and above the Victoria Falls, and points out how that has determined the features of the river. The basalt through which the Batoka Gorge has been cut appears in the course of the Zambesi for 2 miles above the Victoria Falls, causing rapids over rocky bars between many islands. It then disappears, and the river above flows quietly between alluvial flats for 5 miles, the basalt being traceable here and there below the water until above Candahar Island it again rises and constitutes the bed of the river from bank to bank, causing rapids that extend for many miles up the river. Attention is called to a wide tributary valley which joins the main Zambesi Valley on the east at the Falls; and to the Maramba River flowing down it, and its fluviatile deposits. The discovery of stone implements and artificially worked stones in the gravel and the bed of the Maramba is noted.

The difference observable in the artificially worked stones from defined areas on both sides of the Zambesi is shown by a comparison of numerous specimens collected by the author. The very large majority of flakes and flaked stones having no trace of design over those that can be considered as implements, however rough, suggests that the manufacture of stone tools on a large scale was here carried on for use in the sand-covered country on both sides of the Zambesi, where there is no stone; and the difference in the proportion of sharp unworn specimens to those apparently water-worn seems to show that while many were made on the ground, the flakes and refuse of the making of many more were brought down from the tributary valley on the east.

The author considers that there is no evidence as to the age of the implements found near the Zambesi; none have been discovered in gravel that belongs to that river, and the presumption appears strong that they were made from quartzite found on the surface since the Batoka Gorge was eroded.

2. "A Contribution to the Petrography of the New Red Sandstone in the West of England." By Herbert Henry Thomas, M.A., B.Sc., F.G.S.

The paper is supplementary to that which dealt with the mineralogical composition of the Pebble-bed, and was published in vol. lviii of the Quarterly Journal (1902), p. 620. The results obtained are based on the microscopic investigation of a large number of samples taken from various New Red horizons and localities in Devon and Somerset.

The author gives a list of minerals identified, and tables showing their distribution. In the description of certain mineral species, it is suggested that anatase occurs both as detrital crystals and as crystalline groups formed in the rocks since their deposition. The forms presented by grains of staurolite as well as certain crystals of tourmaline with an unusual habit are described.

It is recognized that the various divisions of the New Red Sandstone, namely, the Lower Breccias and Sandstones, the Lower Marls, the Pebble-bed, and the Upper Marls and Sandstones, although linked together by a general similarity of mineralogical composition, present physical and mineralogical differences indicative of variations in the source of supply and conditions of deposition.

The rounding of the grains is most complete (millet-seed) in the sandstones of the Lower Breccias and Sandstones, a feature continued, but in a less striking manner, into the overlying division.

With regard to the vertical and horizontal distribution of minerals, it is found that staurolite is abundant in the Lower Breccias and Sandstones of the extreme south of Devon, but less plentiful northwards; that garnet is present in all the New Red rocks of North Devon and Somerset, but in South and Central Devon only occurs in the Lower Marls and in the Upper Marls and Sandstones.

3.—*March* 24, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communication was read :—

"Glacial Erosion in North Wales." By Professor William Morris Davis, For. Corr. G.S.

An excursion around Snowdon in September, 1907, followed by a further visit in 1908, led the author to the conclusion that a large-featured, round-shouldered, full-bodied mountain of pre-Glacial time, had been converted by erosion during the Glacial Period—and chiefly by glacial erosion—into the sharp-featured, hollow-chested, narrow-spurred mountain of to-day. The peculiar indifference of topographic form to the trend of formation boundaries and the insequent stream arrangement, are what might be expected as the result of prolonged erosion upon a mass of complicated and resistant structure. The author discusses Ramsay's theory of a plain of marine denudation, and is of opinion that the upland seems to deserve classification rather with peneplains; he suggests for it a Tertiary date, which would not be inconsistent with the erosion of open valleys in the uplifted peneplain after its elevation, and argues that Snowdon and its high neighbours had a relief of some 2,000 feet above the plain. As the result of a comparison with the non-glaciated regions of Devon, it is considered that the dissection of North Wales must have been somewhat less developed in pre-Glacial times than in Devon to-day. On this assumption it is possible to make a tentative restoration of the pre-Glacial form of Snowdon: subdued mountains, with dome-like summits and rounded spurs, drained by prevailing graded streams of accordant levels at their junctions. In fact, the characters were those of 'moels' such as Moel Tryfaen or like the well-worn Appalachian Mountains of North Carolina or the Cévennes.

The chief abnormal features of Snowdon are the following:—Alongside the graded summit and slopes of a 'moel' stand the head-cliffs of a rock-walled cwm, in the floor of which talus is now accumulating. The cwm-floors are generally stepped, sometimes more than once, and the streams cascade down into the valleys. The cross-profile of the valleys is often a fine catenary curve, down the sides of which streams fall from hanging valleys. The slope of the main valleys occasionally decreases even to the point of reversal, as where lakes occur; and in the immediate neighbourhood of smoothly graded, waste-covered slopes knobby or craggy ledges and bars of rock often appear. After pointing out that such features are generally associated with glaciation, the author proceeds to discuss two out of four possible hypotheses put forward: "that glaciers are essentially protective agencies," or that they "are active destructive agencies". The consequences deduced from the hypotheses are confronted with the actual facts, and it is found that these, and especially those relating to rock-steps, cannot be explained on the protection-theory, while the theory of a destructive agency seems to explain most of the facts.

These facts are dealt with under the following heads:—Valley-head curves; valley-floors, lakes; valley-floors, rock-steps; valley-sides; hanging lateral valleys; and glacial overflows. With regard to the first, it is shown that there is no systematic relationship between the height of the cwm-cliffs and the distance of the front rock-step; the serration of 'cribs' or arêtes cannot be explained by pre-Glacial or post-Glacial weathering according to the protection theory. It is suggested that it might be possible on the erosion theory to work out and classify cwms according to their age and growth, and as a contribution to this enquiry the cwms of Mynydd Mawr are dealt with. The valley-lakes are likely to be only a small part of the glacial erosion. No consistent explanation of the valley-steps can be found under the theory of ice-protection, whereas they are explicable on the assumption of glacial erosion. They may have originated in resistant beds, and have then retreated up the valleys. The catenary curve of the cross-section of such valleys as those containing Llyn Gwynant and Llyn Cwellin might be expected to result from long-continued ice-erosion; and the occurrence of great cliffs on the sides of these valleys is not inconsistent with such an origin. Several good examples of hanging valleys occur, and they seem to show that the deepening of the main valleys by glacial erosion may be from 200 to 400 feet, and in some cases as much as 500 or 600 feet. The lateral erosion may easily amount to 1,000 or 1,500 feet. The most striking case of a glacial overflow is that at the head of the Nantlle valley, which appears to have carried much of the West Snowdon ice. The head of the pass would seem to have been farther westward and higher in pre-Glacial times.

II.—Palæontographical Society.

The sixty-second annual meeting of this Society was held in the rooms of the Geological Society, Burlington House, on Friday, March 19, Dr. Henry Woodward, F.R.S., President, in the chair. The Report of the Council referred to the completion of the Monograph of Cretaceous Asteroidea, and to the satisfactory progress of the Monographs of Chalk Fishes, Cretaceous Lamellibranchia, Cambrian Trilobites, and British Graptolites. Numerous proposals for new monographs had been received, but the Council were desirous, so far as possible, to complete those in progress before entering upon further undertakings. The Society had sustained several serious losses by death during the year. The late Mr. W. H. Hudleston was a Vice-President and a distinguished contributor. Professor Albert Gaudry had been a member for many years. Sir Thomas Wardle was also an old member, and had served for some time on the Council. An appeal was made for new subscribers to replace these and other members who had been lost. Sir Archibald Geikie, K.C.B., Pres. R. S., was elected a Vice-President in place of the late Mr. Hudleston. Professor E. J. Garwood, Mr. C. Fox-Strangways, and Mr. F. R. Cowper Reed were elected new members of Council. The officers were re-elected—Dr. Henry Woodward as President, Dr. G. J. Hinde as Treasurer, and Dr. A. Smith Woodward as Secretary.

III.—Mineralogical Society.

March 23, 1909.—Principal H. A. Miers, F.R.S., President, in the Chair.

On a Stage Goniometer for use with the Dick pattern of microscope; by Professor H. L. Bowman. The form of goniometer, intended to be screwed to the stage of a microscope with rotating nicols, which was designed by Principal Miers, has been slightly modified by the author with a view to securing increased rigidity and ease of control. The instrument is adapted for supporting and manipulating a small crystal during the examination of etching-figures or other features requiring high magnification, as well as for the determination of its optic axial angle in air or oil, and the extinction angles and other optical characters of the various faces. It is provided with screw motions for adjusting and centreing the crystal, and for regulating the height of the axis above the stage.—On the Electrostatic Separation of Minerals; by Mr. T. Cook. Conductivity is a much more important factor than specific gravity in determining the behaviour of mineral fragments under the influence of an electrostatic charge. The greater susceptibility of good conductors as compared with bad conductors can be made still more pronounced by providing for the escape of the repelled opposite charge, which takes place rapidly in good conductors and slowly in bad conductors. It was shown that, in consequence of this fact, grains of such good conductors as ilmenite, pyrites, galena, or wolfram can be easily separated by means of a rubbed piece of sealing-wax from admixed grains of bad conductors such as calcite, quartz, fluor, or monazite. Minerals having a metallic lustre are good conductors, whereas those which are colourless and highly transparent are bad conductors. It is suggested that there is probably a much closer connection between the conductivity of a mineral and its general optical properties than has been hitherto suspected.—On the identity of Guarinite and Hiortdahlite; by Dr. F. Zambonini, with chemical analysis by Dr. G. T. Prior. The rare mineral guarinite, which occurs sparingly in small yellow crystals in the sanidinite bombs of Monte Somma, has been hitherto regarded as ortho-rhombic, and as essentially a complex silicate of lime, alumina, and soda. A new investigation made by the author on crystals showing terminal faces shows that the mineral is really triclinic, and identical, both crystallographically and optically, with hiortdahlite. Crystals of guarinite show polysynthetic twin lamellæ with oblique extinctions like those exhibited by crystals of hiortdahlite. The chemical analysis showed that the mineral is essentially a fluo-silicate and zirconate of lime and soda, practically identical in composition with hiortdahlite, although the percentage of fluorine was lower than that given in Cleve's analysis of the latter mineral. The numbers obtained in the analysis correspond closely to a formula $3\,Ca\,Si\,O_3\,.\,Ca\,(OH, F)\,Na\,.\,Zr\,O_3$.—Note to a paper "On the Comparison of Refractive Indices of Minerals in Thin Sections"; by Dr. J. W. Evans. Parallel nicols are placed so as to bisect the angle between the directions of vibration in the adjoining crystal sections which make the smaller angle with each other, so that the Becke effect is mainly due to the relation between their indices of refraction. The author discusses in detail the effect of the refractive indices of the different directions of vibration on the result.

CORRESPONDENCE.

SCANDINAVIAN ICE-SHEETS AND BRITISH GLACIAL DRIFTS.

SIR,—I thank Professor Bonney for the very kind way in which he refers to my letter on the Scandinavian ice-sheet. The question should, I agree with him, be approached without shirking difficulties. It would not be possible within the limits of this letter to discuss all the points he raises. I will, therefore, merely deal with the question as to whether, if sufficient ice passed off the Scandinavian Peninsula, it could flow across the deep Norwegian Channel and shallow North Sea and invade England. Professor Bonney says the main point for consideration "for our present purpose is the inadequate 'ramming' power of the ice from the Scandinavian upland, because by far the greater part of the journey to England would have been over land, not by water". If glacier ice be really viscous, the flow would not be the result of 'ramming' from behind. The movement would result from the absence of support in front. Again, he says, "Thus it must either have been forced up and over an undulating floor for over 350 miles before it reached the English coast, or its movement have been practically restricted to the upper layers." If such a form of flow took place, it would not be viscous flow. There would be a more or less steady gradient of the upper surface of the glacier rising from England to the Scandinavian uplands. The stresses due to the existence of this upper slope would act on every portion of the ice-sheet, and the bottom of the ice would drag the floor in the direction of motion even though the motion of the ice at the bottom were uphill. Ice will flow like water until its upper surface has become practically horizontal; but as the former has a viscosity of only 0·01 [1] c.g.s. 793 units, whilst the viscosity of glacier ice [2] is about 125×10^{12} c.g.s. units, water—if we do not consider the effects of inertia—would flow *cæteris paribus* as far in one second as glacier ice would in about 200,000,000 years. Now, if the water in the Norwegian Channel were raised about 100 feet, as Prof. Bonney suggests, and then suddenly released, it would invade England and carry material along the sea bed with it. Ice is not 'rammed' forward any more than water is rammed along a river bed. The spreading out in great sheets over the Antarctic Seas of the glaciers coming down from the Antarctic uplands is proof, I consider, that glacier ice in bulk behaves as a viscous substance, i.e. that the rate of shear is proportional to the stress even when the stress is exceedingly small. A great many very capable field geologists hold that there is ample evidence that an ice-sheet did invade England from the east and north-east, and I always understood

[1] Phil. Mag., 1909, p. 518.
[2] Roy. Soc. Proc., vol. lxxxi, p. 251.

that the main argument of their opponents was that it did not because it could be demonstrated that it could not, a view which I consider erroneous. R. M. Deeley.

Melbourne House,
Osmaston Road, Derby.

THE DISCUSSIONS AT THE GEOLOGICAL SOCIETY.

Sir,—Referring to the letters of Dr. Davison and Mr. Hobson, would not the case be fully met, in the circumstance of the author not being present at the reading of his paper, if the Assistant Secretary were to send the author a copy of the abstract containing the discussion *with a request* that he would return any reply he might wish to make to be inserted as a postscript in the Quarterly Journal? I have myself been permitted to avail myself of this privilege in the case of my paper on the "Dewlish Elephant Trench" (vol. lxi, 1905), and can appreciate its sufficiency. If the author is present there is no hardship, for if his cause is a good one he can strengthen it by replying to his critics there and then, and his reply will appear in the Journal. O. Fisher.

April 3, 1909.

OBITUARY.

FREDERICK GEORGE HILTON PRICE, F.S.A., F.G.S.

Born August 20, 1842. Died March 14, 1909.

We regret to record the death of Mr. Hilton Price, Director of the Society of Antiquaries, who, while distinguished as an archæologist, had also rendered important services to geological science. In 1860, at the age of 18, he entered the banking house of Messrs. Child & Co., Temple Bar, and eventually became head acting partner. With an intimate knowledge of business, of wide culture, possessed of a fine presence and of genial disposition, he was equally welcome on the council of the Bankers' Institute or on that of a learned society.

To the Geologists' Association in early years he gave much time and attention, and carried out the duties of treasurer from 1875 to 1881. He joined the Geological Society in 1872, and served on the Council for a short period in 1878–9. In later years his time, apart from business, was much occupied in archæological pursuits, including Egyptology and numismatics.

In his work upon the Gault Mr. Price was intimately associated with Mr. J. Starkie Gardner, F.G.S., and for many years they subsidized Griffiths, the well-known Folkestone collector, and made rich collections of the very finest Gault fossils. Mr. Gardner's collection was acquired by the British Museum, and Mr. Price's by his friend Mr. Hudleston, of which it still forms an integral part.

To geologists Mr. Price is best known through his detailed researches on the stratigraphy and palæontology of the Gault of Folkestone. He divided the formation into eleven zones, excluding that of *Ammonites mammillaris*, Schloth. (now generally noted as *A. mammillatus*), which he placed with the Folkestone Beds at top of the Lower Greensand. In this respect he followed C. E. De Rance, who in 1868 communicated to the GEOLOGICAL MAGAZINE a paper "On the Albian, or Gault, of Folkestone", in which the zones in the English Gault were for the first time deciphered.

Some of the zones marked out by Mr. Price are now regarded rather as sub-zones[1]; nevertheless, by his painstaking and enthusiastic researches, he added very largely to our information, and extending his knowledge to other regions he was enabled to publish in 1879 a memoir on "The Gault", which embodied his detailed observations at Folkestone, and included descriptions of the formation elsewhere in England and France, with a full list of fossils.

In his paper of 1877 he dealt with the so-called Upper Greensand of Folkestone, showing that the fauna belonged to the basal portion of the Chalk, and he termed this division the zone of *Stauronema Carteri*. It is regarded by Mr. Jukes-Browne as the stratigraphical equivalent of the Chloritic Marl as now defined in the Isle of Wight.[2]

The following is a list of Mr. Price's geological papers:—

1872. (With W. H. HUDLESTON.) "On Excavations on the site of the new Law Courts": Proc. Geol. Assoc., vol. iii, pp. 43–64, with descriptions and figures of two new species of Gasteropoda from the London Clay.

1873. "On a new species of *Rostellaria* from the Gault" [*Rostellaria maxima*, Price, Folkestone]: GEOL. MAG., pp. 97, 98.

1874. "On the Gault of Folkestone": Quart. Journ. Geol. Soc., vol. xxx, pp. 342–66, pl.

"On the Lower Greensand and Gault of Folkestone": Proc. Geol. Assoc., vol. iv, pp. 135–50.

1875. "On the probable Depth of the Gault Sea": ibid., vol. iv, pp. 269–78.

1876. "Excursion to Sandgate and Folkestone": ibid., vol. iv, pp. 554–6.

"Note on an Annelid Bed in the Gault of Kent": GEOL. MAG., pp. 190–1.

1877. "On the Beds between the Gault and Upper Chalk near Folkestone": Quart. Journ. Geol. Soc., vol. xxxiii, pp. 431–45.

1879. "The Gault, being the substance of a lecture delivered in the Woodwardian Museum, Cambridge, 1878, and before the Geologists' Association, 1879": 8vo, London, p. 81.

1881. (With W. J. MORRIS and E. B. TAWNEY.) "Excursion to the East End of the Isle of Wight": Proc. Geol. Assoc., vol. vii, pp. 185–9.

1886. "The Landslip in the Warren near Folkestone" [letter]: GEOL. MAG., p. 240.

1893. (With T. LEIGHTON.) "Excursion to Hythe, Sandgate, and Folkestone": Proc. Geol. Assoc., vol. xiii, pp. 142–51.

H. B. W.

MISCELLANEOUS.

THE LATE MR. W. H. HUDLESTON.—We learn that by his will Mr. Hudleston has left his unrivalled collection of types of Oolitic Gasteropoda to the Sedgwick Museum, Cambridge, and he has bequeathed £1,000 to the Geological Society.

[1] See Jukes-Browne, *Cretaceous Rocks of Britain*, Mem. Geol. Survey, 1900, vol. i.
[2] *Op. cit.*, 1903, vol. ii, p. 15.

No. 540. Decade V.—Vol. VI.—No. VI. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

JUNE, 1909.

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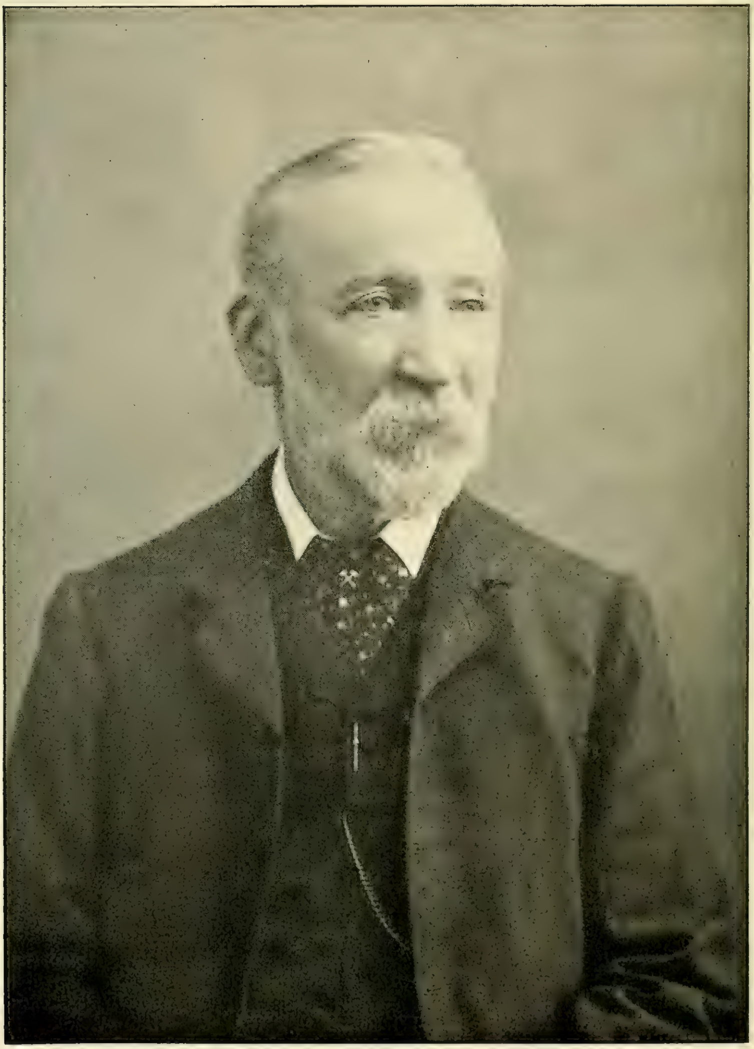
LONDON: DULAU & CO., 37, SOHO SQUARE.



Yours sincerely
R H Traquair.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. VI.—JUNE, 1909.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

Ramsay Heatley Traquair, M.D., LL.D., F.R.S., V.P.R.S.E., F.G.S.,

late Keeper of the Natural History Department of the Royal Scottish Museum, Edinburgh.

(WITH A PORTRAIT, PLATE IX.)

MANY sciences contribute to the progress of geology, but none is more essential to it than that of zoology. The accurate determination of fossils, which can only be done by a trained systematic zoologist, is a necessity for stratigraphical work, and the broad questions of the geography of past ages can only be discussed with the aid of those who understand the distribution of life in the existing world. Dr. Traquair, the eminent ichthyologist of Edinburgh, though scarcely a geologist in the strict sense of the term, may therefore be claimed as one of the leaders in our science, for he has devoted more than forty years to the interpretation of fossil fish-remains, and so laid the foundations of a precise knowledge of extinct fishes which is as important to the stratigraphical geologist as to the biological philosopher.

Ramsay Heatley Traquair was born on July 30, 1840, at the Manse of Rhynd, Perthshire. He was the son of the Rev. James Traquair, minister of the parish, a Midlothian man, who had married Miss Elizabeth Mary Bayly, a native of London. He received his early education in Edinburgh, first at a preparatory school in the suburb of Newington and then at a more advanced school known as the Edinburgh Institution. Being of slight physique compared with other boys of his own age, he found himself unable to compete in games of strength; but being of a quiet and studious disposition and clever at his lessons, he was generally a favourite with his teachers.

Already as a child he showed an ardent love of Nature, both from an æsthetic and from a scientific standpoint. He eagerly read the few books on popular science contained in his father's library. When about 10 years of age he began eagerly to collect butterflies and moths, as well as shells of mollusca. Then about six years later he began to frequent a little shop in Edinburgh kept by an old woman, Mrs. Somerville, who dealt in minerals, rocks, fossils, and foreign shells. Here his interest was vastly aroused by the fossils which the good lady had for sale, and as soon as possible he procured a copy of Page's "Introductory Textbook of Geology", borrowed a copy of McLaren's "Geology of Fife and the Lothians", and armed with a hammer set out on Saturdays and holidays to teach himself field geology as well as to collect all the fossils he could come across.

When hammering one day among the ironstone nodules contained in the Lower Carboniferous shales deposited on the shore at Wardie, near Edinburgh, he came on a portion of a Palæoniscid fish, a wonderful find (!), though the bones of the head were much crushed and broken, but this only stimulated all the more his curiosity to know how they were conformed and arranged. Impelled by this desire for knowledge, he diligently searched for more specimens, but though better ones did turn up, the craniological problem remained unsolved, and he was content to wait for the time when as a University student he would have access to Agassiz's great work, of which he had already heard, and from which he expected all the enlightenment which he craved. He was blissfully ignorant of the fact that the knowledge of the cranial osteology of fossil fishes was as yet only in its infancy.

As he was approaching the age of 17, the time for the choice of a profession had arrived. He had for years cherished the idea of devoting his life to research in the field of natural history, but as it was necessary to have some means of living to fall back on, he chose medicine as offering likewise an admirable training in biological science. Indeed, at that time the doctorate of Medicine was the only University degree in Scotland which testified to such a training. Accordingly, in November, 1857, having passed his preliminary examination, he entered the University of Edinburgh as a student in the Faculty of Medicine. The first thing he did on finding himself entitled to the privileges of a "Civis Academiæ Edinensis Jacobi Sexti" was to rush to the library and demand a sight of Agassiz's "Recherches sur les Poissons Fossiles", but, alas! he did not find there the much desired light on the cranial structure of Carboniferous fishes. That was evidently a subject for future research.

During the next five years Dr. Traquair applied himself to his medical studies and stood well in his classes, although he had resolved not to go in for practice if he could find an opening in the direction of pure science. His favourite subjects were anatomy and zoology, and in holiday time he continued to collect fossils, paying of course especial attention to those of a fishy description. The skill which he acquired in the art of dissection brought him under the notice of the Professor of that subject, the eminent John Goodsir, by whose advice he took up the subject of the Asymmetry of the Flatfishes for his thesis, for which on Graduation Day, August, 1862, he was awarded a gold medal by the Faculty of Medicine.

In 1862–3 Dr. Traquair acted as Prosector to Professor Goodsir, and was employed in making comparative anatomical preparations. From 1863 to 1866 he was Demonstrator of Anatomy in the University of Edinburgh under Professor Goodsir, and he published his thesis on the Asymmetry of the Flatfishes in the Transactions of the Linnean Society in 1866. In the latter year he was appointed Professor of

Natural History in the Royal Agricultural College, Cirencester, where his principal duty was the teaching of botany to agricultural students. Here he studied Oolitic geology and collected many fossils, but had no longer any opportunity to collect Carboniferous fishes. In 1867 he published his first paper on fossil fishes, entitled "Description of *Pygopterus Greenocki*, Agass., with Notes on the Structural Relations of the genera *Pygopterus, Amblypterus*, and *Eurynotus*", in the Transactions of the Royal Society of Edinburgh. This paper was important as containing the beginnings of his original work on the Palæoniscidæ and Platysomidæ, though it suffered in completeness by being founded entirely on specimens collected by himself in the neighbourhood of Edinburgh.

In the month of August, 1867, Dr. Traquair was appointed by the Lords of the Committee of Council on Education Professor of Zoology in the newly constituted Royal College of Science, Dublin, this college being in fact a new development of the old "Museum of Irish Industry". This new appointment afforded him more congenial occupation than teaching botany to agricultural students, though owing to the comparatively small amount of the endowments it could not be looked upon as a permanency. He remained six years in Dublin, but during that time he did not write much. One paper on the imperfectly known Carboniferous Dipnoan fish, *Uronemus lobatus* of Agassiz, attracted the attention of Sir Philip Grey-Egerton, at that time the leading authority on palæichthyology in Great Britain, and gained for him the personal acquaintance both of Sir Philip and of his friend the Earl of Enniskillen, so well known for his magnificent private collection of fossil fishes.

In the autumn of 1873 Dr. Traquair was transferred to Edinburgh to occupy the post of Keeper of the Natural History Collections in the Museum of Science and Art, now, since 1902, known as the Royal Scottish Museum. At that time the "Natural History" Collections in that Museum included also the mineralogical and palæontological collections as well as those of recent zoology. Though his time was much more occupied by official work than in Dublin and his vacations curtailed, he had now the wished-for opportunity of devoting himself seriously to fossil ichthyology as a speciality, for the Museum already contained a large collection of Scottish fossil fishes, including the Hugh Miller Collection and the specimens collected by John Fleming and by Robert Jameson, besides which the Carboniferous rocks round Edinburgh were and are extremely rich in fossil fishes and fish-remains. In his official capacity he was enabled by fresh purchases year by year to develop the fossil fish collection, and more especially that part which was Palæozoic and Scottish, to a high degree of excellence. This was especially desirable in a *Scottish* National Museum, for it is the wonderful richness in fish-remains of its Devonian and Carboniferous strata which especially distinguishes the palæontology of the northern part of the island of Great Britain. Dr. Traquair retained his Keepership for thirty-three years, and retired in August, 1906, having obtained extension of time for one year after reaching the age-limit of 65 years. During that time he also held the Swiney Lectureship in Geology at the British Museum, the patronage of which is vested in the Trustees of that institution, for two periods of five years each, namely, from 1883 to 1887 inclusive and from 1896 to 1900 inclusive. In this capacity he had to deliver each year a course of twelve lectures, and naturally the subjects which he chose for his lectures were always palæontological.

Besides by the specimens of fossil fishes under his charge in the museum at Edinburgh, Dr. Traquair was much assisted in the way of material by successive Directors-General of the Geological Survey (Sir A. C. Ramsay, Sir A. Geikie, and Dr. Teall), who placed at his disposal for description the fish-remains collected by the Survey in Scotland, some of his best material having come to him from that source.

At the time of his leaving for Edinburgh he married the daughter of Dr. William Moss, of Dublin, and Mrs. Traquair prepared a beautiful series of drawings of Palæoniscid fishes to illustrate some of his works.

Dr. Traquair's original writings appear chiefly in the Transactions of the Royal Society of Edinburgh, in the Proceedings of the Royal Physical Society of Edinburgh, in the Geological Magazine, in the Annals and Magazine of Natural History, and in the volumes issued by the Palæontographical Society. As he always has consistently maintained that palæontology is simply a part of biology, his own work was from the beginning based on morphological structure and not on the mere outline of body or configuration of scales and teeth. He showed from their structure that the Palæoniscidæ were more allied to *Polyodon* than to the Lepidosteoid Ganoids, and that consequently their place was with the Sturgeons (Acipenseroidei), and that the Platysomidæ were a specialized offshoot from the Palæoniscidæ. Indeed, his work on these two families may be said to have given the deathblow to the Agassizian idea of the classificatory importance of the external forms of scales. He was the first clearly to prove that the Devonian genus *Cheirolepis* was not Acanthodian but Palæoniscid, though this had been already hinted at by previous writers. In like manner he settled the question as to *Dipterus* being referable to the Dipneusti, and showed that it agreed in all essential points of structure. He described the remarkable fish-fauna collected by the Geological Survey of Scotland from the Upper Silurian rocks of Lanarkshire and Ayrshire, and showed that the Cœlolepidæ, though in his opinion probably derived from an Elasmobranch source, were not sharks but Heterostracan Ostracodermi. And the Ostracodermi he divided into four families, viz., the Cœlolepidæ (*Thelodus* and *Lanarkia*), the Psammosteidæ (*Psammosteus*), the Drepanaspidæ (*Drepanaspis*), and the Pteraspidæ (*Pteraspis*, etc.), and showed how that the mail-plates of the three last families were evidently formed by the fusion of the small Cœlolepid scales with each other and with hard tissue developed in a deeper layer of the skin. He maintained that the Osteostraci were more nearly related to the Heterostraci than had previously been supposed, the minute tubercles covering the outside of the dermal plates of *Cephalaspis* being suggestive that the superficial layers of these plates were also formed by the fusion of Cœlolepid scales. He also devoted special attention to the Asterolepidæ or *Pterichthys* family, and his monograph (Palæontographical Society) of the British genera and species of the family is now all but complete.

Dr. Traquair commenced the systematic study of the fishes of the Old Red Sandstone in 1887, and found their nomenclature in much need of rectification. He pointed out how that Agassiz and M'Coy had, misled by appearances dependent on different conditions of preservation, most unnecessarily multiplied the number of supposed species, e.g. he reduced six supposed species of *Cheirolepis* to a single one! Our knowledge of the genera and species of British Carboniferous Palæoniscidæ (on a monograph of which he is still engaged) is principally due to his work. He was the first to figure and to describe in detail the Lower Devonian fishes of Gemünden in Western Germany. His papers on that subject contain a complete account, fully illustrated, of the remarkable mailed fish, the *Drepanaspis Gemündenensis* of Schlüter, which was previously very imperfectly known. It must also be added that he has produced a great many restorations of fossil fishes for the illustration of his papers, and these have been freely copied in all modern textbooks of geology and of palæontology.

Dr. Traquair has received many well-deserved honours, and the thoroughness and value of his published work are universally acknowledged. He was elected a Fellow of the Royal Society of London in 1881, and received the Honorary Degree of LL.D. from the University of Edinburgh in 1893. He was awarded the Neill Medal of the Royal Society of Edinburgh in 1878, and the MakDougall-Brisbane Medal of the same Society in 1901; the Lyell Medal of the Geological Society of London in 1901; and a Royal Medal of the Royal Society of London in 1907. He is esteemed both abroad and at home as the doyen of palæichthyology and the pioneer in its modern methods, and it is the fervent wish of his many friends that he may long be spared in his retirement to pursue the studies which he has so greatly adorned.

LIST OF SCIENTIFIC WRITINGS.

1862. "On the Occurrence of Trilobites in the Carboniferous Limestone of Fifeshire": Proc. Roy. Phys. Soc. Edin., vol. ii, pp. 253–4.

1863. "Note on an Abnormality in the Ossification of the Parietal Bone in the Human Fœtus": Nat. Hist. Review, pp. 132–3, woodcut.

1865. "Observations on the Development of the Pleuronectidæ": Proc. Roy. Phys. Soc. Edin., vol. iii, pp. 215–22.

1866. "On the Asymmetry of the Pleuronectidæ as elucidated by an examination of the Skeleton in the Turbot, Halibut, and Plaice": Trans. Linn. Soc., vol. xxv, pp. 263–96, 4 plates.

"Observations on the Internal Structure of *Calamoichthys*, a new genus of Ganoid Fish from Old Calabar": Ann. and Mag. Nat. Hist. (3), vol. xviii, pp. 114–17; also in Proc. Roy. Soc. Edin., vol. v, pp. 657–9.

1867. "Description of *Pygopterus Greenockii*, Agass., with Notes on the Structural Relations of the genera *Pygopterus*, *Amblypterus*, and *Eurynotus*": Trans. Roy. Soc. Edin., vol. xxiv, pp. 701–14, plate.

1871. "On *Griffithides mucronatus*, M'Coy" (1869): Journ. Roy. Geol. Soc. Ireland, vol. ii, pp. 213–18, plate.

"On the Restoration of the Tail in *Protopterus annectens*, Owen": Brit. Assoc. Report, vol. xli (Trans. Sect.), p. 143.

"Notes on *Calamoichthys Calabaricus*, J. A. Smith" (1870): Journ. Roy. Geol. Soc. Ireland, vol. ii, pp. 249–54.

"On the Cranial Osteology of *Polypterus*": Journ. Anat. and Phys., vol. v, pp. 166–83, plate.

"Notes on the genus *Phaneropleuron*, Huxley, with a Description of a New Species from the Carboniferous Formation": Geol. Mag., Vol. VIII, pp. 530–5, plate and woodcut.

1872. "On the so-called Tailless Trout of Islay": Journ. Anat. and Phys., vol. vi, pp. 411–16, plate.

"Supplementary Note on *Phaneropleuron* and *Uronemus*": Geol. Mag., Vol. IX, pp. 271–2.

1873. "On *Phaneropleuron Andersoni*, Huxley, and *Uronemus lobatus*, Agass.": Journ. Roy. Geol. Soc. Ireland, n.s., vol. iii, plate and woodcut.

"On a new genus of Fossil Fish of the Order Dipnoi (*Ganorhynchus*)": Geol. Mag., Vol. X, p. 555, plate and woodcut.

1874. "Description of *Cycloptychius carbonarius*, Huxley, from the Coal-Measures of North Staffordshire": Geol. Mag., Dec. II, Vol. I, pp. 241–6, plate.

"On *Uronemus magnus*, a new Fossil Fish from the Coal-Measures of Airdrie, Lanarkshire": ibid., p. 554.

1875. "On the Structure and Systematic Position of the genus *Cheirolepis*": Ann. and Mag. Nat. Hist. (4), vol. xv, pp. 237–49, plate.

"On some Fossil Fishes from the Neighbourhood of Edinburgh": ibid., pp. 258–68, plate.

"On the Structure and Affinities of *Tristichopterus alatus*, Egert.": Trans. Roy. Soc. Edin., vol. xxvii, pp. 383–96, plate.

"On the Structure of *Amphicentrum granulosum*, Huxley": Ann. and Mag. Nat. Hist. (4), vol. xvi, pp. 273–82, plate.

1877. "On new and little known Fossil Fishes from the Edinburgh District": No. I, Proc. Roy. Soc. Edin., vol. ix, pp. 262–72; No. II, ibid., pp. 275–82; No. III, ibid., pp. 427–44.

"On the Structure of the Lower Jaw in *Rhizodopsis* and *Rhizodus*": Ann. and Mag. Nat. Hist. (4), vol. xix, pp. 300–5.

"On the Agassizian genera *Amblypterus*, *Palæoniscus*, *Gyrolepis*, and *Pygopterus*": Quart. Journ. Geol. Soc., vol. xxxiii, pp. 548–78.

Monograph on the Ganoid Fishes of the British Carboniferous Formations. Part I, Palæoniscidæ, with 7 plates. Palæontographical Society.

1878. "On the genus *Rhizodus*": Proc. Roy. Soc. Edin., vol. ix, pp. 657–60.

"On the genera *Dipterus*, *Palædaphus*, *Holodus*, and *Cheirodus*": Ann. and Mag. Nat. Hist. (5), vol. ii, pp. 1–17, plate.

"On Species of *Rhadinichthys* from the Coal-Measures": Proc. Roy. Phys. Soc. Edin., vol. iv, pp. 237–45.

1879. "Fossil Fishes from the Edinburghshire and Linlithgowshire Oil Shales": ibid., vol. v, pp. 113–28.

"Evidence as to the Predaceous Habits of the larger Palæoniscidæ": ibid., pp. 128–30.

"On the Structure and Affinities of the Platysomidæ": Trans. Roy. Soc. Edin., vol. xxix, pp. 343–91, 4 plates.

1880. "The History of Scottish Fossil Ichthyology" (Opening Address): Proc. Roy. Phys. Soc. Edin., vol. v, pp. 137–61.

"Report upon a Collection of Fossils from Nairnside, made by Messrs. Thomas D. Wallace and Alexander Ross of Inverness": Trans. Geol. Soc. Edin., vol. iii, pp. 215–17.

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II.—Albitization of Basic Plagioclase Felspars.[1]

By E. B. Bailey, B.A., and G. W. Grabham, M.A.

(PLATES X AND XI.)

SINCE Cathrein[2] in 1883 investigated the nature of saussurite, it has been well known that albite can arise from the alteration of basic plagioclase felspars. He found that the fine-grained aggregate of minerals known as saussurite has commonly been derived from basic felspar, and that the processes involved in the change have led to little more than a chemical re-arrangement within the limits of the original felspar crystal. The bulk composition of the aggregate thus agrees approximately with that of the felspar from which it has been derived, and the albite which separates out is intermingled with lime-bearing silicates such as epidote, zoisite, and garnet.

Later, Termier[3] has demonstrated the frequent production of albite in the metasomatism of basic plagioclase felspars under conditions which have led to a complete elimination of the original lime. Although the changes investigated by Termier are quite distinct from saussuritization, it is not clear how far they are comparable with what may properly be termed albitization. The albite he refers to is for the most part merely the residue of the original plagioclase, "des matières étrangères formant le tiers ou la moitié, ou même les deux tiers du volume total" (p. 186). He does, however, deal with examples where an actual gain of soda (p. 190) appears to have resulted. Here there would seem to have been a partial replacement of the original lime-felspar by soda-felspar, and this change, which may fairly be designated albitization, is now known to occur in several widely separated localities. Duparc & Pearce,[4] for instance, have described

[1] By permission of the Director of H.M. Geological Survey.

[2] *Zeit. Krist.*, 1883, Band vii, p. 234.

[3] "Sur l'élimination de la Chaux par métasomatose dans les roches éruptives basiques de la région du Pelvoux": *Bull. Soc. Géol. France*, 1898, vol. xxvi, pp. 165–92.

[4] "Sur les andésites et les basaltites albitisées du Cap Marsa": *Comptes Rendus*, 1900, vol. cxxx, p. 96. Two references to the replacement of potash-felspar by secondary albite may here be inserted: F. Becke, "Zur Physiographie der Gemengteile der Krystallizen Schiefer," *Wien K. K. Akad. Wiss. Denkschr.*, 1906, vol. lxxv, p. 28; and A. C. Spencer, "The Treadwell Ore Deposits, Douglas Island," *Bull. U.S. Geol. Surv.*, 1904, No. 259, p. 74.

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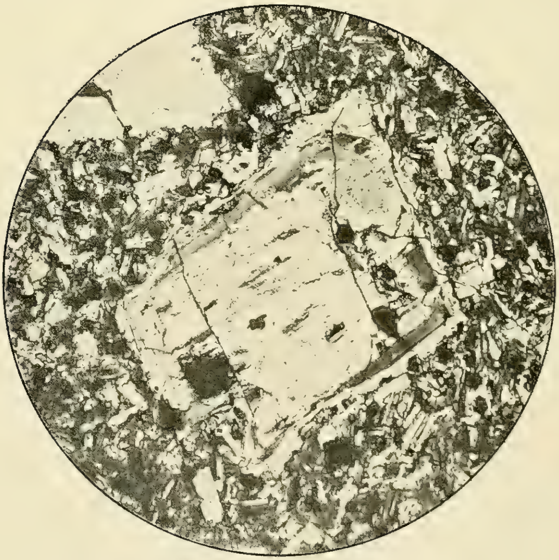


T. C. Hall, Phot.

Microphotographs of Basic Plagioclase Felspars near Lennoxtown.

albitized felspars in certain basalts of Cape Marsa, and we have more recently noticed the same phenomenon in many eruptive rocks of Scotland.

Termier ascribes the production of albite, in the cases which he has studied, to the influence of percolating surface waters,[1] which have above all things leached out the lime from the felspars and other minerals with which they have come in contact. Occasionally, where for some reason the subsoil waters have become unusually rich in soda, they have, according to Termier, been able to leave behind some of this base in partial exchange for the lime removed. More generally, however, the place of anorthite is taken by a silicate containing neither lime nor soda, such as chlorite, and the albite still remaining is merely a residue derived from the original plagioclase. Duparc & Pearce, on the other hand, have not entered upon any theoretical discussion of the processes involved in albitization, while our own experience has led us to regard the change as probably belonging to the category of juvenile reactions which igneous rocks undergo while still hot and richly charged with volatile and soluble ingredients.[2]

Two quite distinct suites of rocks have been specially examined during our inquiry into the rationale of albitization, namely, the Carboniferous lavas and the Permo-Carboniferous intrusions of the Central Valley of Scotland.

Carboniferous Lavas.

Albitization has been noticed among various basaltic and trachydoleritic lavas. It is local in its incidence, for scarcely an example is known from East Lothian, while many occur among the lavas of Arthur's Seat, Edinburgh. Again, in the Cathkin Hills, south of Glasgow, few cases have been discovered, while to the north of Glasgow, in the Campsie Fells and Kilpatrick Hills, every stage leading to complete albitization can be studied (e.g., on the hill-top above Lennoxtown and 150 yards north-east from Carbeth).

The alteration is guided to a notable extent by the cleavage and other cracks of the original felspars, so that kernels and ragged patches of the latter are often preserved in the heart of the secondary albite, and enable us to judge of the composition of the portion which has been replaced. The Campsie and Kilpatrick specimens in the Geological Survey collection demonstrate perfectly clearly that *the more basic the felspar the more liable it is to be albitized.* Thus, in a porphyritic basalt, the phenocrysts are always attacked before the less basic felspars forming the ground-mass, and, in fact, the latter are seldom affected in the least degree until the former have been more or less completely replaced. Not only this, but *in a given felspar the more basic portions are picked out first*, so that even a narrow, alternating zone of more basic composition is replaced, in part at least, before the more acid portions on both sides (Pl. X, Fig. 2); it is, for this

[1] Although not bearing directly upon the point at issue there is much suggestive matter in Sullivan's "Interaction between Minerals and Water Solutions", *Bull. U.S. Geol. Surv.*, 1907, No. 312.

[2] It must be understood that, even if we are correct in ascribing the greater part of the albitization studied by ourselves to juvenile changes, this does not preclude the possibility of Termier's explanation holding good in other districts.

reason, common to find phenocrysts with a core of cloudy secondary albite surrounded by a broad or narrow rim of clear primary felspar of more basic composition (Pl. X, Fig. 1).

The identification of the albite is a simple matter. Its felspathic nature is obvious, since the replacement has been molecular, and the twinning of the original basic felspar has been retained. The refractive index is less than that of balsam, and symmetrical extinctions range up to 16°. It is also the general rule in a composite crystal, cut so as to give symmetrical extinctions, that the extinction, for any particular twin lamella, changes sign where the lamella continues across the boundary separating the albite from the basic plagioclase. Definite cases were investigated in detail according to the optical methods perfected by Michel Lévy, and it was found that the *secondary felspar is albite in the strict sense*, and that *in some cases it replaces felspar originally containing, according to Michel Lévy's stereograms, no less than 80 per cent. of anorthite.* The albite in general does not appear to contain cavities corresponding with the disappearance of the anorthite, for in a great number of instances the total bulk of its inclosures is quite trivial. So much is this the case that there are slides in which it is an open question whether the albite is primary or not, and others (Pl. X, Fig. 1) where a single phenocryst betrays its history by retaining a tell-tale scrap of the original basic plagioclase. There can thus be no doubt in many examples of *a marked introduction of soda into the altered felspar crystals.*

When we inquire into the source of this introduced soda, we find one fact which stands out with special significance. We have seen that, within the limits of any particular felspar crystal, the more basic zones are the more liable to albitization, and that, within the limits of any particular lava, the more basic felspar crystals are preferentially attacked; but now we find the seeming paradox that, within the limits of any particular volcanic district, *the more basic lavas have escaped with less alteration than their neighbours.* If, with Termier, we ascribed the change to the action of percolating surface waters, the exact reverse would have been anticipated, for the basic basalts, on the whole, contain the more basic varieties of felspar. This relative immunity of the more basic lavas is especially well exemplified in Arthur's Seat, where the lower basic portion of the volcanic sequence, and also the well-known basic intrusions of the vent, have escaped unaltered, while the upper, less basic portion of the lava group, consisting originally of highly felspathic basalts and mugearites, has been very extensively affected. In this selective principle we notice at once an analogy between albitization and silicification, and it is reasonable to suppose that the change is of the nature of self-digestion, or, to borrow a convenient term from physiology, of *autolysis.* The soda introduced into the altered basic felspars probably belongs to the lava itself, and so far as this base is concerned the revolution is a matter of internal politics.

The inquiry cannot cease here, for it is of importance to determine, if possible, the stage in the history of the rock when albitization occurred. If it be conceded that the soda introduced into the altered felspars belongs properly to the lava containing these felspars, then it becomes apparent that the albitization cannot have been accomplished by mere weathering. The fact is there is no available source of soda in the rocks as we find them to-day; for, while they are practically holocrystalline, their felspars are the only soda-bearing minerals present, and it will be remembered that of these it is the more basic members which are first transformed.

But it is certain that the process of albitization does not antedate the crystallization period of the ground-mass felspars; where the core of a phenocryst has been replaced the boundary between core and rim is quite irregular; when examined closely the albite extends along cracks out into the rim, and it is obvious that the latter had formed before the alteration took place. Then, too, the ground-mass felspars are occasionally themselves albitized. We are thus led to suppose that the albitization was performed shortly after the consolidation of the ground-mass, and that the agency at work consisted of residual solutions. We may advance the hypothesis that in certain volcanic centres, e.g. Arthur's Seat, some portions of the magma were discharged exceptionally rich in carbon dioxide (or some other unknown constituent); that during crystallization of the lava an unusual proportion of soda was thus retained in solution; and that the residual liquors then began to react with the minerals which had crystallized. Olivine was converted into serpentine and chlorite, while the most basic felspars were replaced by albite. The process may be crudely expressed by saying that *the lava at this stage was stewing in a concentrated solution of sodium carbonate.*

Many specimens from Arthur's Seat, where albitization has proceeded unusually far, offer additional support to the interpretation given above. It is common to find the vesicles of these rocks lined with beautiful little, inwardly radiating crystals of albite, forming a definite outer layer. An inner layer of chlorite, either pennine (11,991)[1] or delessite (12,027), follows the albite, while the centres of the vesicles are occupied by calcite. It is also a feature of these vesicles that they frequently communicate one with another by means of branching cracks, which are usually entirely occupied by albite (Pl. X, Fig. 2). The cracks traverse phenocrysts and ground-mass alike, showing that the lava had consolidated at the time of their formation. The albite occupying them is generally crystallized in lath-shaped form, as in the ocellar structures of camptonites, but a marginal layer is often deposited in optical continuity with the albitized felspars which have been broken across. *Thus, in the lavas which have been most completely albitized, there was still a surplus left* to line the vesicles and fill the cracks formed in connection with the same. To claim vesicle minerals as juvenile products is nothing new,[2] and certainly it is difficult to regard the albite of the Arthur's Seat examples in any other light. Chlorite, which we may suppose originated from the decomposition of the original olivine, evidently crystallized out of solution after the albite, and last of all came calcite.

[1] The numbers given in parentheses refer to slides in the Geological Survey collection.

[2] Cf. A. Harker, "The Tertiary Igneous Rocks of Skye": *Mem. Geol. Survey*, 1904, chap. iv.

We may now briefly notice some of the peculiarities which the secondary albite of these rocks presents.[1] In one specimen from the Arthur's Seat volcano small patches and veins of anorthoclase accompany the albite, where this replaces phenocrysts, but such an occurrence is certainly rare in Scotland. A universal feature, however, is the presence of minute flakes of white mica (of sericitic appearance) scattered through the albite, wherever this latter has replaced basic felspar; the mica is absent, however, from the albite of the veins and vesicles, so that it has probably arisen independently in the pseudomorphs and is not a mere weathering product of the albite. Much time was spent in confirming the identification of this mineral as white mica. It occurs in such small flakes that its polarization tints are often lower than those of augite in the same slide, while, where closely packed, it gives, with the albite, a most misleading low aggregate refractive index as determined by the Becke effect. In some instances, however, patches can be found with a higher refractive index than chlorite (13,080), while it resists the attacks of acid, and its greatest axis of optical elasticity is normal to the cleavage. It thus appears to be identical with the sericites of other localities whose composition has been determined by analysis. It would be interesting to know whether the mica here is muscovite or paragonite, i.e. potash or soda bearing, but as a rule its bulk is too small to be a matter of much importance as affecting the composition of the pseudomorphs. Chlorite is commonly associated with the secondary albite; sometimes it fills the central portions of the pseudomorphs, sometimes it occupies the site of some particular zone (13,119) of the original plagioclase. It will be remembered that in the vesicles chlorite crystallized immediately after albite, so that the appearance of chlorite as a fairly frequent but subordinate constituent of the pseudomorphs is not surprising. As one might expect, the occurrence of calcite in this position is less frequent, but occasional examples are found (13,115). In a unique slide from the Edinburgh City cutting, at the back of the Engine Shed, St. Margaret's Works, a group of phenocrysts occurs replaced by calcite containing unorientated crystals of water-clear albite. In the same slide a broken albitized felspar has received a thin coat, apparently of chlorite, and later an outgrowth of water-clear albite, in optical continuity with itself; the outgrowth in this case projecting forward into a calcite vein. It seems that in these instances the complete precipitation of the secondary albite was delayed beyond the chlorite stage, and thus it happens that the mineral, elsewhere clouded with minute inclusions, is here water-clear. Analcite (12,307) is an occasional associate of the albite in the pseudomorphs, and at least a couple of other undetermined minerals have been noticed in one or two of the slides. Epidote occurs not uncommonly in small amount in the vesicles and groundmass of these albitized rocks (1191), but not in the felspars themselves. It doubtless contains part of the lime removed from the felspars, but

[1] The minerals mentioned in this paragraph have, in other cases, undoubtedly arisen through weathering. It is probable that juvenile and weathering reactions frequently follow the same course, but that the former, under suitable conditions, proceed with a much greater velocity.

most of this latter has probably been carried off in solution as calcium carbonate.

PERMO-CARBONIFEROUS INTRUSIONS.

These rocks are quartz dolerites, occurring as sills and dykes; in composition and age they agree with the well-known Whin Sill of Northumberland. Albitization is a very widespread phenomenon among these intrusions, e.g. in the North Queensferry Sill (12,181). It presents the same features as have just been described in connection with the lavas, only here there is a much greater development of finely divided white mica.

The interesting feature of the Scotch Permo-Carboniferous intrusions in connexion with the problem of albitization depends upon the fact that they carry numerous short irregular *segregation veins very rich in albite.* These are of two classes, described by Falconer[1] as 'red', or 'iron band' and 'blue band' respectively.

	A.	B.	C.
SiO_2 . .	64·54	71·26	71·18
TiO_2 . .	1·22	0·28	0·48
Al_2O_3 . .	13·63	11·87	14·89
Fe_2O_3 . .	0·22	0·10	2·11
FeS_2 . .	1·735	0·256	
FeO . .	4·83	2·12	1·21
MnO . .	0·20	0·06	
MgO . .	1·25	1·08	0·14
CaO . .	2·31	2·88	0·82
Na_2O . .	5·21	6·73	6·85
K_2O . .	2·28	0·054	1·70
SO_3 . .	trace		
F . . .	0·056	0·009	
P_2O_5 . .	0·32	0·10	
H_2O (combined), CO_2 . .	1·86	2·71	0·64
Moisture . .	0·84	0·62	0·24
	100·50	100·12	100·26

A. Blue band, from quartz dolerite, Carriber Quarry, Linlithgow. Analysed by G. S. Blake, quoted from Falconer.

B. Red band, from quartz dolerite, Kettlestoun Quarry, Linlithgow. Analysed by G. S. Blake, quoted from Falconer.

C. Soda-aplite, from quartz gabbro, St. David's Head, Pembrokeshire. Analysed by A. V. Elsden, Q.J.G.S., 1908, vol. lxiv, p. 284.

There is no very satisfactory sliced material of blue band in the Survey collection, but the red bands (13,777, 12,181) are clearly seen to be pink felspathic veins, carrying a fair amount of quartz, with a small proportion of accessory minerals. The felspars, which are seldom free from white mica, occur in neat laths, with trachytic

[1] "The Igneous Geology of the Bathgate and Linlithgow Hill": *Trans. Roy. Soc. Edin.*, 1906, vol. xlv, p. 133.

arrangement, while the quartz is interstitial and sometimes micropegmatitic. Calcite occurs not infrequently, filling the centres of drusy cavities lined by quartz crystals. Analysis proves the absence of orthoclase, so that the nature of the felspar is sufficiently indicated by the fact that its highest refractive index is well below the lowest of quartz.

Now, one cannot but recognize that these segregation veins present a close analogy with the albite veins connecting vesicle to vesicle in the lavas of Arthur's Seat, while at the same time their juvenile origin is so obvious that it has been taken for granted by every writer on the subject. They are so numerous, too, that it is clear that, during the period of their crystallization, the heated interior portions of the sills must have been permeated through and through by soda-rich solutions. It is very difficult to avoid the conclusion that it was under these propitious conditions that the albitization of the originally basic felspars of the consolidated rock was accomplished, together with the production of much of the accompanying white mica.

It will thus be seen that the evidence derived from a consideration of the Permo-Carboniferous intrusions lends some support to the view already arrived at in regard to the processes involved in albitization as exemplified in the Carboniferous lavas. In conclusion, the analogy between this change and another well-known type of decomposition, prevalent in certain igneous rocks of Scotland, may perhaps be alluded to. Dr. Flett has found, in the Midlothian teschenites, a replacement of basic soda-lime felspar by analcite, similar to the replacement by albite in the quartz dolerites, and he regards the change as juvenile or pneumatolytic in character. That analcitization and albitization may be very closely comparable phenomena will readily be granted when it is remembered that, chemically,

$$\text{analcite} + \text{silica} = \text{albite} + \text{water}.$$

EXPLANATION OF PLATES X AND XI.

MICROPHOTOGRAPHS BY MR. T. C. HALL.

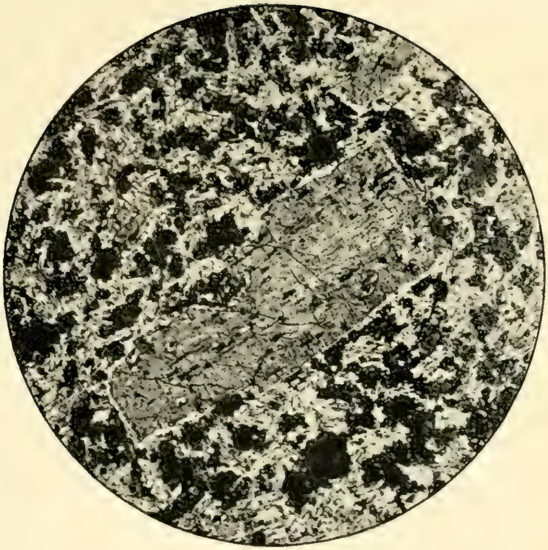
FIG. 1. × 29 dia. Crossed nicols. Basic plagioclase, phenocryst all but completely replaced by secondary albite. A ragged patch of the original felspar shows clear white near the top of the slide. (13,119.) 1400 feet S. 30° W. from cairn on Lairs, above Lennoxtown, Campsie Fells.

FIG. 2. × 43 dia. Crossed nicols. Zoned plagioclase phenocryst. The more basic portions have been preferentially albitized. The centre consists almost wholly of secondary albite, showing white; and an alternating basic zone, showing dark near the top corner, is being preferentially replaced by patches of albite. (13,082.) Crichton's Cairn hill-top above Lennoxtown.

FIG. 3. × 22 dia. Centre of felspar phenocryst entirely replaced by cloudy secondary albite. The rim is plagioclase (not orthoclase), more basic than albite, but doubtless less basic than the original felspar of the central portion now replaced. (12,280.) 100 yards north-east of north corner of Aucheneden Plantation, Kilpatrick Hills.

FIG. 4. × 22 dia. Crossed nicols. Albitized basalt with albite vein. A small round vesicle, filled with albite, is seen just below the vein and communicating with it. These veins appear merely to connect up neighbouring vesicles with one another and not to traverse the rock for any distance. (12,027.) Calton Hill, path opposite west wing of High School, Arthur's Seat volcano.

3



4

T. C. Hall, Phot.

Microphotographs of Basic Plagioclase Felspars.

3. Kilpatrick Hills. 4. Arthur's Seat.

III.—The Depth and Succession of the Bovey Deposits.[1]

By A. J. Jukes-Browne, B.A., F.G.S.

In the report of an excursion organized by the Geologists' Association to Newton Abbot in 1900, Mr. H. B. Woodward stated that a boring had been made by Messrs. Candy & Co. at Heathfield, near the middle of the Bovey Basin, and that it "had been carried to a depth of 520 feet from the surface through clays, sands, and lignites without reaching the base".

As this is the deepest boring which has yet been made in the Bovey Basin, and as no further particulars have yet been published, I applied to Messrs. Candy & Co. for any information that they could give me, and I have their permission to publish the following particulars, with which they were kind enough to furnish me.

The site of the boring is the great clay-pit belonging to Messrs. Candy & Co. close to Heathfield Station, about 3½ miles north-west of Newton Abbot. The depth of the pit is actually 70 feet, and the boring was started on its floor; it was carried down to 456½ feet, so that the depth reached was 526½ feet from the surface, this level being about 90 feet above the sea (O.D.).

The 70 feet of strata exposed in the pit include some 20 feet of superficial deposits of post-Eocene age, gravel, sand, and clay; below these are beds of clay, with one bed of lignitic material about 7 feet thick and a lenticular bed of sand. The first 100 feet of the boring traversed various beds of clay and sand with four beds of lignite. In the next 100 feet only one bed of lignite was met with, but below 200 feet lignites predominated to such an extent that the material traversed is described as consisting principally of "lignite in thick beds divided by layers of brown clay, the beds of lignite being much thicker than those of clay, and the thickest lignite having a depth of over 20 feet". No beds of sand were met with below a depth of 300 feet. The bore ended in a bed of lignite.

The information above given may be summarized as follows:—

	Feet.
Superficial deposits, gravel and sand	20
Clay, with some beds of sand and one of lignite . . .	50
Beds of clay and sand, with four of lignite	100
Beds of clay and sand, with one of lignite	100
Beds of lignite and clay, with a thin bed of sand at 300 feet .	36
Beds of lignite divided by layers of brown clay . . .	220½
	526½

Mr. Woodward states that the dip of the Eocene beds seen in the open pit is 8° to the W.S.W. If the total thickness of Eocene deposits proved by the boring is taken as 500 feet, and allowance is made for the dip, the exact thickness of the beds at right angles to the dip may be stated as 493 feet.

The chief interest of this succession of deposits lies in the fact that beds of lignite predominate so greatly in the lower part, and that beds of sand only occur in the upper 300 feet. When we remember that

[1] A paper read before the Geological Society on February 5.

the basement beds of the series, as seen on the borders of the basin, consist of sands and gravels, such a succession as that proved by the boring is just the opposite of what one would expect.

The marginal beds above mentioned are not shown on the published map of the Geological Survey, because when the survey was made, many years before the issue of the map, these gravels and sands had not been separated from others of post-Eocene date. Mr. Woodward informs me that they hope to remedy this omission, and to prepare a new edition of the map in the course of this year. So far as I have been able to ascertain, the basal gravels do not extend all round the basin, but are principally found on its eastern and south-eastern sides. On the eastern side, from Kingsteignton northwards to Bellamarsh, there is a nearly continuous border of sand and gravel which appears to pass westward under the clays and lignites which have been so extensively worked near Abbrook, Preston, and Knighton. The material is largely sand, but whether there is always gravel beneath the sand has not yet been definitely ascertained, nor have certain tracts of more recent gravel been separated from the older deposit.

I think it will be found that the Eocene gravel is practically restricted to this eastern side of the area and to the small subsidiary basin south and east of Newton Abbot, while round the western half of the main basin, i.e. that part which lies to the west of the River Teign, the basement beds consist of sand, though in places (as at Staple Hill) there are pebbles and blocks of chert in this sand.

The succession proved in the boring is interesting from another point of view, for it confirms the conclusion arrived at by Pengelly in 1861 [1] with respect to the relative age of the beds exposed in the 'old coal-pit' south-east of Bovey Tracey. The section recorded by him as seen in this pit below the 'Head' may be summarized as follows:—

	ft.	in.
Beds of clay, sand, and lignite	19	4
Clays with three beds of lignite	15	0
Fluck beds of lignite with thin clays . . .	18	10
Sand (11 feet) and clay (9 feet) below . . .	20	0
Alternating beds of clay and lignite	22	0
Thick beds of lignite with thin seams of clay . .	22	6
	117	8

From the information communicated by Mr. J. Divett, who then owned this pit, Pengelly showed that a fault must cross the area to the south-east of the exposure. At the old engine shaft 112 yards east of the pit the succession proved (according to Mr. Divett) was the same, but 140 yards further east he made a boring in 1855 to a depth of 99 feet, and traversed a very different set of beds. These consisted of sand and clay in alternating beds, with only one thin layer of lignite, the clay beds varying from 3½ to 10 feet and the beds of sand from 1½ to 13 feet in thickness; the total thickness of sand is 47 feet and that of clay about 39 feet.

[1] See the memoir by Pengelly & Heer, Phil. Trans. for 1862, and issued separately as a volume entitled *The Lignite of Bovey Tracey*, 1863.

Commenting on this fault, Pengelly concludes that "the beds on the east of it are an upper portion of the Bovey deposit, preserved through the intervention of a vertical displacement of at least 100 feet from the denuding action which swept it away on the west". From the particulars stated, it appears that the fault runs very near to the old engine shaft, and it is clear that Pengelly's inference as to the arenaceous series being newer than the lignitic series is based on the similarity of the former to the highest beds in the pit-section.

He also notices the curious fact that the lowest beds found in the 'old coal-pit' consisted entirely of lignites and clays for 53 feet, when a thin bed of sand occurs, and further that above this another thick set of clays and lignites was formed before any more sand was introduced into the area, but he does not suggest any satisfactory explanation of these facts.

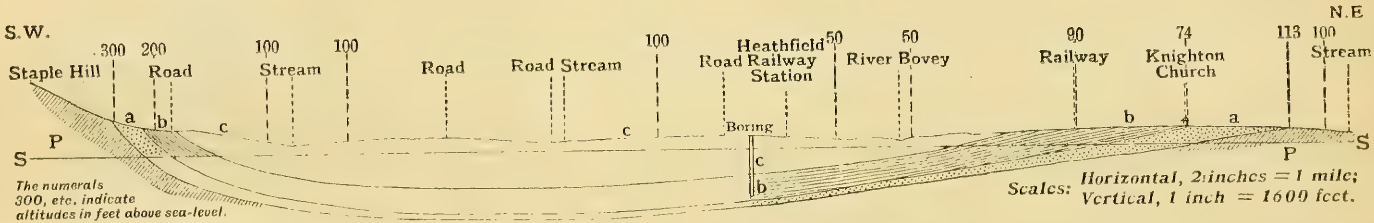
The boring at Heathfield confirms the succession described by Pengelly at the old workings near Bovey, which are about 2 miles to the north-west of it, and proves moreover that the lower lignitic beds are much thicker than he had any reason to suppose.

The highest Eocene beds seen at the Heathfield Potteries are white clays with an interbedded stratum of black clay and lignite, but these are not likely to be the highest beds in the basin, since the dip there is westward, and the ground rises somewhat in that direction. It is indeed very probable that the beds proved by Divett's boring and recorded by Pengelly are newer than any in the Heathfield pit, since by the presence of thick beds of sand they differ as much from the Heathfield section as from the Bovey pit-section.

I think, therefore, we may fairly add at least 90 feet to the total of the Heathfield boring, and as this did not reach the base, but ended in lignite, the bottom of the basin is not likely to be less than 30 feet lower. The total thickness of the Eocene deposits may therefore be estimated at $493 + 90 + 30 = 613$ feet. Finally, we must remember that the series is abruptly truncated at the top.

Of course, it does not follow that the succession proved in the boring and for the western part of the basin should hold good for the eastern part. Near Kingsteignton the pits worked are chiefly in clay, with occasional beds of sand and very little lignite, but their position in the series is not definitely known. The pits worked near Preston, 2½ miles north of Newton, on both sides of the road to Chudleigh, have shown alternating beds of lignite and white clay, both varying in thickness, but both reaching an individual thickness of 10 feet. The prevalent dip here is about 10° to the W.S.W., and the distance from the eastern border of the flat land is about a quarter of a mile; these beds will be about 220 feet above the basal sands.

Here I think we may well ask whether the highest sands and clays, and even the highest lignite and clay of Heathfield, are of the same age as the lignitic series which lies several hundred feet below them. This question can only be answered by a full investigation of the beds themselves and a further search for seeds and other plant-remains. I am glad to learn from my former colleague, Mr. Clement Reid, that he and Mrs. Reid have already entered this field of research and intend to explore it more fully next summer. From what he has told



Section across the Bovey Basin through Heathfield.

me it is evident that the results are sure to be interesting, and that much new botanic material will be obtained.

Until quite recently it has been very generally supposed that the Bovey Basin was a natural lake-basin, and that its present limits were not far within the limits of the original lacustrine area. I have, however, little doubt that the existing basin in which the deposits lie is a tectonic basin, and not in any sense an actual lake-basin. The high dips to the north-east, which are observable on the south-western border of the basin, as at Staple Hill, and which are opposed to the more moderate dips seen at Heathfield and Preston, are sufficient to prove the nature of the syncline.

The Bovey Basin may, in fact, be compared with that of Orglandes near Valogne in the Cotentin, in which marine Eocene and Oligocene beds occur in the form of an outlier separated from the main tract of the Paris Basin. If the Bovey Basin had been filled with marine Bracklesham and Barton Beds, no one would have thought of supposing it to be anything else than a tectonic basin formed by subsequent flexure of the crust. It is only the fact of its contents being entirely of freshwater and terrestrial nature that has perpetuated the very natural mistake which was made by the earlier geologists.

As already remarked, the succession of deposits proved at Heathfield is somewhat remarkable, and the order in which they occur is not what would have been expected if the deposits had all been formed beneath the waters of an ordinary lake. If the Bovey Basin had been part of a lake fed by one or more copious rivers, and if the lignites had been formed by masses of driftwood carried down by these streams during periodical floods, one would have expected the resulting deposits to be an alternating series of sands, clays, and lignites throughout the whole thickness, or possibly an upward transition from gravel and sand through sands and clays to clays and lignites, and finally to the peat and lignite of a silted-up swamp. Instead of this being the case, we have the lignites in the lower part and the alternating series of sand and clay in the higher part.

What, then, are the lignites, and how were they formed? To answer this question we must ascertain what kinds of plants enter into the composition of the lignites. So far as the beds examined by Heer and Pengelly are concerned, they consist of the matted remains of certain trees, ferns, and other plants which seem to have grown and decayed in the place where they now occur.

I am aware that Heer held a different opinion, but I do not think that the facts which he recorded support the view which he expressed. He wrote as follows[1]:—"The lignite beds of the under series consist almost entirely of tree-stems (probably belonging in great measure to *Sequoia Coutsiæ*); these alternate with masses of a brownish-black clay, the dusky colour of which has doubtless been produced by the decomposition of the softer portions of the plant. No leaves offer themselves for recognition, but here and there twigs and seeds and little fruits, as *Carpolithes Websteri* and *C. nitens*. The tree-stems,

[1] *The Lignite Formation of Bovey Tracey*, 1863, p. 25, reprinted from the Phil. Trans. of 1862, pt. ii.

which are piled over one another in huge masses (none of them stand upright) and which every here and there stretch their branches and roots in the layer of clay which has covered them up, have apparently been floated hither, not only from the immediate circuit of hills, but doubtless also from greater distances. Such a mass of timber could hardly have been furnished by the former. Accordingly, we learn from the structure of these lignite beds that they did not originate in a Tertiary peat-deposit, but from a colluvies of wood uniting in a lake."

From the above quotation it is evident that Heer supposed the only alternatives to be either the transport of driftwood into an open lake or the growth of moss in a peat-bog; but there is a third and much more probable method of accumulation, and that is the growth of a forest swamp, like the Great Dismal Swamp of Virginia.

Heer himself admitted (on the same page) that "the entire absence of freshwater shells, and indeed of aquatic animals generally, is certainly very extraordinary; and so is the absence of fruits of *Chara*, which abound elsewhere in Miocene freshwater deposits; the *Nymphæa* seeds, however, afford positive proof of fresh water". He thought that the absence of bog plants might be explained on the supposition that these lignites were formed in the middle of the lake and that the bog plants would not have drifted so far out.

It is now known, however, that the picture of the forest flora given by Heer was based on imperfect information, and that his identifications of some of the plants were not correct. If we turn to the accounts given by Pengelly of the actual composition of some of the lignite beds, and interpret them by the light of more recent knowledge, we shall obtain a rather different idea of the flora, and a very different conception of the conditions under which it grew and flourished.

Pengelly states that the bed of lignite numbered 7 in his section, occurring at a depth of 20½ feet from the surface and having a thickness of 15 inches, was a matted mass "composed of the coniferous tree *Sequoia Coutsiæ* and of the fern *Pecopteris lignitum*".

Of the twenty-fifth bed, which includes over 6 feet of lignite, he says "the lowest 3 inches of the bed is commonly a mat of fragmentary fronds of *Pecopteris lignitum* and *Lastrea stiriaca*, the first being the most prevalent. Above this lie the rhizomes [which Dr. Croker had called 'flabelliform leaves'] in a continuous band about 6 inches thick. . . . The uppermost portion of the bed consists of slabs of 'board coal' of great length, and of a width indicating the existence of trees fully 6 feet in diameter. Bodies occur in this bed having the appearance of roots, with rootlets passing into the clay below".

The twenty-sixth bed is a brown clay 2 feet thick, but has "an almost continuous band of broken lignite at the base" which consists of branches of *Sequoia Coutsiæ* and a number of dicotyledonous leaves.

The forty-sixth bed, at a depth of over 96 feet, is a band of lignite only 9 inches thick, but abounding in the small seeds named *Carpolithes nitens* by Heer. These seeds "are thickly strewed over the surfaces of the laminæ of lignite, and slightly embedded in them, as if the latter had been soft when the deposit was formed".

With regard to the names of the plants above mentioned several alterations have to be made.

In the first place it is probable that the so-called *Sequoia* does not belong to that genus. The same species has been quoted as occurring at Hordwell and in the Hamstead Beds, but Mr. Gardner found that the cones there associated with the leafage were indistinguishable from those of *Athrotaxis cupressoides* of Tasmania, "a small erect tree from 20 to 30 feet high with numerous branchlets which are slender, spreading or pendulous and cylindrical.[1] . . . It is found at Lake St. Clair and along Pine River Valley in western Tasmania." From this it is clear that *Athrotaxis* prefers wet situations like its relative *Taxodium distichum*, which is a notable tree in the swamps of Virginia, Carolina, and Florida.

It has not yet been ascertained if the Bovey tree is the same species, owing to the difficulty of getting well-preserved cones, but the probability of its being the same is great.

Again, the *Pecopteris* of Heer proved to be a species of *Osmunda*, and as many species of this genus thrive best in wet and marshy ground, *O. lignitæ* may well have grown on the very spots where its rhizomes and large leaves are now found in such profusion, and in the same beds of lignite with the *Athrotaxis*.

Lastly, as regards *Carpolithes*, Mr. Clement Reid informs me that it is the fruit of a *Stratiotes*, and may for the present be called *Stratiotes Websteri*. He also tells me that similar fruits occur in the Hamstead Beds, in the Cromer Forest Bed, and in Pleistocene deposits, having also been known under the name of *Paradoxocarpus carinatus*, but that he cannot yet say whether they all belong to one species or not. *Stratiotes* is a water-plant, and the British species is known as the 'water-soldier'. In reply to a question Mr. Reid writes that "judging by the mode of occurrence in the Hants Basin, I should say that *Stratiotes Websteri* was probably a shallow lagoon species which did not mind a little salt. It is found abundantly mixed with fruits of *Limnocarpus*, a genus close to *Potamogeton*".

The evidence afforded by these plants is therefore strongly in favour of the view that the flora of the beds containing their remains is a swamp flora, and consequently that these lower lignite beds have been formed where they are now found by the growth and decay of the plants which occur in them.

Besides those plants which seem to have contributed most largely to the formation of the lignites, the more common forms recorded by Heer are two species of cinnamon, an evergreen oak (*Quercus Lyelli*) said to be "like those seen in Mexico", some species of vines (*Vitis*), the prickly cactus (*Palmacites*), and several species of *Nyssa*, a tree of which several species live in the United States, and one at least is conspicuously a swamp-lover.

In this connection it is important to note another fact, and that is that the Bovey lignites have not, so far as they have been investigated, yielded any mosses, and it is clear that they were not formed after

[1] Mr. G. Smith in his recent book on Tasmania describes the *Athrotaxis* as growing to a height of 40 or 50 feet.

the manner of peat beds in Europe and the more northern parts of America. But it is a fact that south of a certain line of latitude in the United States peat-forming mosses do not flourish, and that they do not occur in the great swamps of Virginia and Carolina. These are forest-swamps with an undergrowth of cane-brakes (*Arundo*), ferns, and other annual plants in the drier parts. In the Great Dismal Swamp the most conspicuous trees are the *Taxodium*, which grows to a height of about 50 feet, the White Cedar (*Cupressus thyoides*), which reaches to 30 feet, and the Black Gum (*Nyssa denticulata*), growing to a height of 40 or 50 feet; and in some parts a climbing grape-vine forms a dense thicket between the trees.[1]

It is certainly, then, to the Great Dismal Swamp on the borders of Virginia and North Carolina that we should look for a modern counterpart of the conditions under which the Bovey lignites were formed. There is no better account of this swamp than that written by Sir C. Lyell and published in his *Travels in North America*, 1842, and there is an excellent summary in his *Principles of Geology*[2] which may here be quoted.

This is "an extensive swamp or morass, 40 miles long from north to south and 25 wide between the towns of Norfolk in Virginia and Weldon in North Carolina. It has somewhat the appearance of an inundated river plain covered with aquatic trees and shrubs, the soil being as black as that of a peat-bog. It is higher on all sides except one than the surrounding country, towards which it sends forth streams of water to the north, east, and south, receiving a supply from the west only.

"In its centre it rises 12 feet above the flat region which bounds it. The soil to the depth of 15 feet [in some places] is formed of vegetable matter without any admixture of earthy particles . . .

"The surface of the bog is carpeted with mosses and densely covered with ferns and reeds, above which many evergreen shrubs and trees flourish, especially the White Cedar (*Cupressus thyoides*), which stands firmly supported by its long tap-roots in the softest parts of the quagmire. Over the whole the deciduous Cypress (*Taxodium distichum*) is seen to tower with its spreading top, in full leaf in the season when the sun's rays are hottest, and when, if not intercepted by a screen of foliage, they might soon cause the fallen leaves and dead plants of the preceding autumn to decompose, instead of adding their contributions to the peaty mass. On the surface of the whole morass lie innumerable trunks of large and tall trees blown down by the winds, while thousands of others are buried at various depths in the black mire below."

From Professor Shaler's account of the Swamp we learn that it rests on unfossiliferous sands derived from a bordering Pliocene deposit, and that there is no great depth of lignitic or freshwater material below the swamp-area. It would seem that the subsidence which led to the formation of the 'Dismal Swamp' was of short duration, but if it had been of greater extent, without bringing in the

[1] See N. S. Shaler, "On the Freshwater Morasses of the United States," in Tenth Ann. Rep. U.S. Geol. Survey, 1888, pp. 261–339.

[2] 10th ed., 1868, vol. ii, p. 505.

neighbouring sea, it is probable that a succession of lignites and thin clay beds would have been formed which would have greatly resembled those of the lower part of the Bovey Series.

The history of the Bovey and Newton Abbot district seems therefore to have been as follows. During the earlier part of the Eocene period, the time represented by the Lower or London Eocene strata, the west of England was a land-surface, and eastern Devonshire was covered by a sloping table of Chalk which was being reduced to the condition of a peneplain by subaerial detrition. After the epoch of the London Clay and Bagshot Sands the south of England seems to have sunk slowly but continuously, allowing the shallow bay or estuary of the Bournemouth Beds to spread farther and farther westward; leading also to the formation of lagoons, lakes, and swamps on the low-lying plains adjoining the rivers which emptied themselves into this bay.

The Bovey and Newton district would be part of this lake-and-swamp area. We know that the granite of Dartmoor was exposed and lay to the west of it, rising doubtless above the level of the swamp land, but not into high and hilly ground as it does at the present day. There may also have been somewhat higher land to the south of it, so that it probably drained eastward or northward. Hence we see that the local conditions, both physical and climatic, were similar to those which have led to the formation of the Dismal Swamp of Virginia; except that the Bovey district was farther away from the seabord of the period, and that continuous subsidence resulted in the accumulation of much thicker masses of lignitic materials.

For a long time it would seem that the vegetation was so luxuriant that in spite of the subsidence the Heathfield swamp was always choked with the decaying vegetable matter which has since been consolidated into the lignite beds. There came a time, however, when the swamp was invaded by the waters of an adjoining lake and the forest was buried under a deposit of lacustrine mud; such invasions became more frequent until at length it was only occasionally that the swampy vegetation could once more establish itself over the same tract of ground.

Finally, if I have correctly interpreted the succession of beds in the Bovey Series, lacustrine conditions were permanently established, and the only deposits formed were white clays and fine yellow sands, both apparently being materials derived from the detrition of Dartmoor. It seems possible that these may be of Oligocene age, but so far as I know there are no open exposures of them, and a special excavation would have to be made for their exploration.

IV.—Wells of the North-Eastern Sudan.

By G. W. Grabham, M.A., F.G.S., Geologist to the Sudan Government.

THE Anglo-Egyptian Sudan territory covers an area of about a million square miles, throughout which the development of communications is of prime importance to the Government. The country varies from barren desert in the north to tropical jungle in the south, and one passes through all intermediate grades between these extremes. In the area between latitudes 12° and 22° north, water is the most important factor in determining the positions of routes, and it is with part of this area that it is proposed to deal. South of this, water is more abundant and other factors have to be considered.

The country is formed of a series of old sedimentary rocks, among which many different kinds of igneous materials have been intruded. These were subjected to extensive earth movements before the volcanic and intrusive rocks immediately underlying the Nubian Sandstone were erupted. In dealing with our subject we may speak of all these collectively as the Older Crystalline Rocks. They are all impermeable except where they are sufficiently decomposed to allow the water to percolate along joints and pores. The Nubian Sandstone Series rests on these Older Crystalline Rocks and fills up the hollows of the old land surface. This series consists mainly of sandstones, but it also includes beds of clay. As the latter never appear to have any great lateral extent, the whole series may be regarded as permeable.

Artesian conditions have not been met with, and water supplies are dependent on rainfall, seepage from the river, and local geological conditions.

The surface deposits vary with the climate. The rain-bearing monsun only reaches about as far north as Berber, and beyond this the rainfall is limited to showers often with intervals of years between them. At Khartoum we have about 4 inches per annum, and the amount increases as one goes southwards and eastwards. Kassala, due east of Khartoum, has about 12 inches of rainfall, and the following list[1] serves to give an idea of the variation in quantity along a more or less east and west belt, about 120 miles south of these places:—

El Obeid, 12 inches.	Wad Medani, 17½ inches.
Dueim, 8 inches.	Gedaref, 24 inches.

Gallabat, a town south-east of Gedaref, has a rainfall of 33½ inches.

On the Maritime Plain the rain does not accompany the monsun, but occurs in the winter. Suakin has about 12 inches of rainfall per annum.

In regions of the Sudan Plains, where the rainfall amounts to about 8 inches or more, the surface deposit is typically Cotton Soil, and where there is less the conditions approximate to those described by Mr. H. T. Ferrar.[2] The Cotton Soil is very similar to the Indian 'Regur'[3] in physical characters. It is fine-grained, absorbs a very large quantity of water during the rains, and, as this evaporates in the dry season, the soil becomes fissured with wide cracks often 6 feet deep. As far as water supplies are concerned, it is quite impervious, for though it will absorb a large rainfall, it is so fine-grained that the water cannot pass through to reach a porous

[1] Rainfall statistics derived from *Physiography of the Nile Basin*, H. G. Lyons, Cairo, 1906.

[2] Geol. Mag., 1907, p. 459.

[3] *Manual of the Geology of India*, 2nd ed., revised by R. D. Oldham, p. 410.

rock beneath, should one exist. The amount may vary from the thinnest covering to over a 100 feet in depth. It covers the country like a blanket, forming level plains broken only here and there by hills of hard rock that rise up like islands in a sea.

Fig. 1.

From the brief description of the country just given it will be seen that wells can be classified according to the way the water is derived. They fall at once into two groups, namely, those in crystalline areas and those in sedimentary rock. The first group can be divided again according as the wells occur in Cotton Soil districts or in the more arid regions to the north. The wells in the Nubian Sandstone Series are not susceptible to this distinction. We shall now pass on to consider these different classes of wells separately.

A general map of the area (Fig. 1) shows the positions of most of the places mentioned, and a dotted line on it roughly indicates the northern limit of the Cotton Soil.

Wells in Areas of Crystalline Rock covered with Cotton Soil.

A well in such a situation requires very special conditions for its existence. The Cotton Soil is impervious, and attempts to make wells in it generally prove the driest spots during the rainy season when the country around is flooded. The blanket of Cotton Soil must be broken by an 'island' of rock, and then, if the rock is capable of decomposing into permeable material, we have the requisite conditions for a water supply. In all successful cases I have seen the soil is pierced by an igneous rock. The water is held in the decomposed rock and débris round the base of the hill, while the surface of the ground is largely composed of sandy detritus from the hill-slopes, through which the water can pass and saturate the porous material beneath.

A few special cases may be mentioned:—

Geili. The hill is formed of syenite, and around the main one there are several ranges of low hills breaking through the plain. The wells are nearly all situated on the plains that separate the different hills. The water is found at a depth of about 60 feet in soft decomposed rock, and is generally of good quality.

Nasla. The rock here is a felsite, and the water is derived from joints, as the rock does not decompose to a spongy mass. The natives have wells at Um Rueishid, about 8 miles north, and these are in similar rock yielding abundant water. The stone is far too hard for the native to tackle with the implements at his disposal, and so, instead of making a vertical well, he has taken the line of least resistance where the joints allowed him to pick his way, and the shafts are even horizontal in part of their course.

El Sofeiya. These wells are in decomposed granite. There is no actual hill, but the country slopes away in all directions from the granite outcrop. The wells are situated at the top of the rise where the soil is sandy, and there are outcrops of fresh rock around them. The water is obtained at a depth of about 50 feet.

There are many other cases, but those I have mentioned are fairly typical. The water is nearly always good, and only in one case have I found it disagreeable. This was from some wells in decomposed granite, and was found to contain magnesia and sulphates by Dr. Beam, who tested a sample at the Wellcome Research Laboratories.

Water has recently been obtained in a well sunk by the Government at Khor Ogod el Bagar, about 20 miles from the river on the road from El Sofeiya to the Atbara. It is situated in a shallow khor traversing a Cotton Soil plain, and there are no hills within 10 or 15 miles. The rock is a foliated quartz-mica-diorite traversed by pegmatite veins. At the time of my visit the work was in quite fresh rock, and the chances of obtaining water in it seemed very remote. Softer rock appears to have been found as the depth increased, and from this the water is derived. The occurrence of water in such a situation is an exception to the rule, and I think it is more likely to be due to seepage from the river than to local rainfall percolating through the Cotton Soil and fresher rock above. In other cases, where the wells have been situated at a distance from the river, harder and fresher rock was found as the depth increased.

Many of these wells appear to be of very ancient date. There are numbers of stone implements to be found on the surface around some of them, and at Geili there is a stone inscribed with hieroglyphics. Many of the old wells may have been lost or forgotten during the troubles of this country, and it appears that stone implements in a locality may be taken as a clue to the previous existence of water supplies, but it must be borne in mind that these might be found in a place where the supply took the form of rain pools and existed for part of the year only.

The wells of the Gedaref district may be mentioned here. They derive their water from an outlier of the Abyssinian Plateau Basalts resting on the Nubian (?) Sandstone. The natives have dug their wells wherever the rock is soft enough, and the water is obtained at small depths in rotten rock.

Wells in Arid Regions of Crystalline Rock.

The Red Sea is flanked by an area of crystalline rocks where deeply carved valleys are partly filled with gravels and detritus, which form a deposit that we may speak of as Valley Fill. This is the only permeable deposit of the district, as the rocks themselves are not sufficiently decomposed, at any rate on the surface, though they may be so under the Valley Fill. There are exceptions to this, for in some favoured places, where high hills rise close to the Maritime Plain, the rainfall amounts to much more than is usual, supports a rich flora, and under these conditions the rocks are decomposed and become permeable. I mention this as such places, though they cannot be called arid, occur within the region, and are marked by very sharply defined boundaries.

There are no rainfall statistics that apply to this area, for the existing stations are on the seaward edge of the Maritime Plain, and another is at Erkowit, an oasis among the hills. There is evidence that it is extremely small, and perhaps does not exceed 4 inches per annum. The state of preservation of the fort, built of sun-dried mud, at Sinkat points to a figure even less than this. The rain occurs in violent storms that seldom affect an area of more than a hundred square miles in extent, and the resulting stream generally flows beyond it. When a shower occurs the water is soon coursing down the hill-sides, and forms a surface stream on the broad valley bottom. The gradient is enough to allow of a rapidly flowing stream, chocolate-coloured, with fine sand and mud carried in suspension. The Valley Fill is very porous, and the level of the water-table near the new stream rises rapidly. The water is absorbed most rapidly when the stream is flowing fastest. As soon as the flow begins to abate, and the size of the particles that can be carried in suspension begins to diminish, the pores of the stream-bed become clogged and infiltration is checked. The final result of this is that, after the flow has ceased, pools remain in the stream-bed and are maintained by a thin film of mud which prevents percolation into the dry sand beneath. It has been proved by holes in the sand near the edge of these pools that the level of the water-table was below that of the pool. It appears, then, that the rate of percolation from a stream into its bed is a function of the size of particle it can carry in suspension, and, consequently, of the speed of the current. I am not aware of having seen this principle put forward before, though, once observed, its truth is apparent.

When the water is absorbed by the Valley Fill it is protected from evaporation, and as it flows slowly down the rock valley it is readily tapped by wells. In Khor Arbat, a valley north-west of Port Sudan, there is a place where the valley narrows and the gravels become constricted in section, with the result that the normal underflow cannot pass and the water is forced out, forming a stream at the surface. This is probably the only place in these arid regions where there is a perennially flowing stream, and it is interesting as containing a small freshwater fauna. There is no evidence of a rock bar across the valley throwing up the water, and the explanation given is sufficient, even supposing that the longitudinal section of the rock valley is a continuous curve.

The wells of this area are all situated in the Valley Fill, from which they derive their water. Where the railway traverses it, a good deal of experience has been gained in sinking wells. From Summit downwards the line follows valleys both towards the Nile and the sea. I can only speak with experience of the seaward side, but Capt. S. F. Newcombe, R.E., tells me that the conditions are similar towards the Nile. The difference of slopes, however, makes the topography very different. In one place on the eastern side he has proved the section of the rock valley beneath the Valley Fill, showing conclusively that there is no need for the line of the surface stream to coincide in plan with the deepest part of the rock valley. This is a point to be borne in mind, for the tendency has been to choose a site near the stream-bed or actually in it. The native ones are probably in the stream-bed as a result of deepening a water-hole, made immediately after the rains, in pursuit of a falling water-table. It appears also that better water is got from wells in this situation than from others at a distance from the bed, and the reason may be that the underflow mainly infiltrates from it and so traverses less Valley Fill in reaching the well. The position of the stream-bed is always marked by trees or denser vegetation, which covers narrow strips of ground alongside it. Seeds have the best chance of germinating and growing up here, as it is the moistest place in the valley, and, once the growth of vegetation begins, the fine dust, whether carried by wind or water, is arrested and forms a good soil among the roots.

As examples of wells in this area the following may be mentioned:—

The Okok wells at Sinkat find their water at a depth of about 30 feet, and are situated high up in the valley, within 7 miles of the watershed. They are in the stream-bed on the north edge of the Valley Fill, and Capt. Newcombe, who dug one of them, tells me that he reached the solid rock only just below water-level. In former times there were other wells at a distance from the bed, but the water is said to have been much inferior to that of the existing ones. There does not seem to have been any attempt to make wells in the middle of the valley, where the Fill is probably deepest.

At Gebeit, lower down the valley and about 14 miles from Summit, there is a depth of over 110 feet of Valley Fill, and good supplies of water are obtained from it at that depth. The total depth of Fill is not known, but in any case it is a great thickness to find close to the watershed, at an altitude of 2000 feet, in a valley that slopes down to the sea in about 70 miles.

There are other wells lower down this valley, and at Salom, where the Port Sudan and Suakin branches of the railway divide, it debouches on to the Maritime Plain which separates the hills from the sea.

Wells are found under the same conditions in practically all the valleys of the Red Sea Hills, such as Khors, Baraka, and Arbat, while the memoirs of the Egyptian Survey [1] show that they also exist further north. Dr. Ball [2] has given us an excellent account of these Egyptian wells, from which it would appear that the valleys only differ from those of the Sudan in having a less abundant supply of water, and consequently the wells are not as frequent.

The wells of Qura, in the loop of the Nile south of Abu Hamed, are examples of another type belonging to arid regions of crystalline rock. Mr. G. S. Laird Clowes [3] describes them as situated in a small valley surrounded by granite hills. They are sunk in hard but fairly porous granite, and he supposes that the presence of water is due to the fact that Qura is the common basin into which several wadis drain, and consequently commands any rainfall that may occur over a large area. Wells of this kind are not comparable with those of the Red Sea Hills, as they depend partly on the porous nature of the decomposed rock, and thus resemble those of the areas further south, where the country is covered with Cotton Soil. I have not personally seen any wells of this type, but from accounts they appear to be of frequent occurrence.

The Maritime Plain, though a distinct area, presents conditions related to those of the Valley Fill. It is about 10 or 15 miles in width, slopes gently seawards, and, like the Valley Fill, is composed of detritus brought down from the hills. Borings have been made and show that these deposits attain a thickness of over 1000 feet. The plain is bounded along the coast by raised and modern coral reefs, broken here and there into harbours at points opposite the mouths of big rock valleys. Its surface is traversed by shallow stream-beds, and storm-water from the hills occasionally passes along them and reaches the sea. Here and among the border hills, as already noted, the rainfall occurs in winter instead of during the summer, as is the case in the rest of the Sudan. The underflow from the Valley Fill must all pass through the gravels of the Maritime Plain, and is increased as it flows towards the sea, not only by the local rainfall, but by the flood-waters from the hills as well. The water is tapped by wells at many places, where small supplies of fairly drinkable water are obtained by the natives. Such wells are found close to the sea in the neighbourhoods of Suakin and Port Sudan.

[1] *Topography and Geology of the Eastern Desert, Central Portion*, p. 251 et seq., analyses, p. 293. *Preliminary Report on the Geology of the Eastern Desert between Latitudes* 22° *and* 25° N., pp. 15–16.

[2] *Cairo Scientific Journal*, 1908, vol. ii, p. 237.

[3] *Cairo Scientific Journal* (Survey Notes), 1907, vol. i, p. 350.

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

V.—The Loop of *Dielasma*.

By D. M. S. Watson, B.Sc., Beyer Fellow in the Geological Department of the Victoria University of Manchester.

One of the most important investigations carried through by the late C. E. Beecher was concerned with the development of the loop in an American species of *Dielasma*, *D. turgidum*, from the St. Louis group of the Lower Carboniferous of Kentucky.

Beecher showed that the loop in early stages was similar to that observed in the adult individuals of the genus *Centronella*, consisting of two simple short brachial processes united at their expanded anterior ends. This development is of much importance from a phylogenetic standpoint, suggesting as it does the development of the Terebratulids and Helicopegmata from forms like the Rhynchonellids and Pentamerids.

So far as I know, it has not yet been confirmed by observations on other species, so that I am glad to be able to describe some similar stages in *Dielasma hastata* from the uppermost Carboniferous Limestone of Castleton, Derbyshire, and *D. elongata* from the Middle Zechstein of Posneck, in Thuringia. These last specimens belong to the Manchester Museum, and were collected and determined by Geinitz. The loops in these specimens were developed by the method invented by the Rev. N. Glass, which I found to be easily applied even to quite small shells.

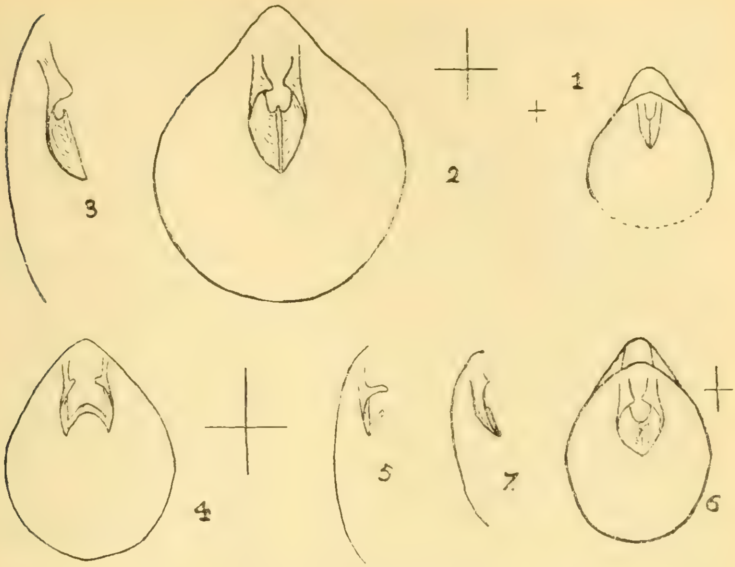
D. hastata (Sow.).

An example 4 mm. long shows a very small typically centronellid loop, about 1·5 mm. long and under 1 mm. wide. The anterior end of the brachial processes are not very much expanded in this specimen. A specimen 10 mm. long shows a loop remarkable for the extraordinary resemblance it presents to the adult *Centronella* loop. In this case the anterior ends of the brachial processes are expanded, and unite to form a strong ridge on the ventral side, which ends both anteriorly and posteriorly in a point. The jugal processes are quite distinct. The whole arrangement of the loop in this example will be easily understood from Figs. 2 and 3. An individual, 15 mm. long and 12 mm. wide, shows a typical *Dielasma* loop with ascending and descending branches.

D. elongata (v. Sch.).

An example of this species 6 mm. long by 5 mm. wide shows a loop very closely resembling that of the *D. hastata* 10 mm. long. It is drawn as Figs. 6 and 7. Three specimens of *D. sacculus vel vesiculosa* under 10 mm. in length showed the adult loop.

Although these observations are very incomplete, it being not easy to get small shells in suitable condition for development, I think they are worth publishing as affording corroborative evidence of the type of development found in the American species.



EXPLANATION OF FIGURES.

1. A specimen of *D. hastata* 4 mm. long, showing the loop viewed from the dorsal side. × 6.
2. A specimen of *D. hastata* 10 mm. long, showing the loop looked at from the ventral side. × 4.
3. The same specimen as that shown in Fig. 2 seen from the side.
4. A specimen of *D. hastata* 15 mm. long, seen from the ventral side. × 2.
5. The specimen shown in Fig. 4 seen from the side.
6. The loop of a specimen of *D. elongata* 6 mm. long, seen from the ventral side. × 4.
7. The specimen shown in Fig. 6 seen from the side.

NOTICES OF MEMOIRS.

ON THE NOMENCLATURE OF THE PALÆOZOIC FORMATIONS OF SWEDEN.

By J. C. MOBERG.

[Translated from the *Geologiska Forenin̈gens i Stockholm Förhandlingar*, 1908, Band xxx, p. 343.]

"DAS Uebergangsgebirge" (Transition rocks), or the oldest but one of the four main groups in Werner's geological scheme, corresponded, as we know, to what we now call the 'Palæozoic'. By and by it was divided up into various systems or periods, but long before that time Werner's scheme had obtained a footing in Sweden, and Swedish geologists, in referring to the Palæozoic formations of the country, used such terms as the Swedish equivalent for 'Transition rocks', 'formatio transitionis', etc. Such was the case, for instance, in Hisinger's *Mineralogical Geography* of 1808, in Wahlenberg's book on the Formation of the Floor of Sweden (1818), and in Dalman's *Palæaderna* (1827), while in 1823 S. Nilsson, in dealing with the geology of Scania, speaks of the 'transition district' of Scania. As late as 1821 Angelin makes use of the heading "Crustacea formationis transitionis" on the title-page of his *Palæontologia Suecica,* and even in 1884 Nathorst, dealing with the geology of South Sweden, tried to reintroduce the appellation 'transition system' as a collective name for the Palæozoic strata of Sweden.

Already in 1834 and 1835 Murchison and Sedgwick had proposed the appellations Silurian and Cambrian for the formations which in England come between the Old Red Sandstone and the primary rocks, i.e. for strata which exactly correspond to the Palæozoic formations of Sweden. For reasons that I will enlarge on later there arose, practically at once, dispute as to where the line should be drawn between Cambrian and Silurian, or, in other words, about the comprehensiveness of these systems in their relation to one another. During the controversies that were consequently raised there poured in from various quarters and to various ends new proposals for the nomenclature of the strata in question. A number of these may be specially named here, since they exercised a more or less considerable influence on the nomenclature used in Sweden.

As far as America is concerned, Emmons formulated his 'Taconic System' in 1848; this, so far as it can really be considered in any way uniform, may be said to correspond roughly to the lower series of Sedgwick's Cambrian. Of more radical importance, however, was Barrande's contribution to the question. In 1846 he proposed the conception of 'Primordial Fauna', i.e. a fauna embracing the oldest known organisms and especially characterized by trilobites with long thorax and small (consisting of few segments) pygidium. Upon this followed, in their proper turns, the second and the third (Silurian) faunas. While in England it was considered adequate to divide the sedimentary rocks in question into only two systems, Barrande divided them into three sections, which proposal—especially since, following this primordial fauna, analogues to Sedgwick's Lower Cambrian could be pointed out in countries widely separated—gradually gained ground, so that in 1878 Barrande, at the International Geological Congress in Paris, called attention to the fact that Murchison himself, in the last edition of his *Siluria*, had made use of a similar terminology, in that he divided his Silurian into Primordial, Lower, and Upper Silurian.

It is clear that the Swedish geologists had, of necessity, to take up a position in reference to this question of nomenclature. But the choice, unless made haphazard, was no easy one. For in this case it is not a question of paying exclusive regard to the priority of the various appellations; it is also of importance, among other things, to investigate whether the terms proposed have a carefully fixed range, and in what measure a certain classification can be said to be suitable for giving us a clear and faithful picture of nature.

Even if the appellations that have come into use for the Palæozoic formations of Sweden vary with different writers, by degrees the threefold division introduced by Barrande seems to have gained universal approval. It may not be out of place here, as throwing light on the circumstances, to give a few examples of the nomenclature used by various Swedish authors after that time.

While Lindström in his *Elements of Geology* (2nd ed., 1859)—a work based on Lyell's *Elements and Principles of Geology* and other works—divides the Palæozoic formations of Sweden into Upper Silurian (= Gothland and Klinta-formation) and Lower Silurian, in which latter was also included the lowest sandstone of the Vestrogothian rocks, later on he made use of the terminology Cambrian, Lower and Upper Silurian, as for instance in his *List of the Fossil Faunas of Sweden*, i (1888).

Angelin, in his geological map of Scania with letterpress, of which two sheets were already printed in 1862, though they only appeared posthumously in 1877, gives the strata in question the common appellation "Silurian, or Older Transition Formations", remarking at the same time that the name 'Silurian System' is not used by anyone in its original sense, and also that, if we pay attention to priority, it would be more correct to use the terms Taconian, Cambrian (or Cumbrian), and Silurian for Barrande's "faune primordiale, faune seconde, and faune troisième".

In Torell's contributions to the petrology and palæontology of the Sparagmite formation he used the name Cambrian or Taconic System for Angelin's regions I–III, the next overlying strata being the Lower Silurian System; and Linnarsson, who in his earlier works (1868–9) simply comprises all the strata in question as Silurian, in all subsequent works calls Angelin's regions I–III Cambrian, IV–VII Lower Silurian, and VIII Upper Silurian.

That Nathorst, who, when he began to occupy himself with the formations we are speaking of, called those strata which include the primordial fauna 'Cambrian', and afterwards tried to introduce the term 'transition system' for the three groups of the 'Cambrian-Silurian' (Cambrian, Lower and Upper Silurian), has already been referred to above. In this place we need merely add, that the proposal in question evidently owed its origin to a desire to accentuate the necessity of introducing a collective name.

In 1880 Tullberg speaks of the Cambrian and Lower Silurian strata at Kiviks-Esperöd and Röstånga, whereas in 1882, in his work on the graptolites of Scania, he divides the Silurian formations into Primordial Silurian, Lower Silurian, and Upper Silurian, thus entirely avoiding the use of the term Cambrian.

Latterly, however, the Swedish geologists have as good as unanimously accepted the division of the Swedish Palæozoic formations into the three groups or systems Cambrian, Lower Silurian, and Upper Silurian; thus, for instance, Törnqvist (1889) in *Some Remarks on the Cambrian and Silurian Corology of Western Europe*, Holm (1901) in *Kinnekulle*, and Wiman (1899) in *Eine untersilurische Litoralfacies bei Locknesjon in Jemtland*.

Nevertheless, the name 'Silurian' has at the same time often been employed as a collective name for *all* the formations in question, viz. by Wiman (1893) in *Über die Silurformation in Jemtland* and by Högbom (1906) in *Norrland.* The appellation Cambro-Silurian or Cambrian-Silurian formations seems, however, to be at least as common (as a collective appellation) as the name Silurian. In this case, then, the terminology has not even yet become properly established.

As far back as 1879 it was proposed by Lapworth ("On the Tripartite Classification of the Lower Palæozoic Rocks": Geol. Mag., Dec. II, Vol. VI) to change the name Lower and Upper Silurian into Ordovician (Ordovian) and Silurian, a proposal that gradually gained ground, and has of late years obtained some footing in Sweden. In 1901 Törnqvist (*Researches into the Graptolites of the Lower Zones of the Scanian and Vestrogothian Phyllo-Tetragraptus Beds*, i) used the divisions Cambrian, Ordovician, and Silurian. In 1906 he lays stress on the fact that he has definitely abandoned the older nomenclature Cambrian, Lower and Upper Silurian (*Some Remarks on the Ordovician System in Skåne*). As these works of Törnqvist's were written in English, and thus were specially addressed to the English public, he possibly attracted less attention to his new terminology from Swedish readers; that, at least, holds good as far as we are concerned. It was also with much hesitation that the writer of these lines, in a paper on the *Dicellograptus* schists of Scania (1907), and so to speak tentatively, exchanged the term Lower Silurian for Ordovician: in our opinion the suitability of the exchange from more than one point of view was not decisive. The new appellation was especially inconvenient in that it did not lend itself to the formation of compound words. Our first impression was that this difficulty might be removed by using the term Ordovian, sometimes used by Lapworth instead of Ordovician. This would have permitted such Swedish compounds as "ordovsystem, ordovfossil", etc. But, as this could evidently only be adopted if the termination *-ician* did not include any part of the stem of the word, we asked the advice of Nils Flensburg, the Professor of Comparative Philology at the University of Lund, from whom we received the following elucidation: The name Ordovices, which is met with in Tacitus (*Agricola*, ch. xviii, and *Annales*, book xii, ch. xxxiii), is made up of the stem *ordo* (or, in Old Cymric, *ord*), meaning 'hammer', and the verbal root *vik*, meaning 'to fight'. Ordovices consequently means 'hammer-fighters', and as the *vik* in it represents an independent link the form *ordov* is of course unallowable. Therefore we must write Ordovician, in which case we could also make use of such compounds as "ordoviklager, ordovikfossil", etc. So much for the purely linguistic point of view.

It is all very well that we should, by introducing the aforesaid denomination, attain to a greater uniformity with the terminology that seems to be naturalizing itself more and more abroad, especially in England and North America. But it would be better, instead of submitting our terminology to this kind of patchwork, once for all to subject this terminology in its entirety to a revision, especially as the moment for this can be said to be at hand. It is not our intention to introduce any innovations; it is merely a question of making a choice from the older terminology, at once consistent with what is *fair* and *suited to the circumstances* in general.

In the first place we must set down that in proportion as the geological researches into our Palæozoic formations have advanced the old conviction that the latter in our country form a connected whole, the various parts of which are not divided by sharp limits, has become a certainty. However, for faunistic reasons it seems advisable to divide the formations in question into *three* groups, in the main corresponding to Barrande's three Silurian faunas. It is no less for the formations considered as a whole than for the various groups that we must establish appellations.

Before entering upon this we must touch, however briefly, upon a very debated question of priority, viz. the name Silurian or Cambrian. In our opinion it is the more bootless to enter into details, as no one is likely to assert that either Murchison or Sedgwick were really fully cognizant of what it was that they stamped with the respective names. That any dispute about the line between the different systems could arise at all is due, of course, to the fact that the authors themselves did not recognize with certainty coeval formations where these in any degree showed varying development. That Murchison's Caradoc was the same as Sedgwick's Bala, was a point on which both were equally in the dark, even if Sedgwick, as it soon appeared, saw that this was the case, at least as far as certain strata were concerned. That Murchison's stratigraphical mistakes, which considerably increased the chaos, did not bring him great distinction, goes without saying, but on the whole we must not forget that palæontological science at that time, when, for instance, the graptolites and their stratigraphical significance were still practically unknown, was insufficient to determine with certainty the stratigraphical succession when the strata were not in a relatively undisturbed position. That both Murchison and Sedgwick added so much to our knowledge of these older Palæozoic strata, that the names given by them must by no means be condemned by reason of the flaws which were inherent in them, and which, we may say, were bound to exist in them, is beyond all doubt. But the manner in which these names should be used, or, in other words, the establishment of the range of their meaning, must concern a period which will have made a real limitation of the idea possible.

To return to the question of what appellations we are to select, our first business is to see what names can be used as a *collective appellation* for these formations. Among the likeliest of these we may mention especially Transition System, Cambro-Silurian, and Silurian. Of these, for reasons we need not repeat here, Transition System is very unsuitable. The same is true of Cambro-Silurian, especially as Sedgwick himself proposed this name in 1843 for all strata from the Bala, inclusive, to the base of the Wenlock, a proposal which, however, he afterwards (1854) withdrew. On the other hand, the name Silurian seems to be quite suitable, not only because the range of the word corresponds with Murchison's latest claims, but because it has often been used, as we pointed out above, as a collective name. *But if it is to be used as such it must, of course, not be admitted as a group name.* Since, for obvious reasons, we retain the names

Cambrian and Ordovician [1] for the two lower groups, it remains for us to choose another name for what is otherwise called Upper Silurian or Silurian.

In 1900 de Lapparent, in his *Traité de Géologie*, proposed for this group the name 'Gothlandien'. And we think there is every reason to accept this proposal. The sedimentary rocks which are here in question are completely represented [2] in Gothland, and no other strata occur among the rocks there. As Cambrian and Ordovician have been named from tribes, we should, perhaps, in case we had to choose the name, take one that would recall to us the Gutar, the Gothland settlers—for instance, Gutnium or Gutnian; but such an emendation of de Lapparent's appellation would be looked upon as exaggerated purism. Already in Angelin's General Map of Scania, there is a mention of a "Fifth or Gothland Group" as being about synonymous with what has latterly been called Upper Silurian. Even if we wish to see in this a pronouncement in favour of the nomenclature here recommended we must point out that as an adjective to the proposed name Gotlandian we ought to adopt a new term, 'Gotlandisk' (Gothlandic), since the Sw. 'gotländsk' (or the representative prefix form, 'Gotland's–') should be reserved for cases where there is some reference to the Island of Gothland or its belongings.

Even provided the name Gotlandian should not readily gain the approbation of strangers—we know how long it was before Lapworth's Ordovician made its way—it can safely be used in our country without danger of being either *not understood or misunderstood.*

This, then, is the nomenclature we propose: *Silurian*, with the three series, *Cambrian*, *Ordovician*, *Gothlandian*. This nomenclature fully takes into consideration the excellent methods in disentangling the formations in question that we owe to Murchison, Sedgwick, Barrande, and Lapworth. And it can scarcely be considered presumptuous if the Silurian geologists of Sweden, in generally adopting de Lapparent's appellation, Gotlandian, recognize in some measure what we hold to be a noticeable contribution made by them and their predecessors to the Silurian division.[2]

If anyone should possess world-embracing views it is the geologist; but, as a matter of fact, even his point of view is not a little influenced by his nearest surroundings—his own country and the prevalent opinions in it. A word or two supplementary to what has been said above seems to me, therefore, to be appropriate on this occasion, since I am now especially addressing English readers.

[1] As it is quite superfluous to repeat here the reasons stated by Lapworth (see op. cit.), in our opinion most satisfactorily, for his proposed name, Ordovician, we will only point out that this name, apart from the fact that its meaning offers a way out of a difficulty in nomenclature acceptable to the various English schools, is also made necessary, so to speak, for us, since on the one hand we wish to retain the name Cambrian, but on the other hand wish to use the name Silurian exclusively as a collective appellation.

[2] However, J. Kiaer, in his *Das Obersilur im Kristianiagebiete*, which has just appeared, expresses the opinion that the lowest strata in Gothland correspond to the *uppermost* part of Llandovery; the lower part of the latter is therefore inaccessible in Gothland. Moreover, he questions whether there is anything there to correspond to the most recent Ludlow strata.

As far as I have been able to discover, the majority of the English geologists at the present time wish the term Ordovician to be generally adopted. And so do I. We are also of one mind that, if the term Lower Silurian is to be rejected, the term Upper Silurian must also be given up. But when the proposal is made to substitute for the latter the term 'Silurian' simply, then I think a false move has been taken, which may lead to confusion not only abroad but also in England. Even if Murchison's term, Silurian, was originally applied to only the upper part of the formations in question, it must not be forgotten that it was created earlier than the term Cambrian, and that also Llandeilo was included in it. Murchison's term, Silurian, has consequently never coincided with what would now be called by that name. And lastly, as we know, he let the name embrace all the strata from the base of the Cambrian up to the base of the Devonian. In this comprehensiveness the name Silurian, especially through Barrande's influence, has also come to be used throughout the world.

To use the name Silurian in the significance that English geologists have of late attempted is, as I have shown above, not justified, as well as very misleading. To discard it entirely is quite unfeasible; not only would it be an act of great injustice towards the renowned author of the Silurian System, but it would be an injustice that would assuredly bring its own punishment.

Since, then, the term Silurian *must* be used, it seems to me that nothing else is possible but to take it in the sense Murchison ultimately gave it, which, through Barrande's influence, has won favour everywhere. If the name Ordovician is introduced, the name Silurian, as far as I can see, must be used as a collective name, and the so-called Upper Silurian receive a fresh name. And as such, de Lapparent's 'Gothlandien' (Gotlandium) would certainly be suitable.

REVIEWS.

I.—Rock Salt: its Origin, Geological Occurrences, and Economic Importance in the State of Louisiana; together with Brief Notes and References to all known Salt Deposits and Industries of the World. By G. D. Harris, assisted by C. J. Maury and L. Reinecke. Bulletin No. 7 of the Geological Survey of Louisiana, 1908. pp. 259, with 21 text-figures and 48 plates of maps, sections, and views.

THE 'salines' of North Louisiana were known to the Indians before the advent of the white man, and they used to resort to those places to obtain their salt. The position of the 'salines' is indicated by the 'licks', where vegetation is prevented from growing, over patches several yards square, by the licking of the ground by cattle.[1] Their presence is further indicated by brine-springs which issue along the beds of streams, and by the sinking of wells. Brine

[1] The "Big Bone Lick", Kentucky, and others of a similar kind were well known to the early geologists by the discovery of abundance of remains of the *Mastodon* and other extinct mammals who came down to lick the salt in prehistoric times. Many arrow-heads of stone have been found, showing that the Indians also frequented these salines, probably to shoot big game which came there for salt as well as themselves.

has been obtained from the springs by sinking vertical hollow logs over their sources along the stream-bed and pumping the salt water. During the past three years it has been proved by boring that vast masses of rock-salt occur beneath some, if not all, of the salines, and in various parts of the State. At one spot in South Louisiana the drill entered rock-salt at a depth of 334 feet and continued in it without change to a depth of 2090 feet; in another, a thickness of 2263 feet of salt was passed through, and after a further depth of non-saliferous strata had been passed through, salt was again encountered of unknown thickness. At this latter locality, Petite Anse, the amount of salt present is estimated at about 2,000,000,000 tons; and, as the author remarks, "no one can claim to have but the faintest idea of the true value of the huge masses of pure rock-salt stored away in the 'islands' and salines of Louisiana." The term 'island' is here applied to the mounds or domes beneath which the salt is obtained by mining.

The salt occurs in the Eocene and Quaternary strata, which consist of clays, loams, sands, and gravels, with occasional limestones and lignites. The details vary much, and in one locality there was found, at successive horizons, limestone, gypsum, occasional oil and gas, and finally below, with unknown thickness, rock-salt. All the mounds and salines thus far prospected have shown the existence, singly or in association, of salt, gypsum, sulphur, dolomite, petroleum, hot sulphurous and saline waters, etc.

The origin of the domes was attributed by Hager to upthrust of faulted masses of Cretaceous and Carboniferous rocks beneath the yielding Tertiary deposits, in which the faulting of the strata below was replaced by simple anticlinal folding. The pressure of gas, oil, water, and of hypothetic igneous plugs have also been referred to as agents likely to account for the phenomena. The present author and his associates attribute the uplifting to the power of growing crystals.

They admit that they have not at present determined the power of growing crystals, but they infer that it will be found to be of the same order of magnitude as the resistance which the crystals offer to crushing stresses. A 4 inch cube of crystallized salt, which had been mined with dynamite, and was apparently more or less inclined to crumble, showed no sign of crushing when put under a pressure of 50,000 lb., the limit of the small hydraulic press used. Further experiments are, however, desirable. The very restricted areas occupied by the salt-masses compared with their thickness is a remarkable feature. With regard to the age of the domes the author considers that they were formed whenever conditions were favourable, and that the various mineral deposits of salt, oil, sulphur, gypsum, etc., though often flowing into Tertiary or Quaternary reservoirs, originated in beds belonging to earlier periods of the earth's history.

A valuable record of salt deposits and brine springs in other parts of the world occupies about two-thirds of this report; and it is remarked that while in France and Germany there are works that cover somewhat the same ground, there is no recent English work on the subject.

II.—The Eruption of Vesuvius in April, 1906. By H. J. Johnston-Lavis, M.D., etc. Reprinted from the Scientific Transactions of the Royal Dublin Society, vol. ix, pt. viii, January, 1909.

THE 1906 eruption of Vesuvius attracted a great deal of attention, as it presented many novel features of interest, and a large number of reports have been written on it by the members of that band of scientific men which gathered in Naples in the spring of that year. Its most important characteristics are now well known, but there was certainly room for an account of it from the pen of Professor Johnston-Lavis. In this paper he gives a brief account of the activity of the volcano up to the end of April, 1906, with a description of the petrographical character of the lava and the ashes emitted. This leads to a consideration of the sequence of volcanic processes within the crater, a subject on which the author has already formulated his views on several occasions. Great changes took place in the configuration of the cone of Vesuvius, and, when the dust-cloud of the eruption cleared away, a remarkable series of deep radial furrows or 'basancos' became visible, traversing the ash-covered slopes which descend from the crater. These were produced by small landslips of the fine dry ash, which initiated avalanches of volcanic sand and stones. As they flowed downward they carved deep narrow valleys, not only in the new ash but also in the older tuffs. Some beautiful views of these are given, and with a couple of excellent maps they add considerably to the interest of the paper.

III.—International Geological Congress: Eleventh Session, to be held in Stockholm, 1910.

At the tenth meeting of the International Geological Congress in Mexico, 1906, the Swedish geologists invited the Congress to hold its next session in Stockholm, an invitation that was unanimously accepted. In view of the extensive preliminary work occasioned by the projected excursions, a wish was expressed by the Swedes that the meeting in question, which should really have taken place in three years' time, might be postponed until 1910. The decision was left to the Swedish geologists, and subsequently 1910 was fixed upon by the Swedish Organizing Convocation for the meeting in Stockholm.

A general meeting of the Swedish geologists was held in Stockholm on March 5, 1907, for the purposes of drawing up a general programme for the work of organization and instructing the Executive Committee. On the retirement of the former Director of the Geological Survey of Sweden, Professor A. E. Törnebohm, his place as President of the Committee was taken by Professor G. de Geer; the Treasurer of the Committee is Professor H. Bäckström; while Professor J. G. Andersson, the present Director of the Geological Survey of Sweden, officiates as General Secretary.

The Swedish Executive Committee considers it advisable that *preference* should be given to the discussion of such questions at the meeting of the Congress in Stockholm as the actual geological phenomena of Sweden or of the polar regions can throw light upon. Particular attention should thus be devoted to the following domains of geological science:—

1. The Geology of Archæan Rocks.
2. The Geology of the Quaternary Period (especially climatic changes in late and post-Glacial times).
3. The Geology of the Polar Regions.
4. Applied Geology (especially the extent and distribution of the supplies of iron-ore in the world).

Numerous excursions have been planned in connection with the Congress.

Before the Meeting.

1. Northern Sweden (Norrland).
   (*a*) Large overthrusts, post-Archæan eruptive rocks, etc. 20 days.
   (*b*) The ore-fields of Cellivaro and Kirunavara. 10 days.
   (*c*) Quaternary formations in Jämtland. 10 days.
   (*d*) Quaternary formations in Norrbotten. 10 days.
2. Spitzbergen. About 3 weeks.
3. Peat-beds in Central Sweden. 6 days.

During the Meeting.

Several one-day excursions.

After the Meeting.

1. Five simultaneous excursions in Southern Sweden, excepting Scania. 12 days.
   (*a*) Archæan rocks.
   (*b*) Cambrian-Silurian beds.
   (*c*) Quaternary deposits.
   (*d*) Ores.
   (*e*) General geology.
2. (To follow 1.) Three simultaneous excursions in Scania. 7 days.
   (*a*) Cambrian-Silurian beds.
   (*b*) Mesozoic beds.
   (*c*) Quaternary beds.

The first excursions (to Spitzbergen and Norrland) begin about July 25, the meeting of the Congress takes place about August 18–26, and the last excursions (in Scania) end in the middle of September.

This programme is subject to alterations; the present scheme is provisional.

All correspondence having to do with the coming Congress should be addressed to the General Secretary, Professor J. G. Andersson, Stockholm (3), Sweden.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—*April* 7, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, and afterwards H. W. Monckton, Treas.L.S., Vice-President, in the Chair.

The President announced that the Daniel-Pidgeon Fund for 1909 had been awarded to Mr. A. M. Finlayson, who proposes to undertake researches on the Genesis of the Sulphidic Ores.

The following communications were read:—

1. "On Overthrusts at Tintagel (North Cornwall)."[1] By Henry Dewey, F.G.S.

In this paper the author deals with the geological structure of the Tintagel area. After brief reference to the stratigraphy north of Bodmin Moor, mention is made of the apparent difference in order of superposition of the beds near Tintagel.

The several types into which the Upper Devonian rocks are divided are next described. The beds in descending order are—

(6) Tredorn Phyllites.
(5) Trambley Cove Gritty Slates.
(4) Volcanic Series.
(3) Barras Nose Beds.
(2) Woolgarden Phyllites.
(1) Delabole Slates.

The above order is preserved for many miles, between the Boscastle coast and Lewannick on the eastern side of Bodmin Moor. A change of strike at Tintagel reveals the anticlinal structure of the district. To the south of the nose of this great fold minor folds cross the strike. These folds increase westwards until they are replaced by overthrusts. Four sections from east to west show the increased folding and overthrusting towards the northern part of the area.

The paper concludes with a reference to the age of the folding.

2. "The Lahat 'Pipe': a Description of a Tin-Ore Deposit in Perak (Federated Malay States)." By John Brooke Scrivenor, M.A., F.G.S. (Geologist to the Federated Malay States Government).

Large quantities of tin-ore have been obtained during recent years in the Kinta district of Perak, principally from detrital deposits, but also in some cases from the limestone which forms the floor of the Kinta Valley. From 1903 till 1907 the Société des Étains de Kinta secured over 1000 tons of dressed tin-ore from a peculiar deposit which had the form of a pipe in the limestone, measuring only 7 by 2 feet at the surface, but widening when followed downwards. It was worked to a depth of 314 feet. The veinstone was a deep red mixture of calcite and iron-oxide, with some quartz, chalybite, and chalcopyrite, but no tourmaline was found in it. In this the cassiterite occurred in irregular pieces and broken fragments, some of which consisted of radiating needles.

In Kinta the tin-ores occur in the limestone in two different ways — (1) As lodes or veins with fresh sulphides but not iron-oxides. The tin-oxide crystals have a definite arrangement. (2) As transformed masses deposited in fissures. The cassiterite is in rounded grains, and quartz, tourmaline, and other minerals, also well rounded, accompany it. For a long time it has been doubtful to which of these classes the Lahat pipe should be assigned, as it presents some features of each class. Recently, however, specimens have been obtained showing veins of arsenopyrite and cassiterite in limestone, and from these the author concludes that the Lahat pipe was originally a vein or lode deposit in the limestone, which subsequently afforded a course for surface waters; these dissolved away the calcite and

[1] Communicated by permission of the Director of H.M. Geological Survey.

oxidized the sulphides, caves being formed into which the insoluble ores were carried by the water. Finally, the brecciated mass was recemented. Some foreign material has been introduced, but the bulk of the contents of the pipe is of local origin and consequently not rounded by transport. In other words, the Lahat pipe is a lode deposit which has been converted into a detrital deposit *in situ*.

3. "On the Sculptures of the Chalk Downs in Kent, Surrey, and Sussex." By George Clinch, F.G.S., F.S.A. Scot.

The author classifies the various forms of sculpture of the Chalk Downs under three heads, namely, (1) dry valleys of simple form, (2) dry valleys of complex form, and (3) wet valleys. He draws attention to the relatively small catchment areas of the dry valleys, and to the large number of tributary valleys found in some districts, two points which he considers have not received hitherto entirely satisfactory explanation.

While accepting the view that frozen conditions in former times altered the drainage system of the Chalk, he argues that the most potent excavating force was the frost itself acting on Chalk saturated or highly charged with water. He propounds a theory to account for (1) the great size and breadth of the valleys in relation to their catchment basins; (2) the ramifications of some of the valley systems; and (3) the remarkable fact that many dry valleys die out just before the crest of the Chalk Downs is reached.

April 28, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, and afterwards Professor W. W. Watts, Sc.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Boulders of the Cambridge Drift." By Robert Heron Rastall, M.A., F.G.S., and J. Romanes, B.A.

For several years past a large number of boulders have been collected from the glacial drifts of Cambridgeshire, and from the post-glacial gravels which have been derived from the drifts. These specimens have been classified geographically and then subjected to a careful petrological examination, with a view to the determination of their origin. Some special collections from Hitchin and Bedford have also been included for comparison. Rocks of Scandinavian origin, and especially those of the Christiania province, are abundant throughout the whole area: such well-known types as rhomb-porphyry and nordmarkite are common. Rocks from the Cheviots and Central Scotland are more abundant than was formerly believed, and specimens have also been identified from the Old Red Sandstone conglomerates of Forfarshire and from Buchan Ness, Aberdeenshire. Lake District rocks probably also occur in small quantity. Much of the Chalk and flints appear to be of northern origin. It is concluded that an older Boulder-clay, containing foreign erratics, the equivalent of the Cromer Till, once extended over the whole district, but was subsequently incorporated with the Great Chalky Boulder-clay. The Scandinavian ice advanced from the direction of the Wash, bringing with it Red Chalk and bored Gryphæas from the bed of the North Sea, and carrying them as far west as Bedford. Rocks from the north of the

British Isles become progressively scarcer from west to east, and the distinctive types are absent to the east of Cambridge. They appear to have been brought by an ice-stream coming from a northerly direction, which probably to a certain extent replaced the Scandinavian ice towards the east.

2. "The Nephrite and Magnesian Rocks of the South Island of New Zealand." By A. M. Finlayson, M.Sc. (Communicated by Professor W. W. Watts, Sc.D., F.R.S., V.P. G.S.)

The magnesian rocks described in this paper are a disconnected series of intrusive peridotites, forming a more or less defined belt along the western portion of the South Island, parallel to the trend of the Island and to the structural and geographic axes of the main Alpine range. The course taken by these rocks apparently follows one of the main Pacific trend lines, the nature of which will be more fully understood with the further elucidation of the structural geology of the region. The rocks are intrusive into sedimentary strata of ages varying from Ordovician to Jura-Trias, and, as far as can yet be determined, all the exposures appear to be of approximately contemporaneous origin.

One of the most interesting groups is at the Dun Mountain, Nelson, where the original dunite of Hochstetter occurs, associated with magmatic segregations of chromite, bands of pyroxenite, serpentine rock, and a variety of rock types of contact-metamorphic origin bordering on the Triassic Limestone which is intruded by these rocks. The rocks of the contact zone include grossularite diallage rock, serpentine amphibole rock, and epidote rock.

In Westland, near Hokitika, the rocks occur as a series of sills which are of two varieties—massive or foliated serpentine rock, and serpentine-talc-carbonate rock. The former are often seen to be of the variety antigorite, with typical thorn structure, and some specimens show the process of serpentinization of augite lately described by Professor Bonney from this region. The serpentine-talc-carbonate rocks are the matrix of the New Zealand nephrite or greenstone, which also occurs as boulders in the adjacent river valleys and glacial drifts.

At Anita Bay, Milford Sound, occur a dunite with marked cataclastic structure, a hartzbergite in which the enstatite is often completely altered to magnesite, and a foliated talcose rock containing stringers and veins of the tough and highly translucent bowenite—the tangiwhai or 'tear-drop' of the Maori. Chemical and microscopic examination leads to the conclusion that the bowenite has here been formed by deep-seated metamorphism of a talc rock, with the development of serpentine and magnesite, the former being transformed into the tough fine-grained bowenite by dynamic forces of considerable intensity.

A notable feature of all the rocks of this peridotite belt is the close association of the most highly serpentinized varieties with evidences of former hydrothermal action accompanying the intrusions. The widespread serpentinization seen in many cases seems to have been largely effected or at least initiated by hydrothermal action.

The nephrite, or Pounamu of the Maori, occurs as nodules and veins in the serpentine-carbonate and talc-carbonate rocks of the Griffin Range, Westland. Its commonest colour is a deep translucent green, but many different shades occur, depending on the percentage of ferrous silicate, on the presence or absence of flaws and cracks, and on included or infiltrated oxides of iron. Some of the dark-green nephrites are among the finest specimens of this mineral in existence. A pale whitish-green variety is also occasionally found. It is, however, rather opaque and never approaches in sheen the famous pale 'jades' of Turkestan.

Microscopically, the nephrite shows a foliated or confused aggregate of very fine fibres, the denseness of the fibrous mass being evidently the cause of its hardness.

It appears to have been originally formed by several modes: (1) by contact-action between peridotites and lime-bearing rocks, (2) by uralitization of pyroxenes, (3) by direct transformation of olivine into finely fibrous amphibole, (4) by deep-seated metamorphism of serpentine-talc-carbonate rock or its prototype.

These modes all suffice to produce the necessary chemical changes, but the transformation to true nephrite has involved, in addition, intense rock-pressure and movement. Thus has finally resulted the dense foliated or felted aggregate of fibres which characterizes nephrite.

CORRESPONDENCE.

CHRYSOLITE, CHRYSOTILE, AND KARYSTIOLITE.

Sir,—May I call the attention of your readers to the inconvenience caused by the similarity between the terms *chrysolite*, a synonym of olivine adopted by Dana as the name of the species, and *chrysotile*, given by Kobell (Jahrb. prakt. Chem., 1843, vol. xxx, p. 469) to the fibrous variety of serpentine. Twice within the last twelve months I have had occasion to use the term 'chrysotile' in publications (Proc. Geol. Assoc., 1908, vol. xx, p. 462; Bull. Imp. Inst., 1908, vol. vi, p. 394), and on both occasions it has been transformed into 'chrysolite'. In the case of the article in the Bulletin I was able to verify the fact that the right word appeared not only in the manuscript but in three successive proofs, and that it was only at the last moment that it was corrected (!) in every place where it occurred by a reader for the press. In the other case the proofs were not available for reference, but the manuscript was found to be correct.

The two words are a continual source of confusion to students, and I would suggest the revival in the form *karystiolite* of the original name of the mineral, *καρύστιος* λίθος, from Karystos, in Eubœa, where it was obtained (Min. Mag., 1906, vol. xiv, pp. 143–5). 'Karistia' was still in use in modern Greek in this sense towards the close of the eighteenth century (id., p. 147). The term 'marmor carystium' appears to have been applied by Pliny to serpentine rock quarried in the same locality (Nat. Hist., iv, 21, and xxxvi, 7).

John W. Evans.

Imperial Institute.
April 30, 1909.

CLIMATE AND TIME.

Sir,—The discoveries of Scott and Shackleton show that in the Antarctic, as in the Arctic, the climate is ameliorating. When Scott visited the Great Barrier in 1902 he found it had retreated many miles since the days of Ross, and Ferrar from other evidence concluded that the ice masses are gradually shrinking in size.

This raises a very interesting point concerning the theories which have been formed to account for warm and glacial periods. According to Croll's theory the cold and warm periods occurred during times of great eccentricity in the earth's orbit, and the cold and warm periods alternated between the north and the south polar areas owing to the precession of the equinoxes. In other words, the climatic changes taking place must be of opposite character in the northern and southern hemispheres, whereas the facts appear to be, as already stated, that the climate is now ameliorating in both hemispheres. Moreover, the great number of cold and warm periods Croll's theory requires seems to me to be greater than is warranted by the geological evidence available.

It is admitted that the total amount of heat received by the earth from the sun each year is only very slightly affected by changes in the eccentricity of the earth's orbit. There is also reason to believe that the obliquity of the earth's orbit has not varied appreciably. We are, therefore, constrained at present to admit that, at least as regards recent glacial periods, the cause of the climatic changes must lie in the variable way in which the heat is received from the sun and reflected or retained during the winter and summer seasons and the indirect results thus brought about.

The essence of Croll's theory is that at times of great eccentricity there are periods during which the difference between the amount of heat received during winter and summer is very great on one hemisphere, whilst on the other hemisphere the quantities of heat received during the two seasons is more equable. When the winters are sufficiently cold the precipitation is almost wholly in the form of snow, and if the snowfall is sufficiently great the summer sun is unable to melt it; for owing to the heat being reflected from the white surface, or intercepted by fog, the part of the hemisphere concerned does not profit proportionately by being nearer to the sun. A great amount of heat is also required merely to change the ice to water.

Now I would suggest that during periods of great eccentricity, when the winter of one hemisphere is in aphelion, the collection of ice and snow is so great that the warmth of summer when the same hemisphere is in perihelion is unable to melt it except in low latitudes, and glacial periods are thus produced concurrently in both hemispheres during times of great eccentricity.

When, during periods of great eccentricity, the equinoxes are in aphelion and perihelion the conditions are also favourable for the collection of snow and ice in both polar areas; for during the time one equinox is in perihelion the equatorial region receives a great amount of heat from the sun, evaporation is promoted, and the precipitation of snow at the poles is increased. On the other hand, the equinox which is in aphelion is cool for both hemispheres. It appears to me that Croll has correctly stated the conditions of climate of the hemisphere the winter of which is in aphelion, but has over estimated the effect produced by the conditions favouring warmth in the hemisphere the winter of which is in perihelion.

The whole problem turns on the probability of the collection of sufficient ice during the ten thousand years of cold winters to resist appreciable melting during the succeeding ten thousand years of hot summers. It appears to me that when a large area has become ice-bound it will take a very long time for the sun's heat falling on that area during times of eccentricity to clear away the ice.

The edge of the Great Barrier is about 800 miles from the South Pole, and Scott found that the ice was moving northward at the rate of about 600 yards per annum. South of the Great Barrier edge there seems to be very little actual wasting of the ice due to melting, so, independent of evaporation, ice formed near the South Pole would take about 2400 years to reach the Barrier edge. It is clear, therefore, that when once a large area has become ice-bound the clearing away of the ice would be a very slow process, especially as the precipitation of snow never ceases.

Just as the coldest time of our winter does not coincide with the shortest day, so during times of great eccentricity the time of maximum cold will not coincide with the time of greatest eccentricity, nor would the periods of greatest warmth coincide necessarily with the moment of least eccentricity.

Croll calculated that during the next twenty-five thousand years the earth's orbit would become more and more circular, and then, in a similar period of time, having regained about its present eccentricity, it would remain nearly constant for another fifty thousand years. From the fact that the ice is shrinking on both hemispheres, the physical conditions resulting from the present degree of eccentricity are favourable to future warmer conditions concurrently in both frigid zones.

I do not assert that the distribution of sea and land with reference to the poles is of no importance from a climatic point of view. If there were no Antarctic land and the south polar area were covered by deep water, the ice formed on the sea near the pole would float into warmer latitudes and readily melt, and thus enable the sea to retain the heat of the summer sun.

Although there is deep water in the Arctic Sea, the sea is so land-locked that the collection of snow and ice formed during the winter cannot fully escape south during the summer, and a great part of the sun's heat is reflected from it into space.

It is possible that at remote periods of the earth's history the distribution of the land and sea may have been so favourable that during periods of small eccentricity very genial climatic conditions may have existed at times at one or other of the poles.

R. M. Deeley.

Melbourne House,
Osmaston Road, Derby.
March 27, 1909.

No. 541. Decade V.—Vol. VI.—No. VII. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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ASSISTED BY

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JULY, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. VII.—JULY, 1909.

ORIGINAL ARTICLES.

I.—The Geology of the Lower Coal-measures of the Derbyshire and Nottinghamshire portion of the Yorkshire Coalfield.

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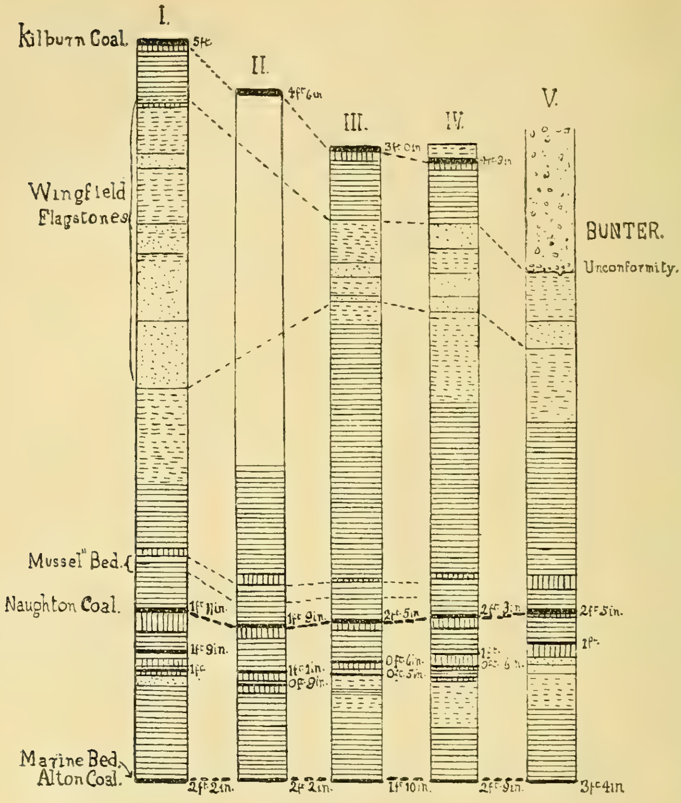
Introduction.

THE lithological character and sequence of the lower part of the Coal-measures of the Yorkshire Coalfield have been well known since the publication of the memoir by the Geological Survey in 1878. No connected account of the explorations in the equivalent measures of the Derbyshire and Nottinghamshire portion of the coalfield has been written; thus the close correspondence which exists between the lower part of the Coal-measures of Yorkshire and that of Derbyshire and Nottinghamshire is still generally unknown.

The sequence under consideration includes more than 800 feet of measures lying between the top of the First Grit of the Millstone Grit Series and a well-known Derbyshire seam, the Kilburn Coal. These lower measures continue from Yorkshire through Derbyshire with a north and south strike which changes to east and west on the southern border of the coalfield. Continuous escarpments of Millstone Grit form the western border of the coalfield, but on the south, with the exception of a small area of the First Grit, the measures below the Kilburn Coal are faulted down and buried under the Triassic rocks to the west of Nottingham.

The object of this paper is to discuss the evidence afforded by bore-holes and sinkings for the presence of these Lower Coal-measures on the southern margin of the Derbyshire Coalfield and their continuation under the Trias of Nottinghamshire; and further to show, by means of plotted sections, the marked southerly attenuation which occurs in the lowest portion of the sequence.

The recent trial shaft at the Kilbourne Colliery affords valuable evidence for the occurrence of these rocks in Derbyshire; from the details given in the Survey Memoir (1), Fig. 1, Section I, and Fig. 2, Section II, have been plotted to serve as a type with which to compare the sections described below.



Scale 150 Feet to an inch.

Fig. 1, Section I. New Shaft at Kilbourne Colliery.
,, II. New Sinking at Oakwell Colliery.
,, III. Boring at Little Hallam.
,, IV. Trial Shaft at Stanton Gate.
,, V. Boring at Ruddington.

Excluding thin coals, these measures contain in descending order four named seams—the Kilburn, Naughton, Alton, and Belperlawn Coals. Additional confirmatory evidence for the identification and correlation of sections is furnished by—

1. The presence of the Wingfield Flagstones some distance below the Kilburn Coal.
2. The occurrence of a marine bed in the roof of the Alton Coal.

The former is a group of sandstones, flagstones, and shales, which, because of its remarkable persistence and the bold escarpment to which it gives rise, was regarded by Green (2) as the most important rock of the Lower Coal-measures of the Yorkshire Coalfield.

The latter consists of a few feet of pyritous shale, with calcareous and pyritous nodules, containing numerous marine fossils of which the most common are *Pterinopecten papyraceus*, *Goniatites*, *Lingula*, and the remains of fish.

This marine bed provides a reliable and easily recognized datum-line for these lower measures, the base of which is clearly defined by the upper limit of the massive and persistent First Grit (Rough Rock).

Detailed Consideration of Sinkings and Borings.

So long ago as 1856 Smyth (3) gave for the Stanton district the following estimate for the thickness of the measures between the Kilburn Coal and the 'Bottom' Coal which "rests almost immediately upon the Millstone Grits":—

	ft.	in.
Kilburn Coal	5	0
Clunch	3	0
Honeycroft Rake	45	0
Measures	252	0
Civilly Rake	60	0
Coal, 'Furnace' (Naughton Coal)	2	3
Dale Moor Rake	21	0
Measures	96	0
Coal, 'Bottom' (Alton Coal)	2	0
Total . .	486	3

Subsequent explorations, whilst confirming the above estimate, have proved a further 50 feet of Coal-measures between the Alton Coal and a coal—the Belperlawn seam—which occurs on the top of the First Grit.

Trial Shaft at Stanton Gate Iron Works. (Fig. 1, Section IV.)—This shaft was sunk on the outcrop of the Kilburn Coal in 1877, at a time when much valuable local knowledge of the Lower Coal-measures had been obtained during the working of the numerous ironstone pits of the district.

This section is of importance, because the coal-seams, Ganister beds, and ironstone 'rakes' are correctly named and carefully described. The thickness of measures between the Kilburn and Alton Coals amounts to 480 feet, thus confirming Smyth's estimate of 1856.

Wollaton Colliery.—An old boring from the bottom of this shaft proved the measures from the Deep Hard Coal down to the Naughton Coal. The Black Shale (Silkstone) seam was proved, but no trace of the Kilburn Coal was found on the horizon where it was expected to occur.

The Little Hallam Boring near Ilkeston. (Fig. 1, Section III, and Fig. 2, Section IV.)—This deep boring for water was put down in 1896 by the Corporation of Ilkeston on a site between the outcrops of the Black Shale and the Kilburn Coals about three-quarters of a mile south of the town.

The first 500 feet were cut by percussive drill, and "as this part of the section was well known it was not accurately observed" (4); for this reason the measures above the Kilburn Coal [1] will not be considered

[1] The thickness of this coal as given in the boring section is probably incorrect.

here. The rest of the boring was done by diamond drill. Owing to the indefinite, not to say mistaken, lithological descriptions the section is somewhat misleading. Fortunately a small collection of cores has been preserved, from an examination of which I have been able to correct and supplement the section. The Kilburn Coal, the Wingfield Flagstones, the Naughton, Alton, and Belperlawn Coals can be identified.

At 1110 feet deep, 25 feet above the Naughton Coal, there occurs a well-marked shell-bed containing many dwarfed specimens of *Carbonicola acuta*.

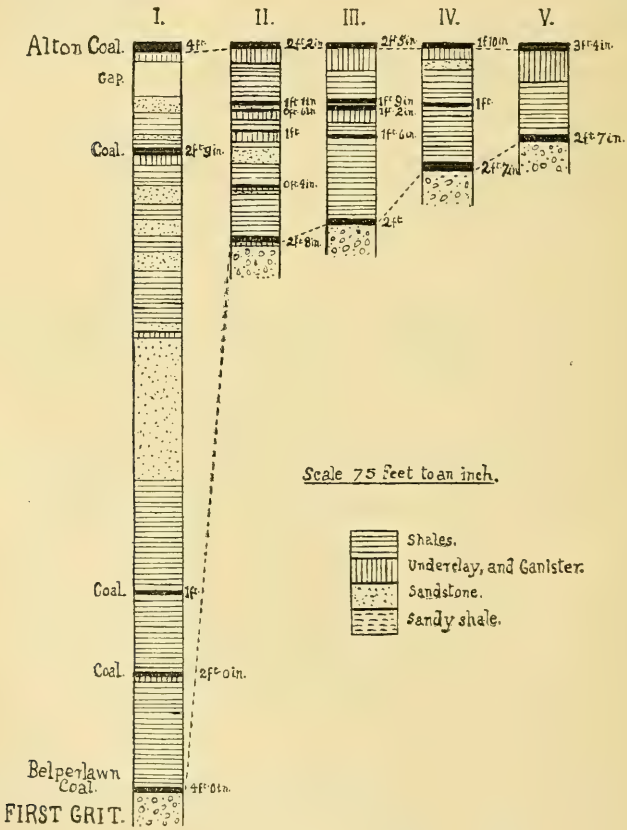


Fig. 2, Section I. General Section at Ambergate.
,, II. New Shaft at Kilbourne Colliery.
,, III. Water Works Shaft at Smalley.
,, IV. Boring at Little Hallam.
,, V. Boring at Ruddington.

At three horizons the term 'burr' is used. The rock so described is composed of numerous small spherulites of siderite set in a very fine-grained light-grey matrix of marl. A fourth bed of siderite, 18 inches thick, forms part of the fireclay floor of the Alton Coal, immediately overlying a bed of hard grey Ganister. I have found similar siderites at various horizons in the Nottinghamshire Coalfield: they closely resemble the Staffordshire example recently described by Dr. Teall (5).

The Ruddington Boring. (Fig. 1, Section V, and Fig. 2, Section V.)—Several references to this important boring have been made (6), and the section has recently been published by the Geological Survey (7). After penetrating 670 feet of Trias the boring proved 440 feet of Lower Coal-measures and 760 feet of Millstone Grit. The following fossils were obtained from an unknown depth by the late James Shipman, F.G.S. (8):—

Carbonicola acuta.	*Anthracomya modiolaris.*
C. acuta, var. *rhomboidalis.*	*Acanthodes Wardi.*
C. aquilina.	

Owing to their wide range these fossils yield no assistance in identifying the horizon reached in this boring.

From a study of a nearly complete series of cores I am able to add the following important details concerning this boring. The published account places the surface of the Coal-measures at a depth of 687 feet; but it must occur a few feet higher, because I obtained pith-casts of *Calamites* sp. at 682 feet. The upper 20 feet of Coal-measures consist of red and grey micaceous sandstone with thin beds of blue marl. As these red measures pass downwards into typical grey sandstones and sandy shales of the Wingfield Flagstones, they must be regarded as Wingfield Flagstones stained by percolation from the overlying Bunter. These beds contain numerous badly preserved plant-remains, including—

Calamites sp., cf. *varians*, Sternb.
Cordaites sp.
Crossotheca sp.

At 689 feet and at 698 feet are two thin bands of breccia composed of angular fragments of marl and hæmatite set in a red sandy matrix. This suggests that erosion has taken place.

The Coal-measures were entered below the Kilburn Coal. Conclusive evidence of the horizon reached in this boring is furnished by the coal 3 ft. 4 in. thick at a depth of 1072 ft. 9 in. The dark pyritous roof-shale in contact with the coal is crowded with flattened marine fossils, including—

Pterinopecten papyraceus.
Goniatites sp.
Schizodus sp.

The floor of the seam is a hard, grey, compact Ganister passing downwards into fireclay. This coal must, therefore, be the Alton Coal.

It has been generally assumed that from Nottingham to Ruddington the Coal-measures dip steeply to the north, but an examination of the cores (which have a diameter of 7 inches) does not confirm this opinion; with the exception of a few feet of false-bedded sandstones belonging to the Wingfield Flagstones, the Coal-measures appear to lie in a horizontal position. After allowing for the faults proved in the

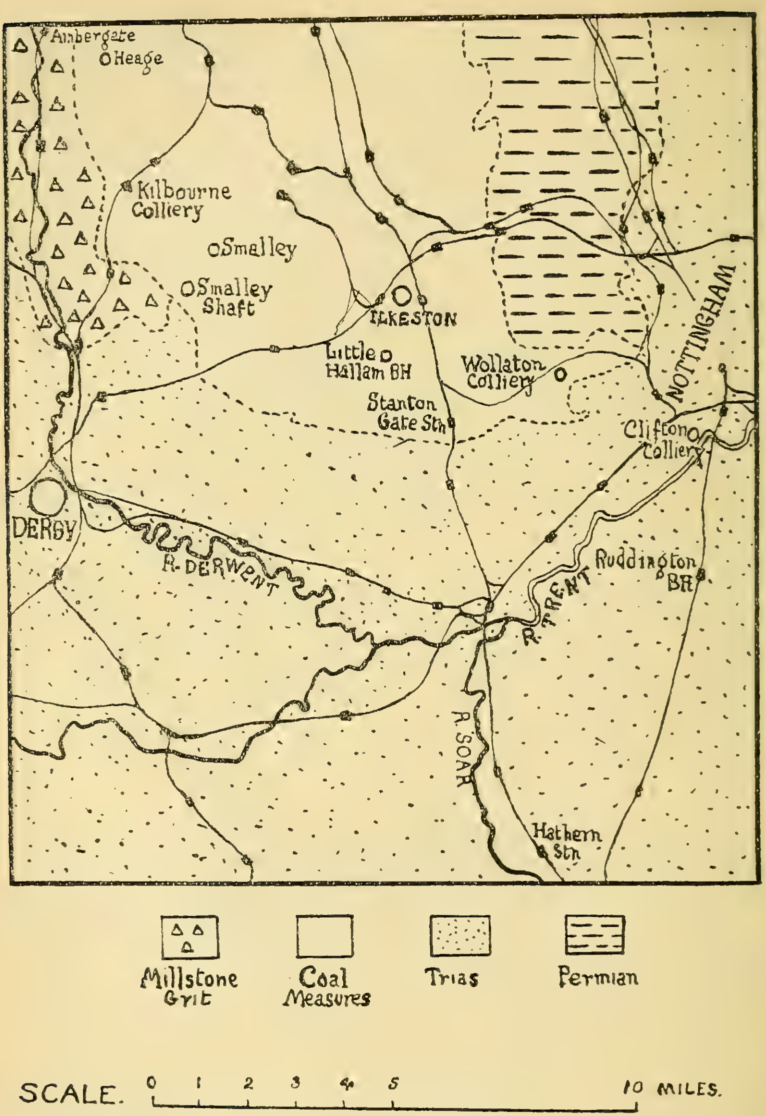


Fig. 3. Sketch-map showing the position of borings and shafts in the Derbyshire and Nottinghamshire Coalfield.

workings of the Deep Hard and the Deep Soft Coals at the Clifton Colliery, 3 miles north of Ruddington, and also for the known southerly rise of the Coal-measures under Nottingham, the position at Ruddington can only be accounted for by assuming the presence of an additional east and west fault, or faults, having a considerable upthrow to the south, in the 1½ miles of unproved ground north of the Ruddington borehole.

Oakwell Colliery, Ilkeston. (Fig. 1, Section II.)—The workings in the Kilburn Coal at this colliery having recently encountered a fault with an upthrow of 95 yards, the opportunity was taken to try the Ganister Coals by means of a trial shaft sunk from a level driven through the fault. The Naughton and Alton Coals were proved. The section closely agrees with the Kilbourne section, and confirms my reading of the adjacent Little Hallam Boring.

Underlying a bed of white clunch, 37 feet above the Naughton Coal, was a shell-bed with numerous specimens of *Carbonicola acuta* and *C. aquilina*.

The Alton Coal, with its marine bed roof, showed the following section:—

	ft.	in.
Black Shales (marine bed)	1	4
Coal	1	11 to 2 ft. 4 in.
Ganister floor } White fireclay }	6	0

The black roof-shales are crowded with flattened fossils, and contain large calcareous and pyritous nodules in which perfect uncrushed fossils occur. The following were collected:—

Lingula mytiloides.
Pterinopecten papyraceus.
Posidoniella lævis.
P. minor.
Gastrioceras carbonarium.
G. Listeri.
G. coronatum.
Dimorphoceras Gilbertsoni.
Pleuronautilus sp.
Orthoceras (more than one species).
Elonichthys sp.
Megalichthys Hibberti.
Acanthodes sp.

General Considerations.

1. *Comparison with the Yorkshire Coalfield.*

The Kilburn Coal.—This important seam is an excellent house-coal throughout the southern portion of the Derbyshire Coalfield, with an average thickness of 5 feet on the western and southern outcrops, but diminishing locally in the workings on the easterly dip. It has not yet been proved under the Trias of Nottingham. Traced northward the seam thins away to less than 2 feet in the Chesterfield area, and further north it is represented only by its underclay. In the southern portion of the Yorkshire Coalfield an underclay occurs on the same horizon, some way above the Elland Flagstones, while north of Huddersfield the Better Bed Coal comes on over this underclay; and this coal, like its equivalent the Kilburn Coal, is immediately overlain by a 'bone-bed' composed of fragments of fish-remains (9).

The Wingfield Flagstones.—The bold feature formed by the outcrop of this rock is known to extend throughout the whole length of the Derbyshire into the Yorkshire Coalfield, where it is called the Elland Flagstone. The work of Hull and Green, and the more recent work of Gibson and Wedd, has resulted in the correlation of the Elland Flagstones with the Upholland Flags of the Lancashire Coalfield, and with the Woodhead Sandstones of the Cheadle Coalfield of

North Staffordshire. In this area it is difficult to define the upper and lower limits of the group, owing to the replacement of part of the sandstones by sandy shales, but even so far south as Ruddington, where the 'flags' are wholly wanting, the sandstones are still quite coarsely grained.

The Alton Coal.—With the possible exception of the area south-west of Chesterfield (10), this coal, with its accompanying marine bed roof, is persistent throughout the Derbyshire Coalfield into Yorkshire, where it becomes the well-known Ganister or Halifax Hard Coal, which invariably has a marine bed roof.

The correlation of this coal with the Bullion Coal of Lancashire and with the Crabtree Coal of North Staffordshire is now well established, and is regarded as strong evidence for the formation of the Coal-measures of the Midland Counties in one basin of deposition.

In Yorkshire the Ganister Coal has been extensively worked as an engine coal. It is interesting to notice that its equivalent in this area, the Alton Coal, possesses identical properties, being a pyritous, quick-burning, good coking coal of variable thickness, used in the past mainly for engine purposes.

The Belperlawn Coal.—This coal, with its underclay, rests immediately upon the top of the First Grit. Towards the south it thins away (see Fig. 2), and, by the intercalation of shale bands, deteriorates in quality until at Ruddington it contains only 10 inches of coal.[1] This seam is the equivalent of the "thin coal and underclay" which is constantly found on the top of the First Grit of the Yorkshire and Lancashire Coalfields.

2. *The Southerly Attenuation of the Coal-measures.*

Figs. 1 and 2 illustrate the general southerly decrease in thickness of these lower measures of the Yorkshire Coalfield. Fig. 2 shows that this attenuation is most marked in the measures below the Alton Coal. It is accompanied by a gradual and progressive loss of the associated sandstones and thin coals, until at Ruddington the measures between the Alton and Belperlawn Coals consist of only 32 feet of fireclay and shales. A similar attenuation occurs in the equivalent measures of the Cheadle Coalfield of North Staffordshire. These facts afford strong confirmatory evidence that in this area and for these lowest measures the old rocks flanking the Charnwood Range were part of the southern margin of deposition of that continuous sheet of Coal-measures of which the Lancashire, Yorkshire, and North Staffordshire Coalfields are the remains.

List of Fossils from the Lower Coal-measures of Nottinghamshire and Derbyshire.

Calamites sp., cf. *schutzei*, Stur.
C. sp., cf. *varians*, Sternb.
Cordaites sp.
Sphenophyllum cuneifolium, Sternb.
Stigmaria ficoides, Sternb.
Sigillaria sp.
Crossotheca sp.
Lepidodendron aculeatum, Sternb.
L. lycopodioides, Sternb.
Lepidophloios sp.
Lepidostrobus sp.
Carbonicola robusta, J. de C. Sow.

[1] Nevertheless, the sinking at the Oakwell Colliery, Ilkeston, is being continued to the Belperlawn Coal.

Carbonicola nucularis, Hind
C. turgida, Brown
C. aquilina, Sow.
C. acuta, Sow.
C. acuta, var. *rhomboidalis*, Hind
Naiadites modiolaris, J. de C. Sow.
Anthracomya modiolaris, Sow.
A. cf. *lævis*, Dawson, var. *scotica*, R. Eth., jun.
Spirorbis sp.
Lingula mytiloides, Sow.
Spirifer sp.
Pterinopecten papyraceus, J. Sow.
Posidoniella minor, Brown
P. lævis, Brown
Gastrioceras Listeri, Mart.
G. carbonarium, Von Buch
G. coronatum.
Glyphioceras bilingue (?), Salter
Dimorphoceras Gilbertsoni, Phill.
Pleuronautilus sp.
Orthoceras (more than one species).
Gasteropoda (of several species).
Acanthodes Wardi, Egert.
Sphenacanthus hyboides, Egert.
Cœlacanthus elegans, Newb.
Megalichthys Hibberti, Agass.
M. intermedius, A. S. Woodw.
Rhizodopsis sauroides, Will.
Elonichthys Aitkeni, Traq.
E. Binneyi, Traq.
Platysomus tenuistriatus, Traq.
Rhadinichthys monensis, Egert.
Mesolepis scalaris, Young
M. micropterus, Traq.
Hoplonchus sp.

Distribution of the Fossils.

The scarcity of exposures in this area, and the difficulty of attaching names to some of the specimens owing to the unsatisfactory state of our present knowledge of the Cephalopoda and Gasteropoda of the Coal-measures, combine to render the list of fossils only a partial indication of the life of the period. Within such a relatively small thickness of measures there is no restriction of particular species to definite horizons.

Plants.—The few plants are all common species; they occur chiefly in association with the coal-seams, and in the sandy beds of the Wingfield Flagstones.

Fish.—Fragmentary scattered fish-remains occur in almost all the shales; they become numerous in the roof-shales of the Kilburn, Naughton, and Alton Coals, forming thin bone-beds composed of scales, teeth, bones, and spines.

The bands of concretionary nodules of clay ironstone, locally called 'Rakes', have in the past yielded numerous perfect specimens of fish.

Remains of fish are usually found not to extend over wide areas. Of these fish-beds, only that in the marine bed over the Alton Coal is persistent throughout and beyond this district; its range would appear to be coextensive with that of the marine bed. Although no attempt has been made to show its persistence in other areas, it has been several times observed in the equivalent marine bed of the Lancashire, North Staffordshire, and Yorkshire Coalfields.

Freshwater (*or Estuarine*) *Mollusca.* — The zone fossil for this sequence and the succeeding measures up to the Deep Hard Coal is *Carbonicola robusta.* The range of *C. nucularis* is a little wider, but outside the zone of *C. robusta* it is very rare. The specimens of *C. acuta* are sometimes dwarfed, and similar dwarfed *C. acuta* have been recorded from the Ganister series of other coalfields (11).

It is interesting to observe (see Fig. 1) that at least one of these 'Mussel Beds' is persistent for some distance, forming a definite horizon of local value in the identification of shaft sections.

Marine Fauna.—With the exception of a bed containing only *Lingula* which occurs below the Alton Coal in the Kilbourne shaft, the marine fossils are found to be restricted to the roof of the Alton Coal.

Conclusion.

The Alton Coal and its marine bed have thus been proved to persist from the outcrop in Derbyshire as far as Ruddington, 15 miles to the south-east, without showing any signs of thinning away.

On the east side of the Charnwood Range borings have shown the Coal-measures to be absent (e.g. at Hathern, 7 miles south-west of Ruddington) (12). It would therefore appear that these Lower Coal-measures continue to the south of Ruddington and finally end abruptly against the older rocks flanking the Charnwood Range.

It is impossible as yet to correlate the Yorkshire and Leicestershire Coalfields since very little is known of the lower measures of the Leicestershire Coalfield, which contains no workable coal-seams. In future explorations it is suggested that search should be made for this Alton Coal marine bed, which would provide a much needed datum-line of prime importance in the correlation of the Leicestershire Coalfield with the other coalfields of the Midland province.

Owing to the strongly unconformable cover of Trias which conceals the Coal-measures to the south of Nottingham there is always the possibility that future borings may (as at Ruddington) unexpectedly encounter these Lower Coal-measures. In such a case it will no longer be necessary, as in the past, for borings to be continued below the Alton Coal marine bed, the explorations described above having definitely proved that in this area the Ganister Coals are of no present value.

I wish to express my indebtedness to the work of Dr. Gibson and Mr. Wedd, B.A., as contained in the recent Survey Memoir on South Derbyshire. My best thanks are due to Mr. E. A. Newell Arber, M.A., Dr. Hind, and Dr. Traquair for assistance in identifying the fossils; to Professor J. W. Carr, M.A., and Dr. Swinnerton, of University College, Nottingham, for facilities in carrying out the work and for permission to break up and examine a series of cores from the Ruddington Boring; to G. E. Coke, Esq., F.G.S., for further cores from Ruddington; to H. J. Kilford, Esq., the Ilkeston Borough Surveyor, for permission to examine cores from the Little Hallam Boring; and to P. M. Chester, Esq., General Manager of the Oakwell Collieries, Ilkeston, for kindly allowing me to inspect the new sinking at that colliery.

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II.—Geology and Petrology of the Intrusions of the Kilsyth–Croy District, Dumbartonshire.

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(PLATE XII.)

I. Introduction.

The group of intrusions of which this paper treats is a part of a series of intrusive rocks piercing the Carboniferous strata of the Midland Valley of Scotland. As a rule, they have forced their way into the Carboniferous Limestone Series in layers roughly parallel to the stratification. At the surface they stand out as rough, craggy hills, often of considerable elevation, rising abruptly out of the plain of the Carboniferous sediments, and frequently ending off in a vertical escarpment of bare rock. They generally confront, at a distance of 1 or 2 miles, the terraced escarpments of Lower Carboniferous lavas, which bound the Midland Valley on the north, west, and south-west.

These intrusions are intimately connected with the great series of E.–W. dykes which traverse the Midland Valley, and form, with them, a group of considerable petrographical individuality, which is represented in all parts of the world.

On the ground the Kilsyth–Croy group consists of four separate masses, extending roughly in a S.W.–N.E. direction. It is connected with three of the great E.–W. dykes.[1]

The two main outcrops, upon which stand the villages of Kilsyth and Croy respectively, extend from Twechar to Banton, a distance of 5 miles, and are separated by the ancient alluvial trough now occupied by the River Kelvin and the Forth and Clyde Canal. This trough, however, cuts through the north-eastern prolongation of the Croy mass. The third outcrop is a thin, sinuous intrusion, about 1 mile south of the Croy mass, which is injected into a higher horizon. Another small mass occurs abutting against the main boundary fault to the north of Kilsyth.

A short general account of the nature and occurrence of these rocks is given in the Geological Survey Memoir (1879) on Sheet 31.[2] In his classic paper on the Carboniferous Dolerites,[3] Allport described the rocks of Gernal Brae and Auchinstarry in the Kilsyth district. Sir A. Geikie has treated of the general relations of these intrusions and the great E.–W. dykes, first in his paper on the Carboniferous Volcanic

[1] See Sheet 31 of Geological Survey of Scotland.
[2] pp. 43–6.
[3] S. Allport, Q.J.G.S., 1874, vol. xxx, p. 553.

Rocks of the Firth of Forth,[1] later in his Presidential Address to the Geological Society in 1892,[2] and finally a detailed account has been given by him in his *Ancient Volcanoes of Great Britain*.[3] Dr. Teall[4] has described rocks from Kilsyth and Croy. Mr. Monckton has described similar rocks from the Stirling district,[5] and Dr. Falconer from the Bathgate Hills.[6]

II. Structure of the Kilsyth and Croy District.

The rocks of this area belong mainly to the Carboniferous Limestone Series. They are bounded by the Millstone Grit on the west, south, and east, and by the Calciferous Sandstone and its intercalated lavas to the north. The boundary here is the main E.–W. fault. The general succession is given below. Only the outstanding horizons of limestone, coal, etc., are given. It must be understood that these are separated from one another sometimes by hundreds of feet of sandstone and shale.

Millstone Grit = Roslin Sandstone.

Carboniferous Limestone Series.	Castlecary Limestone.
	Calmy or Arden Limestone.
	Bishopbriggs Sandstone.
	Index or Cowglen Limestone.
	Blackband Ironstones, Nos. 1–4, with Main Coal of Meiklehill near top.
	Main Coking Coal of Kilsyth.
	Hosie's Limestones.
	Hurlet Limestone.

Calciferous Sandstone Series, with intercalated volcanics.

The dominant structural feature is the sharp anticline in the Carboniferous Limestone Series, locally known as "The Riggin", which runs in a south-west to north-east direction, from Twechar to Banton. The general strike of the beds is therefore south-west to north-east, but the country is much broken by a series of E.–W. faults, the largest of which brings the Calciferous Sandstone and its volcanics into contact with the Carboniferous Limestone Series to the north of Kilsyth. There is also a set of smaller faults, the general direction of which is from north-west to south-east. In the course of the revision of the district by the Geological Survey it has been shown that the structure of the Riggin is not so simple as formerly supposed, but that there is a series of more or less parallel wave-like troughs and ridges having a general N.E.–S.W. trend.[7]

III. Geology of the Intrusions.

Horizon.—The intrusions are, as a whole, roughly conformable to the bedding, although in places they gradually transgress. The main

[1] T.R.S.E., 1879, vol. xxix, p. 505.
[2] Q.J.G.S., 1892, vol. xlvii, proc. 105.
[3] Vol. i, pp. 417–23, 446–61; ii, pp. 140–3, 155–8.
[4] *Brit. Petrog.*, 1888, p. 192.
[5] Proc. Geol. Assoc., 1891–2, vol. xii, p. 242, with petrog. appendix by J. G. Goodchild; also Q.J.G.S., 1895, vol. li, pp. 480–91.
[6] T.R.S.E., 1905–6, vol. xlv, pt. i, p. 137.
[7] *Summ. Prog. Geol. Surv.*, 1905, p. 124.

mass of the Kilsyth–Croy intrusion, for instance, lies between the Index Limestone and the Kilsyth Coking Coal; yet in the south-western prolongation of the Croy mass it has transgressed so as to actually overlie the former seam. To the north-east, however, it transgresses downwards.[1] A detailed section across the area from the north-west to south-east shows at once that the apparently separate masses of Kilsyth and Croy are detached portions of the same intrusion thrown off on either side of the denuded anticline of the Riggin (see Fig. 1). In the extreme north-east of the area, towards Denny, the two outcrops unite where both the intrusion and the anticline are beginning to die out. The sinuous outcrop 1 mile to the south of the Croy Mass belongs to a thin intrusion injected on a platform some hundreds of feet higher in the series. To the north of the Kilsyth Mass a small intrusion occurs on a lower platform, and abuts against the boundary fault between the Carboniferous Limestone Series and the Calciferous Sandstone. It is probably the same as that which occurs in a deep bore at Wester Bedcow near Kilsyth. This horizon is about 270 feet above the Main Coking Coal.

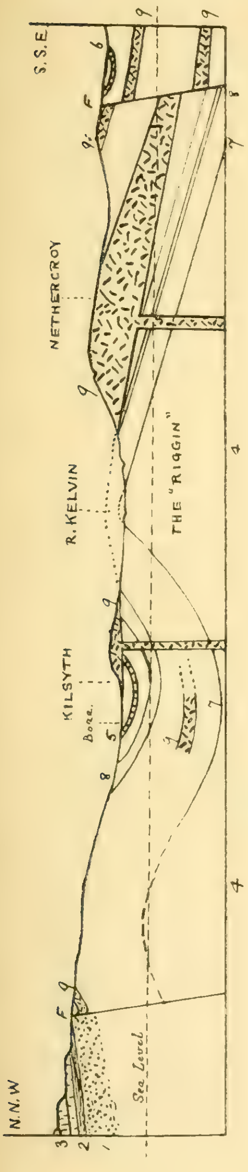


FIG. 1. DIAGRAMMATIC SECTION ACROSS THE KILSYTH–CROY AREA.

1, Calciferous Sandstone; 2, Cement-stones; 3, Calciferous Sandstone lavas; 4, Carboniferous Limestone Series; 5, Index Limestone; 6, Calmy Limestone; 7, Kilsyth Coking Coal; 8, Blackband Ironstones; 9, Diabase intrusions; F, faults. Scale: horizontal, 1 inch = $\frac{1}{3}$ mile; vertical, 1 inch = 1000 feet.

The horizon of the intrusions becomes lower as one proceeds in a north-westerly direction. The great sill of Stirling in this direction is injected just above the Hurlet Limestone, at the base of the Carboniferous Limestone Series.

The intrusion trending southward from Myot Hill, which appears to be the southern continuation of the Stirling mass, is just under the horizon of the Main Coking Coal at the outcrop. A boring in Messrs. A. & G. Moore's Castlerankine field, half a mile east of the outcrop, shows that in this distance the igneous rock has transgressed until it is at least 400 feet below the Coking Coal.

[1] Ibid., 1906, p. 104.

Form.—The form of the Kilsyth–Croy intrusion is that of a flattened and attenuated laccolite, as is well shown in sections kindly supplied by the Carron Co. and by William Baird & Co. (see Fig. 1). In the Nethercroy Pit, worked by the Carron Co., the sedimentaries and the igneous rock dip to the south at an angle of 20°. The 'whin' occupies most of the surface, rising to a height of 481 feet above sea-level. At its thickest part, under the Antonine Wall, it is represented as 346 feet thick in the section supplied by the Carron Co., and this is not the original thickness, as the surface has suffered considerable denudation. But at a point 780 yards south of the Antonine Wall the total thickness is only 190 feet. The greatest thickness in that extension of the laccolite upon which the town of Kilsyth stands is about 150 feet; and although this mass has suffered some denudation, it seems probable that in this direction there is a considerable diminution from the maximum thickness that occurs under the Antonine Wall. At Drumgrew, 2½ miles south-west of the latter point, the thickness has been proved in a bore to be 108 feet.

At the Neilston Pit, north of Kilsyth, and due north of the point of maximum thickness, the igneous rock has been proved to a depth of 100 feet.

Owing to its relatively small thickness as compared with its horizontal extent, the laccolite has caused a quite insignificant arching of the overlying strata.

The term 'laccolite' is used here in the sense of a lens-shaped body of igneous matter supplied through vertical dykes, both upper and lower surfaces being slightly transgressive, whereas in the typical laccolites of the Henry Mountains both surfaces are conformable to the strata.[1]

Relations of the E.–W. Dykes to the Laccolites.

Two long E.–W. dykes terminate in the Croy mass. The more southerly of these begins about 3 miles south of Linlithgow, and on Sheet 31 of the Geological Survey is mapped as cutting through the great sill at Torphichen. After passing through the village of Cumbernauld it is represented as cutting through the sinuous intrusion south of the Croy mass, and before terminating in the laccolite throws off another small protrusion to the south. Its total length is 17 miles. The northerly dyke, passing through the village of Dullatur, continues in a more or less parallel course to that of the Cumbernauld dyke, at a distance of 1 to 1½ miles. It is also represented as cutting through the Torphichen sill, and also through the Kilsyth–Croy laccolite. Its total length is 20 miles. The third dyke is only 2 miles long. It is represented on the Survey map as cutting through the extreme south-western prolongation of the Croy mass.

There can be little doubt but that these dykes stand in the relation of feeders to the intrusions. In the Nethercroy section before cited, a thick vertical dyke (100 feet) rises through the strata, and joins the base of the laccolite in such a way as to leave no doubt that it is the duct through which the igneous material was supplied. This dyke is almost certainly continuous with the Cumbernauld.

[1] Gilbert, *Geology of Henry Mountains*, 1877, p. 19.

A section kindly supplied by the Baird Co. of their workings at Croy and Kilsyth also shows a 100 feet dyke rising through undisturbed strata and joining the base of the laccolite under the town of Kilsyth. On the Geological Survey map the Dullatur dyke is represented as cutting the Croy mass in the neighbourhood of Dullatur. Inside the boundary its trend alters from due E.–W. to E.S.E.–W.N.W. I have been unable to trace in the field the evidence upon which this change of trend was based; possibly it was based upon underground evidence available at the time of the original survey. It is significant, however, that if this change of trend be accepted, and if the dyke be continued in the new direction, it would appear in the position of the 100 feet dyke encountered in the Baird workings. It is highly probable, therefore, that the latter and the Dullatur are one and the same dyke.

The evidence, then, seems to point to the conclusion that the material of the Kilsyth–Croy laccolite was supplied through the ducts represented at the surface by the Dullatur and Cumbernauld dykes, and underground by the thick dykes found in the Baird and Carron workings respectively. This conclusion is supported by the following facts:—

1. The dykes terminate in the laccolite, and appear beneath it in the position of ducts.

2. The thickest part of the laccolite occurs between the two dykes, but nearer to the Cumbernauld dyke, suggesting that the latter supplied most of the material.

3. The laccolite seems to thin away more rapidly to the north and south of the point of maximum thickness, i.e. in directions at right angles to the direction of the dykes, than in the opposite direction, as might be expected if the dykes are the feeders of the laccolite.

Moreover, if lines are drawn connecting points of the same thickness on the laccolite, these are seen to be ellipses of which the major axes are parallel to the E.–W. dykes, although the S.W.–N.E. direction of extension of the laccolite itself is conditioned by the anticline of the Riggin.

4. There is complete petrographical identity between the laccolite and the dykes.

Age of the Intrusions.

The Kilsyth–Croy laccolite appears to have partaken of the flexures of the strata into which it is intruded, and is broken by both E.–W. and N.W.–S.E. faults. There is no conclusive evidence in this district as to the relation of the dykes to the faulting. Four miles to the east of Dullatur the Dullatur dyke is mapped as uprising along a small E.–W. fault. Still further to the east, at Cardrum Moss, there is a slight break in the continuity of the dyke, which may possibly be due to faulting.

In the Denny district the thin sills encountered in Messrs. A. & G. Moore's Castlerankine workings seem to cut through minor faults without dislocation.

The relations of the similar masses of intrusive rocks in the Midland Valley of Scotland outside our immediate district to the main faulting are very much the same. Sir A. Geikie[1] believes that the large intrusive masses of Linlithgowshire are processes from the long dykes. Thus the dyke running eastward from Cadder and Bishopbriggs in the neighbourhood of Glasgow has no fewer than four large appendages, which are in turn cut by younger E.–W. dykes. He also remarks the petrographic identity of the rocks of the dykes and laccolites. He connects these intrusions with the puy eruptions of the Carboniferous Limestone period. "The remarkable group of sills between Kilsyth and Stirling may quite possibly be connected with a group of vents lying not far to the eastward, but now buried under the higher parts of the Carboniferous Limestone, Millstone Grit, and Coal-measures."[2]

The revision of the Bathgate district by the Geological Survey has shown that in some cases the dykes cut the sills, but that in one case at least, at the Knock in the Bathgate Hills, a N.–S. intrusion, continuous with a faulted sill, cuts through one of the E.–W. dykes.[3]

The Survey are also inclined to believe that the dykes cut the sills in the Kilsyth district and that they are later than the faulting.[4]

To summarize, the relations of the laccolites and dykes to each other, and of both to the faulting, appear to be contradictory in different parts of the Midland Valley. The difficulty is probably due to an assumption of strict contemporaneity for the various intrusions, and also for the faulting; whereas it is more probable that both intrusions and faulting, whilst belonging to the same general epoch, were a series of events extending over a long period of time. The earlier intrusions would then be shifted by the later faulting, and the later intrusions would cut through the earlier faults without dislocation.[5]

If the intrusions are in general contemporaneous with the faulting, they belong to that great period of earth-buckling which took place at the end of the Carboniferous and the beginning of the Permian period. The great E.–W. dykes cut through all the strata of the Midland Valley up to the drift, and are therefore post-Carboniferous. None of the E.–W. dykes, however, are found cutting the Permian Red Sandstones of Ayrshire. In all probability these intrusions were a phase of the formation of the great sunken block of strata—the great Rift Valley—which forms the Midland Valley of Scotland. It is a striking fact that the peculiar hybrid petrographic type, granophyric diabase, which forms these intrusions, very frequently occurs in these long massive dykes and their accompanying protrusions in connection with block faulting.

A mass of evidence has now accumulated in support of the late Palæozoic age of these intrusions. Whilst Sir A. Geikie connects the great group of sills from Milngavie by Kilsyth to Stirling with the Carboniferous Limestone puys, he classes the Linlithgowshire group, connected with the more southerly E.–W. dykes, as Tertiary.[6] As before stated, the feeders of the Kilsyth–Croy laccolite appear to cut

[1] *Ancient Volcanoes of Great Britain*, 1897, vol. ii, p. 157.
[2] *Ancient Volcanoes*, vol. i, p. 447.
[3] *Summ. Prog. Geol. Surv.*, 1904, p. 118.
[4] Ibid., 1905, p. 124.
[5] See *Ancient Volcanoes*, vol. ii, p. 158.
[6] *Ancient Volcanoes*, vol. ii, p. 10.

the Linlithgowshire intrusions, and are therefore of later date. If the northern group is of late Palæozoic age, so then are the Linlithgowshire intrusions. Professor Judd is of the opinion that some of the great E.–W. dykes are of Carboniferous age, but some, like those of Eskdalemuir and Cleveland, are undoubtedly Tertiary.[1] The latter may be distinguished petrographically from the Palæozoic dykes. They contain no micropegmatite, have a more basaltic structure, a more acid chemical composition, and are frequently porphyritic. Dr. Teall has remarked the difference between the two sets of dykes in the north of England occurrences.[2] The Tertiary dykes (Cleveland and Acklington) have a SiO_2 percentage of 57–9 and a sp. gr. 2·7–2·8. The earlier dykes (Hett and High Green) have a SiO_2 percentage of 50–3 and a sp. gr. of 2·96. The latter, therefore, correspond exactly with such of the dykes and connected sills of Central Scotland as have been analysed.[3] Recent survey work in Scotland has added much further evidence in favour of the pre-Tertiary age of the great E.–W. dykes of Central Scotland.[4]

IV. Petrology.

The rocks to which the following description applies are those of the Kilsyth–Croy, Stirling, and Milngavie laccolites, and the great E.–W. dykes of Bishopbriggs, Dullatur, Cumbernauld, Blanefield, Whistlefield, and Rowardennan. They are all diabases containing plagioclase, augite, and iron-ores, with a ground-mass of micropegmatite.

Megascopic Characters.

The main mass of these intrusions is composed of a grey, medium-grained, phanero-crystalline rock, hereinafter referred to as the 'normal' type. The grey colour is due to the blending of white and black minerals, the former felspars and micropegmatite and the latter augite and iron-ores. The micropegmatite is not recognizable as such in the normal rock, but in a coarser variety, which occurs sporadically towards the centre of the mass, it appears as large pink areas, and the augite tends to take on a long blady form. This rock consequently closely resembles some syenites and diorites, and frequently figures as such in dealers' catalogues. The marginal facies is a dense, black, basaltic rock, breaking with a conchoidal fracture, and sometimes porphyritic with felspar. Throughout the rock, but much more frequently towards the centre of the masses, there are to be found ramifying, anastomosing veins and strings, up to 2 inches in diameter, of a light-coloured acid material, the so-called segregation veins.

As a larger structural feature, the rock frequently occurs in a rude columnar form, to be seen in the larger quarries and in the natural escarpments. It weathers into large cuboidal blocks with rounded edges and corners. In an extreme phase of weathering it breaks down to a brown or red earth containing exfoliating spheroids of less decomposed rock.

[1] Q.J.G.S., 1889, p. 209.
[2] Q.J.G.S., 1884, vol. xl, pp. 209–47, and *Brit. Petrog.*, 1888, p. 206.
[3] See petrographical part of paper.
[4] See Memoir on Cowal district, 1897, p. 147, and *Summ. Prog. Geol. Surv.*, 1904–6, op. cit.

The sp. gr. of the normal variety varies from 2·90 to 2·93, whilst a coarse rock with large areas of pink micropegmatite from the Dumback Quarry at Croy has a sp. gr. of 2·82.

Microscopical Characters.

In thin section the normal rock is found to consist of a framework of interlocking crystals of plagioclase, augite, and iron-ores, with micropegmatite occupying the interspaces and generally playing the part of ground-mass. Hypersthene occurs sporadically with the augite. Among the secondary minerals are hornblende, chlorite, biotite, serpentine, calcite, and a green pleochroic bastite.

The felspars give long columnar sections, with the edges in the prism zone well defined, but terminations rarely recognizable. Squarish untwinned sections, parallel to 010, are rather abundant; Carlsbad and albite twinning is common, but the pericline is distinctly rare. The maximum extinction angle in albite-twinned sections giving symmetrical extinction is about 28°, which corresponds to a composition $Ab_2\ An_3$, and indicates a labradorite of medium basicity. Chemical zoning is very prominent. Whilst the interior of a crystal may give the maximum extinction angle, the border may give straight extinction, thus indicating a variation in composition from labradorite to oligoclase. This zoning is most pronounced in the square untwinned sections parallel to 010. This is due to the greater range of the extinction angles for the different varieties of felspar in sections parallel to 010 than for sections in other directions.[1] In some specimens from the Milngavie intrusions the felspars are zoned by inclusions.

The alteration of these felspars is a simple kaolinization in the more acid peripheries, but granules of calcite occur in the more basic kernels. Flecks of viriditic material are often to be found inside the felspar, indicating some degree of migration of the more mobile alteration products from the ferromagnesian minerals.

The *augite* is pale-brown, yellow, or almost colourless in the Kilsyth–Croy rocks, but in the Milngavie specimens there is often a faintly pleochroic purple tinge along the borders. A narrow twin lamellation confined to the centre of the crystal is prominent. In some of the coarser gabbroid varieties a basal striation occurs in a sahlite-like augite. In these rocks, also, the augite tends to occur in a long blady form elongated along the '$\mathfrak{c}$' axis.

In some sections it appears to take on to some extent the pleochroism and polarization colours of hypersthene, but not the straight extinction. The chemical analysis (*infra*) shows that the hypersthene molecule must be present to a large extent. This corresponds with the observations of Teall[2] and Elsden[3] on the augites of similar rocks from Northumberland and Pembrokeshire respectively.

The alteration of the augite is a process of considerable interest. The most common type is a peripheral change to brown hornblende.

[1] See Iddings, *Rock Minerals*, 1906, p. 229.
[2] Q.J.G.S., 1884, vol. xl, p. 648.
[3] Q.J.G.S., 1908, vol. lxiv, p. 286.

There is no sharply defined boundary with the augite, and irregular flecks of hornblende occur within the unaltered augite. In this change iron has been thrown out of combination, and reappears as secondary magnetite associated with the hornblende.

Green chloritic or 'viriditic' minerals are the product of another type of alteration. These are generally fibrous, with the fibres arranged in curved bundles or sheaves. They are highly pleochroic, the extremes of colour being straw-yellow and grass-green, or in a highly ferriferous variety from reddish brown to a dark green. This material certainly includes several varieties of chlorite, and is frequently intergrown with highly pleochroic brown biotite.

The basal striation occurring in the augites of the coarser rocks affords a starting-point for a distinct type of alteration. This occurs especially in the interior of a crystal, and consists of an accumulation of dusky granules of calcite arranged along the planes of the basal striation.

The final stage of both the hornblendic and chloritic types of alteration is the production of a pale-green serpentine uniformly sprinkled with specks of separated magnetite. The serpentine is slightly pleochroic, and is sometimes laminated. It is then frequently intergrown with brown hornblende. The bright polarization colours of augite are still retained in isolated areas, but the rest of the crystal possesses the aggregate polarization of serpentine. This type of alteration is well seen in the coarse rocks from Dumback, Fankerton, and Milngavie. In the latter rock the augite appears to pass directly into serpentine without intermediate stages. The serpentine makes its appearance along the cleavage and other cracks, leaving isolated areas of unaltered augite. Amphibolization is very rare in the Milngavie specimens.

In his study of similar rocks from the Bathgate Hills, Dr. Falconer [1] has arrived at the conclusion that amphibolization or chloritization of the augite occurs according as the alteration starts from the exterior or the interior of a crystal. There is nothing in the rocks under consideration to support this view. Both types of alteration appear to start indifferently from the exterior or interior of the crystal.

There is evidence for some local selective attack by weathering agents in the fact that alteration rarely occurs to the same extent in both felspar and augite. Where one is much altered the other is nearly or quite fresh, and vice versa. Thus, in a specimen from Barrwood Quarry, Kilsyth, the felspars are completely kaolinized, whereas, save for a slight peripheral amphibolization, the augite is quite fresh [2]; but in a rock from Nethercroy, about half a mile distant from the above locality, the felspars are quite fresh, whereas the augite is completely altered to a fibrous brown hornblende or to a greenish-brown serpentine.

An *orthorhombic* pyroxene occurs with the augite in some specimens, but is very sporadic in its occurrence. It occurs in prismatic, much cross-fractured, faintly tinted crystals, which in suitable sections

[1] Falconer, T.R.S.E., vol. xlv, pt. i, p. 141.
[2] Cf. Teall on the Corstorphine rock, *Brit. Petrog.*, 1888, p. 190.

show a distinct pleochroism from pale coppery red to a pale green. The crystals are rendered prominent by a marginal alteration to a deep-green, pleochroic, fibrous mineral, which probably bears the same relation to hypersthene as bastite does to enstatite.[1] The cracks also are broadly outlined by the same substance.

The abundant *iron-ore* offers some interesting features. It rarely occurs in other than skeleton crystals. Frequently it is in large, flat plates coating the faces of augite crystals. In one of the coarser varieties from Dumbuck Quarry, Croy, the thin cross-sections of plates are dispersed all over the slide, and all conform to one of three directions, at an angular distance of 120° from one another. The appearance is of a large, discontinuous, triangular framework of plates of iron-ore in which the other constituents have crystallized. The form of this framework shows that this mineral belongs to the ilmenite group. That it is titaniferous is put beyond doubt by the occurrence in some of the more altered rocks of grey leucoxenic decomposition products, and even yellow sphene.

Beside the regular skeletal form above described, there are other curious forms. One is radial like the spokes of a wheel, each spoke being knobbed at the extremity. There are also long saw-like serrated rods. Other types take the form of irregular, closely packed rods, the shape of the whole aggregate approaching to an idiomorphic form.

In addition to the constituents above described, a mesostasis always occurs in the interspaces. In the coarser and fresher rocks this material may be certainly identified as *micropegmatite*. It forms a regular intergrowth of rods of quartz and felspar, and where contiguous to a felspar crystal the felspar of the micropegmatite is continuous with it; and the wave of extinction occasioned by the chemical zoning of the felspar crystal starts in the micropegmatite. In a coarse rock from Fankerton, near Denny, minute triangular grains of quartz in regular rows are embedded in a ground-mass of decomposed felspar. The micropegmatite also occurs as parallel rods of quartz and felspar arranged perpendicular to the edges of felspar crystals. In a rock from a quarry near Dullatur the quartz and felspar rods are arranged radially and give an extinction-brush.

The micropegmatite is nearly always riddled with long needles of apatite. It also contains flecks of 'viriditic' minerals, and is frequently miarolitic. It has undoubtedly formed the channels whereby weathering agents have percolated through the rock, as evidenced by its own frequent decomposition and by the greater alteration of the minerals contiguous to it.[2] As the rock becomes finer in grain, the micropegmatite decreases in quantity and ceases to be identifiable as such. It appears as a greyish or reddish cryptocrystalline substance, riddled with apatite needles, filling up the interspaces between the other constituents.[3] In the basaltic contact-rocks micropegmatite disappears and olivine very rarely occurs.

[1] Teall, *Brit. Petrog.*, 1888, p. 192.
[2] Cf. Holland, Q.J.G.S., 1897, vol. liii, p. 411.
[3] Cf. Teall, Q.J.G.S., 1884, vol. xl, p. 644.

1 2 3 4 5 6

Photo. S. Fingland.

Thin Sections of Granophyric Diabase from the Kilsyth-Croy District, Dumbartonshire.

The latter mineral is never found in this particular type of rock save at the extreme margin.

Irregular grains of *quartz* occur abundantly in the micropegmatite, even where it is freshest. This fact may be regarded as a presumption of primary origin. Considering how prone the micropegmatite is to decomposition, where it has formed the channels for the percolation of weathering agents and for the solutions depositing secondary substances, one would expect that the quartz, if secondary, would appear only where the micropegmatite is decomposed. The presumption of primary origin is strengthened by the occurrence in the quartz of projections and isolated fragments of micropegmatite, apatite, and granules of augite. This is specially well seen in the coarse pink rocks from Dumback and Fankerton quarries.

EXPLANATION OF PLATE XII.

Fig. 1. Granophyric Diabase, normal variety, Colzium Quarry. Ord. light; × 20. The upper half of the field shows a large turbid area of micropegmatite enclosing idiomorphic crystals of plagioclase and augite. The lower half shows a large plate of augite ophitically enclosing felspars. The clear space at the top left-hand is a want in the slide. The black areas are skeletal ilmenite. This slide represents the type that makes up the great mass of the sills and dykes.

Fig. 2. Granophyric Diabase, coarse var., Croy. Ord. light; × 7. Mostly plagioclase, micropegmatite, and ilmenite. Augite altered to serpentinous products. This slide shows the regular arrangement of the plates of ilmenite.

Fig. 3. Granophyric Diabase, coarse var., Dullatur. Ord. light; × 10. This slide also shows idiomorphic plagioclase and skeletal ilmenite embedded in a turbid micropegmatite ground-mass. The augite is altered to serpentinous products which do not appear very well in the photograph. The parallel arrangement of the ilmenite is well shown here also.

Fig. 4. Granophyric Diabase, Fankerton Quarry, near Denny. Ord. light; × 20. Felspar and augite in a turbid ground-mass of micropegmatite, which in places (left-centre of field) passes into clear areas of quartz. In the centre of the field the micropegmatite is composed of minute rods arranged perpendicularly to the idiomorphic felspar.

Fig. 5. Granophyric Diabase, Muchraw, Linlithgowshire. Ord. light; × 10. Clear felspar laths, curved blady augite crystals with 'herring-bone' structure accentuated by alteration, skeletal ilmenite and faintly turbid areas of micropegmatite (top of slide).

Fig. 6. Granophyric Diabase, Fankerton Quarry, Denny. Ord. light; × 20. Augite, turbid felspar, and still more turbid micropegmatite passing at the bottom of the photograph into a large area of quartz. All constituents enclose a great number of needles of apatite. The quartz encloses these and also isolated areas of micropegmatite, and is undoubtedly original.

I am indebted for these photographs to Mr. Samuel Fingland, the University photographer, Glasgow University.

(To be concluded in our next.)

III.—On a New Specimen of the Jurassic Ganoid Fish, *Pleuropholis lævissima*, Egerton.

By Miss Mary S. Johnston.

(PLATE XIII.)

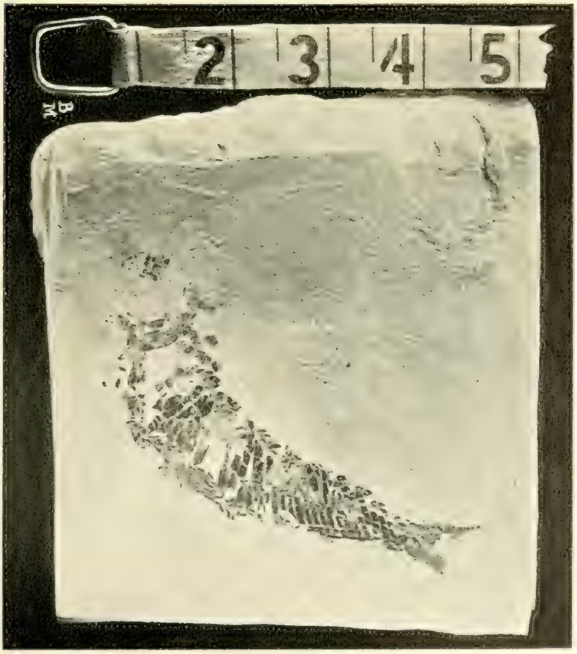
Having in a collection of fossils from the Lithographic Stone of Bavaria a Ganoid fish, I consulted Dr. Smith Woodward, and through his kind assistance have proved it to belong to the rare species *Pleuropholis lævissima*. The species has hitherto been imperfectly known, the only figure being by Egerton of a comparatively small fish, about the specific determination of which there seems to be some doubt. I therefore think the new specimen worthy of description, and it is shown of half the natural size in the accompanying figure. Nearly the whole of the fish is preserved in the fossil, but the head is shown only in impression. Most of the scales are removed from the near side, and the fins are fragmentary (see Plate XIII).

The length of the head, with opercular apparatus, is approximately equal to the maximum depth of the trunk, and contained six times in the total length of the fish. As shown in impression, the frontal region of the skull tapers rapidly to a point in front, where the mesethmoid forms a small expansion, which is as broad as long. The orbit is relatively large, and below it are traces of the bones of the jaws. Among these may be distinguished a part of the arched maxillary and impressions of some displaced fragments, bearing an ornament of fine ridges. The preoperculum widens rapidly downwards to the angle, where the small expansion is shown to be smooth, and below it are remains of broad branchiostegal rays, which are also smooth. The operculum and suboperculum are shown only in impression, but their outline is apparently complete. The operculum is slightly narrower above than below, where its maximum width exceeds two-thirds its depth. The suboperculum is about half as deep as broad, with the posterior inferior angle rounded.

The vertebral column is shown throughout the length of the fish at places where the scales are removed. Centra are seen, but they must have been only feebly ossified, perhaps in the form of rings, as they are very much flattened. Fragments of the ribs are conspicuous on the inner side of the scales, indicating that they also were feebly ossified, but were long and extended nearly to the ventral border. The column ends at the beginning of the caudal fin, where it is slightly upturned, with expanded hæmal spines below its extremity.

The form and proportions of the clavicular bones are not clearly seen, but their external surface is shown to be ornamented with fine vertical ridges. The rays of the paired fins are stout and flattened, with a relatively long, unjointed base and very finely divided distal end. In the remains of the pectoral fin the bases of the ten or twelve rays are widely spread. The pelvic fins, which are inserted just behind the anterior third of the trunk, are much smaller than the pectorals and consist of seven or eight rays, of which the finely divided distal ends are well preserved. The dorsal and anal fins are represented by the merest traces, but the caudal fin is sufficiently well preserved to show that it was forked and symmetrical. A few very slender fulcra are seen on the lower border of the caudal fin.

The scales, which completely cover the trunk, are thick and have a highly polished smooth enamelled surface. Nearly all those on the upper side of the fish have been lost, so that the less polished inner surface of the under scales is mostly seen. The principal scales are very finely serrated on their hinder margin. Their inner face is strengthened by a vertical, wide, flattened rib, which ends in a pointed peg above, and is hollowed at the lower end by a triangular socket for the peg of the next scale below. The excessively deepened flank-scales rapidly decrease in depth in the hinder half of the tail, where



Pleuropholis lævissima, Egerton. Lithographic Stone : Kelheim, Bavaria. (Scale in inches.)

all the scales are diamond-shaped and do not vary much in size. Above the deepened scales in the anterior half of the fish there appear to have been only two series of smaller scales, which are nearly square, being scarcely wider than deep, but on the ventral border there are at least four or five series of still smaller scales which are much wider than deep, united by a very large peg and socket and sometimes deeply crimped rather than serrated at the hinder border.

The principal lateral line clearly turns down one of the foremost deepened flank-scales, and is seen at many points throughout the length of the fish traversing the uppermost row of the small ventral scales. The presence of another slime canal in the normal position of the lateral line is indicated by a foramen on each alternate scale in the deepened flank-series.

The new fish now described is slightly larger than the type-specimen in the Munich Museum, and differs in the delicate serration of its scales. The latter character, however, is so difficult to observe that it may have been overlooked in the type; and the general agreement between the two specimens is so close that there cannot remain any doubt as to their specific identity.

EXPLANATION OF PLATE XIII.

Pleuropholis lævissima, Egerton: photograph of nearly complete fish, one-half nat. size. Lithographic Stone (Lower Kimmeridgian): Kelheim, Bavaria.

IV.—Wells of the North-Eastern Sudan.

By G. W. Grabham, M.A., F.G.S., Geologist to the Sudan Government.

(*Concluded from the June Number, p.* 271.)

THE necessity of providing a water supply for the town and harbour of Port Sudan has led to an investigation of the district, and some interesting water analyses, relating both to the Valley Fill and to the Maritime Plain, have been made. Through the kindness of Capt. Kennedy, R.E., Director of Public Works, and of Dr. Balfour, Director of the Wellcome Research Laboratories, I am able to quote some of them. The analyses are given on p. 318 and have been made, as indicated, either at the Chemical Research Laboratory, Khartoum, in charge of Dr. Beam (W.R.L., Khartoum), or by Mr. Lucas, Superintendent of the Egyptian Survey Department Laboratory, Cairo (S.D.L., Cairo). A rough map of the district (Fig. 2) shows the positions of the localities from which the samples were obtained.

The first six analyses relate to Khor Arbat: I, II, and III are from samples taken 21, 9, and 6½ miles respectively up-stream of the place where the valley debouches on to the Maritime Plain, and where the fourth sample was obtained. A steady increase is shown in the content of salts as the water passes down the valley. The first analysis is of a solitary sample, and waters containing as little or even less solids in solution have been obtained near the locality to which II relates. The other analyses are in each case selected from a large number, and may be regarded as typical.

The fifth analysis represents the composition of some flood-water that passed out of the valley. The figures are not as high as those relating to the normal flow, but they show that even in its rapid passage a flood can pick up a considerable quantity of salts. During the flood the flow in the Valley Fill is in a direction away from the stream-bed, so that it does not appear possible that the salts could be derived through admixture with the normal underflow. Their presence can, however, be explained by the solution of the accumulation of salts formed on the surface of the ground through the evaporation

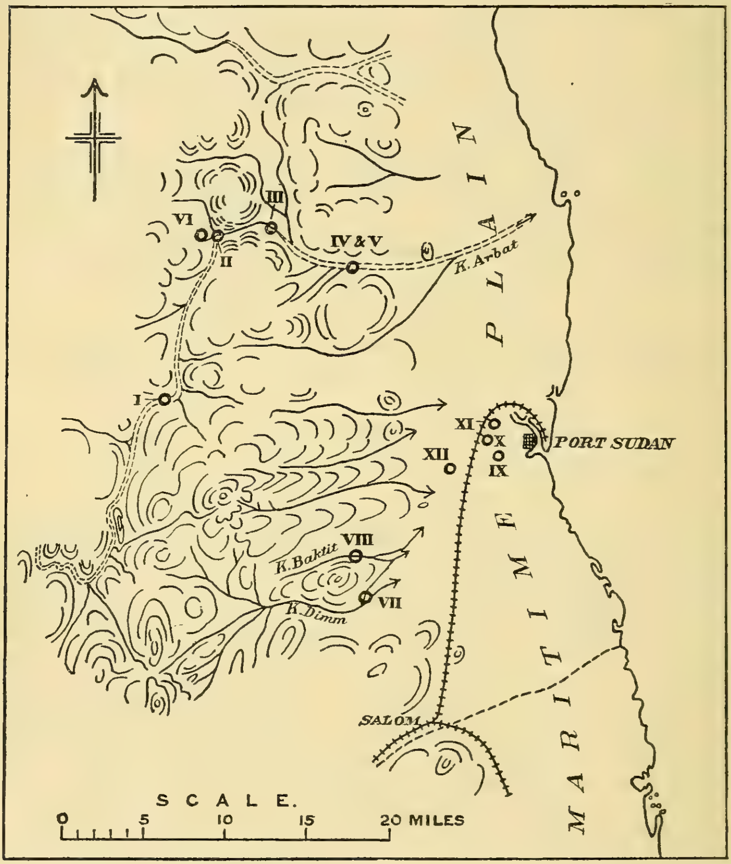


Fig. 2. Map of the vicinity of Port Sudan, showing the position of the localities to which the water analyses (on p. 318) relate.

of water raised by capillary action. This would also account for the resemblance that the proportions of the different constituents bear to one another in flood and normal flow. If such is the case, the quantities of salts should vary in a succession of floods, the later ones containing much less than the first, but figures are not available to test this.

Analysis VI shows the composition of a sample taken from a well at a distance of about 400 yards from the stream-bed, a little way above the place where sample II was taken. The well-water contains rather more solids in solution, and is, as a rule, rather harder than the water from the stream-bed. The analysis of samples from this valley has extended over a period of about a year, and it has been found that the composition of the water is little subject to variation. Isolated samples, it is true, have given markedly different results, but these may be due to a variety of causes and do not affect the conclusion.

VII and VIII are analyses of water from wells in smaller valleys to the south-west of Port Sudan. They contain very much larger quantities of salts than those from Khor Arbat, and, as the drainage areas are composed of similar rocks, it appears that the difference in composition must in some way be due to their relative sizes. The smaller areas receive less rainfall and are more affected by evaporation.

The next three analyses are from wells on the seaward margin of the Maritime Plain, in the vicinity of Port Sudan and within about 2 miles of the sea. Though analyses IX and X show large quantities of salts, they do not represent such saline waters as those of the small rock valleys, while the composition of the sample from Bencini's well is quite comparable with the Khor Arbat analyses. Gypsum deposits do occur associated with those of the Maritime Plain, and, though none are known in the vicinity of these wells, perhaps the high content of sulphates may be accounted for in this way. The 'Far Well', to which the last analysis relates, is situated about 5 miles from the sea, and is intermediate in position between the rock valleys and the shore. It consists of two shafts with a gallery between them, and a constant quantity of water is pumped as a temporary supply for Port Sudan. The figures show rather a high content of chlorides as compared with the sulphates.

The analyses show that the underflow of the Maritime Plain is derived from sources widely different in quality. The underflow from the Valley Fill contains large quantities of salts, but it must be considerably diluted by the purer flood-water and local rainfall. It is therefore not surprising to find some of the wells near the sea yielding a less saline water than those of some of the rock valleys. A boring, made at a point about 1¼ miles south-west of the 'Far Well', traversed the deposits of the plain to a depth of 1100 feet. Both here and in the shallower boring at the 'Near Wells' it was found as a general rule that better water was obtained in the coarse-grained deposits than in the finer muds and sands. The quality also varies with the depth, and the best water is found at the surface of the zone of saturation. In the deep boring some improvement was found towards the limit of depth attained, but the quality of the water was not satisfactory, and the attempt to obtain a supply in this way was abandoned.

The deposits of the Maritime Plain are mainly submerged below sea-level, and the laws governing the flow of water in them offer an interesting problem, but at present the data are insufficient to enable us to discuss it. The greatest flow appears to occur on the surface of the zone of saturation where the best waters are found, but it does not seem possible to say how far the water beneath is to be regarded as stagnant. The rate of flow also depends on the nature of the deposits, and, as these differ, the movement near the surface is not everywhere the same. The striking differences in composition shown by analyses IX, X, and XI, all relating to wells within about 2 miles of the sea, may be accounted for partly by the extents to which the different wells are used, and partly by the nature of the deposits from which the water is derived, whether fine or coarse grained. I have not visited these wells, but I understand that both those of Bencini and Simon Lingo are in 'conglomerate', and that the 'Far Well' is in similar material. The general opinion is that the best water is derived from this 'conglomerate' as opposed to the finer-grained beds. The concentration of salts in finer-grained deposits appears to be a phenomenon of fairly common occurrence, and some of the principles developed by Mr. E. C. Sullivan[1] in connection with the deposition of ore may account for it, but my knowledge of his work is at present only derived from a review kindly shown me by my colleague Mr. Dunn. It is pointed out that if a solution is filtered through a soil the first part of the filtrate is less saline than the original solution, a proportion of the salt remaining behind in the filtering medium. The effect increases with the fineness of grain of the filtering medium, and appears to be due to the different rates of diffusion of the constituents of the solution. This principle would account for the existence of more saline waters in the finer-grained parts of a deposit, and suggests the possibility of these being obtained when the normal underflow is disturbed by a well.

The existence of wells such as Bencini's, yielding a comparatively good water, has led to attempts at obtaining larger supplies by means of pumping. This implies deeper wells, greater lowering of the water-table, and, in consequence, a more saline water is yielded. The analysis of a sample taken from this well in April, 1908, showed only 318 parts per million of solids in solution (W.R.L., Khartoum), while in samples taken since that to which analysis XI relates, and collected after periods of bailing, the quantity was found to have increased to 1110 parts. A sample from Simon Lingo's well, taken in September, 1908, showed 1440 parts of solids per million (W.R.L., Khartoum), but, as a result of deepening and increased pumping, the water became more saline, and was found to contain, as shown in the accompanying table, no less than 2573 parts of solids, and this only a month after the former sample was taken. The 'Far Well' is said to have yielded a better water at first, but, as a result of continual pumping, the water has become more saline, and now appears to maintain approximately the composition shown in the analysis.

Capt. H. H. Kelly, R.E., to whom I am indebted for much of the information about the wells in the neighbourhood of Port Sudan, considers that, in some cases at least, the wells are of considerable antiquity. They have evidently been made by people with a knowledge of construction that the present natives, the Hadendoas, do not possess, and his discovery of a Roman coin in one of the khors where these wells are situated in a measure confirms his conclusion.

Before leaving this area, where the detrital deposits of the Valley

[1] U.S.G.S. Bull. No. 312, 1907.

Fill and Coastal Plain play such an important part in the water-supply conditions, reference must be made to the arid regions of North America, which supply examples of similar conditions. These have been described by Mr. F. H. Newell,[1] and the underground waters of the Salt River Valley have since been fully dealt with by Mr. Willis Lee.[2] The Salt River Valley is partly filled with alluvial deposits carrying a large amount of underflow. The valley is much wider than any among the Red Sea Hills, and, as the surface stream-bed has wandered over it in times of flood, filling up the valley, it has left its trace among the finer deposits in the form of boulder-beds and gravels. These boulder-beds have been found to yield the best supplies of water. This, too, is fairly rich in salts, and the town supplies of Phœnix and Tempe both contain over 1000 parts per million of solids in solution, while some with over 3000 parts is successfully used for irrigation. In the light of this we may look forward to a day when the underflow of the Maritime Plain will be utilized in the same way, and more data will be available for the discussion of the problems connected with it. At present there are gardens at Shata, near Suakin, and small cultivated plots near Port Sudan that show the possibility of using the water in this way.

Wells in the Nubian Sandstone Series.

In sandstone regions the wells are no longer dependent on local condition for their water supply. Most of it is probably seepage from the river, and perhaps some comes from distant areas of greater rainfall, but, provided the sandstone is deep enough to contain the water-table, there is no difficulty in obtaining a supply by means of wells. The importance of this series has long been recognized as affording supplies of water, and in Egypt these are tapped in several oases, where the water rises under hydrostatic pressure from beneath the overlying beds. In the part of the Sudan under consideration the sandstone is found near the Nile and extends from a little way south of Khartoum to Wadi Halfa, where it passes beyond the area. In Egypt the Nubian Sandstone Series is overlain by younger beds, and, though these have been found to occur much further south than it was formerly supposed,[3] they have not yet been discovered in the Sudan.

Towards the south, in many places where grazing is good, the natives have wells in the sandstone. These, frequently 200 feet and sometimes even 300 feet in depth, have been dug by them with the primitive tools at their disposal. The presence of Cotton Soil, though it may prevent the local rainfall reaching the water-table, naturally does not interfere with the well supplies.

The arid regions to the north afford no grazing, and the wells are far apart even on the caravan routes. These generally appear to be situated in hollows beneath the general level of the country, where the water-table is within a few feet of the surface, and have thus been readily found by the natives. Selima Oasis[4] is probably an example

[1] U.S.G.S., Twelfth Annual Report, 1891, p. 215.
[2] U.S.G.S., Water Supply and Irrigation Paper, 1905, No. 136.
[3] W. F. Hume, *Cairo Scientific Journal*, 1908, vol. ii, p. 321.
[4] See Mr. J. Currie's description [quoted], *Anglo-Egyptian Sudan*, Wymans, London, 1905, vol. i, p. 203.

of this, and, though Capt. Lyons[1] has suggested that its existence is related to folding, I do not see that this would affect the level of the water-table unless the clay beds in the series are more extensive than is supposed.

The construction of the railway from Halfa to Abu Hamed led to well digging in the Nubian Desert, and Mr. Dunn tells me that good supplies are obtained in the sandstone at a depth of about 100 feet at No. 4 and No. 6 stations. The famous Murrat wells, close by, have not yet been visited by geologists, but from other accounts they appear to draw their water from Valley Fill among crystalline rocks, and are perhaps just outside the sandstone area. If necessity arises, I have no doubt that successful wells could be made all over this arid sandstone area, both east and west of the Nile, and in many cases, like those already made on the railway, the water would be found at no great depth below the surface.

The composition of the waters may be illustrated by the following analyses which have been published by Mr. Lucas[2]:—

Analyses expressed in parts per Million.

	I.	II.	III.	IV.
Solids in solution .	1712·0	1136·0	668·0	292·0
Chlorine . . .	292·2	83·3	72·0	31·2
Sulphuric anhydride .	563·0	301·7	122·1	43·9
Lime . . .	166·0	230·0	124·0	74·0
Magnesia . .	103·2	61·6	65·2	21·7
Sodium carbonate (*a*)	*nil*	42·4	68·9	*nil*
Sodium bicarbonate (*b*)	302·4	193·2	344·4	210·0

(*a*) Alkalinity to phenolphthalein calculated as sodium carbonate.

(*b*) Alkalinity to methyl orange, less that due to sodium carbonate, calculated as sodium bicarbonate.

I. No. 6 Station. Contains also SiO_2 27·2, Fe_2O_3, and Al_2O_3 13·2.
II. Bir Adiela.
III. Selima Oasis, north well.
IV. Selima Oasis, west well.

From these figures it appears that the waters vary considerably in the amounts of salts they contain, but they all show a good deal of alkalinity. At Selima there are deposits of salt extensive enough to be worked by the natives. The presence of water so close to the surface must lead to a large accumulation of salts by the evaporation of moisture drawn up by capillary action. A marsh is said to exist now, and, no doubt, a small rise in the level of the water-table would convert this into a lake; sheets of water would also appear in other places where only shallow wells exist now. Evaporation would soon concentrate the salts, and it is quite possible that deposits may have been formed in this way. Travellers have reported many bitter wells in the vicinity, and it is not surprising that these waters, in most cases, contain larger quantities of salts than do the artesian ones of Kharga, in which the quantity ranges from 430 to 470 parts per million.[3]

Another point of interest is the presence of large quantities of nitrates in some of these waters. A sample from Nahud, analysed by Dr. Beam, was found to contain no less than 6·5 grams per litre

[1] Q.J.G.S., 1894, vol. l, p. 539.
[2] *Chemistry of the River Nile*, Cairo, 1908, pp. 72, 74.
[3] H. J. L. Beadnell, Geol. Mag., 1908, p. 105.

of nitre, or nearly an ounce to the gallon.[1] The reduction of these nitrates, for instance by iron pyrites, would account for the large amount of nitrogen gas found in the artesian waters of Kharga.

The origin of the water in the sandstone is too extensive a subject to be entered into here. The bulk of the water, at any rate within the area dealt with here, is probably supplied by seepage from the river. This takes place, for the most part, during the flood when the Nile is high and the rapidly flowing current is keeping the pores of the bed freely open. It does not appear that the Nubian Sandstone extends much further south than the limits shown in Rolland's map.[2] The small amount of rainfall occurs in violent storms of short duration, and provided the water forms rapidly flowing streams, the proportion soaking into the ground must be very large. Often it remains in pools, or is retained by the surface soil so that it evaporates away without adding to the underground water.

Concluding Remarks.

There are some special cases of well supplies that do not fall among the classes already described, but call for some notice.

For some time after the rains, water can be obtained from shallow holes made in the sandy beds of khors, but later it either evaporates or percolates away, and seldom lasts until the following rainy season. The occurrence of water in this way presents a curious problem, for in some cases at least, if not in all, there is no impermeable substratum to hold it up; yet there it remains, while the permanent ground water-level may be a hundred feet below. This phenomenon is not limited to sandstone regions, but may occur on the surface of the Valley Fill. As an example the wells in Wadi Mugaddam may be cited. Here the natives find water close to the surface immediately after the rainy season. They deepen the wells as the water falls, but finally it disappears and they have recourse to deep wells in the sandstone. I saw another instance of a similar thing in a small valley half-way between Khartoum and Wadi Mugaddam. The water had been obtained from shallow holes in the stream-bed for some time after the rains, but when I was there a few months later there was no water in a well over a hundred feet deep in the sandstone close by.

Another special case of well supplies is found connected with Khor Gash. In summer this stream comes down in flood from the mountains of Eritrea and loses itself on the plains north of Kassala, and during the rest of the year good supplies of water are obtained in the stream-bed, but the permeable material is not extensive alongside. The case is really analogous to the Valley Fill, with impervious soil taking the place of crystalline rock. The ground around is either alluvial or Cotton Soil, and wells at a distance from the stream-bed have penetrated to a considerable depth without obtaining any water. I am told that the natives have a fairly shrewd idea of the limits within which water is to be found, and these, no doubt, depend on the extent the stream-bed has wandered before assuming its present course.

Large supplies of water are derived from wells in the alluvial deposits alongside the Nile, but these call for no special notice here.

[1] Wellcome Research Laboratories, Khartoum, Third Report, 1908, p. 397.

[2] Reproduced in E. Suess, *La Face de la Terre*, vol. i, p. 259.

ANALYSES EXPRESSED IN PARTS PER MILLION.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Solids in solution	820·0	952·0	968·0	1156·0	696·0	1096·0	3051·0	2992·0	2604·0	2573·0	1034·0	1506·0
Chlorine	211·3	246·5	270·8	343·7	166·7	298·6	1143·1	1247·7	767·3	999·6	179·7	528·8
Chlorine as sodium chloride	348·5	406·7	446·8	567·1	275·0	492·7	1885·7	2058·3	1266·1	1649·0	296·5	872·3
Sulphuric anhydride	93·7	115·3	122·2	144·1	68·8	131·3	375·8	217·5	559·3	420·8	180·6	175·8
Lime	127·3	150·4	132·1	166·8	—	172·2	47·4	245·3	243·8	241·1	173·2	133·8
Magnesia	21·1	42·4	44·3	50·7	—	51·7	42·5	151·3	99·1	96·0	36·2	48·0
Temporary hardness, parts per 100,000	17·0	—	18·0	16·4	24·4	22·8	—	—	15·5	—	—	—
Permanent hardness, parts per 100,000	14·3	—	14·4	23·9	—	18·1	—	—	48·3	—	—	—
Date of sample	—	Sept. 08	Sept. 08	Sept. 08	Aug. 08	Sept. 08	Oct. 08	Oct. 08	Mar. 08	Oct. 08	Aug. 08	Oct. 08

I. Water, 21 miles up-stream from mouth of rock valley, Khor Arbat. S.D.L., Cairo.
II. Stream, 9 miles up-stream from mouth of rock valley, Khor Arbat. S.D.L., Cairo.
III. Stream, 6½ miles up-stream from mouth of rock valley, Khor Arbat. S.D.L., Cairo.
IV. Well in Valley Fill, mouth of rock valley, Khor Arbat. S.D.L., Cairo.
V. Flood, sample taken at mouth of rock valley, Khor Arbat. S.D.L., Cairo.
VI. Well in Valley Fill about 400 yards from bed of stream a little above point where sample II was taken. S.D.L., Cairo.
VII. Arab well, Khor Dimm, 14 miles S.W. of Port Sudan. W.R.L., Khartoum.
VIII. Arab well, Khor Baktit, W.S.W. of Port Sudan. W.R.L., Khartoum.
IX. "Near Wells," about 2 miles S.W. of Port Sudan. S.D.L., Cairo.
X. Simon Lingo's well, about 2 miles W. of Port Sudan. W.R.L., Khartoum.
XI. Bencini's well, about 2 miles N.W. of Port Sudan. W.R.L., Khartoum.
XII. "Far Well," about 5 miles W.S.W. of Port Sudan. W.R.L., Khartoum.

REVIEWS.

I.—The San Francisco Earthquake.

The California Earthquake of April 18, 1906: Report of the State Earthquake Investigation Committee. By Andrew C. Lawson, in collaboration with G. K. Gilbert, H. F. Reid, and others. Carnegie Institution of Washington.

THREE days after the earthquake which destroyed so large a part of San Francisco in 1906, a committee was appointed by the Governor of California for the purpose of investigating the different phenomena, both transitory and permanent. The committee included Professor A. C. Lawson as chairman and several well-known men of science. Working in conjunction with them were also many other observers, who investigated various details and examined the whole of the ground traversed by the great fault, and photographed and measured the displacements of the surface-beds. By the end of the year the materials were nearly all collected, and the results of the discussion when completed will fill two quarto volumes and a folio of maps and plates. Of these the first volume and the atlas are already published. The former contains the record of the facts observed, the detailed account of the fault and of the movements along it which caused the earthquake, the description of the secondary phenomena and of the variations of intensity throughout the disturbed area. The second volume will be occupied by an investigation of the seismographic records of the earthquake obtained at observatories in all parts of the world. The theory of the seismograph will also be considered in some detail. In the atlas the course of the fault is clearly traced, the variations of intensity in the shock are depicted, especially within the city of San Francisco, and the seismograms from nearly seventy observatories are reproduced. In addition to the forty plates in the atlas there are more than three times that number in the first volume, chiefly reproductions of photographs. The report is published by the Carnegie Institution of Washington, and it is evident that no expense and no trouble on their part have been spared to make it the most complete account ever furnished of any scientific phenomenon. Nor have Professor Lawson and his colleagues failed in any way to take advantage of so unique an opportunity. Their work has been admirably done. The immense mass of detail is carefully collated. Whenever possible the editor has allowed the observers to speak for themselves in short notes and papers, which are so neatly inserted that in reading the text there seems to be no breach of continuity.

The advantages of this mode of collaboration are nowhere better illustrated than in the description of the remarkable fault which occupies so large a part of the first volume. The fault was traced by different observers for a distance of at least 190 miles, except for a few short interruptions in which its course is submarine, and there can be little doubt that it reappears after a somewhat longer break still farther to the north, so that the total length of the line is about 270 miles. On the whole, the path of the fault is a slightly curved line running in a general north-west and south-east direction, and, to the north of San Francisco, keeping close to the Californian coast. Its mere length is not, however, its most remarkable feature. Throughout its whole extent there was a sudden displacement of the crust, the ground on the south-west side to a great but unknown depth being shifted to the north-west, and that on the north-east side to the south-east. The amount of the horizontal displacement varies considerably. As a rule it lies between 8 and 15 feet, and in no place exceeds 21 feet. All structures which crossed the line of the fault were severed. Roads and paths were displaced, sometimes by as much as their own width or more, fences were snapped across and their ends separated, piers were broken and shifted, and water-mains ruptured and telescoped. These and other effects are fully illustrated by numerous photographs. In other earthquakes there have been more pronounced changes of elevation along the fault, but in no other known case have the horizontal movements been so persistent over so vast an area. In none, certainly, have the fault-movements been so carefully studied or the investigations of the geologist been aided so effectively by the researches of the biologist and the measurements of the surveyor.

Among the minor sections of the report one of the most useful is that which deals with the relations between the nature of the ground and the intensity of the shock. The distribution of the damage in San Francisco affords decisive evidence on this point. Though the area covered by the city lies only a few miles from the fault, the intensity of the shock was governed more by the nature of the underlying rock or soil than by proximity to the fault. In houses built on rocky ground, especially on the summits of hills, many chimneys remained unshattered; on thick deposits of sand or earth, brick walls were badly cracked and chimneys were generally destroyed; on 'made' land, and most of all on that which occupies the sites of recently filled creeks and marshes, ordinary buildings collapsed and even the best masonry was seriously injured. The lesson conveyed could not be more clearly enforced; yet it is one to which the rebuilders of San Francisco are not paying all the attention which it claims.

The only omission of any consequence in the book is the absence of comparisons drawn between the phenomena of this and other great earthquakes. If the San Francisco earthquake were the only shock known to mankind, the attention paid to it could hardly have been more exclusive. The examination of the points in which the Californian fault resembles, or differs from, those of other earthquakes might with advantage have been more detailed. The scantily observed sound is described, but no surprise is expressed at its general inaudibility. The valuable discussion on the distribution of damage in San Francisco would have received ampler illustration if it had been pointed out that similar relations between the amount of damage and the nature of the ground have been noticed in many other earthquakes. But comparisons such as these would have increased the size of volumes already large enough and have delayed their publication. They can be suggested by other writers, and there can be little doubt that in this report there are facts described and photographs reproduced that will form a veritable mine for workers in nearly every branch of seismology.

C. Davison.

II.—The Stone Ages in North Britain and Ireland. By the Rev. Frederick Smith; with an Introduction by Augustus H. Keane, LL.D. 8vo; pp. xxiv, 377, with 521 illustrations. London: Blackie and Son, 1909. Price 16*s.* net.

FORTIFIED with an introduction from Dr. A. H. Keane, late Vice-President of the Royal Anthropological Institute, the Rev. Frederick Smith has in the volume before us brought forward the results of observation and diligent collecting carried on during a period of nearly forty years. According to Dr. Keane, the author "opens a new and wider chapter in the history of early man by extending the inquiry to the whole of the British Isles and producing for the first time convincing evidence that both Scotland and Ireland were inhabited during the old Stone Age. His claim to have established this fact, against the inveterate prejudice and incredulity even of the most advanced British specialists, lies open before us and demands a hearing". With this latter appeal we are prepared cordially to agree. When, however, Dr. Keane draws attention to the fact that implements of Palæolithic type have been discovered in so many regions of the earth, from South Africa to Korea and South America, and asks what was to prevent primitive man from crossing the border and ranging over North Britain, we turn to the illustrations in this book and are surprised to find not a single characteristic type of Palæolithic implement among the figures that illustrate the Scottish and Irish specimens which Mr. Smith has gathered in situ. What may be regarded as the best example is an implement of flint or agate which was picked up in the bed of the Esk.

The specimens on which Mr. Smith relies are profusely illustrated, and they are undoubtedly of importance as representing a peculiar and persistent type. As the author remarks, Dr. Keane "agreed with me that Nature works miracles if the constant repetition in form and design which groups of the other specimens exhibit were the result of accident and not of human intention". The same remarks apply to Eolithic implements. Single specimens, or a few only, may fail to convince, but a study of the series accumulated by Dr. H. P. Blackmore, Mr. Benjamin Harrison, and others, would impress, if it did not convince, any candid inquirer.

The Scottish specimens collected and illustrated by Mr. Smith have been formed from a variety of rocks, such as basalts, granites, quartzite, dolomitic limestone, and ironstone. Many have been water-worn, others have suffered from weathering which has produced "a kind of mellowing of surface". The forms appear largely to be due to the character of the materials at command, to their texture, and natural jointing and fracture; and the author denies that "the relics of Palæolithic man in Scotland ought to be, and must be, replicas, in form and style of work, of the typical flints".

Many of the specimens which he has collected were found on the seashore or along the beds of rivers. More important are those found in situ in beds of valley gravel and in glacial drift. We cannot in all cases agree with his identification of Boulder-clay, as for instance on p. 90, where on Almond-side, Perth, the deposit is described as "largely sand and gravel highly rolled, with large erratics from one to several hundred-weights here and there in the mass". Evidence, however, is given of the occurrence of glaciated specimens at Crieff, and the discovery induced the author to read a paper on "Evidences of Palæolithic Man in Scotland" at the meeting of the British Association at Edinburgh in 1892, and, as he remarks, "the approach to that great Society was the reverse of encouraging." As a rule, the specimens brought forward by Mr. Smith exhibit no evidence of chipping or flaking, but rather give the idea that the stones are mostly natural in shape but modified by rubbing and polishing until they have assumed a serviceable form. Large examples are mentioned from 10 to 17 inches in length and occasionally weighing as much as 20 lb. A scale of size attached to each figure would have been useful. Among the 'Domestic Forms' are pebbles simply broken, with flat, smoothed surfaces, and other more roughly shaped stones with similar surfaces. These implements are grouped as Palæolithic 'flat-irons'. We have seen broken flint-pebbles with polished ends from the Cannon-shot gravels of Mousehold, Norwich, where a number were collected by Mr. J. T. Hotblack. They may have been utilized as rubbers or pounders. The author figures sundry forms of implements with handles which may have been serviceable as choppers or knives, and others that would appear to have been fashioned after the shape of bones or jaws, one example being referred to as likely to "have done as good service in the hands of Samson as the historic ass's jaw-bone". Some specimens are described as "chisel-like and broad-edged and bell-shaped polished axes" of Neolithic type, and yet of great antiquity, suggesting that there was no great void in time between the epochs of Palæolithic and Neolithic Man.

The author writes with enthusiasm, but at times with a confidence that is not justified, as for instance when he refers to glaciated flints from the Thames gravel at Datchet. In drawing attention to the many specimens he has gathered in Scotland and to the remarkably similar forms he has obtained in Ireland, he has done a service to students of Prehistoric Archæology. Others will be stimulated to investigate the subject. The absence of an index is a serious drawback to the utility of the volume.

III.—Brief Notices.

The New Zealand Geological Survey has issued a memoir on "The Geology of the Cromwell Subdivision, Western Otago Division", 1908, by Mr. James Park, Professor of Mining and Mining Geology in the University of Otago. The country dealt with is a mountainous one, rising to heights ranging from 4000 to 7600 feet on the borders of the mountain plateaux, while the valleys are mostly narrow rocky defiles. The county town, Cromwell, with about 600 inhabitants, is situated on a river terrace at the junction of the Clutha and Kawarau Rivers. The prevailing rocks are mica-schists, most probably belonging to altered Palæozoic formations; they contain bands of chlorite schist, which are regarded as altered contemporary volcanic rocks, and also a dyke of serpentine. In the Cromwell basin there is a great thickness of Pliocene freshwater beds, with seams of lignite of great economic value. Following this lacustrine series there is a great assemblage of fluviatile and glacial drifts, ranging in age from the close of the Pliocene to recent times. All the gravels and glacier detritus are gold-bearing, and most of them have been worked with profit. There are two great systems of lodes in the mica-schists in which gold has been worked, but vein-mining has now ceased. Full particulars are, however, given of the workings. Accounts are also given of silver, antimony, asbestos, graphite, lignite ('coal'), and of water-supply. The memoir is divided into sections dealing with the physiography, general geology, economic geology, and petrography.

THE UNIVERSITY OF DURHAM PHILOSOPHICAL SOCIETY has published as Memoir No. 1, an essay "On a case of Thrust- and Crush-brecciation in the Magnesian Limestone, County Durham", by Dr. D. Woolacott, F.G.S. It is illustrated with 2 plans, 20 photographs, and 4 text-figures. The substance of the essay was brought last year before the British Association at Dublin, and the abstract giving the author's conclusions was published in the GEOLOGICAL MAGAZINE for October.

EARTH TIDES.—In an article on Earth Tides (*Morning Post*, Feb. 23, 1909), it is stated that Professor Hecker, of Potsdam, has arrived at the conclusion that "this apparently solid earth is subject to daily oscillations analogous to the tides, rising and falling twice in every twenty-four hours some twenty centimetres, or about eight inches". It is further stated that independent investigations which have been made in the observatory at Kimberley indicate that there is a gradual rise and fall in the earth's crust of more than 8 inches once daily, a movement attributed to the sun's influence, but not regarded as tidal. It is also mentioned that South Africa has a tilt to the east in summer and to the west in winter.

THE RHODESIAN MINER'S HANDBOOK. By F. P. MENNELL, F.G.S. pp. vi, 167. Bulawayo: Ellis Allen, 1909. 2nd edition. Price 5*s*.

In the GEOLOGICAL MAGAZINE for November, 1908, p. 519, we called attention to this publication, and commended it as a sound and practical guide. We are glad to find that a new edition has been called for, enabling the author to bring his useful work well up to date and to supplement it with further information regarding the mines and mining prospects.

MINERAL DISCOVERIES IN THE NORTHERN TERRITORY OF SOUTH AUSTRALIA.—Mr. H. Y. L. Brown, Government Geologist of South Australia, has issued a report on recent mineral discoveries and further boring operations in the northern territory. Copper-ore has been discovered in a granitic area at Mount Davis Creek, in the Pine Creek District; and tin-ore and gold have also been found in new localities in the same district. Information is given of the borings for gold at Pine Creek and Fountain Head; also of borings for coal at Port Keats and Cape Ford, which were carried to depths of 1505 and 1506 feet. No payable coal-seams were encountered; but at Cape Ford, at 1050 feet, fresh water was struck and it rose to the surface, and the yield at 1374 feet was 1600 gallons per hour.

"THE FORMATION OF GEODES, with remarks on the Silicification of Fossils," is the subject of a paper by Mr. Ray S. Bassler (Proc. U.S.

Nat. Museum, 1908, vol. xxxv, pp. 133–54, with seven plates). After some general remarks on geodic cavities which are common in all kinds of rock, the author refers more particularly to those in limestones and shales, and to the Niagara limestone of Lockport, which is rich in examples. There the cavities in many cases are due to the removal by solution of fossils, or they may be fractures in the strata enlarged by the expanding force of crystallization; the mineral matter lining the cavities is usually dolomite, gypsum, and calcite. Frequently fossils themselves, such as Brachiopoda, furnish the cavities and are lined with crystalline material. The most striking geodes are those of siliceous composition, which occur usually in shaly, fossiliferous strata. The author remarks that "fossils lying in the path of surface-waters are subject to a complete replacement of their substance by silica; when crushed or fractured, fossils may have the breaks lined with a siliceous deposit. In the latter case, continued deposition and the expansive force of the crystals will result in a hollow, rounded mass or geode, lined with inwardly pointing crystals, and on the outside covered with remnants of the fossil". In the well-known Keokuk geode-bed which occurs in the Knobstone division of the Lower Carboniferous at Keokuk, Iowa, the geodes are not disseminated along the planes of stratification, but they lie on the edge or close to joint planes or rifts in the strata through which water had easy access. Elsewhere they occur in the surface-soil and in the beds of streams. Most of them appear to have been formed in the way above mentioned, and to have originated from Crinoids and Brachiopods.

Vegetation of British Peat Mosses.—"The Changes in the Vegetation of British Peat Mosses since the Pleistocene Period" is the title of a paper by Mr. F. J. Lewis (Proc. Liverpool Geol. Assoc., New Series, No. 3, November, 1908). The observations are here confined to Scottish peat mosses from the Southern Uplands to Skye, the Outer Hebrides, and Shetland. The deposits are grouped as First (Lowest) Arctic Bed, Lower Forest, Second Arctic Bed, and Upper Forest. Concerning these the author remarks "that the first Arctic bed contains an Arctic-Alpine flora, which existed over wide areas near sea-level, and this is succeeded first by forest with temperate plants, which in turn yields place to a second Arctic-Alpine association. These successive strata indicate a definite sequence of events taking place simultaneously over the whole of Britain". The Upper Forest is not met with beyond the mainland of Scotland, and in areas examined in the Grampians and in Assynt the deposits comprise two zones, separated by peat with remains of Arctic birch and willow. In the south of Scotland the Upper Forest consists for the most part of Scotch pine. In his concluding remarks the author finds it difficult to reconcile these several stages in the peat with the theory of a single glaciation, as they suggest considerable oscillations in climatic conditions, and agree closely with the scheme of classification proposed by Professor James Geikie. Remnants of local ice-sheets and glaciers may have existed in the mountains when the earlier beds were laid down, and it would have been better if the author had used the word "during" instead of "since the Pleistocene period" in the title of his paper.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—*May* 12, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, and afterwards Dr. J. J. H. Teall, M.A., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Hartfell - Valentian Succession around Plynlimon and Pont Erwyd (North Cardiganshire)." By Owen Thomas Jones, M.A., B.Sc., F.G.S.

In this paper the author deals with the stratigraphical succession and the geological structure of an area of about 40 square miles, lying in the hilly district about 12 to 16 miles east of Aberystwyth. In an historical introduction the work of previous observers, including Sedgwick, Ramsay, and Walter Keeping, is dealt with.

The rocks within the district are divided into three stages, which are further subdivided into groups and zones, as follows:—

VALENTIAN.	C. Ystwyth Stage.	(c) Rhuddnant Group.	2. Rhuddnant Grits.	
			1. Rhuddnant Shales.	
		(b) Myherin Group.	2. Blaen Myherin Mudstones.	
			1. Dolwen Mudstones.	
		(a) Devil's Bridge Group.	Mudstones with thin grit-bands.	
	B. Pont Erwyd Stage.	(c) Castell Group.	3. Flags and shales. (Zone of *Monograptus Sedgwicki.*)	
			2. Shales and mudstones. (Zone of *Cephalograptus cometa.*)	
			1. Mudstones and shales. (Zone of *Monograptus convolutus.*)	
		(b) Rheidol Group.	4. Black shales and mudstones. (Zone of *Monograptus communis.*)	δ. *Leptotheca*-band.
				γ. *Magnus*-band.
				β. *Triangulatus*-band.
				α. *Triangulatus*-var. band.
			3. Flags and black shales. (Zone of *Monograptus cyphus*, s.s.)	
			2. Flags with thin shales. (Zone of *Monograptus*, sp. nov.)	
			1. Flags and shales. (Zone of *Monograptus*, sp. nov.)	
		(a) Eisteddfa Group.	2. Flags, shales, and grits. (Zone of *Cephalograptus ? acuminatus.*)	
			1. Flags with thin shales. (Zone of *Glyptograptus persculptus.*)	
HARTFELL.	A. Plynlimon Stage.	(c) Brynglâs Group.	Mudstones.	
		(b) Drosgol Group.	Grits, conglomerates, and mudstones.	
		(a) Nant-y-moch Group.	Flags with thin shales. (Zone of *Dicellograptus anceps.*)	

The Plynlimon Stage is developed in the northern part of the district, between Plynlimon and Pont Erwyd; the Pont Erwyd Stage along the two valleys of the Rheidol and the Castell, which converge near Pont Erwyd village; while the Ystwyth Stage is developed on the plateau-like tract extending from the Castell Valley to the Ystwyth Valley.

The stratigraphical succession is demonstrated by a series of sections and traverses across various parts of the district, and lists of fossils (mainly graptolites) collected from the various zones are given. The palæontological evidence is in entire accord with the stratigraphical evidence.

The structure shows many points of interest, and is clearly brought out by the mapping. Three types are dealt with — (1) folding, (2) strike - faulting, and (3) normal faulting; but the first is predominant.

The rocks are folded into a primary anticlinal fold or anticlinorium, with a southerly 'pitch' of 10° to 15°. This primary fold is composed of a number of secondary folds of a symmetrical type, with axes ranging nearly due north and south and pitching as above. Occasionally the secondary folds are complicated by smaller folds or crumplings. The effect of the plication structure on the rock-outcrops, and especially on the topographical features, is dealt with in some detail. The latter are shown to be dependent in an important degree upon the pitch, and to a much smaller degree upon the dip of the rocks.

Strike-faults play a minor rôle in the structure, and their effects are of little importance; they have not been observed to carry mineral deposits.

The normal faults of the district are of greater interest. They range in an east-north-easterly direction, and nearly always carry sulphidic ores of lead, zinc, or copper. They appear to be quite independent of the folding, and behave generally as if they were of later date.

A brief account is given of the district lying on the western limb of the anticlinorium between Pont Erwyd, Devil's Bridge, and Aberystwyth. Evidence is given for assigning to the 'Aberystwyth Grits' of earlier observers a position much higher in the geological sequence than has hitherto been attributed to these 'Grits'.

The paper concludes with a tabular list of fossils, correlation tables, and a description of two species of graptolites of zonal importance.

2. "The Geology of the Neighbourhood of Seaford (Sussex)." By James Vincent Elsden, B.Sc., F.G.S.

This paper illustrates the application of zonal methods to field-geology in a Chalk area. It deals with a portion of the South Downs lying between Eastbourne and Newhaven. The inland outcrops of the uppermost zones of the Chalk are mapped. In tracing the boundary-lines fossil evidence is alone relied upon, lithological characters being found untrustworthy. Certain structural features of this area are thus brought to light and discussed.

On the east of the Cuckmere River the beds examined are found to be nearly horizontal. On the west side they are bent into a sharp uniclinal fold, striking east and west. Seaford Head represented a remnant of this fold, the westerly extension of which is destroyed by marine erosion. The low ground between Seaford and Chyngton occupies the trough of the fold, from which dip-slopes rise gently to the north and sharply to the south. There is thus formed a true synclinal depression striking westwards, with a low pitch, into the English Channel. The complete disappearance of the fold on crossing the Cuckmere cannot be satisfactorily explained by the normal process of dying out, the distance being too short for so rapid a recovery. It is suggested, therefore, that a transverse fault may exist beneath the alluvium of that river, thus, perhaps, accounting for the narrow gorge at Cuckmere Haven. The top of the zone of *Marsupites testudinarius*, which lies in an approximately horizontal position at about the level of the 300 foot contour on one side of the river, sinks below sea-level in the trough of the fold on the other side. The fault, if it exists, seems to die away rapidly northwards, since no trace of it has been detected higher up the valley towards Alfriston. This feature would be expected from the nature of the movement. The relation of the Seaford fold to the main flexures of the South Coast is considered, and it is suggested that this fold represents the eastern termination of the structural area known as the Hampshire Basin, being, in fact, a continuation, *en échelon*, of the Purbeck–Isle of Wight system.

Certain existing physiographical features are ascribed to the influence of this flexure, which facilitated the retention of the Eocene cover in the synclinal hollow thus formed. A result of mapping the outcrops, also, has been to prove that the numerous dry valleys in this area are not of the nature of 'sinks' or 'dolinas', but are true valleys of surface-erosion. Attention is drawn to certain features of these valleys.

A brief comparison is made between the fossils of the inland exposures and those of the cliff-section, the most notable difference being the evidence in the former of a *Conulus*-band at the top of the zone of *Micraster cor-anguinum*.

II.—*May* 26, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Cauldron Subsidence of Glen Coe and the Associated Igneous Phenomena." By Charles Thomas Clough, M.A., F.G.S., Herbert Brantwood Muff, B.A., F.G.S., and Edward Battersby Bailey, B.A., F.G.S.[1]

The succession of volcanic rocks in Glen Coe is mainly a series of lava-flows, of which there are three types—augite-andesite, hornblende-andesite, and rhyolite. Agglomerates, tuffs, and sediments form but a small portion of the sequence. The Lower Old Red Sandstone age of the rocks is proved by the occurrence of plant-remains in shales at the base. The sequence is divisible into groups, which are not, however, persistent over the whole area. Each group may contain different types of lava, which interdigitate one with the other. It is probable that the district was supplied from more than one centre, the foci being independent as regards type of material erupted, although their periods of activity overlapped.

[1] Communicated by permission of the Director of H.M. Geological Survey.

The volcanic pile, with patches of conglomerate and breccia at the base, rests upon an uneven floor, evidently a land-surface, of the Highland Schists; and further, the eruptions appear to have been subaerial.

The cauldron subsidence, which let down the volcanic rocks and the underlying schists some thousands of feet, affected an area roughly oval in shape and measuring 8 miles by 5. It is delimited by a fault, the hade of which is sometimes normal, sometimes reversed. The lavas abut against the fault-plane, and are frequently tilted up into a vertical or even overturned position near it. Further evidence for the boundary fault is afforded by the displacement of the outcrops of several members of the Highland Schists.

A zone about a mile wide lying immediately outside the boundary fault has been invaded by a number of masses of granite and porphyrite, spoken of collectively as the 'fault-intrusion'. Where the fault-intrusion comes against the boundary fault it is chilled, and its margin is a smooth even plane, while its junction with the schists is highly irregular. The fault-intrusion causes contact-alteration in the schists outside the fault, but the volcanic rocks and schists inside the fault are scarcely affected by it.

The movement along the fault-plane has caused intense shearing and crushing, leading finally to the production of 'flinty crush-rock'. The latter owes its characters to extreme trituration, probably accompanied by incipient fusion due to frictionally generated heat.

In certain places flanking faults older than the main boundary fault, and accompanied in each case by a mass of igneous rock on their outer walls, are found near the main boundary fault and parallel to it. The subsidence therefore took place in at least two stages.

After subsidence in the cauldron had ceased, a multitude of dykes, mainly porphyrites, but including quartz-porphyries and lamprophyres also, were intruded along lines trending north-north-eastwards and south-south-westwards. It is shown that the dykes add their width to that of the country traversed, and that they have their focus within the Etive granite mass. They have a parallel, not a radial arrangement; and a vast majority are concentrated into two swarms, which extend north-north-eastwards and south-south-westwards from the granite.

The authors discuss several questions arising out of their conclusions. With reference to the relative age of the faulting and the fault-intrusion, it is concluded that they are contemporaneous, and that the uprise of the magma may be considered as complementary to the subsidence. The Glen Coe subsidence is compared with the subsidence which took place in the Askja caldera in Iceland in 1875.

It is considered probable that the lobe of the Cruachan granite, which invaded the sunken area of Glen Coe, was admitted by a further subsidence of part of the rock-mass within the cauldron, and that the granite occupied the cavity thus formed.

A theory is advanced that the Cruachan granite mass also originated in a subsidence of the schists in place of which the granite is now found, the magma welling up the sides of the sinking mass and filling in the subterranean cauldron. Evidence for this is adduced in the form of the intrusion, in the presence of a curved, flanking fault, and in the shearing of early consolidated parts of the mass.

The dykes point to the operation of regional tensional stresses which, co-operating with the pressure of the magma, opened parallel north-north-east and south-south-west fissures. It is suggested that the concentration of the dykes was due to the pasty condition of the internal parts of the granite mass, which yielded to the stresses and caused a localization of fissures in the surrounding solid rocks.

After the intrusion of the majority of the dykes, a further subsidence within the Cruachan granite mass admitted the central core of the Starav granite.

The principle underlying the interpretation of the phenomena described is the upward movement of igneous magmas in correlation with complementary subsidence of portions of the earth's crust.

2. "The Pitting of Flint Surfaces." By Cecil Carus-Wilson, F.R.S.E., F.G.S.

Regular pittings of uniform size are occasionally seen on flints which have been exposed to the weather. They have been referred to by various authors, but no satisfactory explanation of their origin has been given. The author procured some interesting examples occurring in a recent deposit near Folkestone. This deposit is formed of materials which appear to have been washed down from the adjacent chalk hills. The flints appear to have been derived from the sandpipes in the Chalk: their surfaces are much decomposed. The removal of the colloid silica has rendered them very porous, and they absorb a good deal of water. It is believed that the pittings are due to mechanical action. Observations and experiments carried out by the author indicate that such markings cannot have been produced by blows, nor by any process of desiccation, and that the freezing of the absorbed water seems to be the only satisfactory explanation to account for the various details of the phenomenon.

CORRESPONDENCE.

THE GENOTYPE OF *LOXONEMA*, PHILL.

Sir,—About a week after the publication of the Quart. Journ. Geol. Soc., vol. lxv, pt. ii, May, containing in full my paper on the genus *Loxonema*, read on January 13, I received vol. viii of *Essais de Paléoconchologie Comparée*, by M. Cossmann, published in April, but apparently only distributed in June.

It is impossible to bestow adequate praise on this admirable and laborious work, and I feel sorry to be obliged to differ on any point from its learned author. Nevertheless, I have unwittingly taken a different view with regard to the genotype of *Loxonema*, and I consider it advisable to give my reasons for so doing in greater detail. More especially do I feel the need of this since I also at first was in accord with M. Cossmann in taking the Devonian form erroneously described by Phillips as *L. sinuosum* (Sow.) for genotype (Quart. Journ. Geol. Soc., 1905, vol. lxi, p. 564). Further investigation, however, has convinced me that the Silurian *L. sinuosum*, described by Sowerby as *Terebra? sinuosa* (Sil. Syst., p. 619, and pl. viii, fig. 15), must be the genotype. Two considerations have led to this conclusion.

1. Phillips mentions *L. sinuosum* first when enumerating species which he associates with it in the genus, and before he describes his Devonian form which he considers conspecific. When an author does not fix on a genotype it is usual to take as such his first-named species if represented by a sufficiently well preserved specimen, which is the case with this. Phillips' Devonian shell, being quite distinct, has no right to the name *sinuosum*.

2. The first author who clearly declares one of these species to be the genotype should be considered to decide the matter. I have shown that S. P. Woodward and P. Fischer are ambiguous. Lindström by implication selects *L. sinuosum* (Sow.) as genotype, but Professor Koken is the first to do so unequivocally, for in 1889 (Neues Jahrb. f. Miner. B.B., vi, p. 441) he states, "Der Typus ist *L. sinuosum* Sow. aus dem Obersilur." Again, in 1896 (Jahrb. der k.k. geolog. Reichsanstalt, Bd. xlvi, Heft i, p. 117 [81]), after discussing the different forms included by Phillips in the genus, he writes, "*L. sinuosa* Phill. ist also der Typus im wörtlichen Sinne, aber nicht die ganz typische Form, denn Sowerby's *Terebra sinuosa* aus dem Aymestrykalk mit welcher Phillips sie identificirt und welche der ideale Typus der Gattung ist, weicht nicht unbeträchtlich von der *sinuosa* des Clymenienkalkes ab. Wenn man die *echte*, obersilurische *L. sinuosa* Sow. sp. neben eine *Zygopleura* hält sieht man am besten, *wie weit* sich die letztere schon vom Ausgangspunkte der Gruppe entfernt."

Dr. Perner (Syst. Sil. Centre Bohême, pt. i, vol. iv, Gastéropodes, tome ii, 1907, p. 324) writes after the description of the genus, "Type: *Loxonema sinuosum* Sow." On p. 325 he divides the *Loxonema* into two groups, and on p. 327 calls the first "Groupe de Loxonema sinuosum Sow."

M. Cossmann (p. 16) seems to think that Koken considered *Terebra sinuosa*, Sow., a *Zygopleura*, but a reference to the passage quoted above shows the contrary to have been the case. In the preceding paragraph Koken writes, "Die letztere [*L. rugifera*], Phill. ist eine carbonische *Zygopleura*, verwandt mit der devonischen *costata Sdb.*, aber sehr verschieden von den Loxonemen der *Sinuosa*-Gruppe, auf welche der Name zu beschränken ist."

Since M. Cossmann (p. 18) has substituted the name *L. Perneri* for *L. propinquum*, Perner, which was preoccupied, and his work is prior in publication to mine, the species called *L. Perneri* by me (p. 221, and pl. xi, figs. 1–3) must yield to his, and I would therefore suggest the name *L. Cossmanni* for my species.

J. Longstaff.

Highlands, Putney Heath.
June 12, 1909.

ARCHÆAN OR LOWER PALÆOZOIC ROCKS IN THE MALAY PENINSULA.

Sir,—Dr. R. D. M. Verbeek, at the end of his "Rapport sur les Moluques" (edition Française du *Jaarboek van het Mijnwezen in*

Nederlandsch Oost-Indië, xxxvii, 1908, partie scientifique), gives a summary of the geology of the Moluccas and of the whole of the Netherlands Indies. Under the heading "Schistes Anciens" certain passages occur which may be translated as follows (p. 754): "Ancient schists without fossils, of which the age is unknown. Among these there are probably Archæan as well as old Palæozoic rocks. From a petrographic point of view we can distinguish gneiss, mica-schist, amphibole-schist, grauwacke, phyllite, argillaceous schist, etc. The amphibolites, whose silica percentage is generally low, but which contain much plagioclase, may by that be recognized as basic eruptive rocks, most often gabbros, metamorphosed and become schistose owing to orogenic movements. The other rocks are sediments more or less modified . . . (p. 755). The ancient schists are also widespread in the islands of the Celebes, Borneo, Karimown Djawa (Djapara Residency, Java), Billiton, Banka, Sumatra, and in the Peninsula of Malacca (i.e. the Malay Peninsula, I.B.S.). Although a part of these rocks may probably be azoic, among them are certainly others that are younger."

Seeing the recent date of Dr. Verbeek's Report, I think that his remark about ancient schists in the Peninsula calls for some notice.

I well remember, when I first came to the Federated Malay States, a conversation with an official of the Public Works Department, who assured me that a certain limestone in the north of Perak was Laurentian. On gently pressing for evidence, it appeared that the sole reason for this statement was that the Perak Limestone looked like Laurentian Limestone that my informant had seen in Canada some years before.

Had Dr. Verbeek but known that the evidence of the existence of Archæan or Lower Palæozoic rocks outcropping in the Malay Peninsula rested on such slender foundations as are exemplified above, I do not think he would have said that the ancient schists are widespread in this part of the East Indies; and, moreover, had the value of the evidence been better known, statements of a similar nature would not have crept into Professor Suess' *Der Antlitz der Erde* (Miss Sollas' translation, vol. i, pp. 456, 457. Here the term 'Archæan schist' occurs, vol. iii, p. 233. Here the Myophoria beds in Pahang are apparently included in the 'ancient sediments').

But for a small portion of Borneo, the geology of the Malay Archipelago is only known to me by the literature, and the question of the ancient schists in that region is therefore one on which I am not entitled to speak. But after a perusal of the scanty literature concerning the Peninsula, and five years' work in the country, I think I may say that as yet no evidence has come to light of rocks older than the Carboniferous, with the possible exception of inclusions of granite in tuffs and of a quartz-tourmaline rock in conglomerate, both being facts which are now published for the first time.

I trust I may be pardoned if I further trespass on your valuable space by mentioning another point in Dr. Verbeek's Report. On p. 756 Dr. Verbeek goes into some detail concerning the dip of the rocks at Mount Guthrie, Singapore, where I found certain fossils described in the 1906 volume of this Magazine by Mr. R. B. Newton. The dip observed by Dr. Verbeek and Dr. Molengraaf was opposite to that observed by myself, and such is the stress laid on this that, although Dr. Verbeek kindly suggests a sharp anticline as an explanation, I felt, on reading the passage, misgivings as to the accuracy of my own statement. I have to-day re-examined the hill, and find that the section is more luminous than in 1906. Not only has much of the base been removed, exposing fresh rock, but a deep cutting has been made through the hill, cutting about N.N.W.–S.S.E., that is, parallel to the strike of the beds. The place where I observed the dip in 1906 was recognizable, and my observation was correct. The general dip is to the W.S.W., and this obtains at both ends of the cutting. There is, however, some evidence in the section (about 150 feet long) of apparently local but sharp folding and of faulting, such as is frequently seen in a disturbed area, but not of a distinct anticline affecting any considerable portion of the section. As a result of these folds and faults there are local dips to the E.N.E. in four places, while in four places the beds are vertical. The small quarry mentioned by Dr. Verbeek on the south side of the hill, which, but for the cutting, is now covered with grass, doubtless showed a local variation of dip. The matter seems to me to be of no great importance and not worth a figure of the section, but this explanation is due as much to Dr. Verbeek as to myself.

J. B. Scrivenor.

Singapore.
May 8, 1909.

CULM INCLUSION IN COARSE GRANITE.

Sir,—Although sedimentary inclusions in the granites of the Western Counties have often been described, the following occurrence may be worth a note. In the course of a walk from Lustleigh station to Foxworthy Mrs. Hunt called my attention to a fragment of rock protruding from a mass of granite lying by the roadside for road-metal. The roadmen then were clearing rocks in a neighbouring field, distant about two-thirds of a mile from the nearest granite boundary. The enclosing granite was of very coarse matrix with large orthoclases. The inclusion was a rhomboidal fragment of what seemed to have been a culm grit with planes of sedimentation, and with ordinary surfaces of fracture in the usual joint planes; weight about $1\frac{1}{2}$ lb. The points of interest are that, though the fragment is completely crystallized, the boundaries are not dissolved or distorted. Before this very coarse enclosing granite was consolidated the fracture of the culm rocks was much as it is at present. Dr. Flett kindly confirmed my recognition of the fragment as sedimentary. Having seen much granite broken in the neighbourhood during the past twenty-five years for building and road-making, this particular specimen is unique of its kind in my experience. I have since noticed a triangular fragment in the same heap of stones, which I may possibly succeed in getting hold of.

A. R. Hunt.

May 6, 1909.

OBITUARY.

THOMAS MELLARD READE, F.G.S., Assoc. M. Inst. C.E., F.R.I.B.A.

Born May 27, 1832. Died May 26, 1909.

Mr. Mellard Reade was the younger son of William James Reade and Mary Mellard (of Newcastle-under-Lyme). His father, who was a man of high character and studious habits, but not successful from a worldly point of view, had in 1830 opened a school in Mill Street, Liverpool, and there Thomas Mellard Reade was born in 1832. Descended on the father's side from a family of Staffordshire yeomen, of whom the head member settled in Cheshire in 1730, there were among his kinsmen Sir Thomas Reade, Deputy Adjutant-General at St. Helena during Napoleon's captivity, and the Rev. Joseph Bancroft Reade, a pioneer in photography who was elected a Fellow of the Royal Society in 1838. On his mother's side he was a cousin of Mrs. Craik, authoress of *John Halifax, Gentleman*.

After receiving his elementary education in private schools at Liverpool and at Seacombe in Cheshire, Mellard Reade about the end of 1844, before he was 13 years of age, became a pupil in the office of Messrs. Eyes and Son, architects and surveyors, at Liverpool. In their office, and subsequently as a draughtsman in that of another local architect, Mr. H. Horner, he laboured diligently for a period of eight years. Early in 1853 he entered the service of the London and North-Western Railway at Warrington, becoming in due course principal draughtsman in the northern division of the Company's civil engineering department.

The knowledge and experience he had thus acquired during fifteen years enabled him in 1860 to commence private practice in Liverpool as an architect and civil engineer, and in this he was eminently successful. Among many works he laid out the residential estate of Blundellsands in 1865, fixing his own home there in 1868, after having married in 1866 the widow of Mr. Alfred Taylor, C.E. Appointed architect to the Liverpool School Board in 1870, he retained the office until 1902, having designed and superintended the erection and enlargement of many schools. He also carried out much other architectural and engineering work. In 1871 he was elected an Associate Member of the Institution of Civil Engineers and in 1878 a Fellow of the Royal Institute of British Architects.[1]

Although from boyhood he had been interested in science, and especially in geology, it was not until he was about 35 years of age that he began to give special attention to the subject. In 1870 he commenced the long series of geological articles which he communicated to scientific societies and journals, and in 1872 he was elected a Fellow of the Geological Society. His first important paper was on "The Geology and Physics of the Post-Glacial Period, as shown in the deposits and organic remains in Lancashire and Cheshire". This

[1] For most of the above particulars and for the supplementary list of his father's geological papers we are indebted to Mr. Aleyn Lyell Reade, author of *The Reades of Blackwood Hill.*

article was brought before the Liverpool Geological Society in 1871 and published in 1872, while the main facts and conclusions were printed in advance in the Geological Magazine for March, 1872. The full memoir, illustrated by colour-printed maps and sections, was a model of carefully recorded observations; and the author was enabled to make out the succession of changes which affected the region subsequent to the formation of the Boulder-clay. In particular he called attention to the marine Formby and Leasowe Beds which occur between the Inferior and Superior Peat and Forest Beds.

In 1873 he gave an account of the Buried Valley of the Mersey, and predicted that the tunnel which it was proposed to make beneath the river would intersect a gully filled with Boulder-clay. This was verified on the completion of the tunnel in 1885.

The Drift beds of the North-West of England and North Wales formed the subject of two papers brought before the Geological Society in 1873 and 1882, in which he maintained the glacio-marine origin of the Boulder-clay of the lower-levels, regarding as true Till, formed under or in front of the local glaciers, the Boulder-clay of the mountain regions.

He was elected President of the Liverpool Geological Society during the Sessions 1875–7, and again on two subsequent occasions, 1884–6 and 1895–7. In the address published in 1877 he took as his subject "Geological Time", giving tabulated calculations of the total solids in solution removed annually from each rainfall area and group of strata in England and Wales. This essay with additional matter was reprinted in 1879, in a little volume entitled *Chemical Denudation in relation to Geological Time*. It included also a paper on "Limestone as an Index of Geological Time", read before the Royal Society in 1879. Calculating the amount of carbonate and sulphate of lime carried away annually from the igneous rocks on the earth's surface, and the thickness of deposit that would result therefrom, Mellard Reade compared this with the assumed thickness of limestone in the sedimentary crust of the earth, and estimated that a period of about six hundred million years would be necessary for the entire series of stratified formations. Although subsequent researches tend greatly to lessen the estimates of geological time, he may justly be said to have initiated this instructive line of inquiry.

While he continued his researches on local geology he brought his experience on the Drifts to bear on other regions in the north and east of England, in Ireland and Scotland; and he gave much attention to Tidal Action as a Geological Cause, to Pebble Ridges, the Circulation of Water in Sandstone, the Physiography of the Trias, and other subjects.

In 1886 he published his important and elaborately illustrated volume, *The Origin of Mountain Ranges considered experimentally, structurally, dynamically, and in relation to their Geological History*. In it he brought forward the results of much original study and experiment, dealing especially with the effects of underground temperature on the expansion of rocks beneath thick accumulations which prevented the escape of heat, and led to folding, buckling, and uplift of the formations. He also for the first time pointed out that at a certain depth in a cooling solid globe there must be a 'level-of-no-strain', a conception which has been generally recognized as of great significance in indicating that the disturbances are likely to be confined to a comparatively thin crust.

In recognition of this work and of his other contributions to geological science the Murchison Medal was awarded to him by the Council of the Geological Society in 1896, when Dr. Henry Woodward was President.

In 1903 Mellard Reade published *The Evolution of Earth Structure, with a theory of geomorphic changes.* In this work he explained the geographic relief of the globe as due (1) to differential alterations of volume in large sections, which take place with extreme slowness and, being deep-seated, upheave or depress portions of the earth's crust without wrinkling it; and (2) to the tangential creep and ridging up arising from the heating of sediments and variations of temperature, and consequent expansion, within the earth's crust brought about by sedimentary deposition. He further illustrated the subject with the results of many experiments on the folding and fracture of materials, and reproduced the account of investigations made in conjunction with Mr. Philip Holland on slaty cleavage. He also republished some essays on denudation, the permanence of oceans and continents, and other subjects bearing on the question of the structure of the earth and the origin of its main features.

During the last ten years Mr. Reade worked a good deal with Mr. Philip Holland, F.I.C., and together they published papers dealing with mechanical and chemical analyses of Ludlow rocks and Old Red Sandstone and Marl, and also with the subject of sands and sediments, treating these latter materials stratigraphically, microscopically, and chemically. From their observations the authors were impressed with the great amount of micro-sediment met with, such as the very fine powder of quartz which they termed quartz-dust. They observed that clay and iron-oxides are present in the clearest sea-water, and particles of carbonate of lime likewise occur, held up by the clay and not in solution. Finally they pointed out that the sea would carry about and distribute these micro-sediments, and thus make important additions to oceanic deposits.

The final paper by Mr. Mellard Reade, a short article on "The Mechanics of Overthrusts", was printed in the Geological Magazine for February of the present year.

Thus to the last he remained an indefatigable worker on dynamic geology and on the architecture of the earth's crust, subjects to which his professional experience advantageously and perhaps naturally led him. The business of his life indeed afforded him many opportunities, which he fully utilized, of seeing fresh sections of the strata, and it inculcated those methods of precision which characterized his records and experiments.

A severe illness during infancy produced a certain amount of deafness from which Mellard Reade suffered until the end of his days, and it increased with advancing years. On this account he rarely attended scientific meetings other than those of the Liverpool Geological Society. He printed two lists of his geological papers—

1. List of Scientific Papers and Works, 1870–90. Nos. 1–112. 8vo; London, 1890.

2. Second List of Scientific Papers and Works, 1891–1904. Nos. 113–82. 8vo; London, 1905.

The papers enumerated in the above lists amount to 182. The following list includes the papers since published, and it may be remarked that from 1870 to the present year one or more articles, and on an average five, appeared each year:—

Supplementary List of Scientific Writings, 1905–9. Nos. 183–96.

1905. (183.) "Notes on some specimens of Lancashire Boulder Clay": Proc. Liverpool Geol. Soc., 1904–5, vol. x, pt. i, pp. 38–42.

(184.) "Sands and Sediments." Part II: "Geologic Sediments of Marine, Estuarine, or Fresh Water Origin," by T. M. R. and Philip Holland: op. cit., 1904–5, vol. x, pt. i, pp. 48–78.

(185.) "Pleistocene Clays and Sands of the Isle of Man," by T. M. R. and Joseph Wright: op. cit., 1905-6, vol. x, pt. ii, pp. 103–17.

1906. (186.) "Radium and the Radial Shrinkage of the Earth": Geol. Mag., pp. 79, 80.

(187.) "Sands and Sediments." Part III (final), by T. M. R. and Philip Holland: Proc. Liverpool Geol. Soc., Session 1905–6, vol. x, pt. ii, pp. 132–56.

(188.) "Radium and Geology." Letter to *Nature*, vol. lxxiv, p. 635.

(189.) Statement on "Physiography of Coast between Rhyl and Gosforth, and Inferences as to Recurrence of Land Movements in the Future"; also further replies to definite questions: Report of Royal Commission on Coast Erosion, Appendix No. xxii, pp. 209–11.

(190.) "Analyses of Ludlow Rocks," by T. M. R. and Philip Holland; Proc. Liverpool Geol. Soc., 1906–7, vol. x, pt. iii, pp. 198–213.

1907. (191.) "Post-Glacial Beds at Great Crosby as disclosed by the New Outfall Sewer": op. cit., 1907–8, vol. x, pt. iv, pp. 249–61.

1908. (192.) "Oceanic Deeps": Geol. Mag., 1908, p. 19.

(193.) "Analyses of Longmyndian Rocks," by T. M. R. and Philip Holland: Proc. Liverpool Geol. Soc., 1907–8, vol. x, pt. iv, pp. 276–87.

(194.) "A Prehistoric Forest at Waterloo (near Liverpool)," reprinted from the *Waterloo Herald* (newspaper) of October 31, 1908.

(195.) "The Mechanics of Overthrusts": Geol. Mag., November, p. 518.

1909. (196.) "The Mechanics of Overthrusts": Geol. Mag., February, pp. 75–6.

MISCELLANEOUS.

The Burning Cliff near Lyme Regis.[1]—Mr. A. C. G. Cameron, writing from Harcombe Bank, Uplyme, February 9, 1909 (in reference to the letter of "Passer Vennensis" in our February Number), expresses his conviction that paraffin was thrown at times on the 'volcano'. He never witnessed such volumes of smoke arising from the mound of burning shale as are depicted on some of the picture postcards, and he concludes that if they did not touch up their photographs some of the photographers must have brought paraffin with them to enliven the smouldering masses. Mr. Cameron adds that he has taken from the mound beautiful specimens of burnt red shale with Ammonites, "not cooked with paraffin."

Errata in June Number.

p. 242, l. 9 from bottom: *for* Professor of that subject, the eminent John Goodsir, *read* Professor of Anatomy, the eminent John Goodsir.

p. 244, l. 11 from bottom: *for* And the Ostracodermi, *read* And the Heterostraca.

[1] Accidentally omitted from the May Number, p. 228.

No. 542. Decade V.—Vol. VI.—No. VIII. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

AUGUST, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. VIII.—AUGUST, 1909.

ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(PLATE XIV.)

IN these notes it is my object to describe and figure some of the more important Chalk Polyzoa that have not yet been described, or have been described from material less complete than mine.

Genus HOMALOSTEGA, Marss.

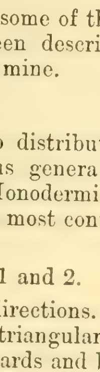
This genus has been dismembered by Canu,[1] who distributed the species grouped under it by Marsson among various genera of his Diplodermiata; but they all appear to belong to his Monodermiata and have enough in common to justify the retention of a most convenient genus.

Homalostega anglica, nov. Pl. XIV, Figs. 1 and 2.

Zoarium always adherent, growing strongly in all directions.

Zoœcium very tumid; aperture subterminal, subtriangular, sides very faintly inflexed, lower lip very faintly curved inwards and bearing a well-marked raised rim, deep slits at the corners.

Avicularia accessory, abundant, laterally symmetrical; they sometimes remain rudimentary in the mature stages of the zoarium (Fig. 2), but normally they become half as long as the zoœcia, round below and tapering gradually upwards to a point, with a small arrowhead-shaped aperture into which project two denticles which are rarely preserved. They lie almost always with their long axes approximately parallel to the lines of growth.



Homalostega anglica. Avicularium highly magnified.

Oœcia unknown, unless occasional inflations of the upper lip of the aperture and the front wall adjoining it are oœcial in nature. Very abundant at Trimmingham, where, and at Norwich and Sherringham, I recorded it in error as *H. pavonia*, Hag. sp., from which, judging

[1] "Revision des Bryozoaires du Crétacé figurés par D'Orbigny": Bull. Soc. Géol. France, 1900, p. 338 et seq.

by Marsson's figures and description [1] (Hagenow's figures and descriptions being inadequate), it is easily distinguishable by the shape of the aperture.

Homalostega biconvexa, nov. Pl. XIV, Figs. 3 and 4.

Zoarium resembling that of *H. anglica.*

Zoœcia tumid, but less so than those of *H. anglica.* Aperture subterminal, biconvex; upper lip semicircular, lower lip very faintly curved outwards in the centre, more so at the sides; shallow slits in the corners.

Avicularia accessory, very abundant, with broad rounded bodies and rapidly tapering pointed beaks which are generally bent round the head of a cell; aperture occupying the greater part of the area, spanned by a bar; when this is broken away the aperture is arrowhead-shaped or diamond-shaped. They lie almost invariably at a distinct angle to the lines of growth and often in pairs, one on either side of a cell and almost meeting round its head.

Oœcia not observed.

Abundant at Trimmingham.

Homalostega vespertilio, Hag. sp. Pl. XIV, Fig. 5.

Neither Hagenow [2] nor Marsson [3] appears to have observed vicarious avicularia in this species. It is very abundant at Trimmingham, and though most colonies, including some of the largest, show no vicarious avicularia, in some they occur capriciously, and I have figured part of a colony in which they are exceptionally numerous. They may be described as ordinary zoœcia of which the apertures have been drawn out to a great length.

The species is very prone to occur as a free unilaminate sheet separated by a very thin layer of chalk from the surface of some fossil.

Homalostega cuniformis,[4] nov. Pl. XIV, Figs. 6 and 7.

Zoarium unilaminate, generally adherent.

Zoœcia very large; irregular growths, to which this species is very prone, often simulate fragments of a dividing wall, or make two cells apparently confluent. Aperture subterminal, semicircular; the lower lip has a broad raised rim; the upper lip rises rapidly from the lower lip owing to the strong inflation of that part of the cell which surrounds the upper lip, making it stand up like the hood of a cradle, and it thickens as it rises.

Avicularia intercalated as initial cells of new lines. Relatively narrow, highly inflated with a central circular aperture from which runs a long, slightly tapering, symmetrical beak consisting of two side walls enclosing a slightly depressed front wall, which at the tip is sharply expanded.

Oœcia occurring very capriciously, very globose.[5]

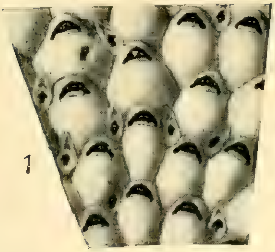
Occurs sparingly, but in large colonies at Trimmingham.

[1] "Bryozoen der Weissen Schreibkreide der Insel Rugen": Pal. Abh., Band iv, Heft i, p. 93.

[2] *Neues Jahrbuch für Mineralogie*, etc., 1839, p. 270.

[3] Op. cit., p. 94. [4] From *cunæ*, a cradle.

[5] The free edge produced over the aperture of the zoarium.



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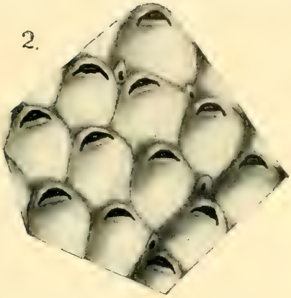

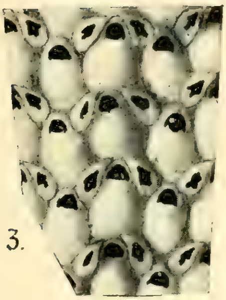

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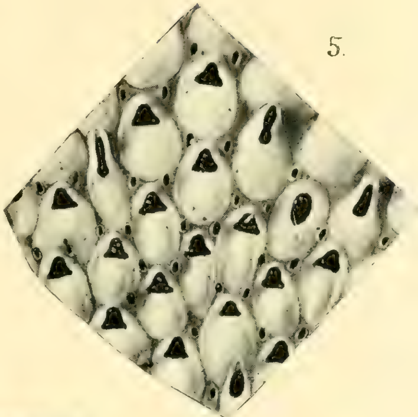

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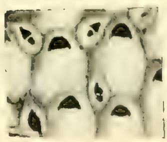

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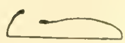

R. M. Brydone phot.

New Chalk Bryozoa.

EXPLANATION OF PLATE XIV.

FIG. 1. *Homalostega anglica.* × 20.
,, 2. Ditto, with rudimentary avicularia. × 20.
,, 3. *Homalostega biconvexa.* × 20.
,, 4. Ditto, with perfect avicularia. × 20.
,, 5. *Homalostega vespertilio.* × 20.
,, 6. *Homalostega cuniformis.* × 20.
,, 7. Ditto, diagrammatic longitudinal section through cell.

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

II.—NOTES ON THE STRUCTURE AND PHYSIOGRAPHY OF THE TARNTAL MASS.

By ALFRED P. YOUNG, Ph.D., F.G.S., etc.

(PLATES XV–XVIII, WITH DIAGRAM AND MAP.)

THE mountain mass known as the Tarntaler Köpfe, situated about 20 kilometres south-east of Innsbruck, is distinctly isolated from other high ground in the vicinity. The peaks rise to heights approaching 2900 metres above sea-level. The geologic features above the level of 2000 metres are of special interest. The adjacent country is occupied by crystalline phyllites, chiefly displayed on the north, and highly foliated calcareous schists developed mostly on the south of the mountain.

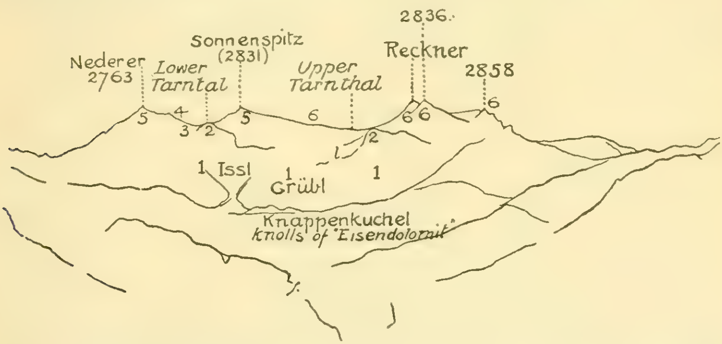

FIG. 9. Diagram illustrating the section (see *infra*), to be compared also with Pl. XV, Fig. 1. The sequence is indicated by the same numbers as on p. 340.

A remarkably large corrie or cirque can be recognized in the accompanying figure, which is a photograph of the mountain from the west (Pl. XV, Fig. 1). The nearer rock-mounds ('Knappenkuchel' of the inhabitants) on the lip of the corrie consist of a dolomite with a reddish weathered surface, the 'Eisendolomit', which rests directly on the phyllites. The section to which attention is here more particularly directed commences at the back of the corrie at about 2150 metres above sea-level with a massive grey dolomite in which no stratification has been detected.

The section from the floor of the corrie, called 'Grübl', to the summit of the Nederer, is as follows (from above downwards No. 1, being lowest) :—

5. Green quartzite schists, with red hæmatite schists, with well-developed plane parallel jointing, frequently with well-marked banding transverse to the foliation (see Pl. XVI, Fig. 3) . . . . 73 metres.
4. Band of dolomite freely penetrated by quartz veins, with dolomite breccia, here called 'Tarntal dolomite'. This rock, broken rather than sheared, has been kneaded into the schists by the folding movements . . 75 metres.

Zone of maximum contortion.

3. Calcareous schists showing conspicuous mechanical foliation. . 95 metres.
2. Limestones distinctly bedded with dip to north-east, otherwise little disturbed . . . . . . 40 metres.
1. Massive dolomite, unstratified, showing brecciation in places without signs of shearing . . . . 330 metres.

The continuation of the series is best shown in the Upper Tarntal, a little to the south of the above. On the floor of the valley, at about 2600 metres, the flaggy limestones, more crumpled than in the Nederer section, are seen to dip to the south under the highly disturbed dolomite (the equivalent of No. 4 in the above section). The slope of the Reckner just above is occupied by hardened schists of the same group as those seen at the Nederer summit. On these rests the great mass of the Reckner Serpentine, some 260 metres in depth.

The intrusive character of the serpentine is well seen at several contacts with the schist, but more especially in a row of occurrences crossing the valley of the Upper Tarntal in a northerly direction. On the steep scarp over the Lizumtal on the east side of this valley is a small occurrence of serpentine completely embedded in the schists. The junction of schist and serpentine is very irregular. The injection at the contacts of small veins and lenses of basic magma into the schists has been described in an earlier paper.[1] The penetration of the serpentine into the schist has taken place for the most part along the foliation planes, which are here crossed by the bedding planes, showing that the foliation was already developed at the time of the intrusion.

As far back as 1859[2] Adolf Pichler announced the discovery of Belemnites and other fossils in place, and affirmed the Liassic age of the higher beds in this locality. In a personal communication addressed at a much later date to Professor Rothpletz, Pichler mentions a specimen of *Ammonites radians* which he collected here and sent to Vienna: this fossil cannot, it seems, be traced. Since that time the only organic remains found have been certain Brachiopods, Lamellibranchs, and corals pronounced to be of Rhætic age.[3]

[1] A. P. Young, "Stratigraphy and Structure of the Tarnthal Mass": Q.J.G.S., November, 1908, vol. lxiv, pp. 596–603.

[2] "Beiträge zur Geognosie Tirols": *Zeitschrift des Ferdinandeum*, 1859.

[3] A. Rothpletz, *Querschnitt durch die Ostalpen*, 1894, p. 75. The fossils named are: *Terebratula gregaria*, *Modiola minuta*, *Gervillia præcursor*, *Corbula alpina*, *Pecten* sp., *Thecosmilia* cf. *fenestrata*, Reuss, and cf. *Convexastræa Azzarolæ*, Stopp.

1

2

Figs. 1, 2. The Tarntaler Kopfe.

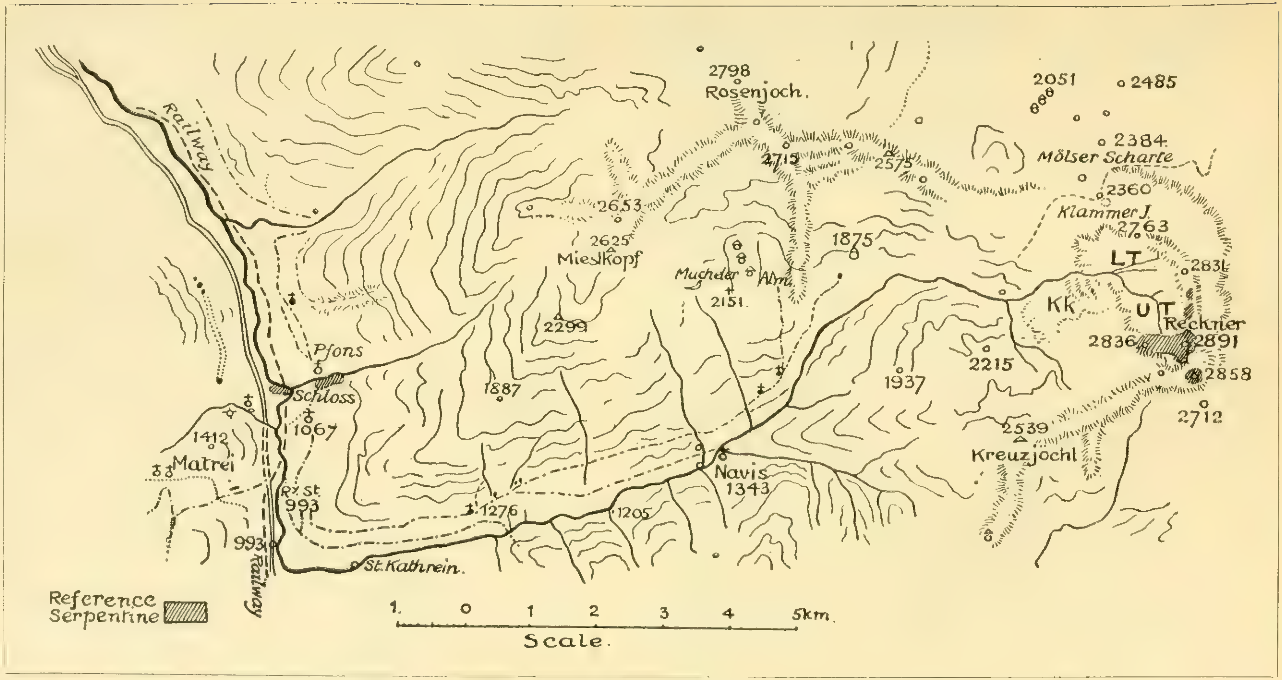

FIG. 10. Sketch-map of the district between Tarntaler Köpfe and Matrei, showing occurrences of serpentine. Height above sea-level in metres from the Generalstabskarte. U.T. Upper Tarntal; L.T. Lower Tarntal; Kk. Knappenkuchel.

So far there exists no tangible evidence of the presence of a Cephalopod fauna in these rocks.

In the summer of 1907 a plate of limestone bearing an Ammonite was found by me at a height of nearly 2500 metres above sea-level on the surface of a scree-cone which has accumulated under the high hanging valley known as the Lower Tarntal. The fossil and its cast were seen lying within 2 feet of one another near the end of a trail of limestone flakes evidently brought down by recent avalanches from the steep cliff at the lower end of the high valley. Somewhat lower on the slope of the same cone, called 'Issl' by the inhabitants (Pl. XVII, Fig. 5), a fragment with a portion of a Belemnite was found. Mr. G. C. Crick, of the British Museum, has kindly undertaken the description of these fossils. These organic remains, like most from the same source, are ill-preserved. It seems nevertheless desirable to keep a record of all such finds for future reference, in the hope that the accumulated material may in the end throw light on the difficult problems here presented.

It may be well to explain that an erratic origin for these fragments is out of the question. All the material of the scree-cone is represented in the standing rocks on the slopes of the Tarntal above. The movement of snow and ice was always in a downward direction. The ravines radiating in all directions are tributary to deep-cut valleys with capacity sufficient to carry off all the ice of this and the neighbouring heights, and the narrow ridges separating the valleys offer no surface along which the ice from the nearer mountain-masses could have been forced up to this level.

At times of highest glaciation the snow-limit must have stood at a level very much lower than that at which these fragments were found. This limit for the Alps is given at 1400 to 1700 metres; under exceptional circumstances it may have reached 1900 metres.[1]

Near this level were the sources of the masses of ice on which depended the transport of blocks to great distances. Obviously no block could be carried above the snow-limit. During stages of advance or retreat, when the snow-line approached 2500 metres, the glacier-tongues were much shortened and left their loads at short distances from the roots.

During the summer of 1908 I again searched this and other screes of similar material, but more especially the standing rocks, the bedded limestones of the cliff above mentioned, and other localities.

The surface of the flake bearing the ammonite is seen to be roughened by minute protuberances, suggesting at first sight an oolitic structure. Many fragments of the same character can be found on the scree-slope of the Issl.

Microscopic slides were prepared from several of these flakes. In a groundwork of comminuted material are embedded larger fragments of calcite, on which the microscope shows structures evidently of other than mineral origin. Dr. Bather, of the British Museum, who kindly examined some of these sections, noted in many of the fragments the reticulate structure belonging to Echinoderms. In

[1] Penck & Brückner, *Die Alpen im Eiszeitalter*, about 1908, p. 1143.

3

4

FIG. 3. The ridge of the Nederer.
„ 4. Reckner (Serpentine) on the right, Kahlewand (Dolomite) on the left.

one instance a section of an Echinoid radiole of Diademoid type could be recognized. This form is probably not older than Upper Trias; the slide on which it occurs was taken from the flake of limestone bearing the Ammonite.

Markings, similar to those above described, are to be seen in microscope sections from the standing rock of the cliffs above the Issl. These observations are in keeping with the conclusion already arrived at as to the source of the fossil.

The breccias of the Tarntal band (No. 4 of section, p. 340) have characters which distinguish them from the breccias which form a small part of the little disturbed mass of Triassic dolomite below (No. 1 of the section). The latter contain little or no quartz; the fragments and matrix are similar in character and are with difficulty distinguished. In the Tarntal band the fragments vary in character, and on weathered surfaces show up well against the matrix; some of the fragments show the original bedding planes. On the Mieselkopf ridge angular flakes of a phyllite nearly a foot in length have been seen among the inclusions in a similar rock. In the Upper Tarntal was found a small block of the breccia which contained numerous inclusions of green talc, a mineral not infrequent in the schists near the serpentine contact.

The question arises—Is the brecciation of the Tarntal dolomite an œcogenous or an apœcous character, i.e. has it been acquired before the rock left its original site or during the movement of translation? Reasons will be given for the view that both brecciation and veining with quartz are œcogenous.

An assemblage of rocks similar to that of the Tarntal mass is seen at the Mieselkopf ridge, at a height of 2560 metres, some 9 kilometres west of the Tarntal. There is the same massive unstratified dolomite several hundred metres in depth, showing no effects of shearing or crushing, surmounted by a band of highly contorted rocks. Here the dolomite breccia, the schists, and the flaggy limestones form several distinct layers which stand at a high angle of dip (Pl. XVIII, Fig. 8, and see Map, p. 341).

The nearer view of the Mieselkopf ridge from the east conveys the suggestion of a sharp synclinal fold (Pl. XVIII, Fig. 8).

In the vicinity the talc-bearing schists are well developed, and at 2460 metres, some 200 metres below the crest, is a mottled red and green calcareous rock without foliation, much like that seen in company with ophicalcite at the serpentine contact, in the quarry at Pfons, near Matrei, some 14 kilometres to west of Tarnthal. At the site under the Mieselkopf the rock forms the core of a band of schist in the strike of one of the vertical layers of schist on the ridge. Some 50 metres higher and in the same strike is an occurrence which may throw some light on the relations between dolomite breccia and schist. Within a space of about 3 feet are some eight or ten vertical plates of dolomite breccia alternating with as many bands of the schist, which is foliated in a vertical plane parallel with the plates. Fine quartz veins traverse the dolomite in all directions, invariably stopping short of the schist which is free from veins. The phenomenon cannot be explained as a stratigraphical sequence. The dolomite breccia, already veined with quartz, appears to have split into parallel-walled plates, between which the other rock was injected, though probably not in its present form.

A microscope section of the schist shows it to consist in great part of fine fibres of minerals of the mica, chlorite, and serpentine groups, with probably some talc, the whole woven into a felt much resembling the more fibrous specimens of the Tarntal serpentine. It contains also clusters of small grains of a carbonate, derived no doubt from the adjoining dolomite; scattered grains of quartz and orthoclase, generally without strain, shreds of a colourless mica with small axial angle ($2\,E = 57°$ nearly; near sericite), and a few zircons, some ilmenite and rutile, all of which might be derived from a gneissic rock; also tourmaline in minute prisms, in some cases large enough to show the interference figure of a negative uniaxal crystal in transverse sections with polygonal outline, and the higher absorption of the ordinary ray in longitudinal sections.

The schist thus represents one of the earlier intrusions of the igneous magma, the foliation being the effect of later dynamic and chemical processes which have not appreciably altered the structure of the dolomite.

This solution of the problem would make the earliest intrusion of the basic magma younger than the Tarntal dolomite, that is, later than Trias if, in accordance with generally accepted views, this breccia is to be correlated with beds of later Triassic age. The alternative assumption, viz. Tarntal breccia older than Trias, is not excluded by known facts and seems to be worth considering.

As already mentioned, the dolomite knolls of the Knappenkuchel have been referred to the Carboniferous on the ground of their resemblance to the 'Eisendolomit' of the Nösslacher Joch, where the rock is associated with grauwackes bearing impressions of *Lithodendron*, *Annularia*, *Sphenophyllum*, and other Carboniferous plants.[1] The Tarntal dolomite has occasionally the reddish tint of the Nösslach rock. All the rocks named contain some quartz.

The alternation of dolomite and schist in the Mieselkopf occurrence is too regular to have been brought about by violent movements of folding and crushing, and is probably for the main part an œcogenous character; the foliation of the schist may be due in part to mechanical causes, and is therefore possibly to some extent an apœcous character.

The talc inclusions in the fragment of Tarntal breccia already mentioned as having been found in the Upper Tarntal can be best explained as due to an injection of fluid magma such as can be seen in schists near the contact with serpentine.

The appearances indicate that the Tarntal breccia was deposited directly on the schists, after these rocks had acquired their foliated character to some extent. It is no longer feasible to treat the breccia as a 'Nappe' separate and distinct from the schists of the Reckner block. The Tarntal dolomite belonged from the first to the transported block, and was carried with it in the movement which landed the rocks in their present position. It follows that the Reckner block of

[1] Kerner, "Der Carbonflora des Steinacherjoches": *Jahrbuch der Reichsanstalt, Wien*, 1897.

Fig. 6. Head of the Lower Tarntal (looking eastward).

Fig. 5. The scree cone, Isl under the Lower Tarntal.

serpentine schist and dolomite is now completely inverted, but whether it is to be regarded as a simple overthrust mass or the lower limb of a recumbent fold cannot be decided on the evidence.

In the Mieselkopf occurrence the alternate plates of schist and dolomite breccia are parallel to the larger bands of dolomite seen on the ridge, from which it appears that the earlier flows of magma were guided by movements of the crust which coincided in direction with the general movement to which the present structure is due.

As regards the tectonic character, the mass of the Tarntal may be divided into two parts. The massive Triassic dolomite with Rhætic and perhaps Liassic limestones in normal position forms the lower part. This may be called the 'Knappenkuchel block'. The upper part of the mass includes the serpentine, schist, and Tarntal breccia, all probably older than the Trias and in inverted sequence. This may be called the 'Reckner block'.

Where the two masses meet is a sheared band formed partly of the upper beds of the lower block and in part of the lower beds of the upper block, approximately bands 3 and 4 of the section on p. 340.[1]

The series on p. 340 and Fig. 9, p. 339, arranged in the original sequence, would stand thus: 6 5 4 1 2 3,—6 being lowest.

Physiography.

A conspicuous topographical feature of this mountain is the Grübl, the great cirque already mentioned. It no doubt owes its present form to ice erosion, by which the massive dolomite has been removed down to the present floor of schists. Small knolls of schist at the lip of the cirque show the well-rounded form of true *roches moutonnées*. The ice-tongue of sufficient mass to mould these knolls must have been fed by an extensive field of *firn*, and the snow-line must have stood for a considerable time at a level above the floor of the cirque, not lower probably than 2250 metres above sea, or 100 metres above the present floor. Above this level the available collecting area diminishes rapidly with the height; at 2500 metres it still includes the whole feeding-ground of the Upper and Lower Tarntal; 100 metres higher, at 2600 metres, little but the slopes of the ridges would remain. It seems, then, probable that the snow-limit at the period in question stood somewhere between 2250 and 2500 metres, or say at about 2400 metres.

We have here evidence of a resting stage during an advance or (more probably) a retreat of the ice. At the period of extreme glaciation the snow-line could not have been higher than 1800 metres, that is, it must have been at least 600 metres lower than the level attained when the 'Grübl' was excavated.

The Lower Tarntal is a straight east and west groove, the erosion of which must be due chiefly to running water. It has been beheaded by the Lizumbach, and the flow of water is now insignificant.

The Upper Tarntal is a basin-shaped hollow 80 metres above the Lower Tarntal, and has also been truncated considerably on the

[1] This modifies somewhat the hypothesis (*a*) (p. 603 of last year's paper) offered before the discovery of the Mieselkopf occurrence.

east side by the Lizumbach. It had an exit on the north-west corner over the Upper Tarntal, to which it was tributary (Pl. XVIII, Fig. 7). On the west side, nearer to the Reckner ridge, are seen earlier and higher openings, by which it drained at one time directly into the Grübl.

All the exits of Upper and Lower Tarntal are now blocked by accumulations of loose material, as seen in Pl. XVIII, Fig. 7. These cannot be due simply to falls from the overlying slopes. The débris must have been arranged by small ice-tongues which just filled the valleys, and the dams represent true end-moraines. The snow-limit at the time must have stood at 2650 metres nearly.

The present snow-limit for the nearer high mountain-masses is placed variously at 2700 to 2900 metres.

Remembering that the snow-limit is higher the greater the mass of the elevated portion of the crust, it would follow that the virtual snow-line for the small mass of the Tarntaler Köpfe is now appreciably lower than the summits (2830 to 2890 metres), but is ineffective in the absence of level surfaces capable of retaining the snow. It is probable that the high valleys have in recent times more than once borne ice-tongues, and may again be filled on the occasion of a fall in the mean annual temperature quite within the range of oscillation possible under present conditions of climate.

The Upper and Lower Tarntal contain several small lakes or ponds; there is one at the lower end of each valley just above the natural dam. The water of these ponds often carries ice till midsummer, another indication of their proximity to the present snow-line.

In this paper the term *snow-limit* has been used as equivalent to the boundary between *firn* and glacier ice. This is perhaps not strictly the case if we define the snow-line as the level above which a free horizontal surface is covered the whole year round with snow. The discrepancy does not affect the general line of reasoning.

REFERENCES TO FIGURES ON PLATES XV–XVIII.

Plate.	Fig.	
XV.	1.	The Tarntaler Köpfe from Mucheler Alm, 4 kilometres to W.: fresh autumn snow. Compare with Fig. 9 in text, p. 339.
	2.	The Tarntaler Köpfe; from the ridge of the Kreuzjöchl, distant 3 kilometres to S.W. by W. Two summits, 2836 and 2891 metres, in the middle of the picture, belong to the main mass of serpentine which shows dark against other rocks.
XVI.	3.	The ridge of the Nederer, showing the strong vertical jointing; from S.S.W.
	4.	Reckner (serpentine) on the right, Kahlewand (dolomite) on the left; from the serpentine peak 2836 metres to W. of Reckner.
XVII.	5.	The scree-cone (Issl) under the Lower Tarntal. From the lip of the Grübl corrie.
	6.	The head of the Lower Tarntal where the valley is beheaded by the Lizumbach; looking eastward.
XVIII.	7.	Lake at the lower end of the Upper Tarntal, with moraine dam beyond; looking westward.
	8.	The ridge to north of the Mieselkopf (2653 metres of map); looking westward.

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FIG. 7. Lake, lower end of the Upper Tarntal with moraine dam (looking west).
„ 8. Ridge north of the Mieselkopf (looking west), 2653 metres on map.

III.—Note on the Mandible of a New Species of *Tetrabelodon* from the Loup Fork Beds of Kansas.

By C. W. Andrews, D.Sc., F.R.S., British Museum (Nat. Hist.).[1]

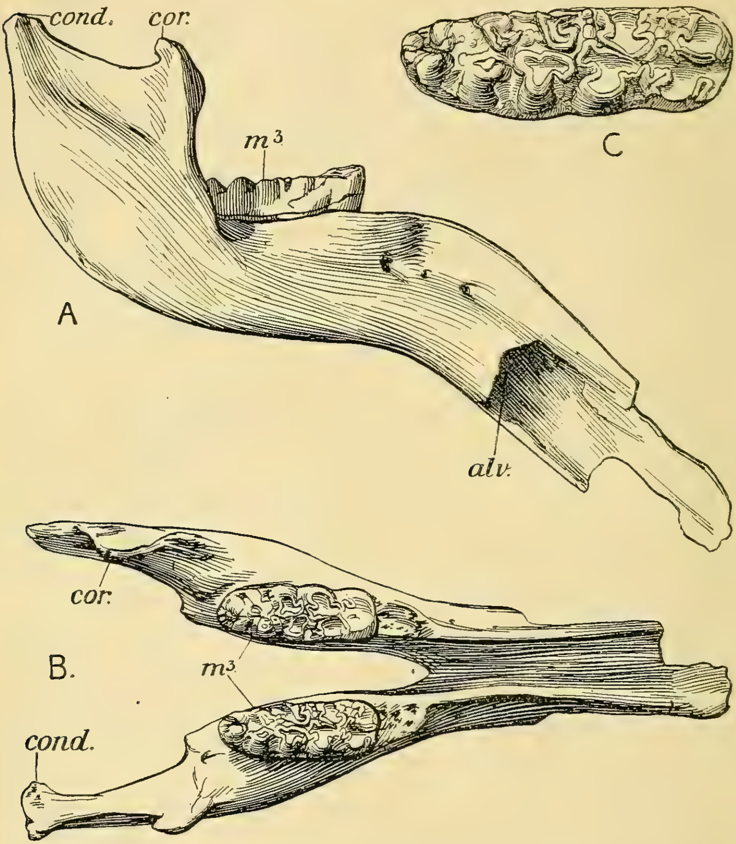
A CONSIDERABLE number of species of Tetrabelodont Mastodons are already known from various horizons and localities in the United States. Several of these from the Loup Fork deposits have been described by Cope,[2] the best known being *Tetrabelodon euhyphodon*, *T. campester*, and *T. productus*. A fairly complete mandible recently acquired by the British Museum seems to indicate that yet another very distinct form existed contemporaneously with those just mentioned. This specimen, which forms the subject of the present note, was obtained from Mr. Sternberg, the well-known collector of fossil Vertebrates, who refers to it in his recently published work *The Life of a Fossil Hunter* (p. 123) under the name *Trilophodon campester*, Cope, from which, in spite of some similarity, I believe it to be very distinct.

The mandible, which I propose to make the type of a new species, *Tetrabelodon dinotherioides*, is from the Loup Fork Beds of North-Western Kansas. It is not quite complete, the upper portion of the ascending ramus being wanting on the left side, while on the right the articular condyle is much worn. The symphysial region also is imperfect, the outer walls of the sockets of the great lower tusks being broken away, while the extremity also is missing, the symphysis when complete probably having been considerably longer. The most striking character of this mandible is the great length and massiveness of the symphysial region (Figs. A, B), which, moreover, is deflected to a greater extent than is the case in any other *Tetrabelodon*, though considerably less so than in *Dinotherium*. The spout-like upper surface of the symphysis is narrow and deep posteriorly, its concavity being about a semicircle; in this region its alveolar edges are comparatively thin and sharp. Anteriorly this surface widens out, its concavity is less marked, and its borders become thickened and rounded. As will be seen from the figures and the table of measurements, the whole symphysial region was very massively developed, and the lower tusks, which perhaps were decurved as in *Dinotherium*, must have been very large, the vertical diameter of their roots being about 11 cm., rather greater than the width from side to side. The mandibular rami are very thick from within outwards, and are deepest just behind the symphysis. Their outer and ventral surfaces are strongly convex transversely. The ventral border is concave from before backwards just behind the symphysis, but farther back becomes strongly convex, passing into the hinder border of the ascending ramus: in fact, the whole posterior and ventral outline of the mandible seen in profile is a sigmoid curve. The condyle is not well preserved on either side; it rises about 23 cm. above the upper surface of the molars. Between the condyle and the

[1] Published by permission of the Trustees of the British Museum.

[2] Cope, "The Proboscidea": *American Naturalist*, 1889, vol. xxiii, p. 291.

coronoid process the upper border is strongly concave; the short coronoid process, which does not rise so high as the condyle by about 4 or 5 cm., is curved strongly backwards. The anterior border of the



Mandible of *Tetrabelodon dinotherioides*, sp. nov., Andrews, from the Loup Fork Beds, North-Western Kansas.

A. Right side of mandible, $\frac{1}{12}$ nat. size.
B. Upper view of entire mandible, $\frac{1}{12}$ nat. size.
C. Upper view of third right lower molar, $\frac{1}{6}$ nat. size.

alv. = alveolus of tusk; *cond.* = condyle; *cor.* = coronoid process; m^3 = third lower molars.

Drawn from original specimen in the Geological Department, British Museum (Natural History).

ascending ramus is convex above but concave below, passing into the outer face of the horizontal ramus a little in front of the posterior end of the last molar tooth. The position formerly occupied by the posterior end of m. 2 is indicated by a flat, roughened surface of triangular form, the anterior angle being continuous with the alveolar edges of the symphysial groove. There are three nutritive foramina on the outer surface of the jaw. They are separated by nearly equal intervals of about 5·5 cm., and the hindermost is about opposite the hinder end of the symphysis.

Of the teeth, the incisors have been entirely lost and the last molars alone remain, the second having been already shed before the death of the animal. The last molars are in a not very advanced state of wear, the posterior lobes being as yet untouched. Each (Fig. C) consists of four transverse ridges and a posterior lobe. Each ridge is composed of an outer and an inner portion distinctly separated. The outer tubercles give a trefoil pattern in wear, while the inner are imperfectly divided into an inner and an outer portion. There is a tendency to the alternation of the outer and inner portions of the ridges, the inner tubercle being situated opposite the anterior lobe of the outer trefoil, the posterior lobe of which almost blocks the transverse valley. There are also some small accessory tubercles in the valleys. The posterior lobe of the tooth consists of an inner and an outer tubercle and a cusp, imperfectly divided into two, forming the extreme posterior angle of the crown. The cingulum is developed on the outer side of the tooth, opposite the openings of the transverse valleys. The whole crown is very low, but at the same time it seems to have been thickly covered with cement, which nearly fills the valleys. The specimen described above appears to indicate the existence of a species widely different from those previously described from this horizon. The only forms with which it might be compared are *Tetrabelodon euhyphodon*, *T. campester*, and *T. proavus* of Cope. From the former of these it is distinguished by the much greater deflection of its symphysial region and the larger number of ridges in its last lower molar. *T. campester* has a much more slender and less deflected symphysial region. In *T. proavus* also, judging from Cope's figure, although the symphysis is more massive than in *T. campester*, it is much less bent down than in the present species, and the whole jaw seems to be more slender.

The dimensions of this specimen are—

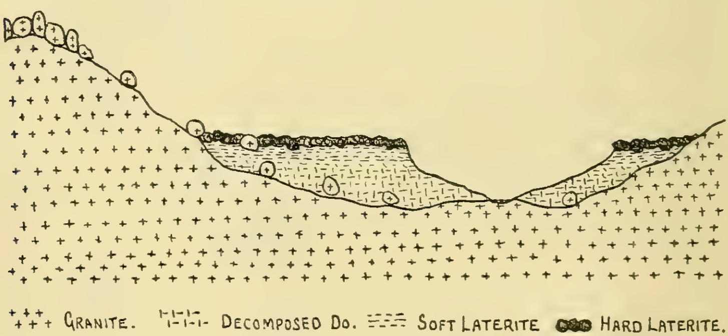
		cm.
Length from condyle to tip of symphysis	(approx.)	126·5
Length from posterior end of m. 3 to tip of symphysis		93·5
Length of symphysis		63·6
Width of ascending process	(approx.)	27·0
Width between condyle and tip of coronoid process		22·5
Depth of symphysis at hinder end		21·0
Vertical diameter of socket of tusk	(approx.)	11·0
Transverse diameter of socket of tusk	(approx.)	7·5
Depth of mandibular ramus at symphysis		21·0
Depth of mandibular ramus opposite anterior edge of ascending process		16·0
Thickness of mandibular ramus beneath m. 3		16·0
Depth of concavity of upper surface of the hinder end of the symphysis		5·0
Width of concavity of upper surface of the hinder end of the symphysis		7·5
Width between the posterior ends of the molars	(approx.)	18·0
Length of last lower molar		24·0
Width of last lower molar		8·7

IV.—Notes on Rhodesian Laterite.

By F. P. Mennell, F.G.S.

A NUMBER of communications dealing with the origin and composition of the material commonly known as laterite have appeared in the Geological Magazine during the past few years. That of Dr. Maclaren[1] is an especially valuable contribution to the literature of the subject, and I think few workers in the Tropics will be disposed to question the substantial accuracy of his conclusions. I shall not attempt, therefore, to discuss the general problem presented by the widespread occurrence of laterite deposits in tropical regions. The object of the present brief communication is merely to place on record a few observations made in another area.

Conditions of Formation.—Mr. J. R. Kilroe in his interesting communication regarding the German bauxites seems inclined to question the necessity of tropical conditions for the accumulation of laterite. He states[2] that on this supposition laterite should be met with everywhere throughout the Tropics. As a matter of fact, it is. In Rhodesia, for instance, it is by far the most abundant superficial deposit. It may be pointed out, however, that it is not tropical heat which is the essential condition, but the alternation of perfectly distinct wet and dry seasons, which is only observed in or near the Tropics. In Bulawayo (20° S. lat.), for example, we have in an ordinary season about 25 inches of rain, which falls in the summer months, say from about the middle of October to the middle of April.



Sketch to illustrate a common mode of occurrence of Laterite.

There may be occasional showers in September or May, but as a general rule June, July, and August are absolutely rainless. Usually, indeed, there is no rain whatever between the end of April and the end of September. Over most of Rhodesia the rainfall is heavier than near Bulawayo, but precisely similar conditions prevail. Scattered over the country, therefore, we find considerable tracts (chiefly on the granite) which are distinctly marshy during the rainy season, but dry up completely when the wet weather comes to a close. Thus among the Matopo Hills there are a number of valleys which may usually be

[1] Geol. Mag., 1906, pp. 536–47. [2] Op. cit., 1908, p. 539.

regarded as swamp from November to March, though many of them are quite dry for the rest of the year. It is, of course, difficult to ascertain the nature of the changes going on beneath the surface of the soil in a present-day swamp, though by digging in the dry season I have found that deposits of a lateritic nature were disclosed at a depth of a couple of feet under the soil. This last is always somewhat peaty, so that there must be abundance of carbonic acid, and possibly other stronger acids of organic origin, to aid in the chemical changes to which the production of laterite is due.

Mode of Occurrence.—The most conspicuous occurrences of laterite are those in which it may be seen lying about all over the surface or showing up through the soil in large blocks. These are due, of course, to changes in the physical geography of marshy tracts. Erosion along a particular line of drainage has led to the formation of a well-defined channel which has drained the swamp and incidentally carried off most of the soil which originally concealed the laterite. There are some very interesting cañon-like valleys cutting through the comparatively level ground between some of the lines of hills in the Matopos, e.g. to the north of Mount Impu. These little cañons are usually about 15 to 30 feet deep, with almost vertical sides, which they owe to the crust of hard laterite overlying the softer material and decomposed granite in which the streams have cut their channels. When the hard bed-rock is reached the process of widening the valleys becomes inevitable, and accordingly most deposits of laterite occur as a capping to terraces on either side of a valley. The slope of these terraces is sometimes considerable. This is not due to erosion, but to the curious feature shown by so many swamps in this country (Rhodesia), of occurring on sloping instead of on level ground. Some of the Matopo swamps which show standing water everywhere have quite a considerable inclination.

The section given shows the general mode of occurrence that we have described. It is based on a sketch made about 10 miles south-east of the World's View in the Matopos.

Underlying Rocks.—It is perhaps well to emphasize the fact that the accumulation of laterite does not appear to be dependent to any extent on the nature of the underlying rocks. Mr. Kilroe does not seem to realize this important fact; indeed, the idea seems prevalent that basalt or dolerite is the general source, though it may be noted that Dr. Maclaren's figured example[1] is stated as overlying quartz-biotite-schist. Laterite occurs, to my personal knowledge, in Rhodesia, resting on nearly every possible description of rock. The following may be cited, the locality of one such occurrence being given in brackets in each case:—

Sedimentary:	Gravel (Somabula).
	Sandstone (North of Gwelo).
	Limestone (Gwanda).
Igneous:	Granite (Matopos).
	Basalt (Shiloh).
	Picrite (Selukwe).

[1] Geol. Mag., 1906, p. 538.

Metamorphic: Hornblende-schist (Bulawayo).
Chlorite-schist (Gatooma).
Schistose Serpentine (Sebakwe).
'Banded Ironstone' (Hopefountain).

As regards the sediments cited in the two first instances, the laterite may perhaps be regarded as of detrital origin, at least in part. In all the other instances it is due to the decomposition *in situ* of the underlying rocks, whose nature is reflected in the constitution of the resulting laterite.

Composition.—The commercial importance attaching to the highly aluminous varieties of laterite has led to their being given much prominence in discussing its origin, and perhaps rather obscured the fact that such deposits are of limited extent. The ordinary forms of laterite are usually more or less conglomeratic, owing to the inclusion of abundant fragments of vein-quartz and of the underlying rocks, as well as drifted sand, etc. The following determinations of the more important constituents of three Rhodesian samples of laterite will serve to illustrate this point.

	A.	*B.*	*C.*
Iron oxide, Fe_2O_3	14·71	32·14	34·8
Alumina, Al_2O_3	1·41	·22	25·9
Combined water, H_2O	4·44	6·37	not det.
Insoluble (+silica)	75·10	60·69	29·2

A represents a light-coloured laterite resting on granite, from the Matopos; *B* a dark-coloured sandy laterite resting on hornblende-schist, near Bulawayo. Both of these were average bulk samples collected by the writer, in which the iron and alumina were first separately determined by the caustic alkali method and then checked by titration of the iron. *C* represents a reddish laterite from Northern Rhodesia presented to the Rhodesia Museum by Mr. L. Ludlow.

A and *B* probably represent the average composition of normal laterite much more nearly than most published analyses. As regards more exceptional varieties, very little investigation would probably reveal much more aluminous types than *C*. Some of the laterites from the Victoria Falls region are known to be very rich in iron, almost pure limonite, in fact. Although the underlying rock is basalt, they are very free, as a rule, from alumina. Some of the Somabula laterite contains a great deal of manganese, and must approximate in composition to wad.

V.—On some Fossils from the Nubian Sandstone Series of Egypt.[1]

By R. Bullen Newton, F.G.S.

(WITH A MAP, PLATE XIX.[2])

Introduction.

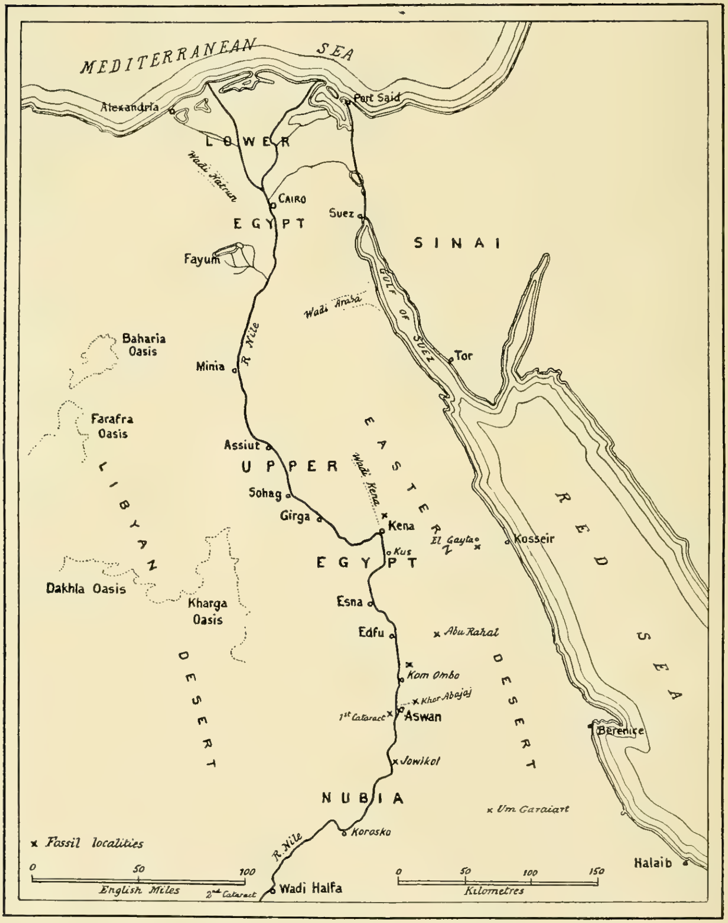
Dr. W. F. HUME, Superintendent of the Geological Survey of Egypt, has recently sent to the Geological Department of the British Museum, for determination and report, a few Pelecypod shells

[1] Published by permission of the Trustees of the British Museum.

[2] Plates XX and XXI, giving figures of the fossils, will appear with the concluding part of the author's paper in September.

SKETCH-MAP OF EGYPT

Showing localities whence fossils have been obtained from the Nubian Sandstone.



of fluviatile origin, directly associated with the marine genus *Galeolaria*, which he, in company with his colleagues Messrs. Crosthwaite and Murray, lately discovered in the ferruginous beds of the Nubian Sandstone Series of Southern Egypt.

As well as placing on record an account of these fossils, this paper includes the description of a remarkably fine example of an *Inoceramus* which Dr. John Ball, of the same Survey, discovered a few years since in another area of Southern Egypt, and in an exactly similar ferruginous deposit of the Nubian Sandstone formation.

The particular locality of the freshwater shells and the annelid tubes is given by Dr. Hume as Jowikol, situated on the east bank of the Nile, 19½ kilometres north of Kalabsha Temple and 40 kilometres south of Aswan. He writes: "The height of the fossil bed above Jowikol was approximately 137 metres above mean sea-level, or about 40 metres above the Nile. No granite was noted on this bank, the nearest outcrop on the east side being a granite range 5 kilometres to the east." The rock is highly ferruginous, of reddish-brown colour, and is distinctly a limonite, showing sometimes a minutely pisolitic structure. Remarking on this formation, Dr. Hume states: "The Nubian Sandstone often contains these hard ferruginous layers, but the greater part of the beds in this neighbourhood are fine-grained sandstones or fine-grained sandy clays."

Dr. Ball obtained his *Inoceramus* from the west end of the Aswan Dam during excavations for a small reservoir, at a height of not more than 20 metres above the old igneous rocks and a somewhat similar height above the Nile. The matrix surrounding this specimen is exactly similar to the Jowikol rock, although some 40 kilometres separate these two regions of the Nile Valley. The rarity of fossil remains in this formation adds an interest to the present specimens, especially as their characters appear to suggest a more definite age for this part of the Nubian Sandstone than has hitherto been acknowledged.

In concluding the preliminary statement the writer wishes to thank both Dr. Hume and Dr. Ball for the interest they have shown in the compilation of this paper. The former has supplied every fact of importance concerning the locality and geology in connexion with his discovery of the *Serpula* and fluviatile mollusca, whilst the latter has been good enough during his vacation in England to furnish information concerning the specimen of *Inoceramus*, as well as to prepare a sketch-map of Egypt including most of the localities referred to in the paper, the reproduction of which as one of the plates it is thought will add a greater interest to this contribution (see Map, Plate XIX).

Bibliography (restricted).

Without entering into the many problems connected with the history of the Nubian Sandstone, it may be of interest to briefly review some of the previous opinions on this subject, but only those having a bearing on the formation as it occurs in Southern Egypt and Nubia itself.

Joseph Russegger[1] was apparently the first geologist to recognize these rocks as the Nubian Sandstone—'Nubischer Sandstein.' He found it underlying the Cretaceous beds of Southern Egypt (Edfu, Aswan, and Kalabsha) and Northern Nubia (Korosko, etc.), associated with concretionary iron sandstone and brown ironstone, and with no evidence of fossils throughout its development. He regarded its age as Triassic and comparable to the European Keuper.

Lefévre,[2] another of the early students of this formation, ascribed its origin to the Cretaceous period, from an examination of the sandstone at Aswan (= Syène). Ehrenberg[3] came to similar conclusions after surveying the same area. He found that the "limestone is incumbent on sandstone—Quadersandstein?—and the two repose on granite and the primary rocks connected therewith".

The first mention of fossils in the Nubian Sandstone was made by Russegger,[4] who recorded the occurrence of dicotyledonous stems and a *Cyclas* from near Aswan, his statement being as follows: "In diesem Sandsteine der mit bunten Thonstraten wechselt, fand ich eine *Cyklas* (Faba, Münster? Steinkern mit einem kleinen Theil der aufsitzenden Schale), die einzige Versteinerung, die ich ausser Dikotyledonenstämmen in diesem Sandsteine in ganz Egypten und Nubia zu finden Gelegenheit hatte." On this occasion the author resigned his previous views of a Triassic age for this formation and determined it as Cretaceous — "Grünsandstein, Quadersandstein, Wealderthon." He also correlated the Sinaitic Sandstones with those of Lower and Upper Egypt and Nubia, and afterwards set out such results in tabular arrangement, which was published in a later volume of his *Reisen*.[5] The sandstone beds at Kalabsha were described as being horizontal.

According to Newbold's work on *The Geology of Egypt*,[6] only coniferous woods were found in the Nubian desert, whilst the silicified woods of the Egyptian desert were dicotyledonous. Newbold was, however, unable to fix the geological position of the sandstone formation.

In his geological description of the first cataract of Egypt, J. C. Hawkshaw[7] referred to the crystalline rocks forming the bed of the Nile being overlain on both banks by a sandstone of variable consistency and frequently impregnated with iron. He also observed that the sandstone contained "no vestige of organic remains, unless some of the nodules and concretions of ironstone can be regarded as indicative of such, as many of these appear at first sight to be the actual casts of shells".

It was Lartet's[8] opinion that the Nubian Sandstone should be

[1] Neues Jahrb., 1837, pp. 665–9; ibid., 1838, p. 630; ibid., 1840, p. 57. Bull. Soc. Géol. France, 1839, vol. x, pp. 234–9.

[2] Bull. Soc. Géol. France, 1839, vol. x, p. 144.

[3] London, Edinburgh, Dublin Phil. Mag., 1841, vol. xviii, p. 394.

[4] *Reisen in Europa, Asien, und Afrika* (Stuttgart, 1843), vol. ii, pt. i, pp. 276, 306, 314, 330, 570, 575.

[5] 1847, vol. iii, pp. 285–9.

[6] Quart. Journ. Geol. Soc., 1848, vol. iv, pp. 324–57. (An abstract of this paper was published in the Proc. Geol. Soc. London, 1842, vol. iii, pp. 785, 786.)

[7] Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 115–19, with geological sketch-map.

[8] Bull. Soc. Géol. France, 1868, ser. II, vol. xxv, p. 490.

correlated with similar rock formations of Algeria, Sinai, Syria, Arabia, and India (Bagh), and so be regarded as Middle Cretaceous or Cenomanian. Lartet found that no intrusions were observable from the underlying igneous rocks.

Bauerman[1] determined the sandstones of Arabia Petræa as similar to those of Egypt and Nubia, having older crystalline rocks below and undoubted Cretaceous above. He thought such beds were of Triassic age.

Ralph Tate's[2] remarks *On the Age of the Nubian Sandstone* are interesting, because a part of the formation in the Sinaitic region was recognized as Carboniferous from the fossils that were found in the associated limestones (*Orthis Michelini*, etc.), whilst the sandstone had yielded impressions of *Lepidodendron* and *Sigillaria*. Tate, likewise, referred to Unger's[3] determination of *Dadoxylon Ægyptiacum* (= coniferous) from the sandstone of Aswan and Um-Ombos of the Nile Valley, which he regarded as contemporaneous in age with the *Lepidodendron*[4] and *Sigillaria*[5] from the Sinaitic region.

In remarking upon the Red Sandstone of Nubia, Coquand[6] called attention to the discovery by Delanoue of *Ostrea Verneuili* of Leymerie, in a boring called 'El-Aoui' (since localized by Zittel as probably in the Wadi Ouh, south-east of Edfu), through 94 metres of 'Grès nubiens', which he considered proved the Garumnian age (= Upper Cretaceous) of that formation.

M. Pomel[7] would not recognize the Garumnian age of the sandstone advocated by Coquand. He regarded the sandstones of Central Sahara as chiefly Devonian, of Sinai and Nubia (the true Nubian Sandstone) as Carboniferous and extending into Abyssinia, Western Guinea as probably Corallian, and of Palestine and Western Barbary as Lower Cretaceous or about the horizon of the Neocomian or Gault.

The *Libyschen Wüste* by Zittel[8] treats very fully of the Nubian Sandstone. He places it in the Senonian group, and refers to *Mosasaurus* (*M. Mosensis*) remains having been found by Figari Bey at a depth of 400 feet in a boring in the valley of Kena in 'Aschgrauen Thon', similar to rocks occurring at Wadi Ouh, a large turtle carapace being also discovered on the same occasion.

The occurrence of *Dadoxylon* in Southern Egypt induced Dawson[9] to regard the Nubian Sandstone of that area as Palæozoic rather than Mesozoic, although he was of opinion that both in Southern Egypt and Sinai there was probably an Upper Palæozoic Sandstone supporting a not dissimilar sandstone of Lower Cretaceous age. Dawson also noted, in a section between Kom Ombos and Aswan, the occurrence of two distinct beds in the Nubian Sandstone, the upper consisting of a ferruginous irregular sandstone, the lower being grey and laminated.

[1] Quart. Journ. Geol. Soc., 1869, vol. xxvii, pp. 17–38.
[2] Quart. Journ. Geol. Soc., 1871, vol. xxvii, pp. 404–6.
[3] Sitzungsb. Akad. Wiss. (Wien), 1859, vol. xxxiii, p. 228, pl. i, figs. 3–5.
[4] Salter, Quart. Journ. Geol. Soc., 1868, vol. xxiv, p. 509.
[5] Holland, Quart. Journ. Geol. Soc., 1866, vol. xxii, p. 492.
[6] Bull. Soc. Géol. France, 1876, ser. III, vol. iv, pp. 159, 160.
[7] Ibid., pp. 524–9.
[8] *Palæontographica*, 1883, vol. xxx, pp. 59, 76, 77, 93.
[9] Geol. Mag., 1884, pp. 391–3.

In connexion with the geology of Wadi Arabah, Professor Schweinfurth[1] referred to the absence of fossils in the Nubian Sandstone (with the exception of silicified wood) as follows: "C'est en vain que certains voyageurs ont essayé de convaincre le monde géologique qu'ils avaient eux-mêmes détaché des pétrifications de ce grès." He further remarks that we often mistake sandstone-looking rocks, which represent in Egypt the lower stage of the Upper Chalk and which are rich in fossils, for the true Nubian Sandstone, which pass insensibly into them.

Professor Walther[2] originated the theory that the so-called 'Nubischer Sandstein' was an æolian dune formation which pointed to the existence of Palæozoic and Mesozoic deserts in Northern Africa.

An iron-ore deposit in the neighbourhood of Wadi Halfa has been described by Captain Lyons[3] as part of the Nubian Sandstone Series. It occurs in lenticular bands, and is usually of strongly oolitic structure containing fragmentary fossil wood, but, so far as his observations extended, without any other organic remains. The Nubian Sandstone was considered of estuarine origin, and not formed in the waters of a vast inland lake as maintained by Professor Edward Hull.[4] Captain Lyons was further of opinion that the sandstone of the Libyan area was Cretaceous, whilst that of the eastern parts of Egypt, Sinai, and Palestine was deposited during Carboniferous times.

When writing upon the geology of the Nile Valley, Professor Hull[5] stated that he had examined parts of the Nubian Sandstone of that area and had found it to be very unlike in mineral character to that of Cretaceous age in Arabia Petræa and the Arabah Valley, but he did not on that account think that such data were sufficient for regarding these distant deposits as of different geological ages.

Remarking further upon this subject, Captain Lyons[6] observed that the Nubian Sandstone to the south-east of Korosko (Nubia) "is laid down on the flanks of the crystalline hills, with little or no dip". It is of quartzose composition of variable colour—yellow, brown, and red, from staining by oxides of iron and manganese. Sometimes a more argillaceous bed is present, but this is not constant. No rock intrusion of the sandstone was observable.

In his extended account of this formation, Dr. Blanckenhorn[7] mentions Russegger's discovery of the shell-cast near Aswan, which was said to resemble *Cyclas faba* of the Wealden formation. He does not favour the Garumnian age of the sandstone as advocated by Coquand. In a correlation scheme of the Cretaceous formations of Egypt he regards the Nubian Sandstone of the Libyan Desert as Campanian, that of the Nile Valley and southern parts of the Arabian Desert as Santonian, and the northern parts of the Arabian Desert as

[1] Bull. Instit. Égyptien, 1888, ser. II, No. 8, p. 156.
[2] Verhandl. Ges. Erdkunde, Berlin, 1888, vol. xv, p. 253.
[3] Quart. Journ. Geol. Soc., 1894, vol. l, pp. 531–47.
[4] Trans. Victoria Institute, 1890, vol. xxiv, p. 317.
[5] Quart. Journ. Geol. Soc., 1896, vol. lii, p. 311.
[6] Quart. Journ. Geol. Soc., 1897, vol. liii, p. 362, with sketch-map showing distribution of sandstone in that area.
[7] Zeitsch. Deutsch. Geol. Ges., 1900, p. 31.

Cenomanian. He quotes *Ostrea Boucheroni* (?) and *Mosasaurus*, as occurring in the Nubian Sandstone of Kena in the Nile Valley, as being of Santonian age; and from El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern or Arabian Desert, he identified *Ostrea Boucheroni* and *O. Bourguignati* as Nubian Sandstone fossils belonging to the Santonian; whilst the siliceous wood stems, known as *Araucarioxylon Ægyptiacum* and *Nicolia Ægyptiaca*, are recognized as being of Campanian age.

In connexion with their survey of the central portion of the Eastern Desert of Egypt, Messrs. Barron & Hume [1] state that east of Kena the softer beds of the sandstone near the summit have yielded a vertebra of *Mosasaurus*. These authors agree with previous opinions, that the Nubian Sandstone has been laid down on an eroded surface of an old igneous region.

Dr. John Ball,[2] in his report on Jebel Garra and the Oasis of Kurkur, referred to the Nubian Sandstone as follows: "With the exception of silicified wood and a single badly-preserved gastropod (*Natica* sp.), no fossils were found by the author in the sandstone of Lower Nubia, but the position of the beds, where overlain by other rocks near Jebel Garra, is such as to leave no doubt of their Cretaceous age."

A further study of this formation by Dr. Hume [3] in the Peninsula of Sinai enabled him to recognize it as probably a marine deposit on account of the coarse conglomerates at its base and the rare occurrence of marine shells in it, referring in this connexion to Dr. Ball's recent discovery of *Inoceramus Cripsi* near Aswan, which had been determined by Dr. Blanckenhorn.

In his memoir on the geology of the Aswan district of the Nile Valley, Dr. Ball [4] acknowledges that the age of the Nubian Sandstone has been a frequent subject of controversy. He mentioned that some similar sandstones of Sinai are Carboniferous, whereas those of the Oases and Nubia itself are Cretaceous. His discovery of *Inoceramus Cripsi*, as determined by Dr. Blanckenhorn, in the sandstone beds close to the west end of the reservoir dam at Aswan, is also referred to.

Again, in the Eastern Desert of Egypt Dr. Hume [5] gathered some valuable information on the Nubian Sandstone Series and some fossils in connexion therewith. He referred to a fossiliferous shale occurring at Abu Rahal, 40 kilometres east of Edfu, at a depth of over 50 metres (a well boring), containing carbonized plant-remains, numerous examples of a *Lingula*, a mytiloid shell, *Septifer* cf. *lineatus* of J. de C. Sowerby, sp., as well as a Ganoid scale: "the aspect of the fauna being thus markedly Cretaceous." Further on in the same report Dr. Hume mentioned the discovery of fern-fragments in the Nubian Sandstone to the north-west of Um Garaiart, in the Wadi Alagi, by Mr. Charteris Stewart, which, according to Professor

[1] *Notes on the Geology of the Eastern Desert of Egypt* (London, 1902), pp. 172, 181, 200.

[2] Survey Department, Public Works Ministry, Egypt (Cairo, 1902), pp. 25–9.

[3] Survey Department, Egypt (Cairo, 1906), pp. 152, 153.

[4] Survey Department, Egypt (Cairo, 1907), p. 67.

[5] Survey Department, Paper No. 1 (Cairo, 1907), pp. 29, 32, footnotes.

Seward,[1] exhibited strong resemblances to the Carboniferous *Pecopteris* and the Wealden *Weichselia.* The results of a further study of this plant enabled Professor Seward to recognize it as part of a frond of *Weichselia,* and although, with considerable hesitation, he was inclined to regard it as of Wealden age, he was aware that no great weight should be attached to such an opinion. The same expert described another fern (in the same paper) from the Nubian Sandstone, found by Mr. H. T. Ferrar east of Edfu, between Wadi Dum and Wadi Abbad, as *Clathropteris Egyptiaca,* n.sp. In connexion with this it is stated that "such evidence as the fragment affords is primarily in favour of Rhætic or Lower Jurassic age", an opinion, however, which is mentioned as being contrary to that of Dr. Hume, who regards the sandstone in which the specimen was found as Upper Cretaceous.

It will be convenient now to tabulate the fossils from the Nubian Sandstone Series of Southern Egypt and Nubia, which have been briefly referred to in the foregoing review of published notices on this subject.

RECORDED FOSSILS FROM THE NUBIAN SANDSTONE OF SOUTHERN EGYPT AND NUBIA.

(The authorities for horizons are placed in square brackets.)

REPTILIA.

MOSASAURUS MOSENSIS, Zittel MS. (=list name).

Horizon.—Senonian [Zittel; Barron & Hume].
Locality.—Kena Valley (boring 400 feet depth).

PISCES.

(Ganoid scale.)

Horizon.—Cretaceous, shales in Nubian Sandstone Series [Hume].
Locality.—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres = 164 feet depth).

PELECYPODA (= LAMELLIBRANCHIATA).

CYCLAS FABA, ? Münster (accompanied by dicotyledonous stems).

Horizon.—"Grünsandstein, Quadersandstein, und Wealderthon" [Russegger].
Locality.—Near Aswan.

INOCERAMUS CRIPSI, Blanckenhorn MS., *non* Goldfuss *nec* Mantell.

Horizon.—Senonian (Campanian) [Blanckenhorn].
Locality.—Aswan, reported by Hume and Ball.

OSTREA BOURGUIGNATI, Coquand.

Horizon.—Senonian (Santonian) [Blanckenhorn].
Locality.—El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern Desert.

OSTREA BOUCHERONI (?), Coquand.

Horizon.—Senonian (Santonian) [Blanckenhorn].
Locality.—Kena, Nile Valley; El Gayta, about 40 kilometres east of Kus, in the southern half of the Eastern Desert.

OSTREA VERNEUILI, Leymerie.

Horizon.—Danian (Garumnian) [Coquand].
Locality.—'El-Aoui,' probably in the Wadi Ouh, south-east of Edfu (well boring 94 metres = 308 feet depth).

[1] GEOL. MAG., 1907, pp. 253–7, with woodcut figures.

SEPTIFER cf. LINEATUS, J. de C. Sowerby, sp.

Horizon.—Cretaceous (shales) [Hume].

Locality.—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres = 164 feet depth).

BRACHIOPODA.

LINGULA sp.

Horizon.—Cretaceous (shales) [Hume].

Locality.—Abu Rahal, 40 kilometres east of Edfu (well boring 50 metres depth).

PLANTÆ.

ARAUCARIOXYLON (DADOXYLON) ÆGYPTIACUM (Krauss), Unger.

Horizon.—Senonian (Campanian) [Blanckenhorn].

Locality.—Aswan and Um-Ombos (= Kom Ombo), between Aswan and Edfu; Dakhla Oasis (recorded by Schenk in Zittel).

NICOLIA ÆGYPTIACA, Unger.

Horizon.—Senonian (Campanian) [Blanckenhorn].

Locality.—Libyan Desert (east of Regenfeld; see Zittel).

WEICHSELIA sp. (= Fern).

Horizon.—Wealden [Seward].

Locality.—North-west of Um Garaiart, Wadi Alagi, Northern Nubia (about 70 kilometres eastward of the Nile).

CLATHROPTERIS EGYPTIACA, Seward (= Fern).

Horizon.—Lower Jurassic [Seward]; Upper Cretaceous [Hume].

Locality.—Between Wadi Dum and Wadi Abbad, east of Edfu.

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

VI.—GEOLOGY AND PETROLOGY OF THE INTRUSIONS OF THE KILSYTH-CROY DISTRICT, DUMBARTONSHIRE.

By G. W. TYRRELL, A.R.C.Sc., Assistant in Geology, Glasgow University.

(*Concluded from the July Number, p.* 309.)

V. MUTUAL RELATIONS AND ORDER OF CRYSTALLIZATION OF THE ESSENTIAL CONSTITUENTS.

THE general appearance of this rock in thin section is of an interlocking framework of plagioclase, augite, and iron-ores, with micropegmatite occupying the interstices. The mutual relations of the felspar and augite vary considerably. The felspar may be entirely enclosed in the augite. In this case it is very basic and only faintly zoned. The most common relation is for the augite to enclose the terminations of the felspar laths, the sub-ophitic structure of Watts.[1] But frequently idiomorphic crystals of augite are found partly or wholly enclosed in felspar. The latter is then more acid than the ophitic felspar, and is broadly zoned. These varying relations may frequently be found within the limits of a single slide.

These facts may be completely explained on the hypothesis that felspar substance separated from the magma during practically the whole process of crystallization; whilst the separation of the pyroxenes was episodal, beginning after the first separation of felspar, thus enclosing some of the earlier basic crystals, and ending before the complete separation of the later, more acid felspars. The latter were therefore

[1] *Ancient Volcanoes of Great Britain*, vol. i, p. 417.

able partly or wholly to enclose crystals of augite. There is no evidence of two separate generations of felspar. The crystallization of the felspar was a perfectly continuous process, the composition varying from labradorite at the beginning to acid oligoclase at the end.

The earlier felspars, augite, and iron-ores are perfectly idiomorphic towards the micropegmatitic ground-mass, but the later felspars, as explained above, appear to be continuous with the felspar of the micropegmatite. This is specially noticeable in the coarser varieties. The micropegmatite is in all probability the eutectic mother-liquor left after the separation of the more basic elements.[1] In an instructive study of similar rocks from India, Sir Thomas Holland has suggested that in a large boss, where the separation of the basic element is comparatively small, the mother-liquor may crystallize as a large body of granophyre. He would thus explain the frequent association of gabbro and granophyre.[2] It would also go far to explain the frequently puzzling and contradictory relations of these two rocks, which in the case of Skye led several careful observers to take conflicting views as to which of the rocks was intrusive in the other.

The Acid Veins.

A thin section of an inch vein from Colzium Quarry, Kilsyth, shows under the microscope an apparently homogeneous mass of kaolinized felspars, with minute grains of quartz, diversified by a few sporadic crystals of augite, many ragged flecks of a deep-green chlorite, and small skeleton-crystals of ilmenite. Between crossed nicols the rock is seen to consist essentially of an interlocking aggregate of small, stumpy felspars, highly altered, but still showing lamellar twinning. The decomposed condition of the crystals prevents a determination of the extinction angle, but by the application of the Becke method to small areas of comparatively unaltered felspar in contact with balsam, it can be shown that the refractive index is lower than that of balsam. The felspar therefore in all probability belongs to albite. This is in accord with the results of Elsden and Falconer on the similar rocks of St. Davids and Bathgate Hills respectively. These veins are similar to many aplites and micro-granites. Petrographically they are soda-aplites or soda-microgranites. In the larger veins quartz and micropegmatite are rare, but with a decrease in the width of the veins there is a corresponding increase in the proportion of these constituents, and the rock becomes more and more like the intersertal material in the diabase.

The Contact Rocks.

Towards the margin the structure becomes more and more ophitic, the felspars become more lathy, the proportion of iron-ore increases, micropegmatite and quartz dwindle and disappear, and the rock finally takes on a thoroughly basaltic structure. The felspar, however, remains of the same species—medium labradorite—as in the coarser rocks, and the increasing basicity towards the margin must be

[1] Teall, *Brit. Petrog.*, 1888, p. 401.
[2] Holland, Q.J.G.S., 1897, vol. liii, pp. 412–14.

attributed to an increase in the proportion of the femic constituents. At the actual margin spherulitic and tachylytic structures sometimes occur, and where in contact with carbonaceous strata the rock suffers the endomorphic metamorphism resulting in the production of 'white trap'.

A slide from a specimen taken from the lower margin of the great Sauchie sill near Stirling shows sparse but uniformly scattered felspar microlites in a greyish cryptocrystalline ground-mass, with numerous small grating-like skeletal crystals of ilmenite. There are interspersed numerous small microporphyritic groups of fresh lathy plagioclase. Here and there are small corroded xenocrysts of quartz.

VI. The Chemical Composition.

Mr. D. P. Macdonald, M.A., B.Sc., Baxter Demonstrator in Geology at Glasgow University, has kindly made me a complete analysis of the normal type from the Auchinstarry Quarry, Kilsyth.

The result is given in Table I, col. I, below—

TABLE I.

	I.	II.	III.	IV.
SiO_2	49·80	50·71	48·02	50·55
TiO_2	1·56	1·92	3·36	1·58
Al_2O_3	17·77	14·78	13·03	15·00
Fe_2O_3	2·29	3·52	2·11	2·54
FeO	8·75	8·95	9·99	7·90
MnO	tr.	·31	tr.	—
MgO	5·67	5·90	4·21	6·25
CaO	8·85	8·21	9·77	7·85
K_2O	·48	1·39	·49	1·10
Na_2O	1·48	2·76	2·17	3·53
H_2O (−)	1·04	1·28	1·05	·55
H_2O (+)	2·62		4·27	3·14
CO_2	—	·25		—
P_2O_5	tr.	—	·395	—
F	—	—	·058	—
	100·31	100·48	100·16	99·99
Sp. Gr.	2·932	2·944	—	2·92

I. Diabase, with micropegmatite (granophyric diabase), Auchinstarry, Kilsyth.
II. Diabase, Whin Sill, Crags near Roman Station of Bourgovicus, Northumberland.[1]
III. Diabase, dark-coloured modification (somewhat weathered), Kettlestoun Quarry, Bathgate Hills.[2]
IV. Quartz Gabbro (intermediate type), east flank, Carn Llidi, 10 yards from margin of sill, St. Davids.[3]

[1] Teall, Q.J.G.S., 1884, vol. xl, p. 654.
[2] Falconer, T.R.S.E., 1905–6, vol. xlv, pt. i, p. 147.
[3] Elsden, Q.J.G.S., 1908, vol. lxiv, p. 281.

The annexed analyses of similar British rocks illustrate the remarkable uniformity of composition prevailing in this type. All are diabasic rocks with quartz or micropegmatite. The only point of difference in the Kilsyth rock is its higher content of alumina and its lower content of alkalis as compared with the rocks of the Whin Sill and St. Davids.

In Table II, cols. I–IV below, is given the mineral composition (norm) of the above rocks, calculated according to the method of Cross, Iddings, Pirsson, and Washington.[1] The augite is assumed to have the theoretical composition CaO, $(Mg.Fe)O$, $2SiO_2$, and the hypersthene MgO, FeO, $2SiO_2$.

TABLE II.

	I.	II.	III.	IV.		V.	VI.	VII.	VIII.
Quartz . .	7·38	1·74	6·60	—	Micropegmatite	10·16	10·08	9·38	6·67
Orthoclase .	2·78	8·34	2·78	6·67					
Albite . .	12·58	23·06	18·34	29·34	Plagioclase .	53·17	46·97	42·53	51·30
Anorthite .	40·59	23·91	24·19	21·96					
Augite . .	2·75	13·63	20·04	13·79	Pyroxenes .	27·14	32·55	31·63	32·34
Hypersthene .	24·39	18·92	11·64	18·55					
Magnetite .	3·25	5·10	3·02	3·04	Iron-ores .	6·29	8·75	9·40	6·75
Ilmenite .	3·04	3·65	6·38	3·71					
Water, CO_2, &c.	3·66	1·53	5·77	3·69	Water, CO_2, &c.	3·66	1·53	5·77	3·69
	100·42	99·88	98·76	100·75		100·42	99·88	98·76	100·75

A remarkable point about these calculated mineral compositions is the very large proportion of orthorhombic pyroxene they show. This is especially marked in the Kilsyth rock. The actual proportion of this mineral, however, is usually small and much lower than that of monoclinic pyroxene. In the Kilsyth rock it is very small indeed. The inference is, then, that the monoclinic pyroxene contains a considerable admixture of the hypersthene molecule. This has been directly proved by analysis in the case of the Whin Sill rock, the similar 'augite-diorite' of Southern India, and the St. Davids rock.

The mineral composition of these rocks shows much greater uniformity if quartz and orthoclase (= micropegmatite) be taken together, also albite and anorthite (= plagioclase), augite and hypersthene (= pyroxenes), and magnetite and ilmenite (= iron-ores), as shown in Table II, cols. V–VIII.

VII. Affinities and Relationships of the Kilsyth-Croy Rocks.

The rocks described in this paper are identical in chemical composition and down to the minutest microscopical details with the Whin Sill, as described by Dr. Teall.[2] The latter, indeed, is the most southerly member of the great group of late or post-Carboniferous dykes and sills of South Scotland and North England. They are

[1] *Quant. Class. of Igneous Rocks*, 1903, p. 186 et seq. [2] Op. cit., p. 28.

essentially the same as the rocks described under various names by Elsden from the St. Davids area,[1] by Harker from Carrock Fell,[2] by Sollas from Barnavave, Carlingford,[3] and by Falconer from the Bathgate Hills.[4] If the search for similar or identical rocks be carried beyond these islands, it is found that diabase with micropegmatite has a worldwide distribution. In Europe it has been described by Tornebohm from Sweden and by Barrois from Brittany; in Asia it has been described by Holland from South India; in North America it occurs in the Lake Superior region and in New England, as described by Lawson, Lane, Hawes, and others; in South America Harrison has described it as occurring in great abundance in the interior of British Guiana; in Africa Howe has described it from the north-eastern territories of the Congo Free State; and lastly it has been described by Prior as occurring at South Victoria Land in the Antarctic Continent.

A feature of these rocks is the remarkably constant chemical composition of the normal type, containing plagioclase, pyroxenes, micropegmatite, and iron-ores in proportions similar to those of Table II. This type makes up the main mass of the intrusions, and must be regarded as representing the actual mass composition of the magma from which the rock was immediately derived. The sometimes highly basic marginal facies and the granophyric veins must be regarded as opposite differentiation products of this magma. Table III gives the chemical composition of a few selected foreign diabases with micropegmatite. These should be compared with the British examples given in Table I.

The mode of occurrence of this rock is also distinctive. It always occurs in thick, massive, vertical-sided dykes, which sometimes continue for many score miles across country, and also as thick, laccolitic protrusions from such dykes. The great E.–W. dykes of the Midland Valley of Scotland are a classic example. The great dykes described by Lawson in the Rainy Lake district of Canada are of exactly the same type.[5] They are all more or less vertical, traverse all formations indifferently, continue for great distances (in one case 100 miles), and are of fairly uniform width (60–150 feet). They are diabases with micropegmatite, precisely similar to the Scottish examples. Moreover, the fissures along which they occur, as in Scotland, are not necessarily faults. The St. Davids Head rocks, according to Elsden,[6] occur in thick vertical sills between almost perpendicular Arenig shales. The augite-diorites with micropegmatite, described by Holland from South India, occur as a great series of basic dykes piercing the older crystallines of that area. One of them is 100 yards wide. An enormous number of these dykes, with their associated laccolites, occur in the interior of British Guiana. They pierce a basement of Archæan gneisses, granites, and schists, and are

[1] Op. cit., p. 28. [2] Q.J.G.S., 1894, vol. i, p. 311.
[3] Trans. Royal Irish Acad., 1894, vol. xxx, pp. 477–512.
[4] Op. cit., p. 28.
[5] "Report on Geol. of Rainy Lake Region": Ann. Rep. Geol. Survey Canada, 1887–8, pt. i, pp. 147–50.
[6] Q.J.G.S., 1908, vol. lxiv, p. 273.

anything from 50 feet to 500 yards wide. The latter dyke causes the great Tumatumari Falls on the Potaro River.[1] In South Victoria Land the rock occurs as great sills in the Beacon Sandstone, and at one point, at least, a large dyke or pipe of dolerite, 50 yards wide, was found cutting vertically through the sandstone beneath a sill.[2]

TABLE III.

	I.	II.	III.	IV.
SiO_2	52·68	51·19	53·26	51·15
TiO_2	—	·40	·70	·44
Al_2O_3	14·14	15·80	15·64	15·92
Fe_2O_3	1·95	3·08	·24	9·34
FeO	9·79	11·20	7·44	2·87
MnO	·44	tr.	·11	·09
MgO	6·38	5·63	8·64	6·48
CaO	9·38	9·58	12·08	10·40
Na_2O	2·56	2·09	1·25	1·19
K_2O	·87	·60	·58	1·61
H_2O	1·60	·30	·76	·11
CO_2	—	none	·04	—
P_2O_5	—	·008	—	·06
F	—	—	—	—
FeS_2	—	·005	—	—
	99·79	100·883	100·74	99·66
Sp. Gr.	2·97	—	—	3·19

I. Diabase, Mt. Holyoke, Massachusetts.[3]
II. Diabase, dyke, Potaro River, British Guiana.[4]
III. Dolerite (with Micropegmatite), Knob Head, South Victoria Land.[5]
IV. "Augite-Diorite with Micropegmatite," Seven Pagodas, Chingelput, India.[6]

In Scotland the great dykes occur as an after-phase of great extrusions of basic lavas. In India the augite-diorite dykes are believed to be associated with the basic Cuddapah lavas. Lawson suggests a relation between the great dykes of the Rainy Lake region and the Animikee and Keweenawan traps of that district. In Skye and other British centres of Tertiary volcanic activity, great extrusions of plateau basalts are followed by the intrusion of gabbro and granophyre in intimate relations, rocks which, if mixed a little more thoroughly, would be identical with granophyric diabase.

[1] Harrison & Perkins, *Rep. on Geol. of Essequibo and Potaro Rivers*, Georgetown, 1900, p. 35. Also Harrison, *Geol. of the Goldfields of British Guiana*, 1908.
[2] Ferrar, *Nat. Antarctic Exp.*, 1907, vol. i, "Geology," p. 50.
[3] Hawes, Amer. Journ. Science (3), 1875, vol. ix, p. 186.
[4] Harrison & Perkins, *Rep. on Geol. of Essequibo and Potaro Rivers*, 1900, p. 64.
[5] Prior, *Nat. Antarctic Exp.*, 1907, vol. i, p. 137.
[6] Holland, Q.J.G.S., 1897, vol. liii, p. 409.

Origin.—As I have not yet completely investigated the literature, I do not know whether these generalizations are true of every occurrence of diabase with micropegmatite. There are obvious difficulties in the way of proving their truth. If they are true, then it is certain that these facts have not only a very important bearing on the petrogenesis of diabase with micropegmatite, but also on petrogenesis in general. In Scotland both plateau basalts and the great dykes of diabase with micropegmatite appear to be connected with the great block fractures due to radial contraction of the earth. If this relation can be shown to hold elsewhere, it may open up attractive speculation as to the association of certain types of igneous rock, and perhaps certain modes of differentiation, with particular kinds of earth-movements.[1] In this field the recent work of Becke and Prior is sufficiently well known.

In the lack of synthetic data bearing on the origin of granophyric diabase, any theory must be regarded as purely speculative. In his very suggestive papers on the Mechanics of Igneous Intrusion,[2] Dr. R. Daly has advocated the theory of abyssal assimilation with subsequent gravity differentiation as a mode of origin of many igneous rocks. He believes that these owe their origin to the interaction of a postulated universal layer of potentially-liquid rock of gabbroid composition in the crust beneath the level of no strain, with the overlying acidic crust, the interaction taking place in chambers formed by 'magmatic stoping'. In one of his papers Dr. Daly hints that the peculiar field relations of gabbro and granophyre, so perfectly displayed in many parts of the United Kingdom, may be susceptible of explanation on the abyssal assimilation theory. It is impossible here, however, even to indicate in the barest outline the detailed facts and calculations upon which Dr. Daly bases his theory.

The suggestion is here put forward that the gabbro-granophyre mélange rocks owe their origin to the interaction of a normal basalt-magma with a highly siliceous country rock, in the manner advocated by Dr. Daly, and that the normal granophyric diabases, with their remarkably constant chemical composition, represent the saturation-point of such a magma with silica. The excess of siliceous matter is believed to be thrown out as a separate body of material usually consolidating as granophyre, in a manner analogous to the separation of the excess of a salt in a saturated solution. The theory thus crudely set forth can only be barely indicated, much less discussed, in this place. It depends largely on further synthetic research as to whether there is such a saturation-point for a basic magma in which silica has been dissolved. That granophyric diabase represents a critical point in the history of its magma may perhaps be inferred from the fact that it is almost entirely made up of intergrowths of related minerals. The iron-ore is made up of intergrown magnetite and ilmenite, the pyroxene probably of submicroscopic intergrowths of augite and

[1] See H. I. Jensen, "Distribution, Origin, and Relationships of Alkaline Rocks": Proc. Linn. Soc., N.S.W., 1908, vol. xxxiii, p. 491.

[2] Amer. Journ. Sci. (4), 1903, vol. xv, p. 269; (4), 1906, vol. xxii, p. 195; (4), 1908, vol. xxvi, p. 17. Also "Secondary Origin of certain Granites": A.J.S. (4), vol. xx, p. 185.

hypersthene, the highly zonal felspars may be considered as intergrowths of various plagioclases, and the final product of crystallization is an intergrowth of quartz and orthoclase.

New synthetic data as to the products of the fusion of plateau basalts or ultra-basic rocks with acid gneisses, schists, and sandstones, under varying conditions of temperature and pressure, might possibly throw some light on the problem. It is worthy of note in this connection that the magma-reservoirs of many occurrences of granophyric diabase may reasonably be supposed to be located in a highly siliceous country rock. The rock is very common in areas of fundamental gneiss, as in Scandinavia, Rainy Lake region of Canada, the interior of British Guiana, and Southern India. In Scotland the area is probably underlain by many thousand feet of Calciferous Sandstone, Old Red Sandstone, and perhaps the Dalradian gneisses and schists.

VII.—The Rhætic Section at Wigston, Leicestershire.

By L. Richardson, F.R.S.E., F.L.S., F.G.S.

At the Glen-Parva Brickworks, Wigston, near Leicester, is the finest section of the Rhætic beds that is to be seen in the Midlands. The large subcircular pit where the beds are displayed at once arrests the attention of the traveller on the adjacent railway as an excavation of more than usual size.

At the base of the pit are the red and greenish-grey-zoned marls of the Keuper, replete with layers of pink gypsum; then come the tea-green marls of the same series, well marked-off from the red rocks below and the markedly black shales of the Rhætic Series above; while at the top, at the western end of the pit, come reddish-stained gravels, and at the eastern the pale-yellowish marls and limestones of the Upper Rhætic succeeded by the basal beds of the Lower Lias with but a sprinkling of gravel here and there.

Naturally so fine a section as this has not escaped attention. It has been measured in detail by Edward Wilson and H. E. Quilter,[1] and investigated later by Mr. Montagu Browne,[2] who, in a report of an excursion of the Leicester Literary and Philosophical Society, has given pictures of the pit, diagrammatic sections, and criticisms on his predecessors' work. Others have briefly referred to it,[3] and Mr. C. Fox-Strangways in the Geological Survey Memoir on "The Geology of the Country near Leicester" (p. 16), has summarized the information that had been published previous to his time of writing.

The object, then, of this communication is obviously not to give a record of an entirely fresh section, but merely to suggest a somewhat different reading of a well-known one.

Commencing at the base of the section, the 12 to 15 feet of "Tea-green Marls" are very distinct, and the line of demarcation between them and the *Pteria-contorta*-Shales is exceptionally sharply defined.

[1] Geol. Mag., 1884, Dec. III, Vol. I, pp. 415–18.
[2] Trans. Leicester Lit. and Phil. Soc., 1901, vol. vi, pt. i, pp. 32–8.
[3] Idem, N.Q.S., 1889, vol. i, pt. ii, p. 14; A. S. Woodward, idem, p. 22.

Mr. A. R. Horwood, of the Leicester Museum, who read through this paper in its manuscript form and kindly made a special investigation of this section at my request, says (*in litt.*) that the lithic structure of the Tea-green Marls is quite different from that of the grey bands that are associated with the red marls.

The bone-bed is ill-defined as a hard bed, but there is usually present gritty matter, replete with fish coprolites, scales, teeth, pebbles, and an occasional fragment of bone, resting directly upon the Tea-green Marls. It is easily found by searching along the actual junction-line and looking closely for the black vertebrate remains. Mr. Montagu Browne remarks that it rests upon "an eroded surface of the marls".

SECTION AT THE GLEN-PARVA BRICK-WORKS, WIGSTON.

			Thickness in ft.	in.	
DRIFT.		Reddish clay, sand, and boulders: 8 to 27 feet.			
LOWER LIAS.	*c*	Shales, thinly laminated, dark grey (weathering yellowish), and crowded with fragments of echinoid-radioles and shell-débris: seen	1	0	Fragments of the radioles of echinoids and débris of *Ostrea liassica*, Strickl., *Plagiostoma* sp., *Volsella minima* (Sow.), and *Syncyclonema* sp.
	b	Limestone, fissile, hard, grey, blue-hearted, crystalline, almost made up of the fragments of echinoid-radioles and oysters: 1 to 3 inches	0	2	
	a	Marl, pale-yellow, sometimes shaly: 0 to 10 inches	0	5	? = Paper Shales.
			1	7	seen
Non-sequence.					
UPPER RHÆTIC.	1	Limestone, pale-yellow, greyish, blue-hearted, occurring in somewhat nodule-shaped masses, but continuous, and usually separating into two beds of like thickness: 10 inches to 1 foot.	0	10	
	2	Marls, yellowish, indurated, or an impure limestone: 4 to 8 inches.	9	9	Annelid-tracks and burrows.
	3	Limestone, impure, irregular, laminated, earthy, grey (weathering brown): 0 to 2 inches.			
	4	Marls, pale-yellow, occasionally laminated, but more often breaking with cuboidal fracture, with sandy and micaceous seams, scattered pyritic nodules, and more or less continuous indurated bands (one of which is particularly noticeable at or near the base): passes down into			
			10	7	

			Thickness in ft.	in.	
Lower Rhætic.	5*a* to 8	Shales, black, at first clayey, with thin seams of sandstone, the most noticeable, 1½ inches thick, at about 3 feet above 9	9	3	
	9	Limestone, pale bluish-grey, with fissures filled in with calcite and occasionally with baryto-celestine	0	5	["*Estheria minuta*," *teste* M. Browne.]
	10	Shales, black, less fissile in the upper portion	13	0	*Isocyprina Ewaldi* (Born.), *Chlamys valoniensis* (Defrance).
	11	Limestone-nodules, pale bluish-grey, septariform, with radiating gypsum	0	3	["? *Estheria minuta*," *teste* M. Browne.]
	12	Shales, fissile, gypseous, somewhat sandy	4	0	*Isocyprina Ewaldi* (Born.), *Protocardia rhætica* (Merian), *Pteria contorta* (Portlock), *Chlamys valoniensis* (Defrance), *Pholidophorus Higginsi*, Egerton, scales of *Gyrolepis Alberti*, Ag.
	13	Rust-coloured layer	0	1	
	14	Shales, thinly laminated in the upper portion, but more thickly laminated below	2	8	*Pteria contorta* (Portlock), *Isocyprina Ewaldi* (Born.), *Gyrolepis Alberti*, Ag. (scales and teeth).
	15	Bone-bed: 0 to 1 inch	0	1	*Acrodus minimus*, Ag., *Hybodus minor*, Ag., *Saurichthys acuminatus*, Ag., *Gyrolepis Alberti*, Ag., *Colobodus* sp., ichthyodorulite of *Nemacanthus* (fragments), etc.
			29	9	
Non-sequence.					
Keuper.	i	Tea-green Marls: 12 to	15	0	
	ii	Red marls with greenish-grey zones and pink gypsum: seen	12	0	
			27	0	seen

The very sharply defined line between the Tea-green Marls and the *Pteria-contorta*-Shales would suggest that this was the case, apart from the fact that it is now known that the Sully Beds intervene where the sequence from Keuper to Rhætic is as complete as it is everywhere in this country. Thus at Wigston the Keuper and Rhætic deposits are conformable to one another, but are nevertheless non-sequential.

On the south side of the pit, namely, that opposite to Glen-Parva Station, and immediately to the west of the ash-tip, it will be noticed that above the really black shales are pale yellowish and greenish-brown marls, somewhat laminated in places, with a pale-coloured limestone-bed at or near their base. Now it is at or may be a few inches below this limestone-bed that I would draw the line between the Lower and Upper Rhætic, thus making the Upper Rhætic the yellowish and practically unfossiliferous portion and the Lower Rhætic the darker and distinctly fossiliferous portion.

Wilson and Quilter drew it at 2 feet below the most prominent limestone-bed in the section, that is, below bed 9; but Montagu Browne would take that bed, his bed G, as the "break between the Upper and Lower Rhætic, which appears", he says, "rather to be determined by the thick band of limestone (G) than by shales that 'pass down' into similar ones" (p. 36).

At an earlier page (p. 32), however, Mr. Montagu Browne writes: "The dark shales following above this basal bone-bed are those known as the Lower Rhætic 'Black Shales', 'Paper Shales', in whole or in part, or *Avicula-contorta*-Shales (D), and are generally carried as far as the second band of limestone (G). In this instance I would prefer to limit them, if not just under the first band of limestone (E), to not far above that horizon, on both lithological and palæontological grounds." So apparently he did not form any very definite idea as to where the line should come.

As Wilson and Quilter remark, the feature of the *Pteria-contorta*-Shales that at once strikes anyone familiar with the Rhætic of the South-West of England is the rarity of hard bands. In the 29 feet 9 inches of deposit assigned to the Lower Rhætic there are only two noticeable hard bands, both limestones. The lower one is a line of well-spaced septariform nodules, more widely separated than Mr. Montagu Browne's diagrammatic section would lead one to infer. The upper and principal band, however, is more continuous, being made up of blocks of septariform limestone less commonly nodular. This bed much reminds one of a similar limestone numbered 9 at Langport and at several other Somerset sections.

There is not so great a variety of Rhætic fossils as might be expected in these beds, but along certain lines such species as do occur are individually very numerous, and fish—more perfect than is often the case—are not uncommon at from 3 ft. 6 in. to 3 ft. 9 in. above the base of the shales. A single ray of *Ophiolepis Damesi* has been found, but not *in situ*. This is unfortunate, for its detection *in situ* would have materially contributed towards the more accurate correlation of the component beds of this section with their equivalents elsewhere, seeing that it probably marks out a niveau at some 2 or 3 feet below the Lower *Pecten*-Bed.

The queried record of *Estheria minuta* in bed E of Mr. Montagu Browne's section, and the apparently certain record from his bed G, require confirmation. Neither limestone looks to me at all like those in which one would expect to find this phyllopod, and Mr. A. R. Horwood—who kindly made a special search at my request—also failed to detect any specimens. I should rather anticipate their discovery in the marls and associated beds of the portion that I have identified as Upper Rhætic.

It is obvious from the details that have been recorded by Mr. Montagu Browne that these beds are subject to considerable variation, and that, as I have also observed, the marls distinguished as *a* (Lower Lias) are often absent and then the fissile limestone *b* comes to rest directly upon the limestone numbered 1. A compound bed is the result, the upper portion of which belongs to the Lower Lias, and the lower to the underlying Rhætic Series. Since the upper portion has yielded *Psiloceras planorbis* on the testimony of both Wilson and Quilter and Mr. Montagu Browne, it is obvious that it belongs to the *Planorbis*-Zone. Wilson and Quilter regard the lower portion as the top-bed of the Upper Rhætic; but Mr. Montagu Browne would claim it as belonging to the "Liassic Basement Beds = Sub-Lias = *Ostrea*-Zone" (p. 37). On an earlier page he says that this "Sub-Lias" is the "White Lias" of some authors, which would lead one to suppose that some authors have used the terms "*Ostrea*-Beds" and "White Lias" synonymously; but I am not aware of any such confusion. Mr. Montagu Browne further states that here and there embedded in the lower portion of the inferior part of the compound bed referred to above are nodules that may represent the Cotham Marble. If such is the case, then the limestone-band that is overlaid by a limestone-bed of *planorbis* hemera and underlaid by nodules on the horizon of the Cotham Marble occupies the stratigraphical position of the *Ostrea*-Beds, Insect and Crustacean Beds, and White Lias of Mid Somerset. The lithic and faunal characters of the bed, however, do not point to contemporaneity with either the *Ostrea*-Beds or Insect and Crustacean Beds, and until the presence of a representative of the Cotham Marble has been more satisfactorily demonstrated, I should prefer to regard the limestone in question, which usually separates into two layers, as comparable with the *Pseudomonotis*-Bed of Garden Cliff, which also admits of similar dual division.

The closeness of deposits containing *Psiloceras planorbis* to undoubted Rhætic Beds is very interesting, and the difference in fauna is readily explained by the magnitude of the non-sequence.

One of the main objects of this communication is to state or emphasize the point that the marls of the Upper Rhætic are not—as supposed in 1884 by Wilson and Quilter, and in 1908 by Mr. C. Fox-Strangways—an argillaceous development of the White Lias of Somerset, and therefore of the same age. Mr. Montagu Browne noticed that these Upper-Rhætic marls of Wigston were represented at Aust Cliff, and records that he convinced his friend Edward Wilson of the fact. The Upper-Rhætic is indeed a most persistent deposit, quite distinct from the White Lias where the White Lias is developed, and everywhere underlying it.

VIII.—The Flow of Antarctic Ice.

By R. M. Deeley, F.G.S.

In his interesting and excellent *Voyage of the Discovery* Captain R. F. Scott *speculates* on the former ice conditions of the Ross Sea and the adjacent ice formations. He regards the views he expresses on this subject as only speculations, so I trust that I shall not be considered ungenerous if I attempt to express what I understand to be his views, and then subject them to criticism. It may be that I have misunderstood Captain Scott. If this should be the case the method of treatment proposed will prevent confusion.

Referring to the Great Barrier ice Captain Scott writes: "On the slopes of Terror Dr. Wilson found morainic terraces 800 feet above the present surface of the ice. Mr. Ferrar showed that nearly the whole of the Cape Armitage Peninsula was once submerged; and, in fact, on all sides of us and everywhere were signs of the vastly greater extent of the ancient ice sheet." "It is not until one has grasped the extent of the former glaciation and the comparatively rapid recession of the present that one can hope to explain the many *extraordinary ice formations that now remain in the Ross Sea*." (The italics are mine.) "The Ross Sea is comparatively uniform in depth north and south: the ice sheet pressing over this level floor would consequently have been more or less uniform in thickness, and, finally, the wastage would have been *more or less uniform over the whole area*." "I imagine that it floated away gradually, and that the present rapidly diminishing Barrier is *the remains of the great ice sheet*." "It is not the only *remains*, for the whole coast bears signs of the old ice sheet in curious ice formations that can be *accounted for in no other way*. Lady Newnes Bay contains a *large fragment of it*; the present ice discharges are wholly insufficient for such a sheet as *fills the bay*." "In the course of the narrative I referred to the long ice tongue in latitude 75° S.; this must also be a *remnant* of the heavier glaciation. Other typical remnants are to be found in the steep snow slopes and ice-cliffs which fringe many parts of the coast. These slopes, which are very common about our winter quarters, start on a bare hill-side, and, *wedge-shaped* in section, gradually increase in thickness till they *end in a perpendicular cliff dipping into the sea, consequently they have no present source of supply*."

Taking these paragraphs together, Scott appears to hold that in Victoria Land there are masses of ice which are not in motion, receive no continuous supply of fresh snow to form fresh ice, and are, consequently, masses of ice which are actual remnants or portions of the great ice-sheet which have not melted.

Mr. Ferrar also seems to hold the same views, for he refers to Piedmonts as "Large areas of ice which lie at the foot of high land, and which have no obvious single source". And again: "The great *snow-fan* between the hills and the stranded moraines on the west side of McMurdo Sound may be taken as an example. This mass of *snow* is about 10 miles long and 5 broad, and the whole of it is aground. It has no obvious source, and the surface rises from a few feet at the *seaward edge* to about 1000 feet on the sides of the foot hills. As it is *practically motionless* it must afford very material protection to the land."

It seems to me to be much more probable that the ice masses or sheets referred to are recruited by the snow which falls on them directly from the clouds or is blown on to them from the adjacent rocky slopes. Also that they are really in more or less rapid motion, and are being wasted away where they reach the sea or a point where the sun is strong and very little snow collects.

In the case of the Great Barrier the ice presents a high vertical face to the sea, and the whole mass is moving from the south at a rate of about 600 yards per annum. Now if we place the origin of the Barrier ice, as such, about 400 miles from the seaward face, near where it is fed by the magnificent glacier discovered by Shackleton, the whole of it will have broken off at the sea face and have been replaced in about 1200 years. No portion of it, therefore, can be a remnant, i.e. the remains of the former ice-sheet. It has merely become thinner, as the supply of snow falling upon the area became less, and the tributary glaciers became smaller, just as the water-level of a river rises and falls as the rainfall varies.

The same argument applies to the other more local ice formations. They commence on a hill-side and thicken as they approach the sea, at which they terminate in a vertical face. Now Scott and Ferrar have shown that the sea has a very rapid wasting effect upon the ice which reaches it. The cliffs are undercut and large masses break off. Even the sea ice is being rapidly melted from beneath when the upper surface is below the freezing-point. The vertical face which faces the sea is maintained by the continual motion of the ice-foot towards the sea.

With regard to the peculiar ice-islands, a photograph of one off King Edward's Land is shown. This I take it is regarded as a remnant of the old ice-sheet. The photograph shows a mass of ice, with an irregular upper surface sloping roughly towards the sea in all directions. It terminates on the sea face in an overhanging cliff of considerable height. May not these ice-islands be rocky islands upon which more snow falls than is melted by the sun? In such a case the ice-cap would reach a thickness sufficiently great to allow it to discharge the ice seawards. A section would show two wedge-shaped areas terminating in seaward cliffs. In other words the ice-islands are the island equivalents of the shore ice.

From the photographs shown, and the descriptions of the various ice formations, I see no signs of extraordinary stagnation. On the contrary, the ice is everywhere in motion, to judge from the usual signs.

Ice is a viscous substance—a peculiar one in some respects, it is true. Water, oil, honey, and pitch are also viscous. To ascertain how these substances will act in any case it is necessary to know how viscous they are. The unit of viscosity is measured by the tangential force per unit area of either of two horizontal planes, at the 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. The viscosity of liquids can be measured in many ways. Thin oils, water, spirits, etc., are best dealt with by measuring their rate of flow through capillary tubes. For thick oils, honey, etc., tubes having larger diameters must be used. For pitch the conditions of flow through large holes in thin plates or the flow down troughs give satisfactory results. For glaciers, if we know the rate of flow, the inclination, and the width and thickness, the result can be calculated directly.

The following table gives the viscosity of some liquids :—

Liquid substance.		*Viscosity in c.g.s. units.*
Glacier ice at 0° C. . . .	about	125,000,000,000,000
Crystalline ice at 0° C. in a direction at right angles to the optic axis		20,000,000,000
Pitch		40,000,000,000
Shoemakers' wax		6,000,000
Mineral cylinder oil . . .	about	10
Sperm oil at 100° F.		·185
Mercury at 10° C.		·016
Water at 20° C.		·010
Alcohol at 20° C.		·001

This table shows the wide range of viscosities to be found in different substances. It will be seen that if the ice-sheets are in a state of stagnation, considering the slopes available for producing motion, the viscosity of the ice of which they are formed must reach an enormous figure. The calculations I made to ascertain the viscosity of the Swiss glaciers gave figures varying from $3{\cdot}274 \times 10^{12}$ to $292{\cdot}2 \times 10^{12}$. Some of the data were certainly somewhat uncertain; but it would appear that all glaciers have not the same viscosity, owing, I think, to differences in the sizes and arrangement of the glacier grains. We have no information, as far as I am aware, of the sizes and arrangement of the glacier grains of the extensive Arctic and Antarctic glaciers; but I do not think that their granular structure can be so coarse that they are in any cases stagnant.

The volume of ice discharged by a glacier of great width in proportion to its thickness is, *ceteris paribus*, proportional to the cube of its thickness. It is no doubt due to this fact that the thicknesses of glaciers and ice-sheets in proportion to their areas do not vary as much as one would at first sight expect them to.

Whenever actual measurements have been made ice-masses have been found to be moving under the influence of gravity. From the nature of the movement which is set up the flow is clearly viscous, and although calculations prove that ice in mass possesses a viscosity which varies somewhat according to its structure, it is always sufficiently small to allow of its more or less rapid flow.

REVIEWS.

The Geological Survey.

I.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1908. pp. iv, 98, with 3 text-illustrations. London: printed for H.M. Stationery Office, 1909. Price 1*s*.

COMPARED with the *Summary of Progress* for 1907, noticed in the Geological Magazine for August last year, the present memoir contains less material, to the extent indeed of 77 pages. The record of the work done has been abbreviated, and this is no disadvantage, as the matter in due course is for the most part reproduced in the memoirs explanatory of the Geological Survey maps.

We learn that the mapping of the Pembrokeshire portion of the great South Wales coal-field has been nearly completed; and that the survey of West Cornwall, including the Lizard area, has been finished. In the Midland district the survey of the Derbyshire and Nottinghamshire coal-field has been carried northwards towards the borders of Yorkshire. In Scotland work has been continued in the Northern, Central, and Western Highlands, including portions of Caithness and the island of Mull, while progress has been made with the re-survey of the coal-fields.

Among the points of special interest to which the Director, Dr. Teall, calls attention, is the evidence of certain 'fold-faults', which have been found to occur in the neighbourhood of Glen Etive, Loch Leven, and Glen Nevis. These are recumbent folds more or less dislocated, and in certain cases subsequently rucked up and involved in other isoclinal folds, whereby the task of the geological surveyor becomes about as difficult as it well can be. In South Wales the oldest Cambrian strata, referred to the Caerfai group of Dr. Hicks, have been proved to rest unconformably on pre-Cambrian rocks. Attention has been given to the marine bands, first described by J. W. Salter, in the Old Red Sandstone of West Angle Bay in Pembrokeshire. They are regarded as representing temporary incursions of the sea into the area prior to and foreshadowing the marine conditions of the Lower Carboniferous.

Observations on the coals of Lanarkshire point to the conclusion that the lateral change from bituminous coal to anthracite is in some way connected with original differences in composition, as was suggested in reference to the coals of South Wales, recently described in a Survey Memoir.

In the Petrographical department investigations have been made on the felspathic hornstones from the aureole of the St. Austell granite, and on nepheline rocks from the midland valley of Scotland.

In the Palæontological department attention has been given to the species of *Productus* found in the Carboniferous rocks, with the view of defining forms that characterize the zonal subdivisions in the Limestone Series. We are glad to learn that a memoir is in preparation on the Secondary formations proved in some of the deep borings in Kent. From the preliminary notices we learn that the Hastings Beds at Dover rest on an irregular surface of Kimeridge Clay, and that the lowest bed of the Lower Lias, which rests directly on Coal-measures at Dover, belongs to the *Capricornus* zone. Elsewhere at Brabourne it appears that the Lower Lias rests directly on Triassic marls, without any evidence of intervening Rhætic beds.

The Appendix contains an article "On a Boring in the Fullonian and Inferior Oolite at Stowell, Somerset", by Mr. John Pringle, who obtained a very interesting series of fossils. They indicate that the Lower Fullers Earth clay should be grouped with the Inferior Oolite Series, and the Fullers Earth rock and overlying clay with the Great Oolite Series.

There is a second article "On the Stratigraphical Position of the Achanarras Fauna in the Old Red Sandstone of Caithness", by Mr. R. G. Carruthers. The Achanarras fauna occurs near Spital, to the south of Thurso, and was originally described by Dr. Traquair as yielding a different set of fishes from that of the Thurso flagstones. The same fauna has now been found near Latheron on the southern coast of Caithness, and its stratigraphical position has been determined to be beneath that of the Thurso flagstones (of Sir A. Geikie) which form the higher portion of the upper or *Coccosteus* group of the Caithness flagstones.

It is to be hoped that Mr. H. A. Allen's valuable Catalogue of Types and Figured Specimens preserved in the Museum of Practical Geology will be continued in future numbers of the *Summary of Progress.*

II.—Stratigraphie des Kohlenkalks in der Umgebung von Krakau. [The Stratigraphy of the Carboniferous Limestone in the Neighbourhood of Cracow.] By J. Jarosz. Extr. du Bull. de l'Académie des Sciences de Cracovie (pp. 689–706), Avril, 1909, Cracovie.

THIS paper commences with the geographical delimitation of the district under consideration and a short historical sketch of the work of previous investigators. Then follows the petrographical and palæontological characteristics of a series of exposures. The examination of the Brachiopods from these exposures points to the presence of two distinct faunas of different horizons and occurring in beds petrographically distinct from one another. The one horizon is distinguished by more or less dark limestones, often bituminous and containing here and there an abundance of chert. This limestone contains at one place (Szklarka-Tal) a thin crinoidal band comparable to the *petit granite* of the lower horizon in Belgium. Forms which are peculiar to this horizon are *Athyris roissyi*, *A. squamigera*, *A. lamellosa*, *Spirifer tornacensis*, *Sp. cinctus*, *Syringothyris cuspidata*, *Productus margaritaceus*, *Pr. spinulosus*, *Pr. mesolobus*, *Chonetes hardrensis*, *Lingula credneri*, *Discina davreuxiana*. The other horizon is characterized for the most part by light-coloured, compact or granular limestones, often becoming whitish, yellowish, or bluish-grey, and sometimes also massive and reddish. Among forms peculiar to this horizon are *Dielasma sacculus*, *Athyris expansa*, *A. globularis*, *A. subtilita*, *Spirifer duplicicosta*, *Sp. trigonalis*, *Sp. ovalis*, *Spiriferina cristata*, *Rhynchonella acuminata*, *Rh. pugnus*, *Rh. pleurodon*, *Rh. angulata*, *Productus giganteus*, *Pr. latissimus*, *Pr. costatus*, *Pr. undatus*, *Pr. wrightii*, *Pr. nystianus*, *Pr. aculeatus*, *Pr. punctatus*, *Chonetes comoides*, *Ch. papilionacea*, etc. After a comparative examination of the faunas and those of Belgium the author correlates the two horizons mentioned, the first with that of Tournay, the second with that of Visé.

The paper is accompanied by a plate of fossil illustrations and a sketch-map of the district.

I. T.

III.—The Darwin Centennial Commemoration.

ON July 1 of last year the Linnean Society held a special meeting to celebrate the fiftieth anniversary of the reading of the papers on "Natural Selection" by Charles Darwin and Alfred Russel Wallace.

It is remarkable that the present year is rendered famous by the centenary of the birth of Darwin, and by the jubilee of the publication of his *Origin of Species*, events which have been fittingly celebrated at home and abroad.

February 12 being the birthday of Darwin, that date was chosen at Oxford, and the hundredth anniversary was celebrated by a reception given in the examination schools by Professors S. H. Vines, E. B. Poulton, and G. C. Bourne. It is noteworthy that the proceedings were opened by the Dean of Christ Church, while an address on "Fifty Years of Darwinism" was delivered by Professor Poulton.[1]

In America, on the same date, besides other gatherings, there was a special celebration at Columbia University, New York, when Dr. Henry Fairfield Osborn gave an address on the "Life and Works of Darwin". This has been printed (in the *Popular Science Monthly* for April), with eight portraits, including that of the bust of Darwin by William Couper, a copy of which in bronze was presented to Christ's College, Cambridge.

Naturally the chief celebration was held at the University of Cambridge, where Darwin, as an undergraduate at Christ's College, gained inspiration in natural science and laid the foundations of his great career.

Proceedings were opened at the Fitzwilliam Museum on June 22, with the reception of delegates and other invited guests by Lord Rayleigh, the Chancellor of the University. The invitations were confined almost entirely to naturalists.[2]

On June 23 Lord Rayleigh gave a brief address in the Senate House, and remarked that "What appeals to all is the character of the man, loved by everyone who knew him, and admired by everyone with a spark of the scientific spirit. It is a pleasure and a stimulus to think of him, working on in spite of ill-health in his study, in his garden, and in his hot-houses, and from his retirement moving the minds of thinking men in a manner almost without parallel".

The presentation by delegates of addresses from all parts of the world was accompanied by a few speeches. Then Sir Ray Lankester, on behalf of British naturalists, referred to the inspiration given to Darwin by Henslow, remarking that it was through "the influence of his splendid abilities and high personal character upon Darwin that Cambridge acquired the right to claim the author of the *Origin of Species* as a product of her beneficence and activity as a seat of learning". If Darwin did not explain the origin of variation, he explained the origin of species by the preservation of minute variations favourable to existence under prevailing natural conditions, and he "furnished the key to the explanation of what are called useless specific characters and of incipient organs".

On June 24 Sir Archibald Geikie delivered the Rede lecture, which was included in the proceedings of the celebration, and he chose as his

[1] See also his recently published *Essays on Evolution*, 1908.

[2] For many particulars here recorded we are indebted to *Nature* for June 10, June 24, and July 1.

subject "Charles Darwin as Geologist".[1] In the course of his lecture he remarked that "Darwin began his active scientific career as a geologist, that it was mainly to geological problems that the earlier years of his life were devoted". While he gained some acquaintance with geology at Edinburgh from Jameson, his interest was not aroused until he proceeded to Cambridge. There he was introduced by Henslow to Sedgwick, with whom he made a geological excursion into North Wales. It was, however, to Lyell's *Principles of Geology*, the first volume of which he took with him on the voyage of the "Beagle", that his enthusiasm in the pursuit of that science was chiefly due. The second and third volumes were afterwards sent out to him.

By his geological observations made during that voyage, in South America and other lands, especially his investigations on volcanic islands, on volcanic phenomena, and continental elevations, and on the structure and distribution of coral-reefs, science was remarkably enriched.

Although some of Darwin's conclusions have not withstood the test of later researches, notably in regard to explanations of particular glacial phenomena, and of certain of the atolls among coral islands, yet his contributions to their science have been so great that, as Sir A. Geikie remarks, "Geologists are proud to claim him as one of themselves and as one of the great masters by whom their favourite science has been advanced." By his extended observations on vegetable mould he illustrated some of the changes which the earth's surface is undergoing; finally, by his *Origin of Species* he illumined the whole aspect of the science, and especially the palæo-zoological and palæo-botanical branches.

On this subject "the far-reaching influence of Darwin's work on the progress of knowledge, and the present attitude of original investigators and thinkers towards the views contained in Darwin's works", are embodied in a series of essays combined in a memorial volume, entitled *Darwin and Modern Science*, edited by Professor A. C. Seward. The essay on "Darwin and Geology" is written by Professor Judd. Another notable volume, entitled *The Foundations of the Origin of Species*, edited by Francis Darwin (1909), contains a sketch of the *Origin of Species*, written by Darwin in 1842, and of great historic interest.

REPORTS AND PROCEEDINGS.

I.—Mineralogical Society.

June 15.—Principal H. A. Miers, F.R.S., President, in the Chair.

Carnotite and an associated mineral-complex from South Australia; by Messrs. T. Crook & G. S. Blake. The carnotite of Radium Hill, near Olary, South Australia, occurs in a definitely crystalline condition. The crystals are tabular and orthorhombic in symmetry. The carnotite

[1] Printed as a separate volume at the University Press, Cambridge, pp. 91, price 2*s.* net.

of Colorado, though not so definitely crystalline, also contains tabular crystals which are orthorhombic in symmetry, and probably identical in mineral characters with those of South Australia. From the general characters of these crystals, it appears that carnotite is a mineral belonging to the Uranite group, and that it may be regarded as the vanadium analogue of autunite. The black lodestuff in which the Radium Hill carnotite occurs is heterogeneous in constitution. It consists essentially of ilmenite, which is impregnated with magnetite, rutile, carnotite, and a mineral which is possibly tscheffkinite. The evidence provided by a study of the complex does not necessitate the view that new minerals are present, such as that to which the name 'davidite' has been given.—On the species Pilolite, and the analysis of a specimen from China; by Mr. G. S. Whitby. The specimen examined is from a new source, and possesses the formula $Al_2 O_3 . 2 Si O_2$, $2 (Mg O . 2 Si O_2)$, $7H_2 O$; a formula which is simpler than those given by Heddle and by Friedel to the pilolites which they investigated. The author considered that for the present the term pilolite should be applied to those varieties of mountain leather and mountain cork which (1) cannot be referred to asbestos on account of their large water-content, (2) cannot be identified with serpentinous asbestos on account of the relatively small amount of magnesia which they contain, and (3) hold their water in such a way that when it has been expelled by heating it is gradually re-absorbed to its original amount from the atmosphere.—Phenakite from Brazil; by Dr. G. F. Herbert Smith. Crystals of phenakite recently discovered at the gold-mine, San Miguel de Piracicaba, Brazil, all display the new form {2352} noted by other observers, and another {4596} lying near it. The tetrahedral character of the symmetry is clearly marked.—Preliminary note on the occurrence of Gyrolite in Ireland; by Mr. F. N. A. Fleischmann. The mineral gyrolite, though well known as occurring in the basalts of the Western Islands of Scotland, has not hitherto been recorded from Ireland. Specimens have now been found in the basalts and dolerites in the neighbourhood of Belfast. The mineral occurs in small spherical aggregates, forming a crust on faroelite; it is associated with apophyllite and occasionally with chabazite. The chemical composition and the optical characters of the mineral agree with those of gyrolite. The mineral is found only in the harder and denser layers of the basalt, and never in the soft highly amygdaloidal layers.

II.—Geological Society of London.

June 16, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "The Carboniferous Limestone of County Clare." By James Archibald Douglas, M.A., B.Sc., F.G.S.

The district with which this paper deals forms the westernmost limit of the great central Carboniferous Limestone plain of Ireland.

The limestone floors nearly the whole of Eastern Clare, from the southern shore of Galway Bay to the banks of the Shannon. This area, for the purposes of description, is divided into two main districts.

The whole of the northern region is formed by a vast elevated plateau of Upper or Viséan Limestone, with a surface more than 100 square miles in extent, which rises on the north and east in steep terraced cliffs, but to the south-west dips gently below the so-called 'Coal-measure' Series. The surface of this plateau is formed of bare rock, devoid of vegetation and presenting the typical appearance of a Karst landscape. The rainfall is considerable, but is nearly all carried off by subterranean channels.

The southern district presents a totally different aspect. The high ground is no longer formed of limestone; that on the east being formed by Old Red Sandstone and Silurian rocks, that on the west by Coal-measures. The older formations appear as two anticlinal flexures, with a north-easterly trend, forming the mountains of Slieve Aughty and Slieve Bernagh, between which lies a broad syncline of Carboniferous Limestone. The margin of this syncline is formed by Tournaisian shales and limestone, the successive zones of which can be traced round its outcrop, while the Viséan limestones occupy the core. Much of the country is obscured by drift, chiefly derived from the underlying rocks.

A study of the limestone fauna shows that the Geological Survey boundary between the Upper and Lower Limestones corresponds with the transition from a Tournaisian to a Viséan fauna; the Lower Limestone cannot, however, be separated from the underlying shales; and the Middle or 'Calp' Limestone contains a fauna distinct from that of the Upper or Burren Limestone, although they are not separable on lithological grounds. An account is given of the zones recognized in County Clare, and a correlation made with the sequence in other British localities.

The Old Red Sandstone is succeeded, to all appearance conformably, by a thin series of sandy shales containing Brachiopods characteristic of the *Cleistopora* zone, at the base of which a band is found containing abundant Modioliform Lamellibranchs. The *Zaphrentis* zone is well developed, the *clathratus* subzone forming the top of the Lower Limestone shales, and the *konincki* subzone the lower stratified limestone.

The most remarkable portion of the whole sequence is included in the *Syringothyris* zone, which is represented by massive grey and white mottled limestones, with a luxuriant molluscan fauna, large Cephalopods being especially abundant. These beds show evidence of deposition in shallow water, affording further proof of a mid-Avonian period of upheaval. The fauna is compared with that of the Waulsortian phase of Belgium. The incoming of a Viséan fauna is well marked at the base of the *Seminula* zone; in the middle of this zone occurs an important bed of Oolitic Limestone, with abundant Gasteropods. The *Dibunophyllum* zone attains a thickness equal to that seen in the Midland area. D_1 is chiefly characterized by the abundance of simple *Dibunophylla*, *Cyathophyllum murchisoni*, Clisiophyllid Lithostrotions, and *Productus latissimo-giganteus*; D_2 by the occurrence of *Lonsdalia* and *Cyathophyllum regium*; and D_3 by the abundance of Zaphrentids, *Caninia*, and Densiphyllids, and the apparent absence of Clisiophyllids and Lithostrotions.

An account of the chief fossil localities, under the headings of the separate Baronies, is then given, and the paper concludes with palæontological notes.

2. "The Howgill Fells and their Topography." By John Edward Marr, Sc.D., F.R.S., F.G.S., and William George Fernsides, M.A., F.G.S.

The Howgill Fells form a monoclinal block, from which the Carboniferous rocks have been denuded. The gentle northern slope probably corresponds very closely with the sloping plane of unconformity between the Carboniferous rocks and the underlying Lower Palæozoic strata. On the south side, the steep slope to the Rawthey is along a block-fault, which has several minor parallel step-faults to the north. The chief drainage was originally north and south from the watershed at the summit of the block, but the swifter south-flowing streams have in several cases captured the head-waters of those flowing northwards, and thus the watershed has been largely shifted to the north. Some of these captures occurred probably in pre-Glacial times, but others undoubtedly took place in the Glacial Period, and others again are still proceeding. The tract was glaciated by its own ice, but 'foreign' ice was conterminous with the local ice on all sides.

The rocks are, from the point of view of errosive effects, nearly homogeneous, and a rounded form of feature was produced by weathering and stream-erosion in pre-Glacial times. The chief erosive effects of glaciation were the truncation of spurs; the formation of conchoidal scoops in the concavities of the valleys; a general widening of the valleys, and but slight deepening, as marked by the slight difference of grade (amounting to but a few feet) at the junction of tributaries with larger streams. A feature of interest is the contrast in this small area between these glaciated valleys and others of V-shaped cross-section, which are typical water-carved valleys unaffected by glacial erosion. The two great hanging valleys of Uldale and Cautley, where the streams plunge scores of feet down waterfalls, are due to river-capture, and not to the deepening by ice of the main valleys.

3. "A New Species of *Sthenurus*." By Ludwig Glauert, F.G.S.

In a large collection of remains of extinct Marsupial mammals from the Mammoth Cave, Margaret River (Western Australia), the author recognized several mandibles of a new kangaroo of the genus *Sthenurus*. He now communicates a detailed description of one specimen, and shows that the new species most nearly resembles *Sthenurus oreas* (De Vis) and *Sth. atlas* (Owen).

4. "Some Reptilian Remains from the Trias of Lossiemouth." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

The fore-limb of *Ornithosuchus woodwardi* is shown in a specimen in the Manchester Museum. It is small, only about one-half the size of the hind-leg. The scapula is much expanded at both ends, and is indistinguishably fused with the coracoid. The latter bone is pierced by a large foramen. The humerus is a slender bone, somewhat twisted, but not much expanded at the ends; it has a distinct ectepicondylar groove. The ulna is very broad at the proximal end, but narrows distally; its proximal portion forms a thin plate of bone. The radius crosses the ulna, its proximal end lying entirely in front of it, while the distal ends of the two bones lie side by side. The carpus cannot be made out. Only metacarpals 1, 2, and 3 are functional; but a possible representative of 4 lies closely pressed to the back of the other three. Both phalanges of digit 1 are preserved, the last being a strong claw.

Ornithosuchus is restored as an animal walking on all fours, with the head carried rather low. The proportions are identical with those of *Ætosaurus.*

A description is given of the skeleton of a very small reptile, interesting as recalling *Ætosaurus* in its armour, and because it shows the whole of the animal except the tail.

5. "Some Reptilian Tracks from the Trias of Runcorn (Cheshire)." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

Very little information exists as to the tracks of the smaller reptilia of the Trias, although several types of footprints have been described from isolated examples. Four types of tracks which occur on the slab of sandstone from Weston Point, described in 1840 by Dr. Black, are discussed in this paper. They belong to forms generally included in the Rhynchosauroid types and to the footprint I, Beasley.

Both pes and manus are impressed in three of the cases, the other being so small that it is doubtful whether the manus would have made a recognizable impression if it did touch the ground.

Footprint A 2, Beasley, has a manus very similar to the pes, but showing some traces of the palm.

Footprint A 8, sp. nov., has five toes in the pes connected by a web. The manus is also five-toed, but corresponds to some extent to I, Beasley. There is a well-marked tail-streak in the track.

E, Beasley, which is very similar to I, really has five digits, the fifth being directed backwards and only just touching the ground.

A very small footprint is described as A 9.

It is suggested that some of these prints may quite well belong to such Thecodonts as *Ornithosuchus.*

6. "The Anatomy of *Lepidophloios laricinus*, Sternb." By D. M. S. Watson, B.Sc. (Communicated by Professor W. Boyd Dawkins, D.Sc., F.R.S., F.S.A., F.G.S.)

A specimen of *Lepidophloios laricinus*, found in one of the coal-balls of Lancashire, shows the internal structure. The species is new, and is of the ordinary lepidodendroid type, but is remarkable for the great size and strength of the corona and the leaf-traces.

Lepidophloios acadianus, Dawson, which is identical with *L. laricinus*, appears to differ in its internal structure, in having still stronger protoxylem-points and leaf-traces.

Lematophloios crassicaule, Corda, which is *L. acerosus*, L. & H., appears to resemble greatly the Lancashire specimen of *L. laricinus* in its structure, and is quite distinct from the specimen of the same form described by Cash & Lomax.

Lepidodendron fuliginosum, Will., a structural species, appears to include a specimen the external structure of which corresponds with *Lepidophloios acerosus*, *Lepidodendron obovatum*, *L. aculeatum*, and *Sigillaria discophora*. Under these circumstances, it is proposed to take no account of the impression-species in considering the synonymy of the structural specimens, and *vice versa*. When the exterior of a structural specimen is actually known, it may be referred to by the name of the structural species, with that of the impression-species added in brackets.

Dr. G. F. Herbert Smith, M.A., F.G.S., exhibited two forms of refractometer. The one (which reads directly to the second, and by estimation to the third, place of decimals) has a range extending from 1·300 to 1·795, and is intended for all translucent substances, especially minerals. The other (which reads directly to the third, and by estimation to the fourth, place of decimals) has a range extending from 1·3200 to 1·4200, and is intended for use with water and solutions in water, especially brines, for which reason it may be called a salinometer. The liquid film is illuminated from above, and the optical arrangements are such that the critical edge is blue, if coloured at all, in white light. Since the refractive indices of liquids change rapidly with the temperature, a water-jacket is provided for controlling the temperature of the observation; a thermometer, reading to degrees Centigrade, is attached underneath the instrument. The glass prisms are removable for cleaning purposes.

The next meeting of the Society will be held on Wednesday, November 3, 1909.

III.—The Royal Society.

Ordinary Meeting, *June* 24, 1909.—Professor J. Cossar Ewart, Vice-President, in the Chair.

"The Possible Ancestors of the Horses living under Domestication." Part I. By J. C. Ewart, M.D., F.R.S.

By some naturalists it is believed that domestic horses are the descendants of a Pleistocene species (*Equus fossilis*), now represented by the wild horse (*E. przewalskii*) of Mongolia; by others the horses living under domestication are said to be a blend of a coarse-headed northern species allied to Prejvalsky's horse and a fine-limbed southern species which in prehistoric times inhabited North Africa, or a blend of a Prejvalsky-like northern species and a southern species closely allied to *E. sivalensis* of the Pliocene deposits of India. The examination of the skull, teeth, and limb bones of horses found at Roman settlements and in the vicinity of pile dwellings indicates that domestic horses originally belonged to several distinct types, viz. (1) a type characterized by long limbs, by a long face, broad and convex between the orbits, and strongly deflected on the cranium, and by the crown of the fourth premolar being from before backwards about 2·5 times the length of the grinding surface of its 'pillar'; (2) a type with slender limbs, a fine, narrow, slightly deflected face, and the crown of the fourth premolar about three times the length of its 'pillar'; (3) a type with fairly slender limbs, a long, narrow, somewhat deflected face, and the crown of the fourth premolar about twice the length of its 'pillar'; (4) a type characterized by short broad metacarpals, a short face, broad and flat between the orbits, and nearly in a line with the cranium, and by the crown of the fourth premolar being twice the length of its 'pillar'; and (5) a type with short wide metacarpals, the face long and strongly deflected, and the crown of the fourth premolar about 1·5 times the length of its 'pillar'. Only the varieties characterized by molars with short 'pillars' are dealt with in this communication. The possible ancestors of the short-pillared varieties are *Equus sivalensis* of Indian Pliocene deposits, *E. stenonis* of the Pliocene deposits of Europe and North Africa, and a new species, *E. gracilis*.

Arabs, barbs, thoroughbreds, and other modern breeds with a long deflected face, broad and prominent between the orbits, and the limbs slender, seem to have mainly sprung from *E. sivalensis*, while certain unimproved breeds, with a deflected face but very short 'pillars', are probably related to *E. stenonis*. Exmoor, Hebridean, Iceland, and other ponies of the 'Celtic' type, as well as ponies found in the South of France, the West Indies, and Mexico, characterized by a fine narrow skull, slender limbs, and the absence of ergots and hind chestnuts, are regarded as the descendants of *E. gracilis*, which includes (1) the small species of the English drift described by Owen as a fossil ass or zebra (*Asinus fossilis*); (2) the small species of French Pliocene and Pleistocene deposits known to palæontologists as *E. ligeris*; and (3) the small species of North African Pleistocene deposits known as *E. asinus atlanticus*, and hitherto believed to be closely related to, if not the ancestor of, zebras of the Burchell type. By crossing experiments evidence has been obtained of the wide distribution of horses of the *E. gracilis* type; that broad-browed Arabs and thoroughbreds with the face nearly in a line with the cranium are mainly a blend of a southern variety of *E. gracilis* (*E. caballus libycus*) and a horse of the 'forest' or Solutrè type, and that heavy breeds have not inherited their coarse limbs from a species closely allied to the wild horse of Mongolia.

CORRESPONDENCE.

VORTICOSE MOVEMENT IN THE EARTHQUAKE OF BENAVENTE, PORTUGAL.

Sir,—On May 14 I visited the well-known convent of Batalha (6 miles south of Leiria) in Portugal. On ascending to the roof the caretaker drew my attention to the effect on the building of the earthquake of Benavente, which occurred at 5 p.m. on April 23, 1909. The roof (of stone) is adorned with numerous four-sided pyramidal Gothic pinnacles. In two of these, while the lower part of each pinnacle has retained its original place, the upper part has been displaced by the earthquake and partially rotated, so that the angle of the upper part, facing (say) north, is turned through part of a circle towards the west. Similar effects have often been recorded.[1] Fourteen (or more) of the slender stone finials, each crowning a separate pinnacle, were broken off by the shock. I cannot be sure of the exact number, as I only saw the freshly fractured bases of three finials from above. In several places on the roof stones were horizontally displaced by the earthquake, from 1 inch at one end of the stone to nothing at the other end.

B. Hobson.

MISCELLANEOUS.

Royal Society.—At the Conversazione held on June 24, 1909, the following specimens were exhibited :—*Sections of Seasonal Clay from Stockholm.*—This clay, which was deposited during the melting and retreat of the great ice-sheet in Sweden, may be described as fossil years and seasons. The alternating bands of dark and light are easily seen, and Baron G. de Geer (from whom the specimens have been received), believes that each cycle represents a year, the lighter rock having been formed during the melting of the snows in spring. He has traced these bands for great distances, and has been able to map the changing limits of the ice-sheet from year to year through a long period. This is the nearest approach to a definite chronology by years that has yet been made by geologists, but it still needs to be linked up to the chronology of human history. Exhibited by Dr. F. A. Bather, F.R.S.

Skull of Megalosaurus from the Great Oolite of Gloucestershire.—This is the first nearly complete skull of a carnivorous Dinosaur found in Europe, and agrees with the skull of *Ceratosaurus*, from the Jurassic of Colorado, U.S.A., in exhibiting a bony horn-core on the nose. The specimen was discovered by Mr. F. L. Bradley, F.G.S., near Minchinhampton. Exhibited by Dr. A. Smith Woodward, F.R.S.

New Museum at Louth, Lincolnshire.—The strenuous efforts of the late Mr. Samuel Cresswell, Mr. Benjamin Crow, Mr. Joseph Larder, Mr. R. W. Goulding, and the band of earnest workers in Louth, have at last been crowned with success in that the Pahud Trustees of that town have placed at the disposal of the Committee of the Louth Antiquarian and Naturalists' Society the handsome sum of £250 towards a proper building. The Committee consider that they will require at least double this sum for the purpose of building and equipping a Museum and meeting-room on a site in Enginegate, the property of the Corporation, and the plan of such a building is now under consideration. The excellent collection of local antiquarian and scientific specimens are at present housed in dangerous and crowded quarters, and any contributor to the fund may be assured that he is helping forward a movement of great value to the town and district. Cheques may be drawn in favour of Mr. B. Crow, the Hon. Treasurer, The Museum, New Street, Louth, Lincs.

[1] Convent of S. Bruno, Stefano del Bosco, Calabria, in 1783; Lyell, *Principles of Geology*, 12th ed., 1875, ii, p. 119; Tokio, 1880; F. Fouqué, *Les Tremblements de Terre*, 1889, p. 56; Belluno, 1873; Aix la Chapelle, 1878; W. H. Hobbs, *Earthquakes*, 1908, p. 92.

No. 543. Decade V.—Vol. VI.—No. IX. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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

SEPTEMBER, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. IX.—SEPTEMBER, 1909.

ORIGINAL ARTICLES.

I.—Preliminary Note on a New Artiodactyle from Majorca, *Myotragus balearicus*, gen. et sp. nov.

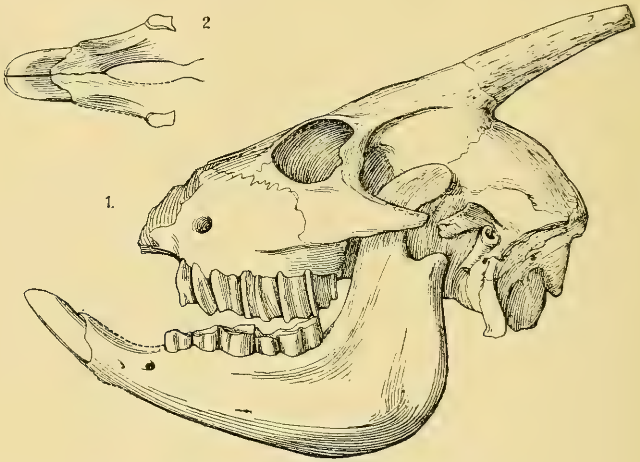
By Dorothea M. A. Bate.

(with four text-figures.)

In March of the present year (1909) the Rev. R. Ashington Bullen, who was then travelling in Majorca, wrote to inform me of the existence of a supposed ossiferous breccia situated on the east coast of that island. This caused a long-deferred project of exploring the Balearic Islands in search of Pleistocene cave-deposits to be carried out, and a month was spent in this manner, although a much longer period would be required for an exhaustive examination of Majorca alone, which was the only one of the group visited. A considerable tract of limestone country was investigated, and the result was the discovery of three ossiferous cave-deposits, including the one mentioned above. Similar remains were procured from each of these, and on examination prove to be those of an ungulate which appears to be without parallel. No great quantity of material was obtained, but this fortunately includes a well-preserved skull of an old individual with the associated mandible and atlas vertebra—the type-specimen, see Fig. 1—as well as a number of perfect examples of various limb-bones.

I hope shortly to be able to communicate a detailed account, with figures and full descriptions, of this collection, but for the present must confine myself to noting the more striking peculiarities of the skull and limb-bones without entering into the questions of affinity and descent. It will be seen from the illustration that the skull and horns are those of a small goat-like animal, while the same may be said of the molar series. The most striking peculiarity of the dentition is that the mandible carries a pair of large and permanently growing rodent-like median incisors, the other incisors and the canine being entirely wanting; it was this which suggested the name for the new genus which seems to be required for the reception of this animal, while the specific name denotes its habitat. It is proposed that it shall be called *Myotragus balearicus*.

The profile view of the skull given in Fig. 1 shows that although the molars approach in size to those of the common goat, the whole skull is characterized by what may be described as a general 'shortening' both before and behind the orbit, the position of which is very high, while its margin is slightly prominent. The lachrymal is short and wide, and the portion of the malar situated in front of the orbit is greatly reduced, causing the eye to be placed very far forward. The opening of the auditory meatus is extremely small. Two roughened projections occur on the upper border of the foramen magnum. The horns, which arise entirely from the frontals, are short and circular in section, the one preserved in the figured specimen measuring 49 mm. (incomplete at tip) in length and 50 mm. in circumference at its base.



Myotragus balearicus, gen. et sp. nov.

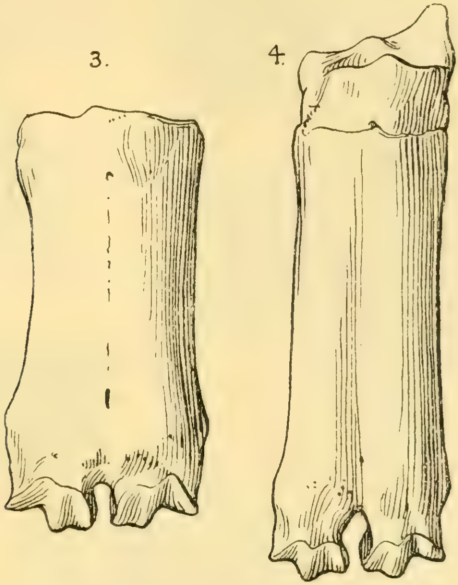
FIG. 1. Skull and mandible from left side. Type-specimen, $\frac{1}{2}$ nat. size.
,, 2. Anterior end of mandible, showing the cutting incisors. $\frac{1}{2}$ nat. size.

The cheek-teeth series measures antero-posteriorly about 48 mm., the upper series being shortened by the presence of two premolars only, by the second molar being very much smaller instead of nearly equal in size to the third, and by the first molar consisting of only one pair in place of two pairs of crescent-shaped columns. Only one premolar is present in the lower jaw, making the number similar to that obtaining in many rodents. Therefore the dental formula of *M. balearicus* is as follows:—

$$\frac{\text{i. ?}\quad \text{p.m. 2.}\quad \text{m. 3.}}{\text{i. 1.}\quad \text{p.m. 1.}\quad \text{m. 3.}}$$

The ventral border of the massive mandible is convex throughout, its length causing the anterior teeth to project upwards to an extent that suggests that the animal's nose must have been very short. The symphysis of the mandible, apparently, was very strong. The two large rodent-like median incisors were doubtless ever-growing, and penetrate the jaw for a considerable distance, beneath the diastema and as far as to below m. 1.

As in rodents, it is their outer surface only which has a coating of enamel, which is slightly grooved longitudinally, and it is this enamel which forms the cutting edge of these two teeth, and the worn surfaces together take the form of a semicircle or crescent-shaped space, as shown in Fig. 2.



Myotragus balearicus, gen. et sp. nov.
Fig. 3. Metacarpal, front view. Nat. size.
,, 4. Metatarsal with distal tarsals, front view. Nat. size.

The general shortening and thickening already mentioned as being so noticeable in the skull appears to have been characteristic of the whole animal, for this tendency is also very strongly marked in the limb-bones. Figs. 3 and 4 show respectively the metacarpal and metatarsal of an adult, the former being 55 mm. in length and 21 mm. in width at the middle of the shaft, while the latter is 59 mm. long (without the tarsals) and 19 mm. broad at the middle of the shaft; the proportions of these two bones are unlike those of any with which they have so far been compared. In some specimens, even when still immature, the distal row of the tarsals (cuboid, navicular, and cuneiform) are fused to the third and fourth metatarsals, as occurs in birds.

The Pleistocene mammalian fauna of an island almost always proves to be of great interest, and generally includes the remains of either primitive survivals related to a Tertiary fauna or forms specially adapted for existence in a restricted habitat, such as the pigmy races which occur in several of the Mediterranean Islands. The case of *M. balearicus* seems to be somewhat obscure; its goat-like cheek-teeth are apparently highly specialized, although the present-day aspect of Majorca seems to afford no clue to causes sufficiently powerful to necessitate the peculiar modifications noted above. It is to be hoped that a further and more detailed study of these remains may throw more light on this interesting problem.

My thanks are due to Dr. C. W. Andrews, F.R.S., for his valuable assistance in comparing the above specimens with material in the British Museum (Nat. Hist.).

II.—On some Fossils from the Nubian Sandstone Series of Egypt.

By R. Bullen Newton, F.G.S.

(PLATES XX AND XXI.)

(*Concluded from the August Number, p.* 359.)

DESCRIPTION OF THE FOSSILS.

Group **PELECYPODA.**

Family **Unionidæ.**

Genus UNIO, Retzius (Philipsson).

Dissertatio Historico-Naturalis Nova Testaceorum Genera, 1788, p. 16.
Type = *Mya margaritifera*, Linnæus.

Synonyms—

Margaritana, Schumacher: Essai d'un nouveau Système des Habitations des Vers Testacés, 1817, p. 123, pl. x, fig. 4. Type = *Margaritana fluviatilis*, Schumacher = *Mya margaritifera*, Linnæus.

Alasmidonta, Say: Journ. Acad. Nat. Sci. Philadelphia, 1818, vol. i, p. 459. Type = *Unio undulata*, Say.

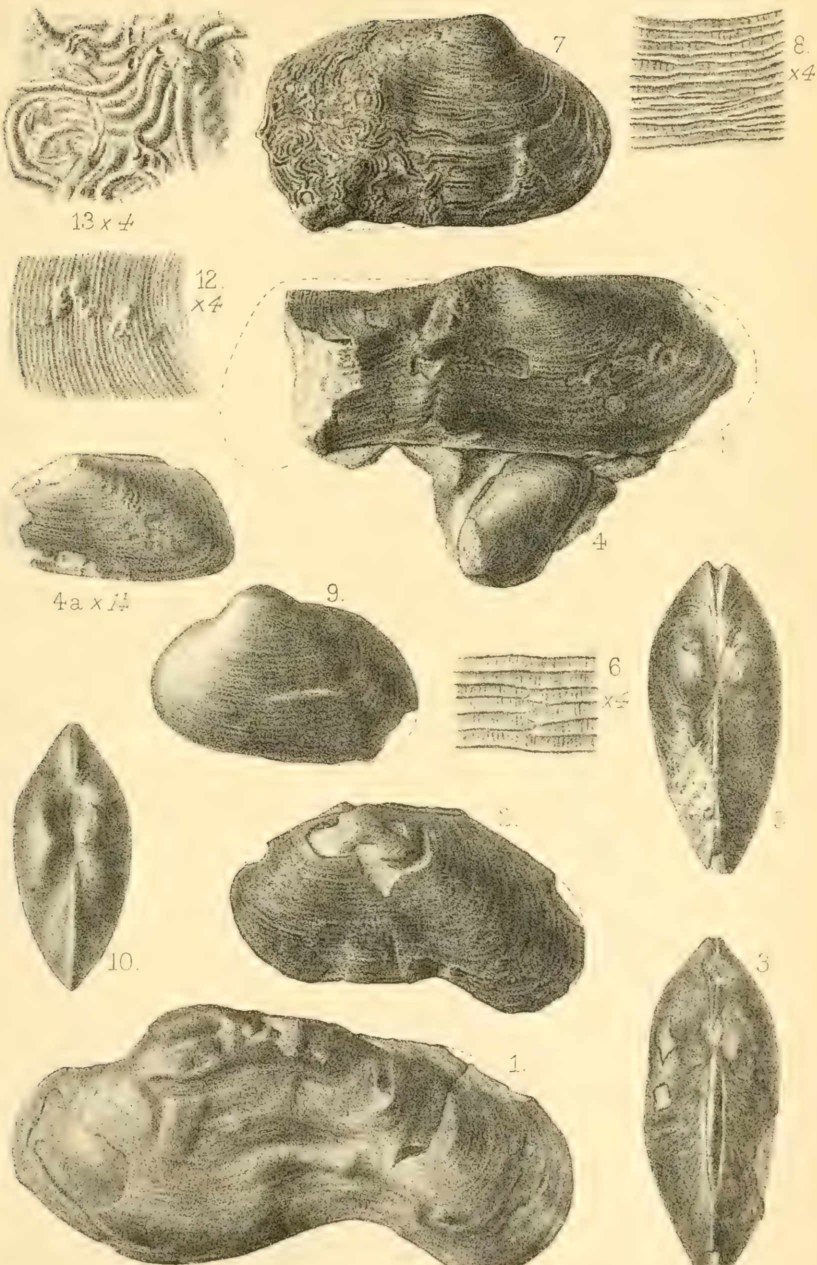
Unio Humei, sp. nov. (Pl. XX, Fig. 1.)

Description.—Specimen consisting of the natural cast of a left valve: form oblong, subtrigonal, mostly compressed; umbo anterior, depressed, incurved, succeeded in front by prominent lunuloid cavity; dorsal margin posteriorly elongate, oblique, continuous with the terminal curvature of margin; anterior region short, deep, slightly inflated on the ventral side of umbonal area; outer margin deeply excavated beneath the umbo, afterwards of oval contour; ventral margin anteriorly inflated, deeply sinuated in rear; posterior region furnished with an obtuse ridge directed obliquely from the umbo to the postero-ventral angle, on each side of which the valve slopes and becomes compressed; lateral face of valve between the anterior inflation and posterior ridge triangularly depressed; sculpture lines obscure.

Dimensions.—Height 35, length 75, diameter 12 mm.

Remarks.—This fossil, although mostly a cast, shows in places certain evidences of shell markings, but which are much too obscure for proper definition; rough lines of growth can also be traced. Its chief characteristics concern the presence of a lunulate area, the great depth of the anterior region being about $1\frac{1}{2}$ times that of the posterior end, and the extensive, somewhat trigonal depression on the lateral face of the valve bordered below by the deeply sinuated margin. There are few forms of fossil Unionidæ which will bear comparison with the Egyptian specimen, although at first sight its affinities might be looked for among Wealden species. Messrs. Koch & Dunker[1] have described *Unio Menkei* from the Wealden deposits of Northern

[1] *Beiträge norddeutschen Oolithgebildes Versteinerungen,* 1837, p. 58, pl. vii, fig. 1.



A. H. Searle, del. et lith.

Nubian Sandstone Fossils
from Egypt.

Germany which shows a slight basal sinuation, but differing greatly in other respects, such as in its contour lines, being of more equal height throughout, and having relatively shorter valves.

A further comparison with a Wealden species might also be made, as, for instance, with the well-known *Unio porrectus*, found chiefly in British localities and first described by J. de C. Sowerby,[1] the type being a transversely oval sandstone cast with fairly inflated valves, but possessing no basal sinuation, the ventral margin curving distinctly outwards. None of the Unionidæ of higher Cretaceous deposits appear to be in any way related to the present specimen.

Occurrence.—This fossil consists of a reddish-brown ironstone cast of a left valve isolated from the matrix. At the posterior extremity is a small portion of the opposing valve, but being somewhat obscure no details of importance can be cited in connexion therewith, except as illustrating complete compression of the valves in that area. An attempt has been made to develop the cardinal region, but without success.

UNIO JOWIKOLENSIS, sp. nov. (Pl. XX, Figs. 7–10.)

Description.—Shell (with closed valves) compressed, sub-oval; umbones anterior and eroded; dorsal margin horizontal, nearly parallel with ventral border; anterior region sloping from umbones, margins elliptically and moderately produced; posterior part obtusely ridged from umbones to postero-ventral corner, with prominent area sloping to rounded marginal extremity; lateral face sloping from umbonal region to basal margin, which is nearly parallel with dorsal line; sculpture showing nearly equidistant, fine, elevated, closely arranged, concentric striations with intermittent lineations.

Dimensions.—Height 30, length 47, diameter 18 mm.

Remarks.—The greater height and more compressed valves of this species removes it completely from its companion form *Unio Crosthwaitei*, although so far as ornamentation is concerned, and its possession of an obtuse postero-umbonal ridge, there is no doubt that both are allied species. This fossil presents a general resemblance to *Unio Menkei* of Koch & Dunker[2] from the Hanoverian Wealden, but differs in its finer ornamentation and the possession of a narrower and more produced anterior extremity. There is a second example of this species, of smaller size and with anteriorly eroded umbones, showing perhaps more plainly the postero-umbonal elevation and the lunuloid cavity. It is in a fair state of preservation, with the exception of the sculpture lines, which are not so distinct as in the larger specimen.

Occurrence.—The face of the right valve of the specimen described is largely covered with the tubes of the Annelid (*Galeolaria filiformis*), especially in the posterior region, otherwise the surface structure of the shell is well preserved. The left valve has been nearly all eroded away, showing the red-ironstone matrix and its microscopically fine pisolitic character.

UNIO CROSTHWAITEI, sp. nov. (Pl. XX, Figs. 2–6.)

Description.—Shell (with closed valves) sub-cylindrical, inflated; umbones anterior; dorsal margin nearly horizontal, arching posteriorly; ligament elevated, prominent, rounded, moderately thick, tapering in rear; anterior region short, no defined cavity

[1] *Mineral Conchology*, 1828, vol. vi, p. 189, pl. DXCIV, fig. 1.

[2] *Beiträge norddeutschen Oolithgebildes Versteinerungen*, 1837, p. 58, pl. vii, fig. 1.

in front of umbones, margin rounded; posterior region obtusely ridged from umbo to postero-ventral angle, sloping and compressed behind; ventral area sinuated at margin; antero-central face of valves obliquely and somewhat triangularly compressed; sculpture consisting of fine, equidistant, concentric, elevated striations, sometimes wavy, bifurcating, and otherwise irregular, with obscure vertical ridging between; rounded, obscure plications of growth are also present.

Dimensions.—Height 25, length 47, diameter 18 mm.

Remarks.—The specimen described has closed valves, between which reposes a well-developed ligament tapering posteriorly and bearing a few obscure transverse constrictions. The eroded umbones and certain cavities present on both valves indicate the effects of past river action before final deposition. The ornamentation is extremely fine and well preserved, and without a lens appears fairly regular, but a closer inspection shows that filament lines are given off from the main concentric striations producing an appearance of bifurcation, these lines being often gently wavy. Comparing it with *Unio Humei*, the species has relatively more convex valves, a less prominent central depression, and a more cylindroid contour. This new form perhaps compares more readily with *Unio subsinuatus* of Koch & Dunker[1] from German Wealden deposits in possessing the ventral sinuation, although the valves are of greater depth, more convex, less rounded and full anteriorly, whilst the posterior extremity is more produced. Another example of the species, of somewhat shorter axis, possesses a well-preserved test with distinct and regular sculpture lines bearing intermittent vertical ridging; its umbones are a good deal eroded. What appears to be another form of this species is associated in the matrix with *Mutela mycetopoides*, together with fragmentary remains of the same shell standing out in relief on the weathered surface of the rock. This specimen exhibits a left lateral view of evidently a young form having a height of 13 and a length of 25 mm. The sculpture lines are extremely fine and numerous, the postero-umbonal ridge is prominent, and a slightly oblique, narrow furrow proceeds from the umbonal region to the ventral border, which may be of accidental occurrence and not structural. The specimen also shows that the umbo is eroded, and that there is little or no sinuation of the ventral margin.

Occurrence.—The specimens representing this species are in a good state of preservation, although, like the other freshwater shells of this collection, no internal characters are displayed. The matrix is of the same reddish-brown ironstone rock, exhibiting a minutely pisolitic structure, and the shells present a blackish metallic colour with a lighter weathering. On the postero-dorsal surface of the left valve of the principal specimen is an example of the *Galeolaria* situated in close proximity to the elevated ligament.

Genus MUTELA, Scopoli.

Introductio ad Historiam Naturalem sistens genera Lapidum, Plantarum, et Animalium, etc., 1777, p. 397 (No. 83).

Type = "Le Mutel", Adanson: Hist. Nat. Sénégal (Coquillages), 1757, p. 234, pl. xvii, fig. 21. (= *Iridina exotica*, Lamarck.)

Synonym—Iridina, Lamarck: Hist. Nat. Animaux sans Vertèbres, 1819, vol. vi, pt. i, pp. 88, 89. Type = *Iridina exotica*, Lamarck.

[1] *Beiträge norddeutschen Oolithgebildes Versteinerungen*, 1837, p. 58, pl. vii, fig. 2.

MUTELA MYCETOPOIDES, sp. nov. (Pl. XX, Figs. 11, 12.)

Description.—Shell (right valve) shallow, soleniform, narrow, sub-cylindrical, sub-arcuate, medially depressed; hinge line straight, linear, parallel with ventral border; umbo nearly central, small, compressed; anterior region obliquely inflated from the umbo, flattened in front, outer margin rounded and gaping; posterior part obliquely and obtusely ridged, having a sloping depressed area in rear; ventral margin concave; surface sculpture consisting of microscopically fine and close striations following the contour lines of the shell, being often irregular and sometimes of network character, and generally grouped within equidistant, rounded plications of growth.

Dimensions.—Height 25, length (approximate) 65, diameter (approximate) 10 mm.

Remarks.—The foregoing description is based upon an external view of a right valve attached to the rock, which, although of fragmentary character, being fractured posteriorly, still preserves some important features of the shell. Through compression and erosion the details of the umbo are not definite, but its almost median position seems to be clearly displayed. The opposing valve is in situ, as can be seen from the presence of the antero-ventral margin, the remainder being entirely hidden in matrix. These front terminal margins are important, since they exhibit the well-marked gape, which is seen to extend ventrally, as in the modern forms of this genus. On the central face of the valve, and near the ventral border, two small vertical depressions occur, produced probably by pressure or otherwise during the life of the mollusc, giving rise to constrictions which locally disturb the regularity of the lines of ornamentation. With regard to sculpture, the growth plications may be said to be fairly well developed in places, whilst the finer striations, only observable with a strong lens, are frequently intertwined and irregular, forming more or less a structure of filaments.

The principal characters of this specimen include the straight hinge line, the nearly median umbo, the posterior ridge, the inward curvature or sinuation of the central region of the valve, the sub-cylindrical contour, and anterior gape. In many of these details it appears to more nearly resemble *Mycetopus* of Orbigny [1] than Scopoli's *Mutela*, that is, judging from the type of the former genus (*M. soleniformis*), which lives in Central South American rivers; but remembering that *Mutela* belongs essentially to African freshwaters, and is moreover found in the alluvial deposits of the Nile,[2] it is more reasonable to suppose that the fossil under consideration represents an ancestral form of that genus rather than of another which belongs to a totally different continent. In order to mark this resemblance the present African fossil has been named *Mutela mycetopoides*.

Occurrence.—The fossil is adherent to a mass of ironstone matrix associated with a small form of *Unio* (*U. Crosthwaitei*). Its surface is mostly of a deep-black colour, besides being much cracked and perforated in places in consequence of erosive agencies. Quite a number of small, rounded, wart-like prominences are present on the fossil, these representing pisolitic grains of iron-ore, the presence of which would denote the highly ferruginous character of the waters

[1] *Voyage dans l'Amérique Meridionale*, 1846, vol. v, pt. iii, Mollusques, pp. 600, 601, pl. lxvi.

[2] Leith Adams, Quart. Journ. Geol. Soc., 1864, vol. xx, p. 15.

prevailing during the period of deposition. The matrix exhibits a light-coloured weathering on the exposed surfaces, and is of minutely oolitic structure.

Family **Aviculidæ.**

Genus INOCERAMUS, J. Parkinson.

Trans. Geol. Soc. [London], 1819, vol. v, pt. i, p. 55, pl. i, fig. 3.
Type = *Inoceramus Lamarcki*, Parkinson.

Inoceramus Balli, sp. nov. (Pl. XXI, Figs. 1–3.)

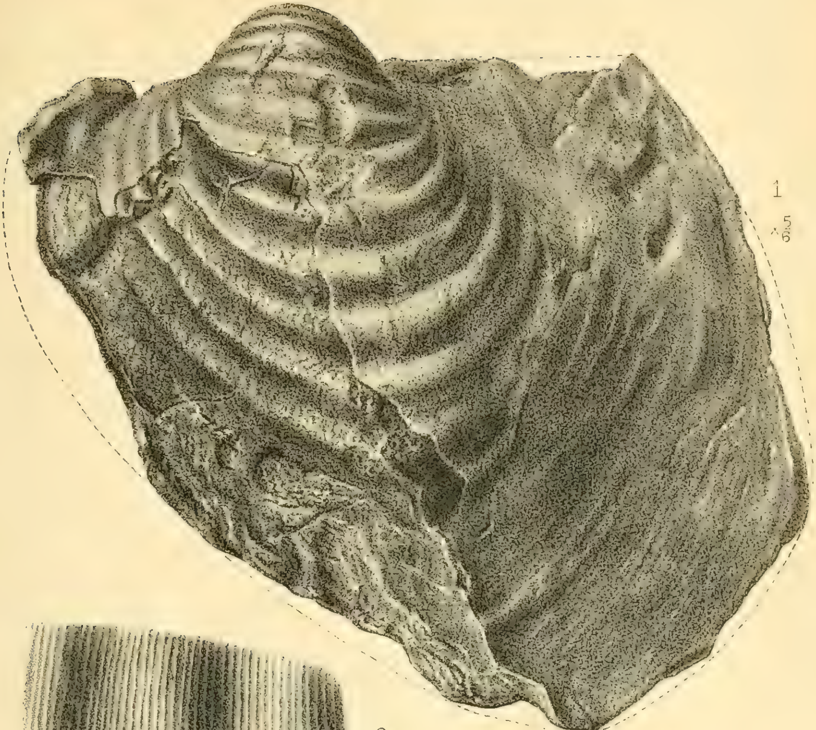
Inoceramus Cripsi, Blanckenhorn MS.: W. F. Hume, "Topography and Geology of the Peninsula of Sinai (south-eastern portion)," Survey Department, Egypt (Cairo), 1906, p. 153; John Ball, "Description of the First or Aswan Cataract of the Nile," Survey Department, Egypt (Cairo), 1907, p. 67. *Non* Mantell *nec* Goldfuss.

Description (specimen with closed valves).—Shell of moderately large size, equivalve, sub-quadrangular from the lateral aspect; valves antero-medially inflated, arched, compressed towards anterior margin, but considerably more so posteriorly and ventrally; cardinal line straight, horizontal, nearly equal in length to the height, longest posteriorly; posterior and ventral margins rounded, anterior, more or less truncated, sub-vertical; umbonal region antero-median, incurved, posteriorly inclined, but with probable anteriorly directed summits; surface of valves with about twenty elevated, prominent, rounded, concentric costæ with laterally attentuated ends, divided by furrows of corresponding width; costæ and grooves broaden as development proceeds, but become lost and insignificant in the area of greatest compression; extremely fine concentric lineations ornament the surface of the ridges and furrows.

Dimensions.—Height 120, length 115, diameter 75 mm.

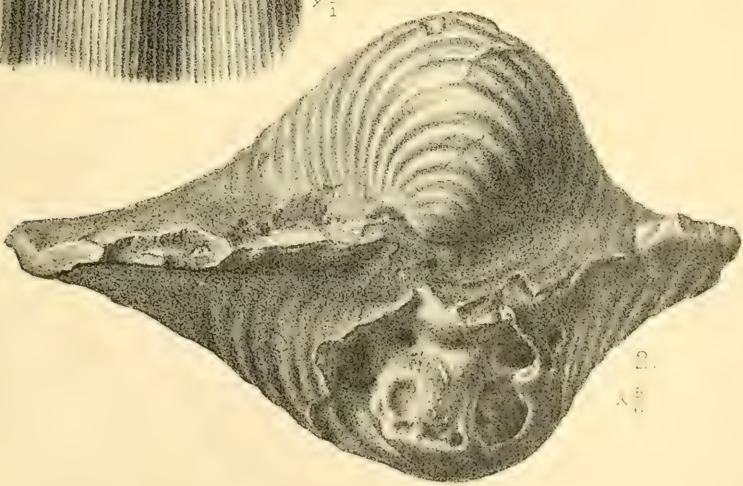
Remarks.—This *Inoceramus* would appear to belong to the group of which *Cripsi* of Goldfuss (*non* Mantell) [1] might be taken as the type; in fact, the specimen has already been so determined by Dr. Blanckenhorn, although important differences exist which would undoubtedly separate it from the species itself. There is the rather quadrangular outline as opposed to the general transversely oval figure of the typical German shell, the presence of the prominent antero-median elevation from the umbonal part downwards, and the more medially situated umbonal area. Chiefly in the well-sculptured costæ and grooves does it approximate to the Goldfussian shell. The posterior inclination of the umbonal region, mentioned in the diagnosis, need not necessarily imply that the shell was opisthogyrous, as it is more than probable that were the summits in preservation they would be found assuming the usual anterior direction hitherto associated with the genus *Inoceramus*. A similar phenomenon may be observed in large examples of *I. concentricus*, Parkinson, of Albian (= Gault) age, which exhibit the prosogyrous character of the umbones followed by a more oblique

[1] Without attempting a revision of the Inoceramoid shells, it is necessary to remind the student that Orbigny was the first palæontologist to recognize the importance of separating into two species the forms which Goldfuss had included under *Cripsi* in the *Petrefacta Germaniæ*. He therefore substituted *Goldfussianus* for *Cripsi*, because the latter name was preoccupied by Mantell for a shell of different form and horizon (Cenomanian), limiting its application to the example represented by fig. 4*d* of the Goldfuss plate 112; whilst that of *regularis* was acknowledged to embrace figs. 4*a*, *b*, *c* of the same plate (see Orbigny, *Pal. Française Terr. Crétacés Lamellibranchia*, 1845, p. 517, pl. ccccxi, and *Prodrome Pal. Strat.*, 1850, vol. ii, p. 250). The nomenclature of some of these Senonian Inocerami has been recently under the consideration of Dr. Joh. Böhm in the *Monatsber. Deutsch. Geol. Ges.*, 1907, No. iv, p. 113.



1 $\times \frac{5}{6}$

3. $\times \frac{4}{1}$



2. $\times \frac{5}{6}$

A. H. Searle del et lith. [illegible]

Inoceramus Balli, sp. nov.
from the Nubian Sandstone of Egypt.

arrangement of the ridges and grooves anteriorly than on the opposing side, and so producing a posterior curvature of the umbonal region. In its actual marginal contour, judging from the lateral aspect, it follows very much the lines of Zittel's *I. Cripsi*, var. *typica*, a Gosau species of Campanian age (Denksch. k. Akad. Wiss. Math. Nat., 1866, vol. xxv, p. 98, pl. xiv, fig. 1), though not so rounded anteriorly where the costæ are more or less vertically disposed, especially on the right valve. Again, the umbonal region of the Gosau shell is much nearer the anterior margin, besides exhibiting a strong anterior obliquity; the costæ are also more numerous, and the valves have not the prominently arched feature of the specimen from Egypt. In general form, therefore, and sculpture characters the specimen favours an Upper Cretaceous horizon, and it may reasonably be regarded as Senonian; in fact, it is more than possible that its real place in the series would be the Campanian stage of that period, as specified on Blanckenhorn's manuscript label accompanying the specimen, because it is in that stage the so-called *Cripsi* and its allies are more generally found in the world's Cretaceous regions, such as the United States, India, Japan, etc.

Occurrence.—The only specimen available is in a good state of preservation with both valves in the closed position, shell structure being seen in places with the delicate surface lineations. The margins are rather imperfect, especially on the left anterior side, where there is evidence of crushing, which was probably effected during the process of fossilization. Since its arrival from Egypt a large part of the matrix of the left valve has been skilfully removed by Mr. Richard Hall, the senior Formatore of the British Museum (Natural History), thus exposing the centrally arched elevation and the extensive areas of depression at the base and rear. Through mineralization and wind erosion the right valve has to a great extent lost the surface and ornamentation of the umbonal region, but all its later characters are well displayed. The matrix is highly ferruginous and of limonite character, being mostly of a reddish-brick colour. Where wind erosion has taken place through long exposure, the surface of the valves is quite lustrous and polished and of a blackish-brown metallic appearance. There are some obscure remains of Annelid tubes on this specimen which from their fineness might probably be referred to *Galeolaria filiformis*. In a recent letter Dr. John Ball kindly furnished the following particulars as to the locality where he was fortunate enough to discover this unique *Inoceramus*:—"It was obtained from near the west-end of the Aswan dam, on the west bank of the Nile, during excavations for a small reservoir, and, as far as I remember, it was quite low down in the local series not more than 20 metres above the old igneous rocks. From the adherent matter you will see it came from one of the more ferruginous beds in the sandstone." Soon after this information was sent, Dr. Ball, then on vacation in England, called at the British Museum and supplied some further details as to the occurrence of the genus in this part of Egypt. He had subsequently found fragments of another *Inoceramus*, of what might be the same species, near the triangulation station of Abajaj, which is about 17 kilometres E.N.E. of Aswan on the east bank of the Nile, in a similar ferruginous rock at about 120 metres above the Nile. Unfortunately this later material is in the Survey Museum at Cairo, and not available at the present moment for comparison with the Aswan specimen.

Group **ANNELIDA.**

Family **Serpulidæ.**

Genus GALEOLARIA, Lamarck.

Hist. Nat. Anim. sans Vertèbres, 1818, vol. v, p. 371.

GALEOLARIA FILIFORMIS, J. de C. Sowerby. (Pl. XX, Fig. 13.)

Serpula filiformis, J. de C. Sowerby: Trans. Geol. Soc. London, 1836, ser. II, vol. iv, pt. ii, p. 340, pl. xvi, fig. 2.

Galeolaria (*Serpula*) *filiformis*, Bronn: Handbuch Geschichte Natur., 1848, vol. i, p. 521.

Serpula filiformis, Stoliczka: Palæontologia Indica, 1873, vol. iv, pt. iv, p. 63, pl. xii, fig. 6; Kossmat, "Cretaceous Deposits of Pondicherri," Records Geol. Surv. India, 1897, vol. xxx, pp. 96, 107, pl. x, fig. 7 (translated from the German).

Serpula (*Galeolaria*) *filiformis*, R. B. Newton: Ball & Beadnell's Report, "Baharia Oasis," Survey Dept. Public Works Ministry, Egypt, 1903, p. 55.

Remarks.—The original account states that this species consists of "smooth, round tubes, slightly curved, and aggregated into elongated, often branching masses. The tubes are rather thick, nearly equal throughout their substance". Although not so entirely fasciculate as is usual with this species, the form from the Nubian Sandstone shares most of the characters as indicated in the first description. It is found adherent to the valves of the unioniform shells (especially to *Unio Jowikolensis*), the tubes curving and intertwining in various directions, and sometimes lying side by side in parallel curvatures more or less contiguous, whilst the posterior ends are occasionally acuminate. The tubes are quite small, barely half a millimetre in diameter, and without the aid of a lens present an almost filamentous appearance. Some obscure indications of transverse striations appear to be perceptible, but this is very uncertain, as the surface shows evidence of erosion, making it difficult to say whether it was not originally polished and smooth as in ordinary examples of this species. The more isolated of the tubes are observed to run parallel with the sculpture lines of the valve. The species was first described from the Blackdown Beds of England, now regarded as of Albian age, the same massive fasciculate type having in more modern years been recorded from the Upper Cretaceous rocks of Africa and India, both Stoliczka and Kossmat having recognized it in the Arialyur Group of Southern India (= Senonian), whilst Messrs. Ball & Beadnell collected it in a ferruginous, sandy looking, more or less calcareous rock of Cenomanian age occurring in the Baharian region of the Libyan Desert of Egypt, associated with other true marine fossils such as *Exogyra Olisiponensis*, etc. Good examples of the species have been figured by Pictet & Renevier[1] from the Aptian deposits of Switzerland, so that its geological range appears to extend almost throughout the Cretaceous Series. It is also mentioned by Stoliczka as occurring in

[1] Descr. Foss. Terr. Aptien St. Croix—Matériaux Pal. Suisse, 1854, pt. i, p. 17, pl. i, figs. 10–15.

the Cenomanian, Turonian, Senonian, Quadersandstein, and Pläner of England, France, Germany, and Austria.

Closely allied forms are Dujardin's[1] *Serpula filosa* from the French Cenomanian-Turonian Series (Touraine district), which has exceedingly fine tubes and is also of fasciculate habit, and *Serpula plexus*, J. de C. Sowerby,[2] from British Senonian rocks. It would therefore appear that this particular type of Annelid being fairly representative of Upper Cretaceous rocks, we may assume that the Nubian Sandstone specimen belongs to that part of the Cretaceous system. Following Bronn, the species is included in Lamarck's genus *Galeolaria*, and it is so determined in the British Museum.

Occurrence.—This fossil forms one of those rather rare instances of a marine organism being found in direct association with another of freshwater character, proving that marine conditions prevailed and were in fairly close proximity to the river agencies which had brought down the fluviatile shells to the area where deposition was in progress. A similar combination of organisms may be mentioned in connexion with a piece of limestone of the 'Munder Mergel' Series of North Germany, regarded as the base of the Wealden (=Purbeckian), which exhibits a small form of *Cyrena* in company with *Serpula coarcervata*, Blumenbach, the specimen being in the British Museum with the registered number A–64.

Conclusions.

From a glance at the list of fossils already known to occur in the Nubian Sandstone of Southern Egypt (see p. 358), it will be seen that the formation is of considerable depth in places, and especially in the Wadi Kena, where Figari Bey (according to Zittel) obtained *Mosasaurus* remains at a depth of 400 feet. This Vertebrate belongs chiefly to the uppermost part of the Senonian (Mæstrichtian), although Blanckenhorn regards the Egyptian occurrence as of older Senonian (Santonian) age. From a boring in the neighbourhood of Edfu at a depth of 308 feet, Coquand reported the finding of *Ostrea Verneuili*, which he considered to be of Garumnian age, a member of the Danian; and later Dr. Hume discovered numerous *Lingulæ* and *Mytilus* cf. *lineatus*, etc., in a well boring at Abu Rahal, 164 feet from the surface, which he stated were of Cretaceous age.

The silicified woods (*Araucarioxylon* and *Nicolia*) of this formation and the fern remains described by Professor Seward indicate its estuarine origin, that is so far as Southern Egypt and Nubia are concerned.

A study of the present fossils supports the Cretaceous view as to the age of this part of the Nubian Sandstone, which, it is interesting to observe, was initiated some seventy years ago by Lefévre after an examination of the rocks as exposed at Aswan.

In speaking of the freshwater shells, which appear to be the only mollusca of that character recorded from the Nubian Sandstone since Russegger's discovery of *Cyclas faba*? of Münster in 1843 from near Aswan, they appear at first sight to bear a relation to Wealden forms,

[1] Mém. Soc. Géol. France, 1835, vol. ii, pt. i, p. 233, pl. xvii, fig. 18.

[2] *Mineral Conchology*, 1829, vol. vi, p. 201, pl. DXCVIII, fig. 1.

but when carefully examined such resemblance is not maintained, nor do they compare with any closeness to similar shells found in the later deposits of the Cretaceous Series. Russegger regarded his *Cyclas faba*? as indicating Greensand, Quadersandstein, or Wealden, but as the specimen was never figured or described, its scientific value at the present day is unimportant. It may be mentioned, however, that none of the unioniform shells now described could possibly be mistaken for the genus *Cyclas*.

The fact that a marine organism accompanies the shells appears to be ample testimony of the estuarine conditions which prevailed during the deposition of the beds, as doubtless the valves, probably in the dead state, were brought along by river action to the neighbourhood of the sea, and so became associated with marine life.

So far as the Annelid tubes are concerned, their determination as *Galeolaria filiformis* appears to be correct, and although this is a species which ranges throughout the Cretaceous system, it is satisfactory to learn of its occurrence in the Arialyur Group (= Senonian) of India, and in the rocks of the Baharia Oasis of the Libyan Desert of Egypt accompanying Cenomanian mollusca (*Exogyra Olisiponensis*, etc.).

The *Inoceramus*, as pointed out, belongs to a group of forms which are restricted to Upper Cretaceous rocks, and mostly to the Campanian stage of the Senonian period. Paul Choffat[1] records *I. Cripsi*, var. *typica*, of Zittel as having been found in a sandstone outlier at Mira in Portugal associated with *Hoplites Vari*, var. *Marroti*, of Coquand, and determined as of Campanian age. Fournel's[2] *Cripsi* (= *regularis*, Orbigny) is found in the Senonian of Algeria.

According to Madagascar[3] lists *Cripsi* (Goldfuss) occurs in that country, and is regarded as Senonian. Both Stoliczka[4] and Kossmat[5] recognize the same form in the Upper Senonian of Southern India, as also does Professor Yokoyama[6] in the Senonian of Japan. Further, Whiteaves[7] has recognized it in the Senonian of Vancouver, whilst under the names of *Sagensis* of Owen and *Barabini* of Morton, Whitfield[8] has identified it among the fossils of the Raritan Clays, etc., of New Jersey, United States.

When it is considered that the typical form of *Inoceramus* of Turonian times is the *labiatus* of Schlotheim, and that the true *Cripsi* of Mantell belongs to the Cenomanian, there seems little doubt that the new species now described, with a facies peculiarly Senonian, might accurately be relegated to that period and possibly to its Campanian stage.

Although a distance of some 25 miles separates the localities from

[1] Recueil de Monographies Stratigraphiques systeme Crétacique du Portugal, pt. ii, Le Crétacique Supérieur au Nord du Tage, 1900, p. 228.

[2] Richesse Minérale de l'Algérie, 1849, vol. i, p. 370, pl. xviii, figs. 31, 32.

[3] Lemoine, *E'tudes Geologiques dans le Nord de Madagascar*, 1906, pp. 222, 230.

[4] Mem. Geol. Surv. India, Pal. Indica, 1871, p. 405, pl. xxvii, fig. 3.

[5] Records Geol. Surv. India, 1897, vol. xxx, p. 82 (correlation table).

[6] Palæontographica, 1890, vol. xxxvi, p. 175, pl. xviii, figs. 6, 7.

[7] Geol. Surv. Canada, 1879, pp. 170–3.

[8] Mon. United States Geol. Surv., 1885, vol. ix, pp. 75–9, pl. xiv, figs. 15, 16, and pl. xv, figs. 3–5.

which these fossils were obtained, the lithological nature of the matrix is identical in both areas, and may therefore be regarded as of similar age, so that the fauna of the Jowikol Beds exhibiting fresh-water and marine characters is consequently of estuarine origin, and, moreover, may be determined as of Senonian horizon.

EXPLANATION OF PLATES.

Plate XIX.

Topographical sketch-map of Egypt, showing localities of Nubian Sandstone Fossils, from the original designed by Dr. John Ball (see *ante*, p. 353).

Plate XX.

Unio Humei, sp. nov.

FIG.

1. Left lateral view of specimen.

Unio Crosthwaitei, sp. nov.

2. Left lateral aspect.
3. Dorsal view of same, showing ligament and eroded umbones.
4. Younger form of probably the same species, associated with *Mutela mycetopoides*.
4*a*. An enlarged view of the same specimen. $\times 1\frac{1}{4}$.
5. Dorsal view of another specimen with ligament, and valves slightly open at the ends.
6. Surface structure of same, showing concentric lineations, sometimes bifurcating, and transverse ridging. $\times$ 4.

Unio Jowikolensis, sp. nov.

7. Right lateral view of specimen, with adherent Annelid tubes.
8. Surface structure of same, showing irregular lineations with transverse ridges between. $\times$ 4.
9. Smaller specimen of the same species, left lateral aspect.
10. Dorsal view of same, showing eroded umbones.

Mutela mycetopoides, sp. nov.

11. Right lateral aspect of specimen on matrix, associated with a probably young form of *Unio Crosthwaitei*.
12. Magnified view of surface structure in the postero-dorsal region. $\times$ 4.

Galeolaria filiformis, J. de C. Sowerby.

13. Portion of the colony adherent to the valve of *Unio Jowikolensis*. $\times$ 4.

The above specimens were obtained from Jowikol, on the east bank of the Nile, between Kalabsha and Aswan.

Plate XXI.

Inoceramus Balli, sp. nov.

1. Left lateral view of specimen slightly reduced in size. $\times \frac{5}{6}$. Showing the prominent costæ and compressed regions.
2. Dorsal view of same, exhibiting the elevated and arched character of the umbonal region and its inclination posteriorly. $\times \frac{5}{6}$.
3. Surface structure, showing the fine lineations on the costæ and grooves—a restored figure. $\times \frac{4}{1}$.

This specimen was from the west end of the Aswan Dam.

Note.—Unless mentioned to the contrary, the figures on Plates XX and XXI are represented of the natural size. The specimens belong to the Museum of the Geological Survey of Egypt.

III.—Notes on new or imperfectly known Chalk Bryozoa (Polyzoa).

By R. M. Brydone, F.G.S.

(*Continued from p.* 339.)

(PLATES XXII AND XXIII.)

Membraniporella monastica, nov. Pl. XXII, Figs. 1–3.

Zoarium always encrusting.

Zoœcia pyriform, average length and breadth ·43 mm. and ·28 mm.; aperture semicircular, with a small tubercle at each side; front wall normally formed of five pairs of spines, the space between the lowest pair being filled by a triangular plate perforated at the apex and possibly tubular, as when it is broken off its base proves to be perforated; when there is a preceding zoœcium with an oœcium the fifth pair of spines and the triangular plate disappear, and the space so left is filled by the preceding oœcium, which always carries a small avicularium, possibly a relic of the triangular plate; the spines are not always strictly paired; the backbone is often depressed and pierced by irregular pores.

Oœcia subquadrate, expanded above, free edge nearly straight.

Avicularia. Besides the small avicularia on the oœcia there are many independent avicularia scattered irregularly between the zoœcia; they are long, narrow, and tumid, with triangular apertures, and resemble a monk's cowl.

The front wall is very fragile, and slight attrition will turn a specimen into a spinose *Membranipora*, but the avicularia and oœcia will still enable its true nature to be recognized.

Abundant at Trimmingham.

Membraniporella castrum, nov. Pl. XXII, Figs. 4 and 5.

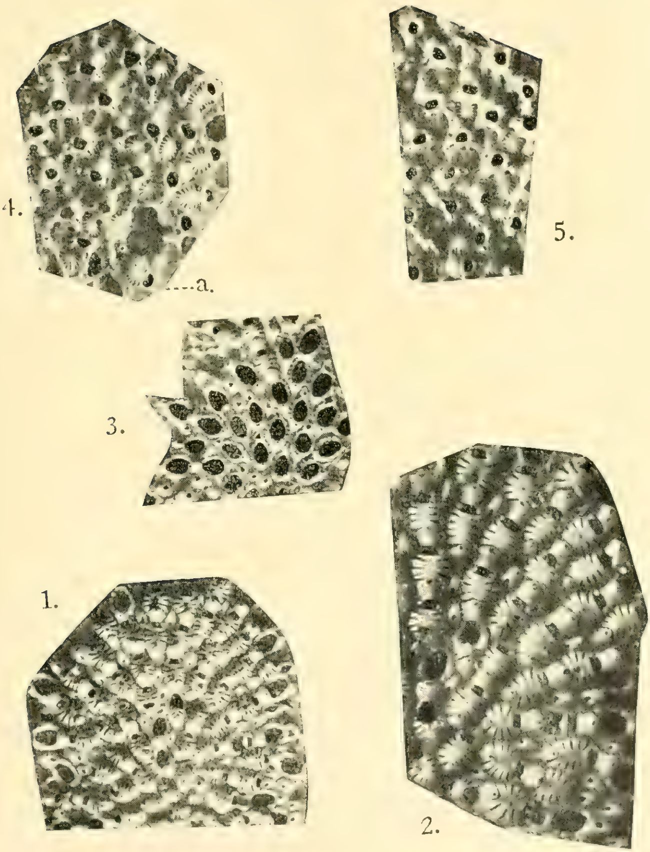
Zoarium always encrusting.

Zoœcia deeply sunk inside an embankment of secondary structures, average length and breadth ·58 mm. and ·33 mm. The primary form appears to be shown in Fig. 4, at *a*, as slightly pyriform with a semicircular aperture and a front wall composed of from 13 to 16 radiating and more or less paired spines, the first pair thickened and bearing a stout triangular tooth projecting into the aperture. In the mature form the walls and the lower lip of the aperture are strongly elevated and tiny mandibular avicularia appear at the corners of the aperture, and these structures blend with one another and the similar structures of adjoining zoœcia to form a large secondary aperture of irregular shape and high enclosing wall round the front wall. From a depression in the middle of the lower side of the lower lip of the secondary aperture a broad bar with a median furrow descends gradually to the front wall.

Oœcia large, globose, projecting through the margin of the secondary aperture, within which their free edges are sometimes visible.

Avicularia. Besides the pair normally present at the corners of the aperture, similar avicularia occur occasionally on the walls and round the aperture.

Fairly common at Trimmingham.



R. M. Brydone phot.

Chalk Bryozoa (Polyzoa).

CRIBRILINA OSTREICOLA, nov. Pl. XXIII, Figs. 1 and 2.

Zoarium always encrusting.

Zoœcia pyriform, average length and breadth ·45 mm. and ·28 mm.; aperture semicircular, lower lip often curved slightly outwards; front wall composed of from 13 to 15 spines more or less arranged in opposing pairs and separated by furrows with a large pore at the outer end and otherwise finely punctate.

Oœcium large, globose, the free edge corresponding in outline with but slightly smaller than the upper lip of the aperture.

Avicularia very numerous and of three classes, all of duller texture than the zoœcia. The most abundant are small and slender, with a strong inflation of the upper end, in which a slit-like aperture is set, and lie in almost continuous lines between the lines of zoœcia. The second class are mandibular, of regular occurrence, and often vicarious, with a central oval aperture surrounded by a slender ring, and a rounded symmetrical beak. The third class (possibly vibracularia) occur very irregularly and are large and quadrangular, with a relatively very small oval aperture rather above the centre.

Very abundant at Trimmingham, mainly on *Ostreæ*.

CRIBRILINA SUBVITREA, nov. Pl. XXIII, Figs. 3 and 4.

Zoarium always encrusting.

Zoœcia small, average length and breadth ·45 mm. and ·28 mm.; aperture transversely oval, with a deep subtriangular slit in the lower lip; front wall tumid, with many imperforate radiating furrows too faint to be accurately counted.

Oœcia tumid, elongated, subtriangular, very faintly keeled and transversely furrowed, free edge corresponding in outline with but smaller than the upper lip of the aperture.

Avicularia of two classes. The first class small, narrow, pointed, with oval apertures, usually in pairs like horns at the head of the zoœcium, very constant. The second class (possibly vibracularia) are vicarious, polygonal, with very small central circular apertures, occurring irregularly and often in bands and groups.

These vicarious avicularia and some of the zoœcia are depressed below the general surface, and have a dull appearance like that of roughened glass. The dull zoœcia show the radiating furrows much better than the normal ones.

This species is very closely related to the form identified by Beissel[1] with *Cellepora elegantula*, Hag., undoubtedly in error, but is easily distinguishable by its imperforate surface and vicarious avicularia. Marsson[2] has referred Beissel's form to *Schizoporella cornuta*, Hag. sp., but it is clearly a strict *Cribrilina*, and being unnamed may be called *Cribrilina Beisseli*. *C. subvitrea* is technically a *Schizoporella*, but its close relationship to *C. Beisseli* makes me feel justified in regarding its furrows as genetic and classifying it as a *Cribrilina* until the time comes for the Cribrilinidæ to be dismembered.

Abundant at Trimmingham.

[1] *Über die Bryozoen der Aachner Kreidebildung*, Haarlem, 1865, p. 60.

[2] Op. cit.

HOMALOSTEGA CUNIFORMIS, mihi. Pl. XXIII, Figs. *5a–d.*

A specimen with oœcia occurred when there was still time to revise the original diagnosis (*ante*, p. 338) that no oœcia were known, but it was too late to add to Pl. XIV, Figs. 6 and 7. I now give figures of some oœcia, the one figured as *5b* being probably perfect.

EXPLANATION OF PLATES XXII AND XXIII.

PLATE XXII.

FIG. 1. *Membraniporella monastica.* × 20.
,, 2. Ditto, part of same specimen. × 40.
,, 3. Ditto, part of worn specimen. × 20.
,, 4. *Membraniporella castrum.* × 20.
,, 5. Ditto, another specimen. × 20.

PLATE XXIII.

,, 1. *Cribrilina ostreicola.* × 20.
,, 2. Ditto, another specimen. × 40.
,, 3. *Cribrilina subvitrea.* × 20.
,, 4. Ditto, part of same specimen. × 40.
,, *5a–d. Homalostega cuniformis.*

(*To be continued.*)

IV.—ON THE SKULL OF *TAPINOCEPHALUS.*

By Professor R. BROOM, M.D., D.Sc., For. Corr. Z. S. Lond., Victoria College, Stellenbosch, Cape Colony, South Africa.

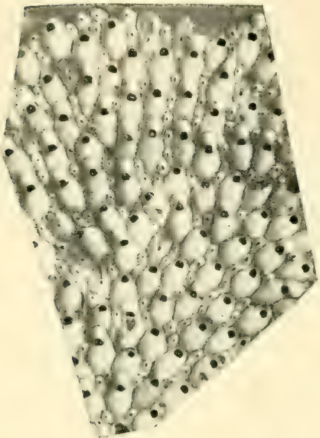
(WITH TWO TEXT-FIGURES.)

IN 1876 Owen described the tip of the snout of a large fossil reptile from South Africa under the name of *Tapinocephalus atherstoni.* Although a few vertebræ and other bones of the skeleton are known, as no further remains of the skull have been found we have been in complete ignorance of the affinities of this one of our largest Karroo reptiles.

In the Seeley Collection in the British Museum there is a nearly perfect but somewhat crushed skull which pretty certainly belongs to the genus *Tapinocephalus* and, although it is about one-third smaller, perhaps to the type species. Another specimen shows the postorbital portion of the skull. To these specimens Dr. Smith Woodward has called my attention, and very kindly given me permission to describe them.

The skull consists of a broad, high, rounded posterior portion and a broad, flat snout. The orbit is near the middle of the skull, and there is on each side a single temporal opening, and the quadrate is carried well forward and lies under the postorbital arch. The general structure will, however, be better understood from the figures given. Fig. 1 represents a side view of the skull slightly restored, and with the distortion corrected. Many of the sutures are obscured, but sufficient can be made out to leave no doubt as to the nature of the skull. The temporal arch is essentially similar to that in the Therocephalians and Anomodonts, being formed entirely by the squamosal and the jugal, both of which are very large. The quadrate is also large, but mainly hidden by the squamosal. Owing to the advanced position of the quadrate the lower jaw must have been short, its

1.



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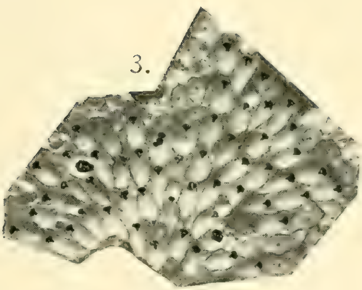

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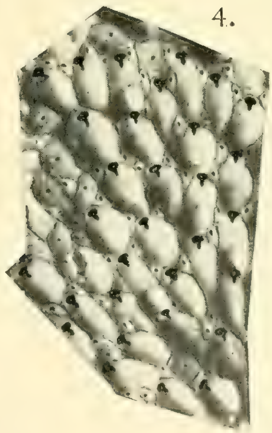

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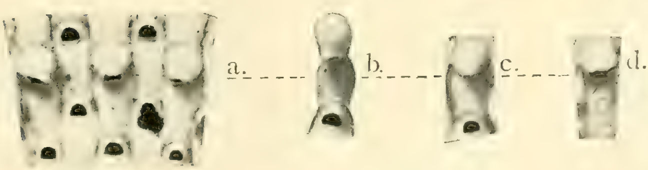

R. M. Brydone phot.

Chalk Bryozoa (Polyzoa).

probable shape being represented by the dotted lines. Fig. 2 represents the under side of the skull, and shows a most interesting condition of the palate. Between the large internal nares are a pair of prevomers, and behind and to the outer side of the nares a pair of small palatines. The pterygoids are large, and in front meet the prevomers. Externally they form large descending processes along the inner sides of the mandibles. There are no teeth on the palate, and there appears to be no transpalatine.

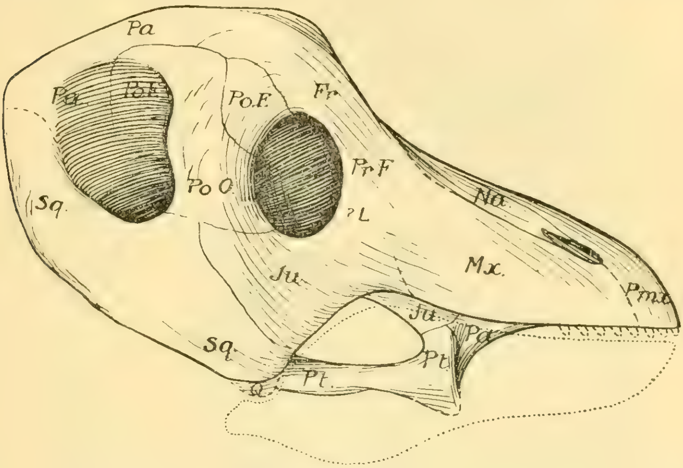

Fig. 1. Profile of skull of *Tapinocephalus atherstoni*, Owen: Karroo formation, S. Africa (greatly reduced).

The occiput is very large and slopes upwards and backwards. In general structure it appears to resemble that of *Dicynodon*, but it is not well preserved in either specimen. The condyle is large and rounded and the foramen magnum small. There is a very large exoccipital which meets the descending squamosal and also the quadrate. As in *Dicynodon* there appears to be an ossified tympanic. As preserved the skull measures 500 mm. in length, but if uncrushed would probably be about 30 mm. more.

Of skulls hitherto described the only one closely allied to that of *Tapinocephalus* is *Delphinognathus*. Though *Tapinocephalus* differs from *Delphinognathus* in having a very feeble dentition, there is little doubt it should be placed in the same sub-order, Dinocephalia of Seeley.

The Dinocephalians have relations with both the Therocephalians and the Anomodonts. In the structure of the palate they come nearest to the Therocephalians, but in most other respects the affinities appear to be nearer *Dicynodon* and its allies. Most probably they are an offshoot from an early Therocephalian closely related to that which started another line of descent and gave rise to the Anomodonts.

Though the locality of Seeley's specimen is unknown, there can be little doubt it is from the *Pareiasaurus* zone of the Gouph.

In examining Owen's type in the light of this new skull it becomes manifest that two of Owen's identifications are wrong. The two bones internal to the nares which he regarded as nasals are the nasal processes of the premaxillaries, and the two bones which form the nasal floor and lie between the prevomers ('vomers') and the

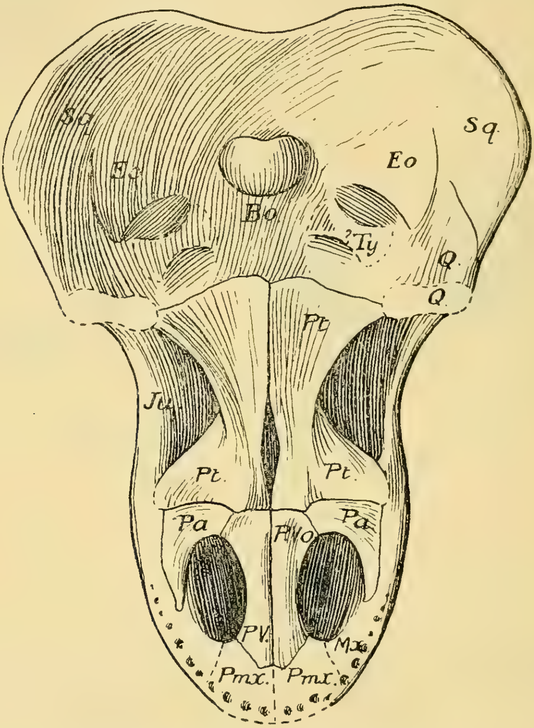

FIG. 2. Palatal aspect of skull of *Tapinocephalus atherstoni*, Owen: Karroo formation, S. Africa (greatly reduced).

maxillaries, and which were regarded as palatines by Owen, are apparently septomaxillaries. This presence of septomaxillaries is very interesting, as they appear to occur in *Pareiasaurus* and are present in Therocephalians, Cynodonts, and Monotremes, but are absent from Anomodonts.

V.—NOTE ON THE ASSOCIATION OF CASSITERITE AND SPECULAR IRON IN THE LODES OF DARTMOOR.[1]

By DONALD A. MACALISTER, Assoc.R.S.M., F.G.S.

(WITH FOUR TEXT-FIGURES.)

SITUATED in the neighbourhood of Birch Tor, in the heart of the granite mass of Dartmoor, at an elevation of between 1300 and 1400 feet, there are a number of tin-mines which have been worked

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

fitfully from remote periods (Fig. 1). The region is wild and lonely, and has in a marked degree all the scenic peculiarities of the moorland districts of the west of England.

The area over which mining has been carried on is about $1\frac{1}{2}$ square miles, and is readily distinguished from the surrounding country by the numerous immense open-cuts or gullies (loc. 'gunnies') which have been made in it along the 'backs' or outcrops of the more important lodes; while the heaps of veinstone debris and mine refuse in the valleys combine to make it a picture of desolation.

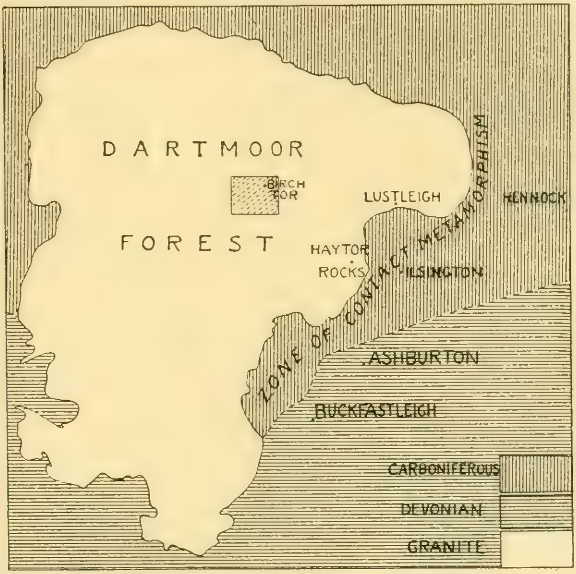

Fig. 1. Key-Map showing position of Birch Tor, Haytor, and other places mentioned in the text.

The ordinary granite of the district is coarsely porphyritic and contains well-formed crystals of dark mica. Tourmaline is a common accessory mineral, and occurs as individual crystals or stellate patches, or as nests of schorl-rock.

In the lode area the ordinary granite has been invaded by a multitude of dykes of granophyre, fine-grained granite, and elvan, which are so poorly exposed as to be unmappable, but the extent of their distribution is indicated in the figure by the shading (Fig. 2).

The principal mines are the 'Birch Tor and Vitifer' and the 'Golden Dagger', and these are, at the present time, only working in a small way. Wheal Catherine, Bushdown Tin-mine, and numerous other small mines have long since been abandoned.

The following table of the total yield of tin-ore from the mines during the periods for which statistics are procurable will best indicate the scale upon which they have been worked:—

Mine.	Dressed 'Black-Tin'.	Period of Working.	Remarks.
	Tons.		
Birch Tor and Vitifer.	670	From 1852 to 1865; 1872 to 1882; 1887 to 1890; 1903 to 1907.	In 1882 the metal contained in the Black-tin amounted to 64 per cent.
Golden Dagger.	170	From 1882 to 1906.	In 1882 the metal contained in the Black-tin amounted to 55 per cent.
New Birch Tor.	394	From 1859 to 1874.	

The lodes depicted in the illustration have been mapped on the spot from such evidence as is afforded by open-cuts, lines of trial pits,

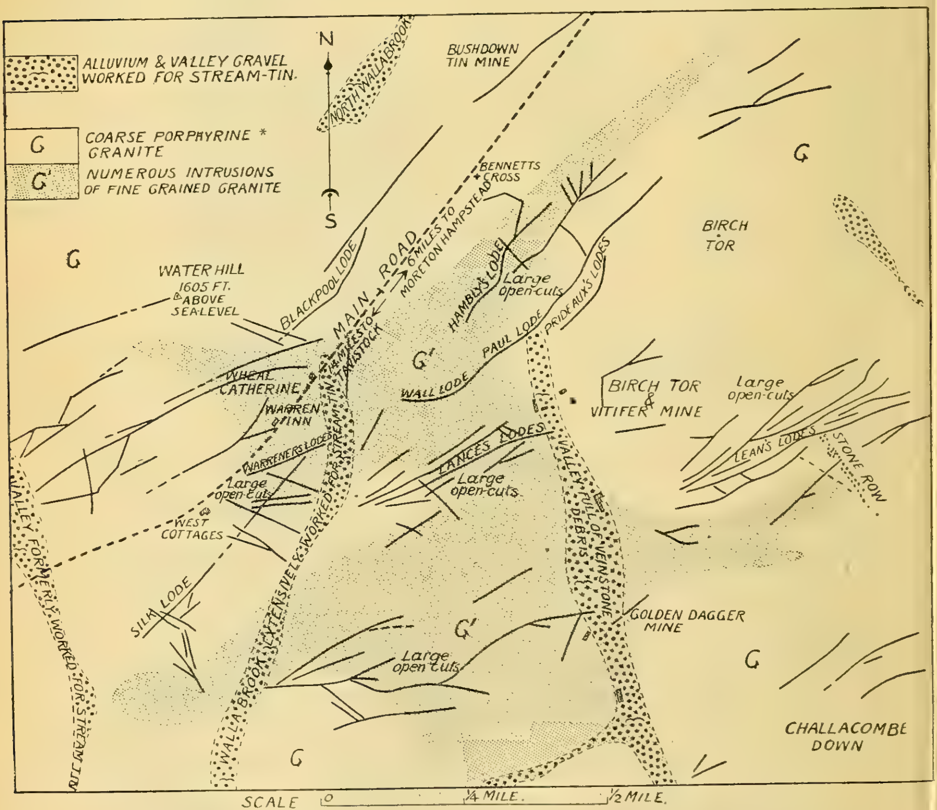

FIG. 2. Geological Map of the Birch Tor Mining District, Dartmoor.

* *Coarse Porphyrine* should read *Coarse Porphyritic.*

or other artificial excavations, and the names given to them are those by which they are known locally. Their general bearing ranges between E. 25° N. and E. 45° N.

The lodes are simply more or less vertical fissures filled with gangue or veinstone showing no signs of brecciation. In width they vary from that of a mere rift or crack up to 2 feet or more. In many of the open-cuts it will be seen that much of the material worked away is a rotted, somewhat kaolinized granite traversed by innumerable minute vertical fissures crossed by mineralized horizontal pseudo-bedding planes of the granite. In other cases (e.g. Lean's Lodes) massive siliceous veins occupy fissures of considerable width.

The special interest in these lodes lies in the intimate association of the cassiterite with specular iron-ore, and in this connexion Lean's Lodes, which, by means of an adit level, have been worked for 200 fathoms eastwards from the valley, are particularly good examples.

The veinstone consists of massive quartz with streaks and nests of fine acicular blue tourmaline.

The tinstone and specular iron-ore occur intimately mingled with one another or as separate veins, and are, in both cases, frequently accompanied by much fine tourmaline. Chalcopyrite and mispickel are absent, and with the exception of a little iron pyrites, which occurs sporadically here and there, sulphides do not occur.

A chemical examination of the specular iron-ore, which has the form of small, brilliant spangles, proved it to be quite free from titaniferous minerals.

The structure of the veins as a whole does not reveal any evidence that there was a definite sequence in the order of deposition of the minerals, which may therefore be regarded as contemporaneous. Fig. 3 is a diagrammatic sketch of a thin slice of the ore as seen through the microscope. The minerals depicted are quartz, cassiterite, specular iron-ore, tourmaline, and a little mica. The cassiterite occurs as granular aggregates or as well-formed prisms, which are often long and slender. The specular iron-ore shows opaque lath-shaped sections, and occurs in close association with the cassiterite, but is never enclosed by the latter. The study of its relationship with the cassiterite indicates that it crystallized after the latter, for it sometimes occurs interstitially or appears to have partly crystallized round the cassiterite. It has a closer connexion with the tourmaline, which bears, as a whole, a similar relationship towards the cassiterite. The tourmaline has the form of fine dull-blue needles or fibres radiating from a point or scattered through quartz. It also occurs as zoned prisms with acicular fringes at the ends. The mica is of rare occurrence, and is seen only in minute aggregates, as indicated by the letter *M* in the figure. All these minerals are embedded in quartz of one generation. Under crossed nicols the latter has the appearance of a coarse mosaic. It contains numerous inclusions of slender tourmaline needles and fluid cavities with bubbles. The sequence of crystallization appears to have been (1) cassiterite, (2) specular iron-ore and tourmaline, (3) quartz.

The actual proportion of cassiterite in the material mined I could not ascertain, but, on the assumption that it is 2 per cent., the amount of specular iron present must, at the lowest computation, be well over 8 per cent., since for every ton of dressed Black-tin obtained nearly 4 tons of specular iron have been removed by a magnetic separator, and a still greater amount has been washed off in the processes the material subsequently undergoes. It would be safe to say that the lode contains about 20 per cent. of iron-ore.

The employment of the magnetic separator is merely to free the tinstone from the iron-ore, and, with the exception of 25 tons of specular iron-ore containing 58·8 per cent. of iron, which were sold in 1906 at the rate of £2 a ton, the ferruginous by-product has proved so far useless, since it is a variety too hard to be readily ground to a pigment and not quite suitable for the smelter, even if enough could be obtained.

Fig. 3. Microphotograph of Specular Iron-Tinstone from Birch Tor. *Q*, quartz, all of one generation, in which the other minerals are set; *C*, cassiterite; *S*, specular iron; *T*, tourmaline; *M*, fine mica.

Other occurrences of specular iron in the neighbourhood and elsewhere will now be referred to so as to compare them with that of Birch Tor.

The neighbourhood of Lustleigh, which lies to the east, has long been known as a producer of micaceous or 'shining' ore, and De la Beche states that among its uses this mineral was formerly employed under the name of 'Devonshire Sand', which was sold at the rate of from £3 3*s*. to £8 8*s*. a ton as a writing sand. As it is a soft variety of specular iron it has in recent times been used chiefly as a pigment, but a little has also been smelted.

In a paper read in 1895 [1] Mr. Joseph S. Martin described the nature

[1] J. S. Martin, "Micaceous Iron Ore near Bovey Tracey": Trans. Manchester Geol. Soc., 1895, vol. xxiii, p. 162.

of the veins of micaceous iron-ore at the Hawkmoor and Shapter Mines in the parish of Bovey Tracey, near Lustleigh, and mentioned that one of them contained cassiterite. As these lodes have the same general direction as those at Birch Tor, there can be no reasonable doubt that they are of the same age and differ from them only in the larger proportion of iron-ore they contain.

From the Hawkmoor and Shapter lodes, which vary in width from 2 inches to 2 feet, the amount of shining ore obtained between the years 1892 and 1902 was over 1200 tons (including a small quantity from Plumley and Shuttamoor). The ore was a soft variety of specular iron used almost exclusively as a pigment, and according to official returns realized from £4 to £5 a ton.

Although I do not contend that all the ferruginous deposits in this district have a similar mode of origin, it is a suggestive fact that the specular-iron-cassiterite veins should happen to occur in a district already so rich in other ores of iron, such as the magnetite and limonite (brown hæmatite) of Haytor and Ilsington[1] and other localities on the west of Dartmoor.

The nature of the magnetite deposits of Haytor have been studied by (Sir) Clement Le Neve Foster, J. H. Collins, and Dr. Busz, and the results of their work are of interest in this connexion. Dr. Busz examined the ore microscopically, and discovered it to be associated with fibrous hornblende and a little apatite and garnet.[2] Dr. Foster in 1875 stated that the ore contained, in addition to magnetite, actinolite, garnet, axinite, some iron pyrites, chalcedony, chalybite, and fluorspar. He made alternative suggestions regarding its origin, stating that the ore might be either metamorphosed bedded iron-ores, i.e. contact-altered beds of iron-ore once similar to those of Cleveland, or else the result of deposition of iron-ore along beds by means of ferruginous emanations derived from the granite.[3]

After visiting the magnetite mines near Haytor I carefully examined typical specimens of the ore. Although entirely within the metamorphic aureole of the Dartmoor granite, the general structure of the ore and its relation to the country rock left no doubt in my mind of its being an epigenetic deposit and not the result of contact metamorphism acting on a ferruginous bed. Nor are there any greenstones in the mine to account for the presence of the magnetite. The country rock consists of banded Culm sediments, some layers of which show contact alteration phenomena, such as spotting, while others are tough, fine, compact, siliceous bands or coarser micaceous sandy layers, varying from a fraction of an inch in thickness to several inches. Here and there thin veins of granite penetrate the beds. The ore itself consists mainly of hornblende and magnetite, and occurs along certain bands in the sediments. In these orey bands the magnetite occurs as a microscopically fine crystalline layer, ranging up to a foot or so in thickness, which either ends off abruptly against the adjacent siliceous

[1] Over 45,000 tons of iron-ores were raised between 1858 and 1882 from the parish of Ilsington.

[2] Neu. Jahrb. f. Min. u. Geol. (Bauer), 1899–1901, vol. xiii, p. 102.

[3] C. Le Neve Foster, "Notes on Haytor Iron Mine": Quart Journ. Geol. Soc., 1875, vol. xxxi, p. 628.

bands or merges insensibly on both sides into a mass of radiating, curved, green fibres and sheaves of hornblende, which in turn ends abruptly against the adjacent beds of the Culm. Throughout the hornblende small, well-formed, or microscopically fine crystals of magnetite may be seen. The magnetite also occurs as well-formed octahedra encrusting cracks in the hornblende mass and sometimes in association with transparent vein-quartz and a micaceous mineral. As a whole the structures are reminiscent of those seen in some tin veins in killas, in which tin-ore occupies the same relative position with regard to greisen, chlorite, or schorl-rock that the magnetite does to the hornblende (Fig. 4).

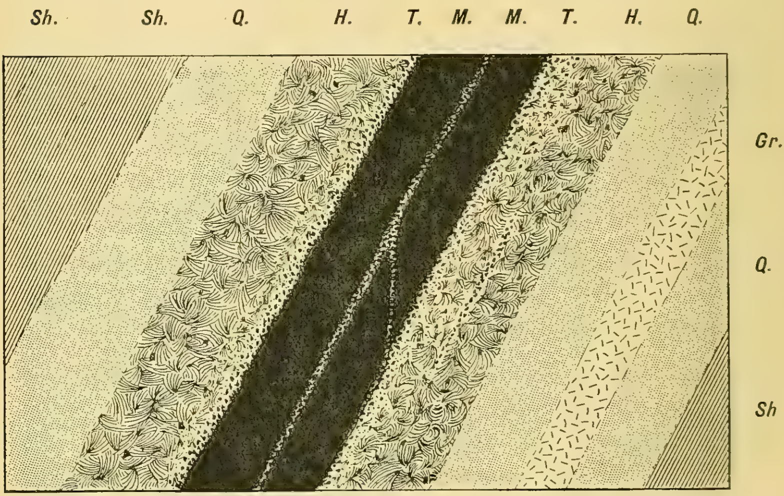

FIG. 4. Diagram illustrating the structure of the magnetic iron-ore deposits at Haytor (reduced to $\frac{3}{4}$ nat. size). *M.*, dense, finely crystalline magnetite with cracks encrusted with well-formed crystals; a little fibrous hornblende is seen in places; *T.*, transition between magnetite and hornblende; *H.*, fibrous hornblende with scattered crystals and specks of magnetite; *Q.*, dense fine siliceous rock resembling a very fine quartzite or chert; *Sh.*, spotted shale; *Gr.*, granite vein.

It appears to me that it is possible to link the ore genetically with the tin-specular-iron veins of Birch Tor, on the assumption that they were impregnations or metasomatic replacements along calcareous beds of the Culm at the time they were undergoing thermal metamorphism. The magnetite deposits may be paralleled with those of Pennsylvania, where calcareous rocks have been replaced by this ore by heated ferruginous solutions.[1] It should be borne in mind, however, that there are many lodes of iron in the west of England, particularly those characterized by the presence of chalybite and small amounts of manganese (e.g. Perran Iron Lode, Newquay, and the lodes of

[1] C. Spencer, Bull. 359, U.S.A., 1908.

Exmoor and Combe Martin), which were undoubtedly formed after the tin-lodes and were in no way connected with pneumatolytic actions. Such lodes are not here being considered.

The geological conditions under which specular iron is found in the tin-lodes of Birch Tor are quite in accord with its usual mode of occurrence, since its common habitat is the crystalline schists and the acid eruptive rocks (both volcanic and plutonic), where it is sometimes accompanied by magnetite. It has been artificially prepared by Messrs. Fouqué and Levy, and has been observed in copper works slag [1] and as a sublimate in alkali works.[2] Its occurrence in the west of England has been frequently recorded, but its connexion with tin-ores has been seen only in small quantities.

Near Hennock a vein of specular iron-ore 2 feet in thickness has been recorded by Lysons.[3] Similar ore has been worked at South Molton, and occurs at Buckfastleigh. During the survey of this district a vein of specular iron-ore in white quartz was found on the north of Water Hill. The specular iron here occurs in unusually large tabular crystals $\frac{1}{4}$ inch across. In small quantities it is present in the lodes of Wheal Maudlin (St. Austell), Wheal Beauchamp (Gwennap), and Tincroft (Camborne).

To go further afield, it is of interest to know that the mineral occurs plentifully in tin-ore veins of the Mückenberg district at Ober-Graupen, and pseudomorphous after wolfram and fluorspar near the Zinnwald, Bohemia. It occurs in Framont (Vosges) near an intrusion of quartz porphyry, and has recently been noted in tin-ore of the Rooiberg district, Transvaal.

The general conclusions are that the lodes of Birch Tor may be regarded as a special sub-type of tin veins in which the characteristic minerals are quartz, tourmaline, cassiterite, and specular iron free from sulphides, except a little accessory iron pyrites. In the genetic classification based on mineral associations it occupies a transitional position between hæmatite lodes and tin-lodes with sulphidic minerals, as follows:—

1. Hæmatite (including specular iron-ore. Magnetite and ilmenite also come into this group).
2. Specular iron-ore (with magnetite ?) and cassiterite.
3. Cassiterite and wolfram.
4. Cassiterite and wolfram with mispickel, chalcopyrite, and other sulphides (and, rarely, argentiferous galena).

The veins of types 2, 3, and 4 are further characterized by the presence of such minerals as tourmaline and fluorspar, and are accompanied by alterations of the country rock to greisen, schorl-rock, and china clay rock.

[1] W. Terrill, "Note on Artificial Crystals of Specular Iron found in a Copper Works Slag": Min. Mag., 1884, vol. v, p. 48.

[2] A. Arzruni, "Comparative Observations on Artificial and Natural Minerals": Zeit. f. Kryst.. 1890, vol. xviii, p. 44.

[3] *Magna Britannia* (Devonshire), 1822, p. cclxviii.

VI.—On the Correlation of the English Tertiary Beds with those of the Continent.

By Dr. A. von Koenen, of Göttingen, Germany; For. Corr. Geol. Soc. Lond.

SCHIMPER (*Traité de Paléontologie végétale*, t. iii, p. 680) established in 1874 his Étage paléocène pour les "Sables de Bracheux, Travertins anciens, Lignites et grès du Soissonnais", which are coeval with the Thanet Sands and the Woolwich Series. As there is a natural break between these and the London Clay (= the French Sables de Cuise), and as the Eocene contained more varied faunas than the Oligocene, Miocene, and Pliocene Tertiaries, I accepted that division in my description of the Kopenhague fauna, which formed the Lower Palæocene, together with the Montien of Belgium, older marine beds which are unknown in England.

Quite recently M. Gustave Dollfus kindly sent me his paper "On the Classification of the Beds of the Paris Basin", published in the Proceedings of the Geologists Association in 1909, vol. xxi, pp. 101–18, where (p. 103) he says that I had proposed the term Palæocene for the Montien; "that name is now accepted by many authors and the only objection we have to it is that this name was created by Schimper for the 'Lower Nummulitic'," etc. I wrote about this to M. Dollfus and asked him to correct this statement. Somehow these errors appear singular in an otherwise most able and important paper, but he told me to correct it myself, and it appears that the error has been caused partly by mistake or misprint or by momentary lack of memory. I need not refer to the matter further, but I must notice that all the Lower Tertiaries were named 'Terrain Nummulitique' in older times, and the pre-Nummulitic part of them is exactly the 'Lower Nummulitic', the Palæocene of Schimper including the Montien and the Calcaire pisolithique.

In the same paper (p. 108) M. Dollfus tries to invalidate the evidence adduced by me in my paper in the Quart. Journ. Geol. Soc., May 1864, p. 98, where I showed that out of 56 species of Mollusca from Brockenhurst 6 were peculiar to that locality and the Headon Beds, 46 (not 43) exist in our Lower Oligocene, 21 (not 28) in the Barton Clay, and 23 are characteristic Lower Oligocene species. The Brockenhurst fossils mentioned by me were in the splendid collection of Fred. E. Edwards (now in the British Museum), named and compared by him with his Barton and High Cliff fossils. It is not likely therefore that the number of species common to Brockenhurst and Barton will increase very much. On the other hand, I had a large part of my Lower Oligocene fossils with me, so that they were compared with the English fossils by Mr. Edwards and myself directly. If I really did not mention some of the Brockenhurst species in my monograph of the Lower Oligocene, I may have forgotten it or omitted them, because I had no specimens for a renewed comparison. Out of twelve species of corals from Brockenhurst only two are said now to be identical with species from the Paris Basin and others to be similar; that gives no proof whatever of their relative age. In our Lower Oligocene, which cannot be divided into two different zones, there are other genera of corals besides *Balanophyllia*, so that there can be no possible comparison with the Brockenhurst Corals. The Molluscan fauna of the Lower Oligocene is exactly identical with the Tongrien inférieur of Belgium, and is very rich (I described 756 species), that of our Rupel Clay being rather poor, so that it is quite impossible that a larger number of fossils could pass from the former to the latter (which contains about 200 species, 70 of which are common to the Lower Oligocene, as I stated in my monograph, p. 1443), and the Upper Oligocene has a well-characterized fauna discovered last year as far west as Boncelles, north of Liége. I must therefore object to separating the Oligocene only into two divisions and to the putting the Brockenhurst Beds in the Upper Eocene.

It is a mistake or misprint that I once cited the Venus Bed from the Lower Headon Series, instead of the Middle; the Lower may belong to the Eocene, which is otherwise represented in the most northern parts of Germany by clay with Crabs and a few Mollusca of the London Clay and basaltic tufa, as in Denmark (Moler). The important beds of brown coal between Halle, Magdeburg, and Brunswick are still doubtful, though I rather believe them to be of Eocene age.

As to the Aquitanien, I am not sure that it is everywhere clearly defined, so that it may belong partly to the Upper Oligocene and partly to the Lower Miocene, containing mostly brackish and fresh-water beds, which so often form "des terrains de passage", or intermediate beds.

VII.—Obsidianites in the Malay Peninsula.

By J. B. Scrivenor, M.A., F.G.S., Geologist to the Federated Malay States Government and formerly of H.M. Geological Survey of the United Kingdom.

THE appearance of Professor E. Weinschenk's paper[1] at the close of last year on two specimens of Moldavite from Kuttenburg, in Bohemia, affords a convenient opportunity of recording occurrences of the related 'obsidianites' (referred to by Professor Weinschenk as Billitonite and Australite) in the Malay Peninsula.

The literature dealing with the occurrences of obsidianites in the Malay Archipelago and Australia is unfortunately scattered. The subject has been fully treated, however, and in view of the origin suggested for Moldavite by Professor Suess and supported by Professor Weinschenk, namely, that these peculiar pieces of glass fell on the earth as meteors, it is interesting to note the lunar-volcanic origin suggested for obsidianites by Dr. Verbeek in 1897,[2] and the admission of the probability of a meteoric origin by Dr. Krause in 1898.[3] On the other hand, Mr. E. S. Simpson,[4] while describing West Australian

[1] "Die kosmische Natur der Moldavite und verwandter Gläser": Centralblatt f. Min. Geol. u. Palaeontologie, December 15, 1908, No. xxiv, pp. 737–42.

[2] R. D. M. Verbeek, "Glaskogels van Billiton-Jaarboek v. h. Mijnwezen in Nederlandsch Oost-Indië": Wetenschappelijk Gedeelte, 1897, pp. 235–72, pl. i.

[3] P. G. Krause, "Obsidianbomben aus Niederländisch Indien-Jaarboek v. h. Mijnwezen in Nederlandsch Oost-Indië": Wetenschappelijk Gedeelte, 1898, pp. 17–31, pl. i.

[4] E. S. Simpson, Geol. Survey of Western Australia, Bull. No. 6, Notes from the Departmental Laboratory, 1902, pp. 79–85, pls. i, vi–viii.

obsidianites in 1902, inclines, apparently, towards the view of their having been derived from terrestrial volcanoes. References to earlier literature will be found in the works of the above-mentioned authors.

A detailed description of the obsidianites in the Malay Peninsula is unnecessary, since they agree with those described and excellently figured by Dr. Verbeek, Dr. Krause, and Mr. Simpson. Dr. Verbeek figures also two specimens of Moldavite (Bouteillesteenen) from Bohemia for comparison with the obsidianites.

With one exception all the specimens that have come under the writer's notice were found in tin-ore bearing alluvium in the Blat and Gambang Valleys in the district of Kuantan, Pahang. The exception is a small obsidianite from the Sudu Seremban Tin-mine, Negri Sembilan, collected by Mr. Leonard Wray in 1904 and now in the Perak Museum, Taiping.

Mr. H. C. Robinson has informed the writer that obsidianites have been found elsewhere in Negri Sembilan, namely, at Gemas and on the Triang River.

Generally the Pahang obsidianites show the "brilliant black lustre, making them appear, as Krause says, as if varnished or lacquered",[1] and they also show the sculpturing that is the chief feature of these remarkable bodies. Sometimes, however, they are distinctly water-worn, which robs them of their lustre and impairs the minute detail of the sculpturing.

A partial analysis of a specimen by Mr. B. J. Eaton, Government Chemist, Kuala Lumpur, shows—

SiO_2	72·60 per cent.
Al_2O_3 and Fe_2O_3 . .	26·00 ,,
CaO	4·00 ,,

The mean specific gravity of three large specimens was found to be 2·46.

The alluvium in which the obsidianites are found is sandy and contains few pebbles. These are mostly quartz, but others of quartz-porphyry and dolerite occur, both rocks being found in situ in the district.

None of the specimens examined by the writer show any trace of the shell of glass which Professor Weinschenk describes[2] as covering about one-third of the surface of the two specimens of Moldavite from Kuttenburg; but seeing how thin and fragile this skin is, its absence in a bed of alluvium containing rolled pebbles is not to be wondered at.

As the writer has no facts to record regarding the Pahang obsidianities helping to terminate the doubt that exists as to their origin, he does not propose to discuss the theories that have been put forward at any length. Professor Weinschenk considers[2] no stronger proof could be given of the cosmic nature of Moldavite than the glass skin, which is interpreted as the result of fusion of the surface of the stones as they fell through the atmosphere, unless they should be observed actually falling. Without assuming the pre-existence of volcanoes now disappeared, the theory of a meteoric origin is the only one that explains the wide distribution of these bodies. The objection that no undoubted meteorites of the same composition are known

[1] Simpson, op. cit., p. 81. [2] Op. cit., p. 739.

is obvious, and if, as the writer understands Mr. Simpson to be inclined to think, obsidianites are bombs hurled enormous distances from terrestrial volcanoes, a thin skin of fused glass might be formed during their descent. To the writer, however, a meteoric origin seems the more probable.

Obsidianites are now known to have been found in the following localities in Malaysia:—Billiton (Verbeek, op. cit.); Mt. Moeriah, Djapara, Java (pp. 245, 246); Pleiari, Tanah Laut, S.E. Borneo (pp. 246, 247); Sungri Riam, Tanah Laut, S.E. Borneo (pp. 246, 247); Bungaran (Natuna Archipelago) (Krause, op. cit.); Blat and Gambang Valleys, Pahang; Gemas and Sungri Triang, Negri Sembilan (H. C. Robinson); Sudu Seremban, Negri Sembilan (L. Wray).[1]

NOTICES OF MEMOIRS.

British Association for the Advancement of Science. Abstract of Address to the Geological Section by Arthur Smith Woodward, LL.D., F.R.S., V.P.Z.S., Sec. G.S., Keeper of Geology in the British Museum, President of the Section. Winnipeg, Canada, August 26, 1909.

The circumstances of the present meeting very clearly determine the subject of a general address to be expected from a student of extinct animals. The remarkable discoveries of fossil backboned animals made on the North American continent during the last fifty years suggest an estimate of the results achieved by the modern systematic methods of research; while the centenary celebration of the birth of Darwin makes it appropriate to consider the extent to which we may begin deducing the laws of organic evolution from the life of past ages as we now know it.

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There has been an unfortunate tendency during recent years for the majority of geologists to relinquish the study of fossils in absolute despair. More ample material for examination and more exact methods of research have altered many erroneous names which were originally used; while the admission to scientific publications of too many mere literary exercises on the so-called 'law of priority' has now made it necessary to learn, not one, but several names for some of the genera and species which are commonly met with. Even worse, the tentative arrangement of fossils in 'genetic series' has led to the invention of a multitude of terms which often serve to give a semblance of scientific exactitude to the purest guesswork, and

[1] The Pahang obsidianites, like obsidianites elsewhere, have been stated to be pieces of slag resulting from smelting operations. A comparison of the physical and chemical properties of obsidianites and slag from a furnace in operation shows how wide of the mark this view is. A more interesting theory emanated from a Malay Rajah, who told the writer that he had collected a number of these stones and believed each to contain a gem in the centre. A valuation was asked for, and the writer felt sorry that it should fall to his lot to destroy the Rajah's belief by cracking one open for his inspection.

sometimes degenerate into a jargon which is naturally repellent to an educated mind. Nevertheless, I still hope to show that, with all these difficulties, there is so much of fundamental interest in the new work that it is worth while to make an effort to appreciate it.

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In this connexion it is necessary to combat the mistaken popular belief that the main object of studying fossils is to discover the 'missing links' in the chain of life. We are told that the idea of organic evolution is not worthy of serious consideration until these links, precise in character, are forthcoming in all directions. Moreover, the critics who express this opinion are not satisfied to consider the simplest cases, such as are afforded by some of the lower grades of 'shell-fish' which live together in immense numbers and have limited powers of locomotion.

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They even expect continual discoveries of links among the rarest of all fossils, those of the higher apes and man. The geologist, on the other hand, knowing well that he must remain satisfied with a knowledge of a few scattered episodes in the history of life which are always revealed by the merest accident, marvels that the discovery of 'missing links' is so constant a feature of his work. He is convinced that, if circumstances were more favourable, he would be able to satisfy the demand of the most exacting critic. He has found enough continuous series among the mollusca, for example, and so many suggestions of equally gradual series among the higher animals, that he does not hesitate to believe without further evidence in a process of descent with modification.

* * * * * * *

Among these general features which have been made clear by the latest systematic researches, I wish especially to emphasize the interest and significance of the persistent progress of life to a higher plane, which we observe during the successive geological periods. For I think palæontologists are now generally agreed that there is some principle underlying this progress much more fundamental than chance-variation or response to environment, however much these phenomena may have contributed to certain minor adaptations. Consider the case of the backboned animals, for instance, which I happen to have had special opportunities of studying.

We are not likely ever to discover the actual ancestors of animals on the backboned plan, because they do not seem to have acquired any hard skeleton until the latter part of the Silurian period, when fossils prove them to have been typical and fully developed, though low in the backboned scale. The ingenious researches and reasoning of Dr. W. H. Gaskell, however, have suggested the possibility that these animals originated from some early relatives of the scorpions and crustaceans. It is therefore of great interest to observe that the Eurypterids and their allies, which occupy this zoological position, were most abundant during the Silurian period, were represented by species of the largest size immediately afterwards at the beginning of the Devonian, and then gradually dwindled into insignificance. In other words, there was a great outburst of Eurypterid life just at the time when backboned animals arose; and if some of the former were actually transformed into the latter, the phenomenon took place when their powers both of variation and of multiplication were at their maximum.

Fishes were already well established and distributed over perhaps the greater part of the Northern Hemisphere at the beginning of Devonian times; and then there began suddenly a remarkable impulse towards the production of lung-breathers, which is noticeable not only in Europe and North America but also probably so far away as Australia. In the middle and latter part of the Devonian period most of the true fishes had paddles, making them crawlers as much as swimmers; many of them differed from typical fishes, while agreeing with lung-breathers, in having the basis of the upper jaw fused with the skull, not suspended; and some of them exhibited both these features. Their few survivors at the present day (the Crossopterygians and Dipnoans) have also an air-bladder, which might readily become a lung. The characteristic fish-fauna of the Devonian period therefore made a nearer approach to the land animals than any group of fishes of later date; and it is noteworthy that in the Lower Carboniferous of Scotland—perhaps even in the Upper Devonian of North America, if footprints can be trusted—amphibians first appeared. In Upper Carboniferous times they became firmly established, and between that period and the Trias they seem to have spread all over the world; their remains having been found, indeed, in Europe, Spitzbergen, India, South Africa, North and South America, and Australia.

The Stegocephala or Labyrinthodonts, as these primitive amphibians are termed, were therefore a vigorous race; but the marsh-dwelling habits of the majority did not allow of much variation from the salamander pattern. Only in Upper Carboniferous and Lower Permian times did some of their smaller representatives (the Microsauria) become lizard-like, or even snake-like in form and habit; and then there suddenly arose the true reptiles. Still, these reptiles did not immediately replace the Stegocephala in the economy of nature; they remained quite secondary in importance at least until the Upper Permian, in most parts even until the dawn of the Triassic period. Then they began their flourishing career.

At this time the reptiles rapidly diverged in two directions. Some of them were almost exactly like the little *Sphenodon*, which still survives in some islands off New Zealand, only retaining more traces of their marsh-dwelling ancestors. The majority (the Anomodonts or Theromorphs) very quickly became so closely similar to the mammals that they can only be interpreted as indicating an intense struggle towards the attainment of the higher warm-blooded grade; and there is not much doubt that true mammals actually arose about the end of the Triassic period. Here again, however, the new race did not immediately replace the old, or exterminate it by unequal competition. Reptiles held their own on all lands throughout the Jurassic and Cretaceous periods, and it was not until the Tertiary that mammals began to predominate.

As to the beginning of the birds, it can only be said that towards the end of the Triassic period there arose a race of small Dinosaurs of the lightest possible build, exhibiting many features suggestive of the avian skeleton; so it is probable that this higher group also originated from an intensely restless early community of reptiles, in which all the variations were more or less in the right direction for advancement.

In short, it is evident that the progress of the backboned land animals during the successive periods of geological time has not been uniform and gradual, but has proceeded in a rhythmic manner. There have been alternations of restless episodes which meant real advance, with periods of comparative stability, during which the predominant animals merely varied in response to their surroundings, or degenerated, or gradually grew to a large size. There was no transition, for instance, between the reptiles of the Cretaceous period and the mammals which immediately took their place in the succeeding Eocene period: those mammals, as we have seen, had actually originated long ages before, and had remained practically dormant in some region which we have not yet discovered, waiting to burst forth in due time. During this retirement of the higher race the reptiles themselves had enjoyed an extraordinary development and adaptation to every possible mode of life in nearly all parts of the globe. We do not understand the phenomenon—we cannot explain it; but it is as noticeable in the geological history of fishes as in that of the land animals just considered. It seems to have been first clearly observed by the distinguished American naturalist, the late Professor Edward D. Cope, who termed the sudden fundamental advances 'expression points', and saw in them a manifestation of some inscrutable inherent 'bathmic force'.

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The demonstration by fossils that many animals of the same general shape and habit have originated two or three times, at two or three successive periods, from two or three continually higher grades of life, is very interesting. To have proved, for example, that flying reptiles did not pass into birds or bats, that hoofed Dinosaurs did not change into hoofed mammals, and that Ichthyosaurs did not become porpoises, and to have shown that all these later animals were mere mimics of their predecessors, originating independently from a higher yet generalized stock, is a remarkable achievement. Still more significant, however, is the discovery that towards the end of their career through geological time totally different races of animals repeatedly exhibit certain peculiar features, which can only be described as infallible marks of old age.

The growth to a relatively large size is one of these marks, as we observe in the giant Pterodactyls of the Cretaceous period, the colossal Dinosaurs of the Upper Jurassic and Cretaceous, and the larger mammals of the Pleistocene and the present day. It is not, of course, all the members of a race that increase in size; some remain small until the end, and they generally survive long after the others are extinct; but it is nevertheless a common rule that the prosperous and typical representatives are successively larger.

and larger, as we see them in the familiar cases of the horses and elephants of the Northern Hemisphere and the hoofed animals and armadillos of South America.

Another frequent mark of old age in races was first discussed and clearly pointed out by the late Professor C. E. Beecher, of Yale. It is the tendency in all animals with skeletons to produce a superfluity of dead matter, which accumulates in the form of spines or bosses as soon as the race they represent has reached its prime and begins to be on the down grade. Among familiar instances may be mentioned the curiously spiny Graptolites at the end of the Silurian period, the horned Pariasaurians at the beginning of the Trias, the armour-plated and horned Dinosaurs at the end of the Cretaceous, and the cattle or deer of modern Tertiary times. The last case—that of the deer—is specially interesting, because fossils reveal practically all the stages in the gradual development of the horns or antlers, from the hornless condition of the Oligocene species, through the simply forked small antlers of the Miocene species, to the largest and most complex of all antlers seen in *Cervus sedgwicki* from the Upper Pliocene and the Irish deer (*C. giganteus*) of still later times.

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Finally, in connexion with these obvious symptoms of old age in races, it is interesting to refer to a few strange cases of the rapid disappearance of whole orders of animals, which had a practically worldwide distribution at the time when the end came. Local extinction, or the disappearance of a group of restricted geographical range, may be explained by accidents of many kinds; but contemporaneous universal extinction of widely spread groups, which are apparently not affected by any new competitors, is not so easily understood. The Dinosaurs, for instance, are known to have lived in nearly all lands until the close of the Cretaceous period; and, except perhaps in Patagonia, they were always accompanied until the end by a typically Mesozoic fauna. Their remains are abundant in the Wealden formation of Western Europe, in the deposits of a river which must have drained a great continent at the beginning of the Cretaceous period; they have also been found in a corresponding formation which covers a large area in the State of Bahia, in Brazil. They occur in great numbers in the freshwater Upper Cretaceous Laramie deposits of Western North America, and also in a similar formation of equally late date in Transylvania, South-East Europe. In only two of these regions (South-East Europe and Western North America) have any traces of mammals been found, and they are extremely rare fragments of animals as small as rats; so there is no reason to suppose that the Dinosaurs suffered in the least from any struggle with warm-blooded competitors. Even in Patagonia, where the associated mammal-remains belong to slightly larger and more modern animals, these fossils are also rare, and there is nothing to suggest competition. The race of Dinosaurs seems, therefore, to have died a natural death. The same may be said of the marine reptiles of the orders Ichthyosauria, Plesiosauria, and Mosasauria. They had a practically worldwide distribution in the seas of the

Cretaceous period, and the Mosasauria especially must have been extremely abundant and flourishing. Nevertheless, at the end of Cretaceous times they disappeared everywhere, and there was absolutely nothing to take their place until the latter part of the Eocene period, when whales and porpoises began to play exactly the same part. So far as we know, the higher race never even came in contact with the lower race; the marine mammals found the seas vacant, except for a few turtles and for one curious Rhynchocephalian reptile (*Champsosaurus*), which did not long survive. Another illustration of the same phenomenon is probably afforded by the primitive Carnivora (the so-called Sparassodonta), which were numerous in South America in the Lower Tertiary periods. They were animals with a brain as small as that of the thylacines and dasyures which now live in Tasmania. They appear to have died out completely before they were replaced by the cats, sabre-toothed tigers, and dogs, which came down south from North America over the newly emerged Isthmus of Panama at the close of the Pliocene period. At least, the remains of these old carnivores and their immigrant successors have never yet been found associated in any geological formation.

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I am therefore still inclined to believe that the comparison of vital processes with certain purely physical phenomena is not altogether fanciful. Changes towards advancement and fixity which are so determinate in direction, and changes towards extinction which are so continually repeated, seem to denote some inherent property in living things, which is as definite as that of crystallization in inorganic substances. The regular course of these changes is merely hindered and modified by a succession of checks from their environment and by Natural Selection. Each separate chain of life, indeed, bears a striking resemblance to a crystal of some inorganic substance which has been disturbed by impurities during its growth, and has thus been fashioned with unequal faces, or even turned partly into a mere concretion. In the case of a crystal the inherent forces act solely on molecules of the crystalline subject itself, collecting them and striving, even in a disturbing environment, to arrange them in a fixed geometrical shape. In the case of a chain of life (or organic phylum) we may regard each successive animal as a temporary excrescence of colloid substance round the equally colloid germ-plasm which persists continuously from generation to generation. The inherent forces of this germ-plasm, therefore, act upon a consecutive series of excrescences (or animal bodies), struggling, not for geometrically arranged boundaries, but towards various other symmetries, and a fixity in number of multiple parts. When the extreme has been reached, activities cease, and sooner or later the race is dead.

Such are some of the most important general results to which the study of fossils has led during recent years; and they are conclusions which every new discovery appears to make more certain.

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Serious difficulties have also become apparent during recent years in determining exactly the origin of the mammals. For a long time after the discovery of the Anomodont or Theromorph reptiles in the Permian-Trias of South Africa, it seemed more and more probable that the mammals arose in that region. Even yet new reptiles from the Karroo formation are continually being described as making an astonishingly near approach to mammals; and, so far as the skeleton is concerned, the links between the two grades are now very numerous among South African fossils. Since these reptiles first attracted attention, however, they have gradually been found in the Permian and Trias of a large part of the world. Remains of them were first met with in India, then in North America, and next in Scotland, while during the last few years Professor W. Amalitzky has disinterred so many nearly complete skeletons in the north of Russia that we are likely soon to learn more about them from this European country than from the South African area itself. Quite lately I have received numerous bones from a red marl in Rio Grande do Sul, Southern Brazil, which show that not merely Anomodonts but also other characteristic Triassic land reptiles were likewise abundant in that region. We are therefore now embarrassed by the richness of the sources whence we may obtain the ancestors of mammals.

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The mystery of the origin of the marine mammals of the order Sirenia and Cetacea appears to have been diminished by the discoveries of the Geological Survey of Egypt, and by those of Dr. Andrews and Dr. Fraas in the Eocene and Oligocene deposits of the Mokattam Hills and in the Fayûm. It is now clear that the Sirenians are closely related to the small primitive ancestors of the elephants; while, so far as the skull and dentition are concerned, we know nearly all the links between the early toothed whales (or Zeuglodonts) and the primitive ancestors of the Carnivora (or Creodonts). The most primitive form of Sirenian skull hitherto discovered, however, is not from Egypt, but from the other side of the world, Jamaica; and exactly the same Zeuglodonts, even with an associated sea-snake, occur so far away from Egypt as Alabama, U.S.A. The problem of the precise origin of these marine mammals is therefore not so simple as it would have appeared to be had we known only the Egyptian fossils. The progress of discovery, while revealing many most important generalities, has made it impossible to vouch for the accuracy of the details in any 'genealogical tree'.

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It would be easy to multiply instances, but I think I have now said enough to show that every advance in the study of fossils reveals more problems than it solves. During the last two decades the progress in our knowledge of the extinct backboned animals has been truly astonishing, thanks especially to the great explorations in North America, Patagonia, Egypt, Madagascar, and South Africa. Whole groups have been traced a long way towards their origin; but with them have been found a number of previously unknown groups which complicate all questions of evolution to an almost bewildering extent. Animals formerly known only by fragments are now represented by nearly complete skeletons, and several which appeared to have a restricted geographical range have now been found over a much wider area; but while this progress has been made, numerous questions have arisen as to the changing connexions of certain lands and seas which previously seemed to have been almost settled. The outlook both of zoology and geology has, therefore, been immensely widened, but the only real contribution to philosophy has been one of generalities. Some of the broad principles to which I have referred are now so clearly established that we can often predict what will be the main result of any given exploration, should it be successful in recovering skeletons. We are no longer bold enough to restore an entirely unknown extinct animal from a single bone or tooth, like the trustful Cuvierian school; but there are many kinds of bones and teeth of which we can determine the approximate geological age and probable associates, even if we have no exact knowledge of the animals to which they belong. A subject which began by providing material for wonder-books has thus been reduced to a science sufficiently precise to be of fundamental importance both to zoology and to geology; and its exactitude must necessarily increase with greater and greater rapidity as our systematic researches are more clearly guided by the experience we have already gained.

REVIEWS.

I.—The Natural History of Igneous Rocks. By Alfred Harker, M.A., F.R.S. 8vo; pp. xvi, 384, with 112 diagrams and 2 plates. Methuen & Co., London. Price 12*s*. 6*d*. net.

FOR more than twenty years Dr. Harker has advocated that the igneous rocks should generally be treated in reference to geological age and to the part which they have played in the tectonics of the earth's crust. Many papers have been published that consist of descriptions of the microscopic structure and mineral constituents of rocks, with little or no reference to the geological history of the region from which they have been collected. This descriptive side of petrology, or petrography, is but a part of the 'rational petrology' that should be dealt with in relation to historical geology.

It must be remembered, however, that in many cases it has not been possible to determine the particular age of intrusive rocks, and it is therefore not surprising that petrographical details have often been "relegated to a more or less perfunctory appendix" in various publications. Our knowledge, however, has vastly increased during the past quarter of a century, a fact very clearly shown in the volume before us.

While recognizing that "cosmogony is at least as much in the province of the geologist as in that of the astronomer", the author is content to refer very briefly to hypotheses relating to the genesis of our planet, and to the possible influence of radium on the temperature gradient, as "the present situation is so unsettled that one who is not directly led to discuss these large questions may legitimately adopt towards them an attitude frankly agnostic". Moreover, "the problems of petrology are in great measure independent of the speculations of cosmogony."

We have, therefore, a suitable starting-point in the data furnished by geological observation, data which from an historical point of view are supplied more fully in the British Isles than elsewhere. The geological record indicates that there were great periods of igneous activity, separated by intervals of quiescence; but that there is no evidence of a decline of igneous energy, nor of any differences in the types of intrusive or extrusive rocks in different ages. In most cases, where clear evidence has been obtained, the sequence of events has been (1) volcanic or extrusive, (2) large plutonic intrusions, (3) minor intrusions.

The indiscriminate use by some writers of the terms 'vulcanicity' and 'volcanic rocks' for igneous phenomena in general, is deprecated by the author. The superficial outbursts cannot be regarded as the most important results of igneous action unless from a present-day and personal point of view. Despite the enormous outpourings of lava that have taken place in some regions, it is pointed out that intruded rock-masses enter much more largely into the outer crust of the earth, and there is more to be learnt from the records displayed in eroded regions of former igneous activity than from a contemplation of active volcanoes. An analogous process is in many respects applicable to the study of glacial phenomena. In the case of igneous rocks, however, "Instead of applying a knowledge of processes now going on around us to elucidate the record of past ages, we must seek rather to use the history of the past to explain the phenomena of the present."

As the author remarks, "Igneous action, in its dynamic aspect, consists in the moving of a body of magma from one situation to another, in response to differences of fluid pressure; but whether or not some part of the magma is forced out at the surface depends upon conditions of the second order of importance."

Without discussing at any length the origin of igneous magmas, the author points out that modern volcanoes negative the idea that they draw *directly* upon a common source or 'stock-reservoir', as evidenced by differences in the levels of lava columns in adjacent areas and in the composition of ejected materials. Nevertheless, community of relationship and of origin is met with in some cases, indicating an extensive magma-basin or series of basins. The ascertained facts lead to the conclusion that there are reservoirs of molten magma of different magnitudes and permanence, and that when exhausted by eruption or solidified, subsequent outbursts may be caused by re-melting or by fresh accessions of molten material from deeper sources. Indeed, "the largest igneous rock-masses known to geologists may represent subsidiary reservoirs, which were only off-shoots from the main basin and at a higher level. In confirmation of this, it is found that such masses very generally give evidence of distinctly intrusive relations, and are sharply separable from the contiguous rocks, which, though highly metamorphosed, show no sign of fusion."

Geological evidence proves that there has been a general, but not invariable, correspondence between igneous action and important movements in the earth's crust, such as those of elevation and depression, folding, faulting, and overthrust; and "the cause of the displacement of bodies of rock-magma is to be sought in readjustment of the Earth's crust, which has become subjected to powerful stresses as a consequence of deformation".

These crust-movements are termed respectively the movements of plateau-building and of mountain-building. In plateau-building there may have been upheaval or depression of great blocks, and the volcanic action manifested in connexion with them takes the form of fissure eruptions. In mountain-building the main movements were due to lateral thrust, accompanied by much folding and overthrusting, and by what the author terms central eruptions. These eruptions are regarded as due chiefly to relief of pressure in certain deep-seated parts of the crust, where "such conditions of temperature and pressure prevail that solid and liquid rock are in approximate thermal equilibrium".

In the case of fissure eruptions the outpouring may be due to "the mere pressing outward of the fluid magma through fissures concurrently opened, with a corresponding settling down of the heavier solid crust which overlay the magma". Thus the Inner Hebrides form parts of a sunken faulted area, on the margin of which igneous outpourings took place.

The old idea that eruptions may be caused by the penetration of oceanic water to the region of the molten magmas is shown to be untenable, the theory requiring us "to believe that steam can force its way, against enormous pressure, through capillary channels in the deeper parts of the Earth's crust". On the other hand, water is present in all igneous rocks, amounting "on the average to about 1½ per cent., a proportion quite sufficient to endow the molten rock with the properties displayed in volcanic eruptions". The author is rather disposed to consider, not that the sea is the source of volcanic water, but that vulcanicity "is the original source of the oceanic waters, and is slowly adding to them".

In giving, largely in his own words, a summary of his views on the more generally interesting phenomena of igneous action, we have left little space for any account of the author's more detailed descriptions of fissure and central eruptions, and of the types of rock met with in plateau-building and mountain-building—of sills and laccolites, of phacolites, dykes, and batholites. In some cases, as pointed out, laccolites may be the immediate cause of folding and faulting, in others they appear as a consequence of displacements.

The idea of certain large magma basins is supported by a study of petrographical provinces, but the magma itself may undergo such differentiation that drafts from it differ widely in composition. The mutual relations of associated igneous rocks, the order of intrusion, and the order of crystallization are all dealt with, as well as various rock-structures and the effects of pneumatolytic action. The author is opposed to the view that there is any great amount of assimilation of bordering rocks by intrusive masses.

The final chapter deals with the classification of igneous rocks, and the author leaves to the future the establishment of a satisfactory genetic classification.

In conclusion, we may commend the work, not only as a record of knowledge based on extensive personal research, but as one exhibiting great thought and care in the systematic presentation of facts and of philosophic judgment in dealing with the explanation of them.

II.—Geological Survey Memoirs.

1. The Geology of the Small Isles of Inverness-shire. By Alfred Harker, F.R.S., with contributions by G. Barrow, F.G.S. pp. ix, 210, with 10 plates and 50 text-illustrations. Price 4*s.* 6*d.* Hand-coloured geological map, Sheet 60 (Scotland); price 10*s.* 3*d.*

The Small Isles include Rum, Eigg, Canna, Sanday, Muck, and Oigh-sgeir, with some smaller islets. The rocks described include the Torridonian of Rum, the Jurassic (Great Oolite Series and Oxfordian) of Eigg and Muck, the newly discovered Upper Cretaceous rocks of Eigg, and the Tertiary igneous rocks, representatives of which, together with glacial and later superficial deposits, are met with in all the islands. Of special interest are the researches on the Tertiary gneisses of Rum, which closely resemble those of the Lewisian formation, and the further observations on the intrusive character of the pitchstone of the Sgùrr of Eigg. Considerable additions are made to our knowledge of the Secondary rocks and fossils, notably in the discovery of chalky sandstone with flints, Foraminifera, and fragments of *Inoceramus*, probably representing a part of the Chalk formation.

2. The Geology of the Country North and East of Harrogate. Second edition. By C. Fox-Strangways, F.G.S. pp. v, 100, with 8 plates and 6 text-illustrations. Price 2*s.* 6*d.* Hand-coloured geological map, Sheet 62 (old series 93 N.W.), England; price 8*s.* 3*d.*

It is satisfactory to find that a new edition of the memoir on the popular inland watering-place of Harrogate has been required, and that the author of the original edition (dated 1873, but not issued until 1874) has been able to prepare it. The work is illustrated by a useful colour-printed map of the immediate neighbourhood of Harrogate, and by interesting pictorial illustrations, from photographs by Mr. Godfrey Bingley, of the Plumpton Rocks, the Knaresborough Dropping Well, etc., and by new sections showing the general structure of the district. The physiography receives more attention. There is a full account of the Harrogate waters, and a practically complete bibliography relating to the geology and mineral waters of the district.

We note that the price of the hand-coloured map, which has not undergone revision, has been raised from 3*s.* to 8*s.* 3*d.* In fact, an examination of the Geological Survey List of Memoirs, Maps, etc., for 1909 shows that the prices of a large number of maps have been raised so as in many cases to be prohibitive. Thus the geologist who could purchase the Drift edition of Sheet 6 (Bromley, Maidstone, Tunbridge Wells, etc.) for 8*s.* 6*d.* is now expected to pay 26*s.*! The same change in price has been made in the Drift map of Lincoln, Sheet 83. The map of Norwich, 66 N.E., formerly priced at 3*s*., is now 9*s*. 9*d*., and the Scottish map 37 (Inverary, etc.) has been raised from 6*s*. to 25*s*. 3*d*. This is surely a retrograde movement on the part of H.M. Treasury.

III.—Handbook for Field Geologists. By C. W. Hayes, Ph.D., Chief Geologist, United States Geological Survey. Second edition. Small 8vo; pp. ix, 159, with 18 figures. New York and London: Chapman & Hall, 1909. Price 6*s*. 6*d*. net.

THIS little handbook is one that may be consulted advantageously by all field geologists, by teachers, and by students who are desirous of joining the staff of a Geological Survey.

After referring briefly to the physical and mental qualities and adaptability to conditions requisite in a field geologist, the author rightly urges that a thorough grounding in chemistry, physics, zoology, and botany is the best preparation for geologic work, and that this should be secured even at the expense of certain geologic information that can be better learnt during the progress of field-work. Some knowledge also of mathematics and of modern languages is regarded as essential.

The requirements of the geological surveyor vary naturally in different regions, his work being much more arduous and diversified not only in complex mountain regions, but in countries where the climate is extreme and where topographic maps have to be constructed.

In the United States Geological Survey, under the Director, there are four branches: the Geologic Branch under the Chief Geologist, the Topographic Branch under the Chief Geographer, the Water Resources Branch under the Chief Hydrographer, and the Technologic Branch under an Expert in Charge.

The present handbook contains instructions relating almost exclusively to the geologic branch, and we miss therefore any special advice with regard to water supply; the investigation of oil and gas fields, however, is included.

Among other qualifications necessary in the United States it is held that "A geologist must possess a practical knowledge of horsemanship, of boating, and of general woodcraft, so that he will be equally at home in the saddle, in the canoe, or on foot in a trackless forest". Useful instructions are given in the matter of outfit, and neatness in dress is strongly urged.

As the author observes, "Directions for making and recording observations and for the use of the schedules are intended to insure thoroughness and system, not to relieve the observer of the necessity for thought." Ability to write clear and concise English is regarded as second in importance only to scientific knowledge.

The study of previous geologic work is recommended prior to a field survey; thus, "Such previous work should be utilized to the utmost, but the geologist should guard, on the one hand, against following former conclusions slavishly and, on the other, against going out of his way to prove his predecessor in the wrong."

While urging the necessity of accurate, systematic work, "the field geologist must avoid the opposite extremes of becoming lost in a mass of detail which cannot be represented" on the map. When, however, the author remarks "It requires the same alertness at the end of a long day as at its beginning", we should be inclined to recommend that if alertness begin to fail the geologist should leave intricate ground to make necessary traverses or devote himself to collecting rock-specimens or fossils, or return forthwith to camp.

There are helpful notes on the uses of various instruments, with mathematical calculations and data for determining thicknesses, depth, and faults; advice is also given on mine surveys and on the collection of rock-specimens, minerals, and fossils. Concerning fossils it is recommended that "All specimens taken from one bed in one locality, though representing many species, should be given the same number and label".

A committee is appointed on the United States Geological Survey to deal with geologic names, advising in reference to new terms suggested for stratigraphic divisions, etc.

In the second portion of this book there are detailed instructions for special investigations on petrologic and chemical subjects, structural geology, glaciers and glacial deposits, and metalliferous deposits, with due regard to both scientific and practical applications.

We may cordially commend the book to all Government geologists and to those engaged in private economic and other geological field-work.

IV.—On the Anaspidacea, living and fossil. By Geoffrey Smith. Quarterly Journal of Microscopical Science, vol. liii, pt. iii, May, 1909.

In 1907 Mr. Geoffrey Smith, of New College, Oxford, undertook a journey to Tasmania, chiefly for the purpose of investigating the structure and development of the 'Mountain Shrimp', *Anaspides tasmaniæ,* which is of special interest on account of its relationship to the fossil Syncarida of Palæozoic rocks. In the present memoir he sets forth the results of his researches and also attempts a review of all that is known regarding the living and fossil Syncarida. Besides adding largely to our knowledge of the internal structure of *Anaspides*, Mr. Smith discovered, in the 'Great Lake' of Tasmania, a very interesting new member of the same group, which he names *Paranaspides lacustris*, so that, with *Koonunga cursor*, described in 1907 by Mr. O. A. Sayce, we now know three living species of Syncarida. This is not the place to discuss the account given of the living forms, but it may be mentioned in passing that the figures of the limbs and mouth-parts are extremely sketchy and that the discussion of their morphology is in many respects inadequate; throughout the descriptions of the thoracic limbs the ischiopodite is termed the propodite, and the statement on p. 502 that an extra thoracic somite "has been supposed to be present in the Euphausiidæ" appears to be entirely imaginary.

Of the fossil forms, the author, we gather, does not profess to have any first-hand knowledge. This is the more to be regretted since a re-examination of the fossils in the light of our knowledge of the living forms could hardly fail to yield results of much interest. As it is, the only fossil yet examined in this light is *Præanaspides*, recently described in the pages of this Magazine by Dr. Henry Woodward.[1] For the others Mr. Smith reproduces, in diagrammatic fashion, the restorations given by the older writers, and attempts to extract from these restorations material for a more detailed comparison with the living forms than has hitherto been given. The results of this comparison are expressed in a new classification of the group, in which *Præanaspides* is included in the Anaspididæ and the other fossil genera (except *Acanthotelson*) in a distinct family, Gampsonychidæ. The reasons for taking this step are not apparent from the definitions which Mr. Smith gives for these families; and, in any case, it is decidedly premature in view of the manifest imperfections in our knowledge of the fossils. The suggestion that *Acanthotelson* may be a primitive Amphipod seems singularly inappropriate.

In discussing the relationships of the Syncarida to the other Malacostraca, Mr. Smith emphasizes, with justice, the many primitive characters of this ancient group: but the place which he assigns to them in the phylogeny of the Malacostraca leads to some strange conclusions. For example, the carapace, which is well developed in the Phyllocarida, the most primitive of the Malacostraca, is supposed to have been lost in some Syncarid-like ancestor of the Peracarida and Eucarida, and to have been re-developed independently in each of these groups. Only the strongest evidence would justify the assumption of so remarkable a course of evolution, but, as a matter of fact, there is no evidence at all. We know from the researches of Peach (recently reviewed in these pages) and others that coeval with the fossil Syncarida were a variety of Crustacea presenting the 'caridoid facies'. These Crustacea possessed a well-developed carapace, and may, for all we know, have presented all the characters which we regard as primitive in the recent Syncarida. Some of them had already developed, as Dr. Henry Woodward has shown in *Pygocephalus*, the brood-pouch of the Peracarida, which Mr. Smith derives from an entirely mythical brood-pouch of the Phyllocarida. It is quite possible that among these caridoid Carboniferous forms may have been the common ancestor of the Eucarida and Peracarida, if that ancestor is not to be sought for in a yet earlier period, as is suggested by the Devonian 'Isopod' *Oxyuropoda*; and it is a reasonable assumption that the Carboniferous Syncarida also arose from one of these caridoid forms by suppression of the carapace while retaining other primitive and generalized characters. W. T. Calman.

V.—Die Anheftung der Brachiopoden als Grundlage der Gattungen und Arten. [The Attachment of Brachiopods as Basis of Genera and Species.] By N. Yakowlew. Mém. du Com. géol. St. Petersbourg, nouv. sér., 1908, livr. xlviii, pp. 1–32.

In this contribution the author demonstrates that the views expressed by him in a previous article entitled "Sur la fixation des

[1] Geol. Mag., 1908, Dec. V, Vol. V, pp. 385–96.

coquilles de quelques *Strophomenacea*" (Bull. Com. géol., 1907, vol. xxvi, pp. 181–201) are also applicable to the *Spiriferacea* and *Terebratulacea*. Some of the conclusions arrived at are given herewith.

The attachment of Brachiopods gives rise to alteration in the shape of the shell. Considerable difference may occur in this respect between neighbouring individuals dependent upon the relative conditions of attachment of each individual. Distinctions of shape in the shell arising from such a cause cannot, however, be considered as even of varietal value. The Devonian *Spirifer verneuili*, Murch., and *Sp. rugulatus*, Kutorg., each affords instances of great variability within the limits of the species, and many of these variations have given rise to new specific designations. The development of the ear-like extensions is affected by the nature of the attachment, but the usually curved condition of the areal surface depends upon the straightness of the hinge-margin, and not upon the attachment of the areal portion to an underlying body. In certain cases the change undergone by the members of the *Spiriferacea* consequent upon the attachment has given rise to so-called generic differences as in the case of *Cyrtia* and *Cyrtina*.

The type of the genus *Cyrtia* (*Cyrtia exporrecta*, Dalm.) is synonymous with *Spirifer plicatellus*, an examination of the Stockholm Museum collection of Silurian fossils from Gottland having shown that the distinguishing feature (the presence in *Cyrtia* of a pedicle opening in the pseudodeltidium) is inconstant. In fact, *Cyrtia exporrecta* represents individuals of *Spirifer plicatellus* differing primarily in the growth of an elevated area, and the correlative appearance of a circular opening in the pseudodeltidium. The Devonian *Cyrtia murchisoniana* represents a group which undoubtedly belongs to one species, while the relationship of *Cyrtina heteroclyta* and *Spirifer elegans* is considered to be analogous to that between *Cyrtia exporrecta* and *Spirifer plicatellus*. The *Spiriferacea* of the Alpine Trias present peculiar difficulties, and it is doubtful in many cases whether we have to do with *Spiriferinæ* or *Cyrtinæ*. The author differs from Bittner and Zugmayer in the latitude allowed in the interpretation of several species. The Upper Palæozoic *Cyrtinæ*, like the Triassic, are held to be traceable from *Spiriferina*. *Cyrtina carbonaria*, McCoy, is shown to possess a plate adjacent to the spondylium, which plate is considered by the author to correspond to a pseudodeltidium. A similar feature is proved to exist in *Spiriferina suessi*. Attachment is also considered in its bearing upon the convergence characters of Brachiopod development. The fixation is found to have a relationship not only to the development of a high area and a pseudodeltidium but also to that of a spondylium. *Terebratula*, *Trigonosemus*, and *Terebrirostra* are treated from the same standpoint. In agreement with Davidson *Cistella neapolitana* and *C. biplicata* are considered synonymous, the differences between the two being occasioned by the nature of attachment. In the latter part of the article attention is drawn to the occurrence in certain districts of several Brachiopod types characterized by elongation of the ventral valves. Thus there occur in the Permo-Carboniferous of the Donjetz Basin elongated *Spiriferina* and *Meekella*, and *Spirifer* *curvirostris* and *Strophalosia* in the Permian of Kirilov; in the Polish Devonian fauna *Reticularia* and *Spirifer* become drawn out, while *Retzia* and *Spiriferina* occur in the Alpine Triassic fauna, and *Scacchinella*, *Tegulifera*, elongated *Meekella*, and *Spiriferina* in the Permo-Carboniferous of the Carinthian Alps. The contemporaneous occurrence of such forms is due to external conditions, probably as a result of the rapid accumulation of large masses of sediment.

The paper is accompanied by two plates of fossil illustrations.

I. T.

VI.—Brief Notices.

1. Rhodesia Museum.—From the Seventh Annual Report, 1908, just to hand we learn that the Directors of the British South Africa Company have presented a piece of ground 140 by 150 feet in Bulawayo for the purpose of extension of the premises. The Trustees of the Beit Bequest have granted £2500 towards the cost of the new buildings, and a start will be made during the present year in the building of new quarters on this permanent site, allowing for future extensions. The geological accessions are mainly confined to minerals, of which the curator, Mr. F. P. Mennell, reports a fine series. Mr. E. C. Chubb, the curator of Zoology, has paid especial attention to the exhibition of local birds, of which the Museum now possesses a good collection.

2. New Ideas on the Formation of Coral Reefs.—Dr. F. Wood Jones gave a demonstration at the Zoological Society's meeting on June 15 of the method of formation of coral reefs. The purpose of the demonstration was to show that the theories of subsidence put forward by Darwin and of solution put forward by Murray were both untenable in the light of actual facts. A fresh hypothesis—that sedimentation is the most important factor—was substituted for these theories: and it was pointed out that the atoll was in reality a structure analogous to the *Porites* colonies, the upper surfaces of which were made basin-shaped by sediment obliterating the zooids of the central area; that the deposition of sediment below the "limiting line of sedimentation" probably accounted for the bathymetrical limit of the reef-building corals, and for the formation of sedimentation banks up to that line; that in the making of an atoll from the basin-shaped reef the winds and the waves played the greatest part, and that atoll lagoons tended to shoal owing to the deposition of sediment within them; that Le Conte in 1856 had said that Barrier reefs stood out from shore because they were limited on one side by the depth and on the other by the muddiness of the water, and that his pronouncement accorded with every known fact; that the question of the formation of coral structures was a zoological one and was to be solved by a study of the living zooid, and that the chief agent inimical to the growth of the zooid was the deposit of sediment.

3. New Foraminifera.—Professor P. S. Pavlovic has published in the *Annales géologiques de la Péninsule balkanique*, 1908, vi, a study of the Foraminifera of the Mediterranean beds of Servia from various

localities. A very fine *Frondicularia*, which he has called *paucicana*, is the chief novelty. Mr. Heron-Allen and Mr. Earland describe in the Journal of the Quekett Microscopical Club, April, 1909, a singular species ascribed to the genus *Technitella*, which builds itself a test entirely of echinoderm plates secured without visible cement. It was found in the Moray Firth. Remarks are made as to the singular selective powers of the Foraminifera (Arenacea) as regards their building material, parallel instances of which occur to us among the caddis-worms, certain Australian caterpillars, and the conchyliophoroid mollusca.

4. Mr. R. J. Lechmere Guppy has contributed an article on "The Geological Connexions of the Caribean Region" (Trans. Canadian Inst., 1909, vol. viii). He remarks that the hypothesis commonly called 'the Atlantis Theory' has occupied his attention since 1865, and he now offers a further statement on the subject. He concludes that there was in Tertiary times a land connexion between the Caribean region and North Africa, and a sea connexion between the Caribean Sea and the Pacific. These features probably existed in Cretaceous times, and came to an end at the close of the Miocene period, "when the final remnant of the Atlantis disappeared and the Isthmus of Panama rose above the sea level, and the last gap in the Andes was closed."

5. Warth's Igneous Rocks.—We have received from Dr. H. Warth a "Classification of Igneous Rocks according to their Chemical Composition" (reprinted from the Proc. Royal Society, Edinburgh, 1908, vol. xxviii). This is an amplification of a paper printed in the Geological Magazine for March, 1906, p. 131, and it is accompanied by an index.

6. Department of Mines, Ottawa.—In the *Summary Report* of the Geological Survey Branch of the Department of Mines, Ottawa, Canada, for 1908, the Director, Mr. R. W. Brock, calls attention to the need of a large increase in the Staff of the Survey in order to cope with the demands occasioned by the rapid opening up of the country. Field-work is, moreover, hampered in some areas by the want of accurate topographic maps, and this, it is hoped, will be remedied by the establishment of a Topographic division. The investigation of the water resources of the Dominion is becoming more and more important, and it is noted that a Well-boring Records division has been formed. The Survey is endeavouring to get in touch with the drillers all over Canada, and sample bags, etc., are sent to them which they can return free of charge. Reports on work carried out in various parts of the country are contributed by members of the field-staff, and special reports on mineralogy, palæontology, zoology, and ethnology are given by the officers in charge of those branches.

7. The Care of Natural Monuments, with special reference to Great Britain and Germany, is the title of a small book by Professor H. Conwentz, Prussian State Commissioner for the Care of Natural Monuments (Cambridge, 1909; price 2*s.* 6*d.* net). The author draws attention to various ways in which natural scenery is disfigured

and plants and animals are wantonly destroyed. He admits that a great deal has been done in this country, especially to protect monuments of archæological interest and to preserve commons and open spaces; and we are glad to note that so lately as July last steps have been taken by the National Society for the Preservation of Places of Interest for the purchase of part of Cheddar Gorge, which has for some time been defaced by quarrying operations. Geology has received attention in the preservation, sometimes in situ or by the removal and care elsewhere, of boulders and large concretionary masses of rock such as greywethers; while in Victoria Park, Glasgow, there is preserved a small tract of Carboniferous rocks with fossil trees. Geological sections opened up in soft strata are not readily to be retained, but these and openings in hard rock are too often rendered obscure and exceedingly foul by the shooting of rubbish into them—a barbarous practice that in many instances may lead to pollution of water supplies—while even at some seaside resorts that are regarded as 'salubrious', cliffs are utilized as dumping-grounds for refuse.

8. The Dawn of Human Intention.—In an essay on "The Dawn of Human Intention: an Experimental and Comparative Study of Eoliths" (Mem. Manchester Lit. and Phil. Soc., 1909, price 1*s.* 6*d.*), Professor Alfred Schwartz and Sir Hugh R. Beevor have carefully considered and summarized the reasons for belief in the artificial shaping and use of Eolithic implements. While recognizing that Eoliths are of great antiquity, dating back in this country to the Pliocene period, they follow Mr. Rutot in noting evidence of their manufacture at earlier and later periods, and therefore they propose that the term be applied to the form of the stone implements, using other terms such as *Kentien* to indicate the chronological position of the industry. The authors have made a large collection of Eoliths from the gravel of Croxley Green, near Rickmansworth, a deposit that has also yielded many Palæolithic implements of *Chelléen* type.

9. The Geological Survey of Western Australia. — Bulletin No. 32 (1908) contains three reports by Mr. Harry P. Woodward:—No. 1. "Notes on the Geology of the Greenbushes Tinfield," which is situated in the south-western division of the State upon the Bunbury Bridgetown Railway, 159 miles from Perth. Tin-ore (cassiterite) has for some years been worked in the Alluvial deposits, but the claims have been practically exhausted. Attention is now directed to the parent rocks, which consist of foliated granites with greisen, pegmatites, and quartz veins. These dyke rocks yield the tin-ore, also tourmaline and other minerals, including ores of tantalum. Much ore has been obtained by hydraulic sluicing on disintegrated and highly weathered portions of the rock-masses; elsewhere shafts have been sunk. The Reports Nos. 2 and 3 deal with the Mount Malcolm Copper-mine and with Fraser's Gold-mine in the Yilgarn Gold-field.

10. Philippine Islands.—"A Geologic Reconnaissance of the Island of Mindanao and the Sulu Archipelago" has been published by Mr. Warren D. Smith (Philippine Journ. Sci., 1908, iii). Mindanao is the southernmost of the Philippine Islands, and the Sulu Archipelago extends between it and the north-eastern portion of Borneo. Coal has

been worked on Mindanao, and some gold has been obtained in a region of schistose rocks. The Sulu group consists mainly of volcanic rocks and coral formations.

11. Museum of Practical Geology, Jermyn Street, S.W.—A Short Guide to the Museum (pp. 48, and price 1*d.*) has just been issued. It contains useful plans of the several floors of the Museum, and descriptions of the principal objects exhibited, including minerals, rocks, fossils, geological maps, and models. Many changes and improvements have been made in the display and arrangement of specimens since 1896, when the last handbook to the Museum was published. Space might have been found in this new Guide for a Table of Contents.

CORRESPONDENCE.

THE USE OF THE WORD 'LATERITE'.

Sir,—I have just seen in the last number of the Imperial Institute Bulletin (1909, vol. vii, No. i) a review of Professor J. B. Harrison's *Geology of the Goldfields of British Guiana*, in which the reviewer takes exception to Professor Harrison's use of the word 'laterite' as being "wider than is either usual or desirable" (p. 134 of the Bulletin), and the reviewer states that only products of weathering containing free aluminium hydroxide in hot, moist climates should be considered as laterite.

In the light of the recent literature on the subject, the proposition that it is desirable to restrict the term 'laterite' to that product of weathering in hot, moist climates which contains free aluminium hydroxide carries great weight; indeed, I had almost said that it is the counsel of perfection, one attribute of which it certainly possesses, namely, that it is impracticable. The reason of this is that the term 'laterite' has been used, in the Malay Peninsula at least, for many years by a large body of engineers for what are essentially masses of iron oxide replacing portions of weathered rock and filling fissures in such rocks near the surface. This (Malayan) laterite is most abundant in weathered schists, and is largely used for public works. Small quantities of aluminium hydroxide may or may not be present in these masses of ironstone, but that question is of no immediate importance to the engineer, who values the stone for its hardness.

I have talked this matter over with one of the senior officers of the Public Works Department and he agrees with me that 'laterite' is an engineer's rather than a geologist's term, covering rocks of varying composition; and I am strongly inclined to think that we should do well to call rock that we say are bauxites by their accepted mineral name, instead of attempting to lay down what shall and what shall not be called 'laterite'.

It is clear that the reviewer of Professor Harrison's book does not appreciate the difficulties awaiting those who attempt to instruct engineers in the use of the term 'laterite'. It is a task that would, I think, end in only unnecessary friction, a result such as would be expected were a geologist to insist on the controllers of the asbestos industry in Canada labelling their goods 'fibrous serpentine' or 'chrysotile'.

J. B. Scrivenor.

Batu Gajah,
Federated Malay States.
July 4, 1909.

OBITUARY.

EDWARD DELMAR MORGAN.

Born 1840. Died May 18, 1909.

Born at Stratford, in Essex, in 1840, Mr. Morgan was well known as an ardent geographer who had travelled much in Russia, in Persia, Central Asia, in the Congo region, and East Africa. For many years he was a resident in St. Petersburg. Since returning to England he lived at 15, Roland Gardens, S.W., and at Effingham House, Copthorne Crawley. Here he undertook the duties of Honorary Secretary of the Hakluyt Society, and edited volumes of *Early Voyages to Madagascar and the Mascarene Islands* (with notes on the extinct birds the Dodo and Solitaire); also of *Travels in Russia and Persia*. He was elected a Fellow of the Royal Geographical Society in 1869, and had served on the Council.—*Geographical Journal*, July, 1909.

JOSEPH FREDERICK WHITEAVES, LL.D., F.G.S., ETC.

Born December 26, 1835. Died August 8, 1909.

We regret to record the death at Ottawa, in his 74th year, of Dr. Whiteaves, Palæontologist, Zoologist, and Assistant Director to the Geological Survey of Canada. In October, 1906, we published in the Geological Magazine a full account up to that date of the life and work of Dr. Whiteaves, together with a portrait. He continued his researches on palæontological and zoological subjects until the close of his life, and we are glad to add that he was awarded the Lyell Medal by the Council of the Geological Society in 1907.

MISCELLANEOUS.

University College, Dublin.—Under the Irish Universities Act of 1908 the Dublin Commissioners advertize appointments to be made to the various professorships. The differences in the stipends are remarkable. Experimental Physics is estimated to be of the value of £800 a year, Chemistry £750, Zoology £600, and Geology £500.

No. 544. Decade V.—Vol. VI.—No. X. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

PROFESSOR W. W. WATTS, Sc.D., M.Sc., F.R.S., V.P.G.S.
DR. GEORGE J. HINDE, F.R.S., &c., AND HORACE B. WOODWARD, F.R.S., &c.

OCTOBER, 1909.

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

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. X.—OCTOBER, 1909.

ORIGINAL ARTICLES.

I.—The Mechanism of Volcanic Action, being the Opening Address to Section III (Vulcanology) of the International Geographical Congress.

By H. J. Johnston-Lavis, M.D., F.G.S., etc., Professor of Vulcanology in the Royal University of Naples.

(PLATES XXIV AND XXV, AND TEXT-PLATE.)

IN a discussion of this kind it is advisable to be as concise as possible, eliminating minor details, so as to give prominence to the main outlines of any theory one holds. This communication, which the Council of the Ninth International Congress of Geography have honoured me by asking me to address to you, I propose to put into the form of a 'credo'. To this I shall add a few fundamental facts upon which my reasoning was based, leaving minor ones for discussion at greater leisure elsewhere. For convenience I propose to divide my theory into two sections. In the first I shall review what may be conveniently called deep volcanic action, and in the second that group of phenomena that occur when igneous matter nearly reaches the surface or actually finds an exit thereon. Unfortunately, in the first case I am obliged to rely on hypotheses and deductions, whereas in the second section, that of superficial volcanic action, there are a number of fundamental facts and observations upon which to base speculation, and to which I propose to draw your attention.

Of one fact we are certain, and that is our globe is surrounded by a solid crust, which wherever it can be examined shows unmistakable and almost universal evidence of compression, wrinkling, and dislocation. This crumpling and crushing are equally inexplicable, unless we admit that since the initial solidification of the earth's crust its lower, still cooling part or support has undergone contraction so as to crowd together the already cooled burden of the upper part that this contracting mass carries.

No one has yet attempted to even suggest that the part of our globe subjacent to the solid crust has shrunk from other causes than a loss of heat. We may therefore look upon the idea of contraction as due to cooling to be a universally accepted fact.

In the old theory of the earth-crust crumpling over a contracting and cooling nucleus, fluid, or partially so, it always appeared to me to be inexplicable how fluid matter could be squeezed out, or why the water on the surface of the earth did not rush down to fill up the vacancy that the contracting interior tended to produce between itself and the arch of the crust. This perhaps is expressing the facts in simple commonplace terms, but is sufficient to illustrate the incompatibility of this hypothesis with the fact of some of the liquid interior of the earth rising through the fissures towards the surface and being squeezed out by the contracting crust.

The hypothesis that tangential thrust did not exist, but that the earth-crust was shrinking on an entirely or partially fluid nucleus, would have satisfied the vulcanologist, but is contrary to the incontrovertible evidence of tangential compression, as seen in the plications and over-thrusts existing upon the entire surface of the globe, or at least that part above sea-level. This hypothesis was based upon the conception that the earth's crust was acting as a single unit.

To Messrs. Mellard Reade and C. Davison[1] is due the credit of making an analytical study of the functions of different parts of the earth's crust. That work demonstrated that theoretically we can divide the cooling surface of the earth into a series of shells. The outer shells that have reached approximately the mean atmospheric temperature will, of course, have stopped contracting, whereas the shells nearest to the heated nucleus will be those losing their heat most rapidly, and therefore undergoing greatest contraction. This contraction must inevitably cause crowding, crushing, and crumbling of those shells that are nearer the surface, just as a stretched sheet of rubber coated with a layer of stiff clay would do when allowed to contract.

Somewhere between the surface shells of compression and the deepest shells of greatest cooling and contraction there will be a shell in a state of equilibrium, which the authors call the zone of no contraction. This zone, which was originally quite at the surface of our globe, tends to sink lower and lower as the general refrigeration or isotherms of our planet proceed downwards. Were the shells of cooling and contraction of great tensile strength, such as the experimental sheet of rubber, already referred to, we can quite understand how any fluid in the earth's interior would tend to be squeezed out, but are met by two difficulties—(1) is there any fluid in the earth's interior? and (2) is the tensile strength of the contractile shells sufficient to have a squeezing power?

Three classes of views have been held as to the constitution of our

[1] C. Davison: "On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling, etc." (Phil. Trans. R.S., 1887, vol. clxxviii); "Note on the Relation between the Size of a Planet and the Rate of Mountain Building on its Surface" (Phil. Mag., Nov., 1887); "On the Straining of the Earth resulting from Secular Cooling" (Phil. Mag., Feb., 1896); "On Secular Straining of the Earth" (Geol. Mag., May, 1889, Dec. III, Vol. VI, No. 299, p. 220). T. Mellard Reade: *The Origin of Mountain Ranges*, 1886. See also H. J. Johnston-Lavis: "The Extension of the Mellard Reade and C. Davison Theory of Secular Straining of the Earth to the explanation of the Deep Phenomena of Volcanic Action" (Geol. Mag., June, 1890, Dec. III, Vol. VII, pp. 246–9).

globe. Some hold that it is like an egg—a solid shell with a fluid interior; others maintain that by the increase of gravity as the centre is approached there is a solid nucleus which is potentially fluid were it not for this gravitational condensation, so that there would be a solid nucleus, a solid crust, and a stratum of liquid rock separating them. Finally, there is a third school who holds that the highly heated nucleus, although potentially fluid, is really solid in consequence of pressure or, more correctly, gravitational condensation.

No known rock that we are acquainted with gives the conception of having sufficient tensile strength to be capable of exerting any really contractile or squeezing power on fluid enclosed within it or surrounded by it. There will be a tendency as the inner shells contract to split by fissures. Such fissures would extend from within outwards, and would be top-shaped in section, with the edge extending up to the neutral zone of no contraction, and their lower limit at the inner surface of the lowest shell (Fig. 1, E, F). Such a fissure might be simultaneously filled by the fluid rock-paste beneath.

How this filling will take place requires consideration. As there is reason to disbelieve in any considerable constricting power of the inner cooling shells, and that even if such constricting power did exist it would be annulled by the development of fissures within its mass, it is evident one must look to other causes. The welling up into the fissure of the fluid rock, if we admit a fluid nucleus or a stratum or shell of such fluid, might be due to the settling down by gravitation of the cooled blocks[1] of crust limited by the fissures. If, on the contrary, we admit the immediate contact of the lowest cooling shell with a highly incandescent nucleus (P), solid by pressure, but potentially fluid when this pressure is removed, we can well see what would take place. As soon as the fissures and therefore fluid in the inner cooling shells begin to form, their location and their edges will represent a site of diminished pressure. The subjacent and neighbouring but potentially fluid rock will in consequence liquefy and expand and fill the fissure. As the fissure broadens and extends so will the expansion and liquefaction increase *pari passu*.

Liquid rock may thus reach up to the neutral zone of no contraction, but its extension further must be a matter of chance. It is evident that if the shells of compression were in every part homogeneous and coherent, then no upward-pointed fissure could be formed. In practice neither of these conditions is fulfilled. It is obvious that the crowding and crushing will be most complete in the shells of compression (Fig. 1, C) where these are carried on a continuous block of contraction (Fig. 1, A). I mean by a block a portion bounded by fissures formed in the contracting part of the earth-crust. Where the shells of contraction are fissured (E, F) there the crowding of the superincumbent masses of cooled rock will not take place. As a result, each block or island of contractile crust, with its compressed burden, will tend to tear away from the adjoining blocks or islands, so that the limiting fissures in the contractile joints will extend up into the compressional shells (G, H).

[1] These blocks are quite different to the blocks referred to by some recent writers on terrestrial mechanics.

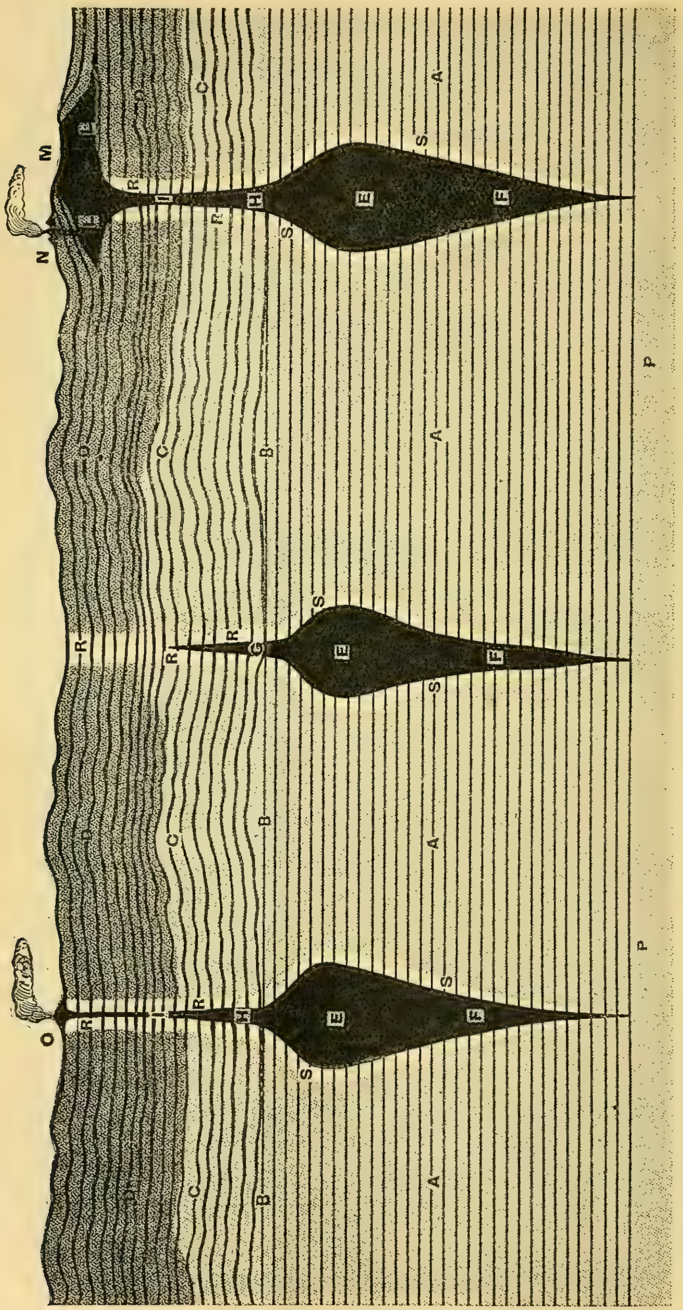

Fig. 1. Diagram showing the theoretical shells of contraction, compression, and fissuring on the earth's crust by process of cooling. Proportions greatly exaggerated. (For explanation see p. 443.)

This exactly fits in with what is frequently found in the distribution of volcanoes along the edges of areas of marked compression or mountain regions. It will explain also the presence of volcanoes having a linear arrangement between closely situated mountain chains or areas, as in South America. Great rifts, such as those of Central Africa and some cañon districts, are probably of such origin. In earthquakes of tectonic origin it has been pointed out [1] that the piers of damaged bridges have usually been found to have approached each other. This would evidently take place in the areas of positive compression (Fig. 1, C, C). On the other hand, in exceptional cases the piers have been found to have been separated. This might well occur in the area of negative compression (R), or what might well be termed the *areas of retraction*. The much larger proportion of the former effect on the bridge piers would no doubt be in the much greater ratio of compressional areas to retractional areas on the earth's surface.

May not ocean basins be in part due to blocks or islands of the contracting zones exerting that diminution of volume in a vertical more than in a horizontal direction, as we have so far been considering it to be? The peculiar abysmal ocean troughs often at the edge of ocean basins and parallel to chains of volcanoes or interrupted by them could well be explained by the same circumstances. I do not claim that ocean basins are alone due to this cause, but to a combination of these conditions with perhaps the slipping, shearing, and corrugating of the primitive crust over a fluid envelope, and even the tetrahedral collapse of a cooling globe. I lay down here but a general principle to which there may be many exceptions due to the vicissitudes of cooling and the variation in the materials concerned in any particular region, not to speak of the changing position of the earth's axis, the crustal inertia of Professor G. H. Darwin, etc.

Liquid rock having thus reached a considerable way to the surface, either as simple dykes (Fig. 1, I, I), laccolytes, or sills (Fig. 1, L, L), and so forth, is now in a situation suitable for the second series of phenomena, constituting what I call surface volcanic action, to come into play.

Surface Volcanic Phenomena.—Two schools of vulcanologists have held opposed views as to the origin of the volatile constituents contained in fluid igneous rock. One class of writers maintain that the gaseous contents are primordial, and have been contained in the igneous paste from the time that our globe condensed from the nebulous state. Others attribute all the volatile matter still retained in cooled igneous rock or evolved at volcanic mouths and fumaroles to the volatilization of water met by the igneous rock in its journey towards the surface. Probably both are right, but I propose to bring before you a series of my observations that point incontrovertibly to the fact that by far the major part of the volatile constituents of a magma are acquired by it on its journey towards the surface.

As condensation took place in our planet from a nebulous state, as each layer or shell of rock materials passed from the gaseous to the

[1] Professor Hobbs, Ninth International Congress of Geography, 1908.

liquid state, and probably solid, it is evident that those most volatile would be the last to change their physical state. That some of the more volatile ones were entangled or held in solution by the less volatile is quite likely, but the amount must have been small.

Another possible source of volatile matter in the deep-seated igneous matter may well be due to a slow osmosis or diffusion extending over vast periods of time and directed by the varying affinities of one class of matter for the other.

A quarter of a century ago, as a result of a careful and detailed study of Vesuvius[1] and other volcanoes, I was able to show that a volcano the more continuously active it was in the emission of igneous material the more tranquil was the character of emission, and that practically under such conditions lava was the only product. I showed also that the longer were the intermissions in the extrusive efforts of a volcano the more the ejecta tended to issue in a broken up and fragmentary condition, from the larger and more violent evolution of volatile or gaseous materials. We thus had the whole gamut of products—scoria, pumiceous scoria, scoriaceous pumice, pumice, and pumice dust—bearing a distinct ratio to the time that any volcano had been in a condition of 'repose'.

Two explanations offered themselves to my mind for this state of things. One was that the persistent evolution of volatile materials primordially stored up in the original volcanic paste escaping continually therefrom had collected in the volcanic chimney and blew out the magma; the other that the volatile materials were acquired by the igneous magma where in contact with water-bearing rocks in the upper strata of the earth's crust.

Were the former the case one would expect that the first products of an eruption should be less gas-filled or gas-bearing than the latter, but this is not the case. My observations, which demonstrate the fundamental facts upon which eruptive action of a volcano depends, show unmistakably that the first materials yielded in a normal eruption after a long period of 'repose' of a volcano are the richest in volatile elements, and that as the eruption proceeds the amount of gases in the issuing magma steadily diminishes, as shown by the diminished vesicularity and increased crystalline individualization of the essential ejecta.[2]

The class which interests us in the present question is the group of the *essential ejecta*. I found that when one examines the stratified deposits of the ejecta thrown out during an explosive eruption, that is, an eruption of great violence taking place after a long period of repose

[1] "The Geology of Monte Somma and Vesuvius": Q.J.G.S., 1884, vol. xl, pp. 35–119.

[2] In my paper "On the Fragmentary Ejecta of Volcanos" (Proc. Geol. Assoc., vol. ix, pp. 421–32 and 3 figs.) I divided such ejecta into three classes. *Essential ejecta* are those materials that issue in a fluid state, and consist either of the volatile constituents or the magma in which these were contained, that produced the particular emission in question. *Accessory ejecta* consist of the older volcanic materials of the same vent torn away, expelled, and mixed with the essential ejecta of an eruption. *Accidental ejecta* consist of either volcanic materials from other centres, or sedimentary or other rocks of the sub-volcanic platform, also torn out, expelled, and mixed with the two before-mentioned ejecta.

of an old volcano, or the initial outburst of a new one, the materials, as they fell from the air, show a definite arrangement, and vary in character in correspondence with different phases of the eruption.

To illustrate what these characters are I propose to choose a classical example in that of the great outburst of Vesuvius that overwhelmed Pompeii, Herculaneum, Stabia, Oplontis, and other towns around the foot of Somma-Vesuvius. If we examine the deposit of materials that fell during the eruption of A.D. 79 in the streets of Pompeii, or preferably outside the town as the falling houses have disturbed the regularity of the stratification within the walls, we find it made up of several beds. Immediately reposing on the old land surface is a stratum of very white light pumice. I use the word 'white' in comparison with that above it. If we collect a quantity of this we shall see that its bulk is very great for its weight. To the naked eye it is composed for the most part of a glassy vesicular base, with here and there scattered crystals of felspars, hornblende, pyroxene, and biotite, besides occasionally extraneous minerals caught up in the magma. Microscopically it is made up of a network of straw-coloured glass, with innumerable minute micro-crystals of leucite, all of a remarkably uniform size, besides which are a very few scattered microliths of hornblende, augite, mica, and felspars, obviously pre-eruptive in birth (Pl. XXV, Figs. 5 and 6). At wide intervals, of course, occur the porphyritic crystals above named. The main mass, however, is made up of glass, so that all the vesicles have been able to assume well-rounded outlines. The size of the vesicular spaces is very great in proportion to the amount of solid material enclosing them, making the pumice a very light one in weight.

Reposing on the bottom stratum, and rather suddenly graduating up from it, is the main bulk of the ejecta. The pumice composing this is much heavier, darker in colour, ranging from a brownish grey to a greenish grey. The porphyritic enclosed crystals are the same as those in the bottom, white pumice, and practically average the same size. They appear to be more frequent, but this is due to the pumice being denser; more of them are therefore to be seen in the same area, as it were more crowded together.

Microscopically this pumice very much differs from the subjacent white variety (Pl. XXV, Figs. 7 and 8). Nearly the whole of the glass has been replaced by innumerable microliths. The small leucites have increased but little in size, though they seem more numerous. This I attribute to the less amount of open space left by the vesicles. The augite microliths constitute the main bulk, and minute grains of magnetite are abundant. Some small microliths are probably distinguishable as felspars. Generally the vesicular cavities are much smaller. The vesicle walls are no longer smooth, but rough from the projecting microliths that in the process of rapid cooling grew and projected in all directions, and are not arranged with such parallelism that is seen in flow-structure with rods already in existence at an earlier date.

Both these divisions of *essential ejecta* are more or less mixed with *accessory* and *accidental ejecta* torn from the sides of the crater and the sub-volcanic platform. I mention this as it has a bearing on the composition of the third and uppermost part of the materials shot out during an *explosive* eruption. This third or uppermost portion consists of a coarse or fine dust (ash), and when examined microscopically is seen to be to a large extent composed of detached microliths and loose crystals mixed with a large quantity of *pulverized accessory* and *accidental ejecta*. Whenever one examines the ejecta of explosive eruptions the same order is found. The above-mentioned characters are better seen in the case of very fluid intermediate or basic magmas, and I have given figures of the ejecta of an earlier explosive eruption of Somma-Vesuvius, Phase III, which is free from leucite (Pl. XXIV, Figs. 1–4).

When eruptions are of a less violent explosive character the first part may be pumice and later a more compact and micro- and partially crystalline rock may issue, such, for instance, as the black pumiceous trachytic scoria ejected by the last efforts of Monte Nuovo, the main mass of the cone having been built up of a light buffish-white trachytic pumice.

In still less marked explosive eruptions, or where a large amount of material is ejected extending over some time, the final product may issue as a continuous mass and constitute a lava.

What, then, is the interpretation of this regular succession of ejecta having different characters? We know that the surface rocks of the earth's crust are as a body usually very aquiferous, and that as one descends the rocks become drier and drier. All the water has been squeezed out by superincumbent pressure. Of course, we know that according to the nature and composition of the rocks the depth to which aquiferous material extends will be extremely variable.

Let us figure to ourselves what would take place in a mass of fused silicates and oxides filling a fissure extending up through non-aquiferous into more and more aquiferous rocks. The prolonged contact would result in the *gradual solution* of the H_2O of the aquiferous strata in the fused paste, just as carbonic acid would be dissolved under pressure, but at ordinary temperature, in water. In the former case the critical point of H_2O does not come into the question. We know little of the temperature and pressure that this compound can exist at when dissolved in silicates and oxides. Furthermore, even if dissociated probably its components could pass into solution and re-combine again when temperature was lowered sufficiently. A careful study of volcanic action leads me to believe this process to be a slow one, so that if a fairly regular flow of melted rock takes place up the fissure through the aquiferous strata little H_2O is absorbed, and igneous outflow shows little violence, so that lavas are the chief products.

If the volcanic canal has never reached the surface, or is cut off from it by an old plug of solidified ejecta, then as the igneous magma acquires more and more H_2O its tension will steadily rise. Its loss of heat energy will be very little, as the H_2O and other volatile matters it has dissolved occupy a small volume. Still, in certain cases the magma may, as the result of different sources of heat loss, undergo complete cooling and consolidation. Not unlikely many hydrated rocks owe their origin to this cause. All evidence points to the heat energy or specific heat of basic rocks being lower in relation to their

Phase III, Monte Somma, showing vast difference between the pumice ejected at the commencement and middle of an explosive eruption.

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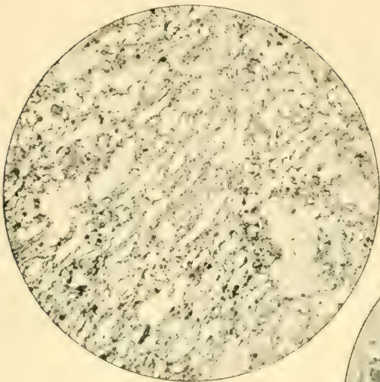

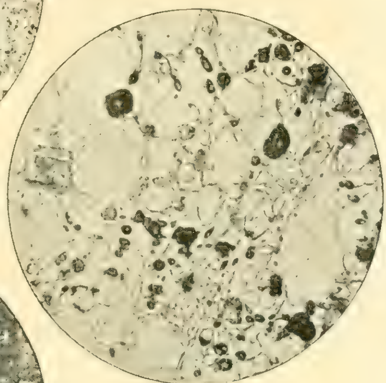
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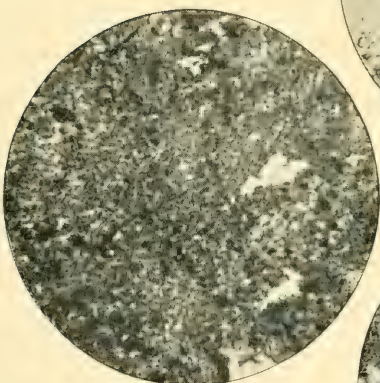

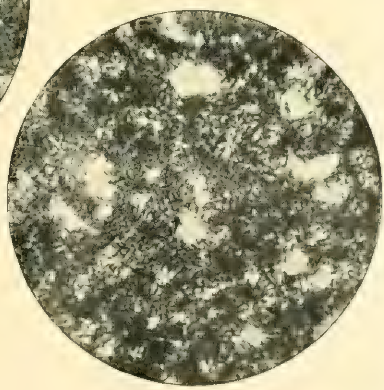
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Dr. H. J. Johnston-Lavis microphot

Pumices and Pumiceous Scoria from explosive eruptions, Monte Somma and Vesuvius.

fluidity, which would explain in part why hydrated rocks are more frequent amongst them than are acid ones, as more frequently they would be cooled to consolidation before they found issue at the surface.

In many cases, however, the tension of the magma will steadily rise as it acquires more and more volatile matter from the surrounding rocks.[1] A moment will be reached when the tension has gradually attained such intensity that the earth's crust is rent by an extension upwards of the fissure. This fissure may reach the surface and make a new volcano, or the obstructing plug of an old one may be cleared away. In either case an explosive eruption will result.

Now the first portion to issue will be that part of the magma at the top of the fissure that has been in contact for the longest time with the more aquiferous rocks, and consequently will be richer in acquired volatile materials than that below. It may be a pure glass, or a certain number of crystals may have individualized under the intratelluric conditions of slow cooling. Once free from compression H_2O, etc., will separate from the non-volatile silicates and oxides as bubbles, undergo enormous expansion, escape in great part, and afford the explosive agent in the ejection of the remaining fluid-froth still holding much gas in the vesicles. This sudden expansion means a tremendous loss of heat energy, and the vitreous matter is so rapidly cooled that it has no time to individualize into microliths or crystals, or the crystals already existing to grow in size.

We know from the effect of pumice on combustible substances, as wood, bread, cloth, etc., as at Pompeii, that nearly all the latent heat has been used up in this expansion, so that only partial roasting has resulted. Thus has been produced the first white light pumice of an explosive eruption by the extremely rapid expansion and cooling of a pure or nearly pure glass.

As the upper contents of the volcanic canal blows out, that part of the magma lower down follows. This next portion has been a shorter time probably in contact with aquiferous rocks; these latter, being deeper, are usually poorer in H_2O. The consequence is that this second batch of magma will contain less volatile matter, expansion will be slower, there will be less loss of heat required for expansion, so that there will be time and other more favourable conditions for part of the glass to individualize into microliths. (Compare 1, 2, 5, 6, with 3, 4, 7, 8, Plates XXIV and XXV.) This second batch of magma furthermore will have lost less heat energy in consequence of having had less H_2O to dissolve, but also being deeply seated and in hotter rocks it will have lost less heat by conduction.

As we go deeper in the volcanic conduit these same differences will be exaggerated, so that as the magma escapes almost all the glass may be converted into microliths so as to leave little material to hold them together, whilst the evolution of volatile gases will be sufficient

[1] I use H_2O not to assume any special physical state of that substance. I also refer to it specially as being the principal volatile material of igneous magma; but I fully appreciate the salts and gases derived from their decomposition, as likewise the rarer materials that were acquired by and can be separated from igneous rocks by a high temperature, to which Monsieur Brun and others have furnished us with such interesting details by their studies.

to separate them into dust, producing the pulverized material constituting the essential part of the last and topmost deposit of an explosive eruption.

If the igneous paste rises from still greater depths it may come from little or non-aquiferous parts of the conduit, which, together with a higher specific heat from fewer losses thereof, will allow it to gush forth in a non-fragmented state as a lava.

The want of uniformity in the water-bearing rocks at different depths is too well recognized for us not to see the influence on possible departures and irregularities which might result in the sequence of ejecta having the characters I have shown you as the simplest expression of an eruptive phase.

In an open chimney of a volcano in chronic activity the constant circulation up the volcanic conduit allows of too little time for the magma to acquire much volatile materials, and it is only when this outflow is more or less impeded at the vent that more volatile materials are acquired and the volcano assumes paroxysmal or explosive fits.

In conclusion, I may say I have tried to summarize the trend of my researches for the last thirty years, and if you will try to read the whole phases of volcanic activity in this light *you will find it the only satisfactory explanation universally applicable to all cases of the eruptive mechanism.* No other theory that has been advanced has ever been based on the characters of the actual *essential ejecta*, and no other one fits without exception the whole range of the very varied phenomena of volcanicity.

EXPLANATION OF PLATES XXIV AND XXV.

Pumices and pumiceous scoria from explosive eruptions of Monte Somma and Vesuvius (*essential ejecta*).

Plate XXIV.

Fig. 1. Light white pumice, bottom part of Phase III, period 1. The section is seen to be mostly composed of a clear glass with only an occasional porphyritic crystal or microlith. Magnified 11 diameters.

,, 2. Part of the same section, magnified 50 diameters. Most of the vesicles are sectionized and open, and support the very rare porphyritic crystal by sections of the thin shells of glass. A few vesicles still contain air.

,, 3. Heavy chocolate-brown pumiceous scoria produced later by the same eruption, Phase III. Notice how much smaller are the vesiculæ and how the mass of rock material is principally composed of microliths. Magnified 11 diameters.

,, 4. The same, magnified 50 diameters. Here the numerous large smooth-walled vesicles of Fig. 2 are replaced by few small rough-walled spaces into which the microliths project.

Plate XXV.

,, 5. Light white pumice, bottom part of Plinian pumice that buried Pompeii, Phase VII, period 1. The section shows the material to be mostly a clear glass crowded by microliths of leucite only with few exceptions. Magnified 11 diameters.

,, 6. Part of same section, magnified 50 diameters, showing these characters more accentuated.

,, 7. Heavy greenish-grey pumice from high up in the pumice stratum. Here the rock is composed of a dark, almost opaque network of microlithic matter in which magnetite is abundantly distributed. The microliths are almost hidden by the opacity of the magnetite and augite grains. Magnified 11 diameters.

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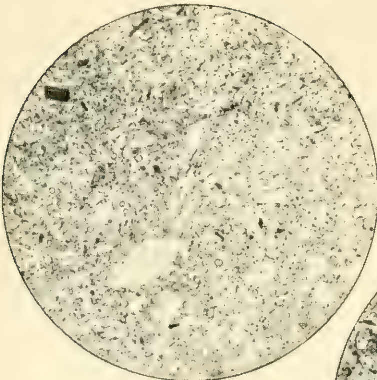
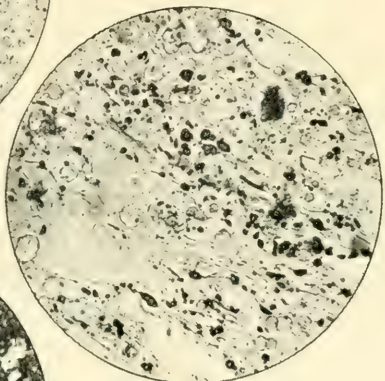


Phase VII, period 1, Pompeii eruption of A.D. 79, to illustrate same difference as last Plate.

6



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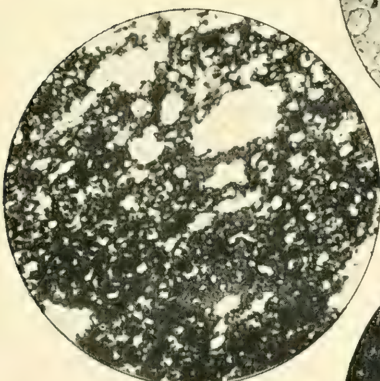

Dr. H. J. Johnston-Lavis microphot.

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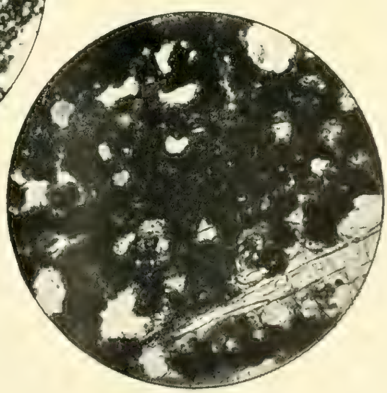

Punices and Puniceous Scoria from explosive eruptions, Monte Somma and Vesuvius.

FIG. 8. The thinnest possible section to make is shown in this figure, magnified 75 diameters, exhibiting the extensive individualization of the glass into opaque microliths. The leucite microliths are represented by spots of imperfectly transmitted light where the crystal grains reach both sides of the slice, but are partially overlapped by augite and magnetite all around.[1]

DIAGRAM, p. 436.

A Shells of contraction.
B Neutral zone or zone of neither contraction nor compression.
C Dry shells of compression.
D Aquiferous shells of compression.
E Fissure between shells of maximum cooling and contraction filled by liquefaction of the edges of these shells by diminished pressure.
F Same, but in the shells of less cooling and contraction.
G Fissure extending up between two areas of compression and islands of contraction, but not reaching the aquiferous shells.
H The same, but reaching into the aquiferous rocks.
I The same, but having reached aquiferous shells has been enabled to extend upwards by explosive action into a laccolite and sill in one case and directly to a volcano in the other.
L Laccolite and sill exposed by erosion at M.
N Volcano supplied from uncooled part of laccolite, aquiferous rocks, and from rift I.
O Volcano supplied from rift I and aquiferous rocks around top of same.
P Portion of globe undergoing practically no cooling.
R Area of ineffective compression or retraction and depression.
S Area of ineffective contraction and of low pressure.

II.—NOTE ON TWO CEPHALOPODS COLLECTED BY DR. A. P. YOUNG, F.G.S., ON THE TARNTALER KÖPFE, IN TYROL.[2]

By G. C. CRICK, Assoc.R.S.M., F.G.S., British Museum (Natural History).

(PLATE XXVI.)

THE two Cephalopods—an Ammonoid and a Belemnoid—referred to in the present note were obtained in the summer of 1907 by Dr. A. P. Young from the Tarntaler Köpfe, an isolated mountain-mass in Tyrol, to the north of the Tuxer Alps, and about 20 kilometres south-east of Innsbruck. The Ammonoid was found "at a height of nearly 2500 metres above sea-level, on the surface of a scree-cone which has accumulated under the high hanging valley known as the Lower Tarntal", and the Belemnoid was found "somewhat lower on the slope of the same cone". They are the fossils referred to by Dr. A. P. Young on p. 342 of his paper on the Structure and Physiography of the Tarntal Mass, published in the August number of this Magazine (pp. 339–346), where a photograph of the scree-cone is given (Pl. XVII, Fig. 5), and now form part of the National Collection.

The Ammonoid[3] and its impression are displayed on the weathered surfaces of two plates of grey limestone that were found within 2 feet of one another. Since the impression does not supplement the details exhibited by the fossil itself, no mention is made of it in the following description. The specimen (Pl. XXVI, Fig. 1) has been not only crushed, but so greatly distorted during fossilization that its

[1] Had this specimen been chosen from the top of the essential ejecta of Phase III the thinnest section capable of being cut would have been opaque. It was taken, therefore, from a transition stratum (see p. 440).

[2] Published by permission of the Trustees of the British Museum.

[3] British Museum (Natural History), register number C. 12113.

form is now elliptical, the longer and transverse diameters being about 130 and 82 mm. respectively; the ellipse is obliquely truncated at one end by a natural fracture. Portions of only two whorls, the outer and the penultimate, are preserved; only a little more than one-half of the outer whorl is present, but the greater part of the penultimate whorl is more or less imperfectly preserved; the innermost whorls are not shown. At the anterior end of the specimen, that is, near one end of the longer diameter, the height of the whorl is about 33 mm., and the width of the umbilicus about 100 mm.; whilst at a quarter of a whorl back, that is to say, near the end of the transverse diameter, the height of the whorl is only 23 mm., and the width of the umbilicus 41 mm. The whorls were evidently comparatively narrow, and very evolute, with apparently scarcely any inclusion. The ornaments consist of simple, nearly straight, forwardly-inclined, and not very widely-spaced ribs, but it is difficult to estimate the exact width of the interspaces, or even the exact width (or height) of the whorls, because, owing to the distortion which has taken place during fossilization, the whorls are relatively narrower, and the ribs further apart near the extremities of the transverse diameter than they are near the extremities of the longer diameter. The ribs are nearly straight on the sides of the whorl, but turn somewhat abruptly forward almost close to, though without crossing, what is now the margin of the specimen. Although rather prominent, the bend of the rib does not appear to have been raised into a distinct tubercle. Unfortunately the fossil is so crushed that the form of the periphery cannot be seen. The margin just referred to, however, does not appear to have been at the centre of the peripheral area, but rather to have been the ridge bordering that area on one side, and separated from a median keel by a more or less distinct longitudinal groove. Near the earliest part of the outer whorl that is preserved there appear to be traces of three or four suture-lines, so that it would seem that the greater part of the outer whorl now present formed part of the body-chamber; no suture-lines are visible on the penultimate whorl. Naturally the suture-lines have participated in the general distortion of the specimen, and are now very obscure; they do not appear, however, to have been ceratitic.

The condition of the specimen renders any identification extremely difficult. The form of the peripheral margin and the general character of the suture-line, so far as it can be made out, seem to remove it from such genera as *Ceratites* and its allies, whilst these characters, together with the nature of the ribbing, suggest its reference to the Arietidæ. The fossil bears a striking resemblance to a figure given by Parona [1] of a specimen from the Lower Lias (*C. Bucklandi*-zone) of Alpe Loggio sopra Ponna (Vall' Intelvi), Lombardy, that he refers with a query to Dumortier's species *Arnouldi*, [2] a species included

[1] C. F. Parona, "Contribuzione alla conoscenza delle Ammoniti liasiche di Lombardia," pt. iii, Ammoniti del calcare nero di Moltrasio, Careno, Civate nel Bacino lariano (Mém. Soc. Pal. Suisse, vol. xxv, 1898), p. 11, pl. xv, fig. 5 (*Arietites* (*Arnioceras*) *Arnouldi*).

[2] E. Dumortier, *Études paléontologiques sur les dépôts jurassiques du Bassin du Rhône*, pt. ii, 1867, p. 27, pl. v, figs. 1, 2; pl. vi, figs. 1–6.

by Hyatt in his genus *Arnioceras*.[1] If the affinities of the specimen are really, as they appear to be, with that genus, the fossil seems to belong to the Lower Lias, though not to the lowest part of the Lower Lias, that is to say, that it is not of Hettangian, but rather of early Sinemurian age.

The Belemnoid (Pl. XXVI, Fig. 2)[2] is displayed in section upon the uneven weathered surface of a small piece of grey limestone, which, however, appears to be rather more dense than the matrix of the Ammonite just described. The specimen is 53 mm. long, being truncated posteriorly by the edge of the small piece of limestone on which it is exposed. The anterior half of the fossil is occupied by the alveolus. The guard as exposed is about 6·5 mm. wide, and therefore appears to have been comparatively slender; its sides are almost parallel; its posterior portion appears to be a little inflated, but this may be due to the fact that the exposed surface is uneven, so that the section which is exhibited does not lie in one plane. The angle of the alveolus as shown is about 16°, but as the plane of section may not be median, and may even be oblique, this angle may not represent, but be somewhat greater than, the real angle of the phragmocone. No portion of the phragmocone is preserved. The substance of the guard consists of a blackish, crystalline, imperfectly laminated material, the laminæ being a little oblique, both from side to side as well as from back to front of the specimen; these are sometimes accompanied by thin films of whitish calcite, but the guard does not exhibit indications, either of a radiate structure, or of concentric rings, or of a central axial line. No portion of the surface of the fossil is shown, but, judging from the transverse section of the truncated posterior portion of the guard, this appears to have been smooth. The specimen is clearly referable to the Belemnitidæ. The sub-family Aulacoceratinæ includes the four genera *Aulacoceras*, *Asteroconites*, *Dictyoconites*, and *Atractites*, in all of which, except the last-mentioned, the guard is variously ornamented; in *Atractites* it is smooth. If, therefore, our conclusion as to the nature of the surface of the guard is correct, the specimen, if referable to this sub-family, can only belong to *Atractites*. But the angle of the alveolar cavity, and the widening out of the portion of the guard around the alveolus, lead to the inference that the fossil does not belong to the genus *Atractites*.

Notwithstanding the present condition of the structure of the guard, the fossil appears to be referable to a subdivision of the genus *Belemnites*. The species is, however, quite indeterminable, though it may be stated that the guard was evidently much more slender than in such a form as Miller's *Belemnites acutus*.[3]

Notwithstanding their imperfect character these Cephalopods are of importance with reference to the alleged existence of Liassic rocks on the Tarntal mass. In 1859 Pichler[4] (p. 202) recorded the presence of

[1] A. Hyatt, *Genesis of the Arietidæ*, 1889, p. 162.

[2] British Museum (Natural History), register number C. 12114.

[3] J. S. Miller, Trans. Geol. Soc., ser. II, vol. ii, pt. i, 1826, p. 60, pl. viii, fig. 9.

[4] Adolf Pichler, "Beiträge zur Geognosie Tirols": Zeitschr. des Ferdinandeums für Tirol und Vorarlberg, 1859, Folge iii, Heft viii.

metamorphosed fossiliferous Lower Lias, and indicated the same on the map accompanying his work. The only Cephalopods mentioned, however, were Belemnites, stated to be easily distinguishable by their structure, though sometimes broken and their parts displaced.

Visiting the locality subsequently, Rothpletz[1] found there rocks containing Brachiopods, Lamellibranchs, and Corals, which he regarded as of Rhætic age, whilst in an overlying limestone, which Pichler considered to be of Lower Liassic age, he found only *Pentacrinus* ossicles, which, in his opinion, might belong to either Winkler's *Pentacrinus bavaricus* of the Kössener Schichten, or to the *Pentacrinus psilonoti* of Quenstedt from the Lower Lias. In reply to Rothpletz's inquiries Pichler stated that he could not remember the Belemnites, but only two Ammonites "(*radians !*)",[2] which he found in this grey limestone thirty-four years ago; also that he sent these specimens to the Geological Survey of Vienna, where, according to Rothpletz, they appear to be now unknown.

Although it is much to be regretted that the present specimens are very imperfectly preserved, it seems desirable to record them, since they serve to show the presence of a Cephalopod fauna on the Tarntaler Köpfe, and it is hoped that other examples may be obtained which will indicate the precise age of the beds yielding these fossils. It may be mentioned that the Ammonite found by Dr. Young differs entirely from Ammonites of the *radians* type.

It may be noted that on the highest part of the Kesselspitz (2722 metres above sea-level), some 16 kilometres west of the Tarntal mass, Professor Frech[3] records, above the Rhætic, the existence of Liassic beds containing indeterminable Belemnites, *Aulacoceras*, and Ammonites referable to the genera *Lytoceras*, *Arietites*, and *Phylloceras*. From the *Aulacoceras*, which he compared with *A. liassicum* (Gümbel), as figured by Mojsisovics[4] (p. 55, pl. iv, fig. 4*a*), together with an *Arietites*, he regards the fauna as Lower Liassic. The absence of *Psiloceras* and *Schlotheimia*, genera characteristic of the Hettangian, or lowest part of Lower Lias, is noted.

EXPLANATION OF PLATE XXVI.

Fig. 1. Weathered surface of slab of limestone, exhibiting an Ammonite (? *Arnioceras*); from the Tarntaler Köpfe, in Tyrol. Five-sixths nat. size.

Fig. 2. Weathered surface of a fragment of limestone showing Belemnite in section; from the same locality. Five-sixths nat. size.

Both specimens were collected by Dr. A. P. Young, F.G.S., who has presented them to the British Museum (Natural History).

[1] A. Rothpletz, *Ein geologischer Querschnitt durch die Ost-Alpen*, etc., 1894, pp. 74, 75, and 83.

[2] The trivial name *radians* has been applied by different authors to various Toarcian and Bajocian species of Ammonites. For synopsis of these species see S. S. Buckman, Mon. Inf. Ool. Amm. (Pal. Soc.), pt. iv, 1890, pp. 188–90.

[3] F. Frech, "Gebirgsbau der Tiroler Zentralalpen mit besonderer Rucksicht auf dem Brenner": Wissenschaftliche Ergänzungshefte zur Zeitschrift des D. u. O. Alpenvereins, Bd. ii, Heft i, 1905, pp. 1–98.

[4] E. v. Mojsisovics, "Ueber das Belemnitiden-Geschlecht *Aulacoceras*, Fr. v. Hauer": Jahrb. d. k. k. geol. Reichsanst., Wien, Bd. xxi, 1871, pp. 41–58, pls. i–iv.

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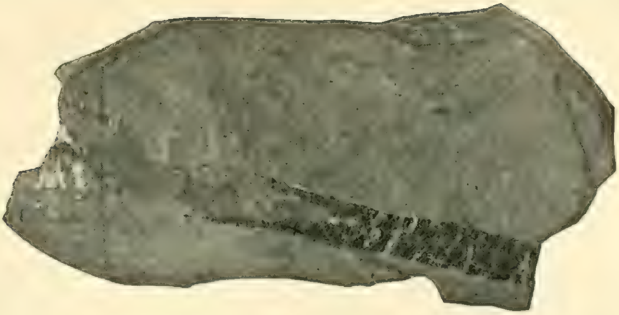

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Cephalopods from the Tarntaler Köpfe, in Tyrol.

III.—*Spirorbis* - Limestones in the 'Permian' of the South Staffordshire and Warwickshire Coal-fields.[1]

By T. C. Cantrill, B.Sc. Lond., F.G.S.

South Staffordshire.

A PERIOD of nearly forty years has now elapsed since several bands of *Spirorbis*-limestone were met with in the so-called Lower Permian rocks of the South Staffordshire Coal-field during the sinking of the Sandwell Park and Hamstead pits in the neighbourhood of West Bromwich. From the published accounts of those sinkings, in the first case by Mr. Henry Johnson, and in the second by Messrs. Meachem and Insley and Dr. Robert Kidston, *Spirorbis*-limestones appear to have been found at 206 feet above the base of the 'Permian' at Sandwell, and at 329 and 795 feet respectively at Hamstead.

But although the group of red marls and sandstones sunk through in the pits occupies a considerable area in the Clent Hills district, a few miles to the south-west, no surface outcrops of any such limestones had been discovered. It was particularly desirable, therefore, that an examination should be made of the sections of these red rocks afforded by the pipe-trench of the Birmingham Waterworks (Elan Supply), with a view to finding the surface positions of the bands of limestone met with in the pits, and of any others that might be present.

During the month of August, 1901, I was commissioned by the Director of the Geological Survey to examine the sections along the pipe-trench between the gathering ground at Rhayader, in Radnorshire, and the terminal reservoir at Frankley, near Birmingham. Several new facts were brought to light, and the more important of the results were recorded in brief in the *Summary of Progress* of the Geological Survey for 1901.[2] The following additional particulars of the discovery then made of outcrops of *Spirorbis* - limestone in the 'Permian' ground bordering the southern end of the South Staffordshire Coal-field may prove not uninteresting to those who have been watching the effect of recent investigations on the systematic status of the 'Permian' of Salopian type.

The pipe-track enters the 'Permian' at the village of Hagley, 3 miles south of Stourbridge, and continues wholly in those rocks as far as the terminal reservoir at Frankley, 5 miles farther east (see sketch-map, Fig. 1). These 'Permian' beds overlie the Coal-measures conformably, so far as is known, and are themselves covered unconformably by the Bunter Pebble Beds. They are well displayed in numerous brook-sections, and the highest member, the well-known 'trappoid' breccia, rises on the Clent and Walton Hills to a height of over 1000 feet above sea-level.

Mr. W. Wickham King[3] gives the Clent Hills sequence substantially as follows:—

[1] Communicated by permission of the Director of the Geological Survey.
[2] Mem. Geol. Surv., 1902, pp. 60–4.
[3] Quart. Journ. Geol. Soc., vol. lv, 1899, p. 97. See p. 111.

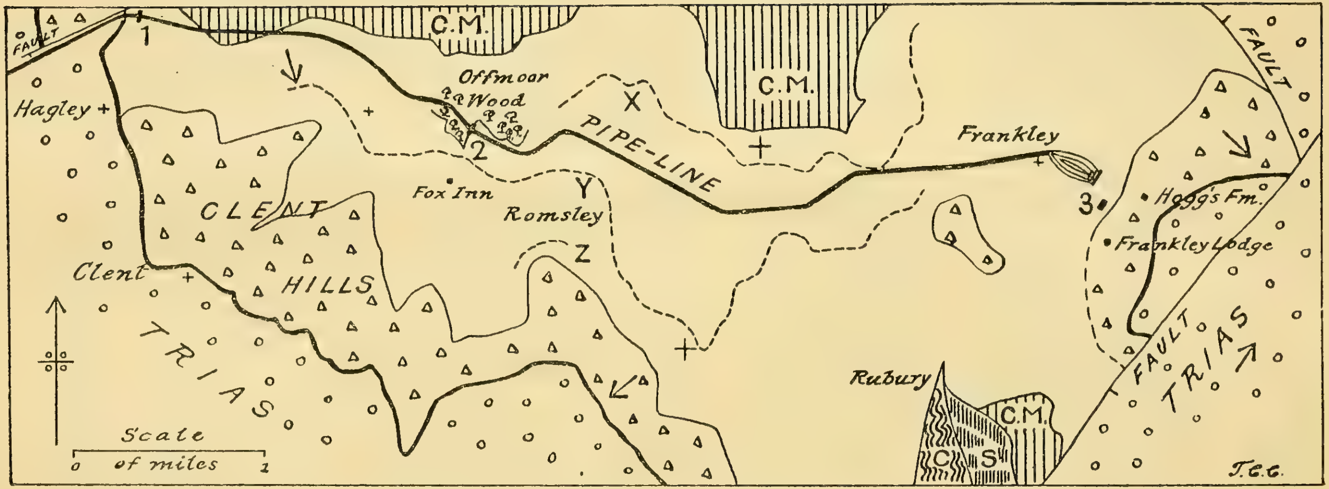

FIG. 1. Sketch-map (based on the Geological Survey map, Sheet 54 N.W.) showing course of pipe-line across the 'Permian' beds between Hagley and Frankley. Outcrops of *Spirorbis*-limestone are marked 1, 2, and 3. The Coal-measures (C.M.) crop out on the north, and again at Rubury on the south-east, where they overlie Silurian (S.) and Cambrian (C.) rocks. The Triassic rocks are marked by circles, and their base is shown by a heavy line. The trappoid breccia is shown by triangles. The unshaded portion of the map shows the outcrop of the Middle and Lower subdivisions of the local 'Permian', with outcrops of cornstone (X, Y, and Z).

				Feet.
Salopian 'Lower Permian'	Upper (C)	Trappoid breccia		450
	Middle (B)	6. Marls, and one thin band of sandstone	50	295
		5. Cornstone	10	
		4. Marls, and 3 to 4 feet of brown sandstone	100	
		3. Cornstone	10	
		2. Marls	100	
		1. Cornstone and calcareous red sandstones	25	
	Lower (A)	Sandstones and marls, say		200

With the trappoid breccia (C) we have no concern here. The so-called cornstones of the Middle division (B) appear to be calcareous sandstones containing small, rather angular chips and pebbles of pyroclastic rocks, with occasional pebbles of limestone.

The Lower Sandstones and Marls (A), which I correlated in 1895 with the fossiliferous beds of Sandwell, Hamstead, and Wyre Forest,[1] and claimed as Coal-measures, have since been identified by my colleague Dr. Walcot Gibson[2] with the Keele Beds of the North Staffordshire Coal-measures. The beds consist of red and crimson marls, mottled blue, with some pale-red sandstones and occasional bands of conglomeratic cornstone; some of the sandstones and marls are characterized by small green decoloration spots or 'fish-eyes'.

Hagley.—The pipe-trench entered these Keele Beds about 250 yards west of Wassel Grove Lane at Hagley.[3] At a point 100 yards west of the lane the debris from the trench contained small pieces of grey limestone, which, though they did not yield the characteristic Annelid, were clearly pieces of *Spirorbis*-limestone, derived doubtless from an outcrop close by (Fig. 1, 1). This band apparently lies not more than 50 feet above the base of the Keele Beds, the lowest members of which form a slight escarpment, about 300 yards to the north-east, easily to be recognized where it crosses the Birmingham Road immediately west of the Gipsy's Tent Inn. Obviously, then, this band of limestone is a new one, and will not do for any of those found at Sandwell, Hamstead, or in the Wyre Forest district: it is much too low in the sequence.

Romsley.—The same crimson marls with red sandstones apparently extend in an easterly direction through Hagley Wood and Offmoor Wood, and were open to view at several points on the pipe-trench, which gradually crosses the outcrop and slowly ascends the sequence. Just where the pipe-line emerges from Offmoor Wood, at a point 500 yards N.N.E. of the Fox Inn at Romsley (Fig. 1, 2), the debris again contained small pieces of limestone, though here also the fossil was not forthcoming. The horizon at which this outcrop occurs is probably at least 250 or 300 feet above the base of the Keele Beds, and to judge by the 1 inch geological map it is certainly considerably higher than any horizon so far reached by the trench, and I think there is little doubt that it lies well within the Middle subdivision (B).

Between Horsepool Farm and the Halesowen Railway the trench seems to have entered on a paler-coloured group of beds, containing some greenish-grey sandstone and conglomeratic cornstone. The tip

[1] Quart. Journ. Geol. Soc., vol. li, 1895, p. 528.
[2] Ibid., vol. lvii, 1901, p. 251.
[3] Old Series 1 inch map, 54 N.W.; 6 inch, Worcestershire, 9 N.E.

at Long Kettle's Wood, Frankley Green, consists of red marls, some being 'fish-eyed', with red and pale-grey sandstones. Red marls were exposed at the end of the pipe-trench 100 yards north-east of Frankley Church.

Frankley.—Here the bottom of the terminal reservoir, which lies in the valley of Merritt Brook, between the church and Hogg's Farm,[1] was being excavated to a depth of 12 feet, in red marls, with green mottlings, containing beds of soft red sandstone, the bedding being nearly horizontal. At the site of the filter-beds (Fig. 1, 3), which are situated a short distance west of Hogg's Farm, there occurred, among the marl and sandstone debris, numerous small pieces of limestone which after much search yielded a single specimen of *Spirorbis pusillus*, together with a few Ostracods.

As it was important to ascertain the exact source of these limestone pieces, I communicated with Mr. Fred. W. Macaulay, the engineer in charge, and from information he was good enough to supply it appears that the limestone outcrop was met with at some excavations for the filter-beds on the south side of Merritt Brook, at about 250 yards N. 20° W. of Frankley Lodge Farm. The limestone bed was found practically on the surface at the south side of the excavations, but dropped below the bottom of the excavations (10 feet below the surface) some 120 feet north of the outcrop. Allowing for a slight fall of the surface in the direction of the brook, this means that the limestone has a northerly dip of 5° or 6°. The bed was found to vary in thickness from 1 foot to 1 ft. 6 in.; the stone was rather rotten and friable. Mr. Macaulay had previously noticed pieces of the rock lying in an adjacent hedge, and evidently dug up from the field during draining or ploughing operations. Here, then, we have a third outcrop of *Spirorbis*-limestone in the 'Permian' beds.

Now it will be observed, on an inspection of the Geological Survey map (54 N.W.) and the accompanying sketch-map (Fig. 1), that the three points at which the limestones crop out lie on successively higher horizons. Indeed, the Frankley Lodge outcrop, judging by the Survey map, is only a few feet below the base of the trappoid breccia, i.e. only a few feet below the top of the Middle subdivision (B). This, it is true, assumes the breccia to be conformable to the beds below, but I am not aware that any evidence to the contrary has been produced. According to the Horizontal Section, sheet 50, which passes through Frankley Lodge Farm, the base of the breccia is 450 feet above the base of the Keele Beds. But whether the breccia is conformable or not to the beds below, there seems no escape from the conclusion that the Frankley Lodge outcrop is high up in the Middle subdivision (B), and that the pipe-trench has proved three distinct limestone bands in the local 'Permian'. Hence it follows that not only the Lower subdivision (A), but the Middle subdivision (B) as well, must be correlated with the Keele Beds of North Staffordshire and relegated to the Coal-measures.

The three limestones appear to lie respectively about 50, 250, and 450 feet up in the 'Permian'. Those proved at the Sandwell and

[1] Six inch map, Worcestershire, 10 N.W.

Hamstead pits are 206, 329, and 795 feet above that horizon. It is therefore not possible at present to identify any of the outcrops with the bands passed through in the pits.

WARWICKSHIRE.

During the years 1902–5 occasional visits to the neighbourhood of Nether Whitacre, between Birmingham and Nuneaton, and a brief sojourn near Maxstoke, a few miles farther south, gave me the opportunity of looking for outcrops of *Spirorbis*-limestone in the 'Permian' rocks of the Warwickshire Coal-field. A *Spirorbis* band has long been known to occur in the ordinary Coal-measures at 150 feet below the base of the 'Permian', and its outcrop was laid down and described by Mr. H. H. Howell in the Geological Survey maps and memoir fifty years ago.[1] Mr. C. Fox Strangways,[2] too, in his recent revision of the Baxterley district, obtained evidence of a second band in the ordinary Coal-measures of that locality. But although the Warwickshire 'Permian' rocks have hitherto not been known to contain such limestones, as long ago as 1895 I made bold to claim them as Coal-measures, on the grounds that from all the available descriptions there was every reason to regard them as the equivalents of the Salopian Permian of the Wyre Forest district,[3] wherein I had recently found a *Spirorbis*-limestone and a thin coal-seam between 200 and 300 feet above the base of the group. Moreover, I find that Mr. William Andrews, F.G.S., of Coventry, in 1890 published the opinion that the Warwickshire 'Permian' are red Coal-measures, basing his conclusions apparently on the grounds of their lithological resemblance to the beds proved at Hamstead Colliery.[4]

Nether Whitacre.—But a passage in the Survey memoir on the coal-field shows that over fifty years ago Mr. Howell himself actually noticed a *Spirorbis*-limestone in the 'Permian' rocks, though its abnormal position with regard to the only known band (i.e. the one 150 feet down in the ordinary Coal-measures) misled him and prevented his realizing the significance of his discovery. After describing the outcrop of the band in the Coal-measures, Mr. Howell says (pp. 28, 29)—

"There can be little doubt that the limestone exists under the Permian rocks between Arley Wood and Sybil Hill near Kingsbury, although it is impossible to point out its precise position beneath that formation. There are, however, some indications of its having been wrought at Whitacre Hall, about halfway between Arley and Kingsbury. It was certainly burnt there, for the old kilns remain, and fragments of the limestone partially burnt are seen lying about the fields, but whether it was brought from Arley Wood, or Kingsbury Wood, or quarried on the spot, could not be ascertained, the works having been long abandoned. It is quite possible that the limestone may have been quarried here, exposed by the denudation of the Permian rocks."

[1] Sheets 62 S.E. and 63 S.W.; also *The Geology of the Warwickshire Coal-field*, 1859, pp. 26–9.

[2] *Geology of the Country between Atherstone and Charnwood Forest* (Mem. Geol. Surv.), 1900, p. 20.

[3] Quart. Journ. Geol. Soc., vol. li, 1895, p. 528. See p. 547.

[4] See a paper entitled "On the Bore-holes at Coventry", read before the Warwickshire Naturalists' and Archæologists' Field Club, March 26, 1890. (The reprints are issued without the particulars necessary for more exact citation.)

From an examination of the map I had always failed to see how the Arley Wood limestone, in the absence of serious faulting, could reappear at Whitacre Hall (three-quarters of a mile north-east of Nether Whitacre), and had come to the conclusion that what Mr. Howell had seen was in reality a limestone in the 'Permian', and not the Arley Wood band at all. This surmise I was able to confirm by an examination of the ground near Whitacre Hall in August, 1902.

At about 250 yards south of the Hall, in the south-eastern corner of a pasture-field adjacent to the public road, there are several old marl-pits, 8 or 10 feet deep, partly filled with water and bordered by dwarf oaks and thorns. In these pits, which were evidently excavated in crimson marls, were several pieces of dark-grey bituminous limestone, ranging in length up to 10 inches, and 5 or 6 inches thick. After producing nearly a barrowful of road-stone I succeeded in obtaining two specimens of *Spirorbis pusillus.* Whether the pits were dug for the purpose of extracting the limestone or for the sake of the red marl, there is little doubt that the limestone crops there. I saw no traces of the old kilns seen by Mr. Howell. To the north-east small pieces of limestone are to be seen on the surface of the farm-road leading eastward up the hill from the Hall; a large mass was noticed in the bottom of a grass-grown excavation close to this road and 600 yards east of the Hall; others, still farther east, were found in old pits near a barn by the side of the Hurley road. All these occurrences taken together suggest an outcrop running north-eastward toward Bull Barn, and although it would be impossible to lay down any definite line for it without further field-work, I have not the slightest doubt that we have here a band of *Spirorbis*-limestone which at a very moderate estimate of dip must be quite 150 to 200 feet above the base of the 'Permian'. There is no question, in my judgment, that the outcrop occurs, not in the ordinary grey and yellow Coal-measures exposed by denudation, but in the typical 'Permian' beds which are to be seen in quarries and other sections in the immediate vicinity.

Maxstoke.—Five miles south of Whitacre Hall another outcrop of limestone emerges among the 'Permian' marls immediately east of the boundary fault at a point three-quarters of a mile south of Maxstoke. A reference to the Geological Survey map (62 S.E.) shows the western margin of the 'Permian' to be a westerly down-throw which, ranging southward through Nether Whitacre, Maxstoke, and Meriden, throws down the Keuper Marl (f^6) on the west against the 'Permian' on the east, while a narrow strip of Lower Keuper Sandstone (f^5) emerges from beneath the Marl at Maxstoke and persists southward. Three-quarters of a mile south of Maxstoke a brook, rising at a strong spring at the foot of the wooded escarpment of Quarry Wood and Daniel's Wood (see Fig. 2), flows under the Maxstoke–Meriden Road, and passes a few yards north of the Hermitage Farm, on its way to join the Blythe. In the road, a few yards south of the brook, a shallow cutting shows about 4 feet of sandstone, chiefly soft and fine-grained, though some of the rock is calcareous and hard and contains small red and yellow fragments of marl. The bedding appears to be horizontal. Proceeding eastward, up-stream, sandy soil, blocks of sandstone, and one or two outcrops bring us nearly as far as the first fence on the south. All the beds so far appear to be referable to the Lower Keuper Sandstone, as indicated on the Survey map.

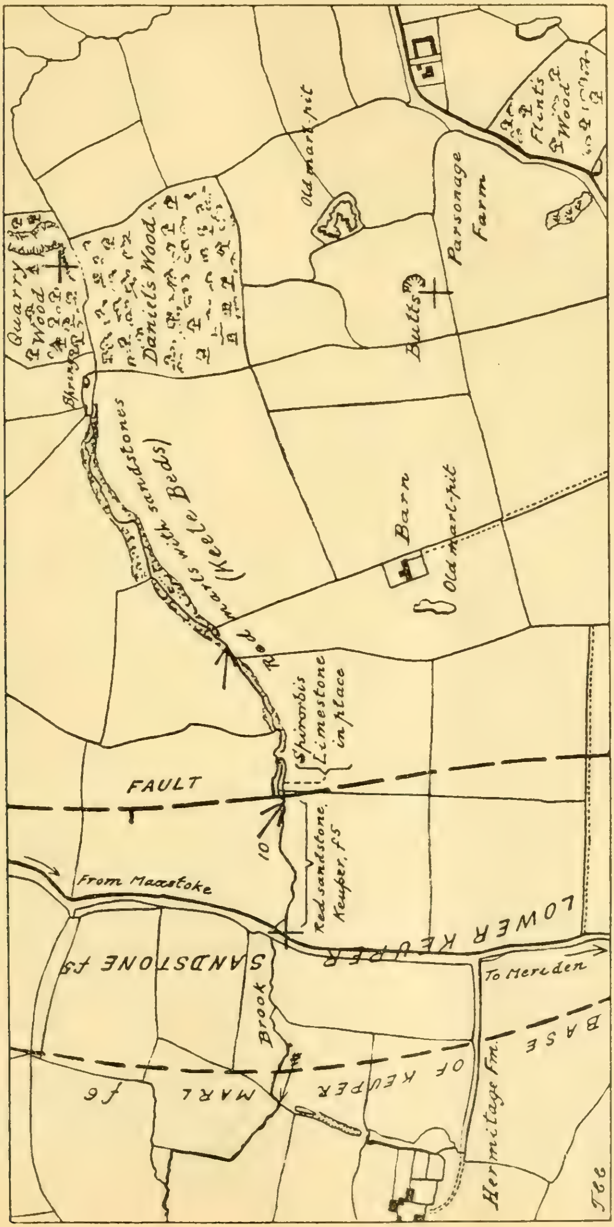

FIG. 2. Sketch-map, on scale of 6 inches to 1 mile, showing *Spirorbis*-limestone outcrop in Keele Beds near Maxstoke, Warwickshire. The base of the Keuper Marl is taken from the Geological Survey map, Sheet 62 S.E.

About 30 yards above this hedge, however, numerous small pieces of limestone suddenly appear in the stream. The rock is dark grey, bituminous, and fine-grained, and yielded a few Ostracods, but no *Spirorbis*. At 40 yards above the hedge (and about 260 yards from the road) the limestone appears in place, embedded in red marls of the usual bright-red 'Permian' tints. On the north side of the channel it projects at intervals for a distance of 3 or 4 yards; on the south also it can be detected; it is about 6 inches thick, and weathers into detached blocks not more than a foot across. The bed appears to be horizontal, and crops out in the banks of the channel at a height of about a foot above the water. The outcrop probably forms a small inlier immediately east of the fault, which presumably separates these 'Permian' beds from the Keuper Sandstones exposed down-stream and in the road-cutting. The actual fault-line is not visible, but I should draw it at the first fence, where the sandy soil on the west gives place to marly soil on the east. The supposed Keuper is to be distinguished from the 'Permian' only by the absence of bright-red and other marls; the sandstones themselves seem much alike. (Incidentally, the Survey map shows the fault some 300 yards too far to the east.) Still farther up-stream the exposures are chiefly of bright-red marls with subordinate sandstones, till the escarpment of Quarry Wood is reached and introduces a more sandy group of beds which have been quarried there and in a quarry (later used as rifle-butts) west of Parsonage Farm.

Here, then, we have a limestone which, though it did not yield *Spirorbis*, contains Entomostraca, and will probably be found to contain the characteristic Annelid also. It is lithologically similar to the limestones found in the so-called 'Permian' rocks of Wyre Forest and in the Keele Beds of North Staffordshire. Its position in the local 'Permian' sequence can at present only be guessed at. The Warwickshire 'Permian', as described in the Survey memoir and maps, seems capable of the following rough grouping:—

	Feet.
3. Red marls with sandstones	700
2. Calcareous sandstones, with the Corley conglomerate near the base .	300
1. Red and brown sandstones and marls, with some calcareous conglomerates	1000

A study of the Survey maps leads me to believe that the Hermitage Brook limestone must be placed near the top of No. 1, and that it is certainly as much as 600 feet above the base of the local 'Permian'. It follows, therefore, that this subdivision (No. 1) at least can be correlated with the Keele Beds of the North Staffordshire Coal-measures, and I am now still more disposed than I was in 1895 to refer the whole of the Warwickshire 'Permian' to the Coal-measures, and to regard them as the equivalents of Dr. Gibson's Keele Beds, till such time as any part of the series can be shown to be true Permian or Trias.

In conclusion, it is to be hoped that during any sinkings through these Keele Beds now proceeding or in contemplation, a sharp look-out will be kept for *Spirorbis* and Entomostracan limestones, as well as for thin coals and plant-remains, as they will undoubtedly form a most useful guide in estimating depths to the productive measures below.

IV.—The Old Granites of the Transvaal and of South and Central Africa, by Cuthbert Baring Horwood, A.R.S.M., Assoc. M.Inst.C.E., F.G.S., with a Petrographical Description of the Orange Grove Occurrence, by Arthur Wade, B.Sc. (Lond.), A.R.C.S., F.G.S.

Introduction.

JUST over three years ago I described[1] the field relations, chemical composition, and petrographical characteristics of the Old, and also of the Newer, Red Granite of the Transvaal. As then, so now, I cannot do better than introduce this subject with the words of the late Charles Darwin[2]—"Granite to the geologist is classic ground; from its widespread limits, and its beautiful and compact texture, few rocks have been more anciently recognized. Granite has given rise, perhaps, to more discussion concerning its origin than any other formation. We generally see it constituting the fundamental rock; and, however formed, we know it is the deepest layer in the crust of this globe to which man has penetrated". South and Central Africa furnish no exception. Their granites, which are of astonishingly widespread occurrence, of varying and often characteristic texture, have been classic ground to geologists, as the numerous papers concerning them and their mode of origin and relative geological age well testify.

In this paper, which is divided into two parts, I propose in the first portion to give a few general notes on and to describe the Old Granites of the Transvaal and South and Central Africa; to review and summarize the knowledge which has gradually accumulated during the last decade concerning these Old Granites and associated gneisses, and from this, together with my own work in the field, to draw certain conclusions and deductions, the chief one being that in South and Central Africa there exists a fundamental or primary granite-gneiss formation, which has not up to the present been generally recognized.

In the second portion Mr. Arthur Wade, from a study of my slides, has given a very detailed petrographical description of the Old Granite occurring at Orange Grove, on the southern edge of the Johannesburg–Pretoria granite boss, about 3 miles north-east of Johannesburg. He has also added notes on its position in the New Quantitive Classification lately proposed and adopted by eminent American petrologists. Although this occurrence is not the most typical, yet it is sufficiently so, and we have selected it as being that which is best known in the Transvaal on account of its proximity to the Rand.

We had hoped to compare the chemical composition and petrographical features of these Old Granites with those of the old grey soda granite which forms the nucleus of the Cordilleras of the Andes of South America, but we were unable to find any record of an analysis or any petrographical description of this latter rock.

Part I. Description of the Old Granites.

The Old Granites are of a dull-grey colour, and are frequently characterized by the presence of porphyritic felspars, which are often

[1] *The Witwatersrand and Associated Beds*, by C. B. Horwood, June, 1905 (Esson & Perkins, Johannesburg), pp. 64–84.

[2] *Journal of Researches*, by Charles Darwin (Ward, Lock, & Co.), p. 276.

corroded; pink varieties also occasionally occur, as, for example, near the Yokeskey River on the farms Rietfontein (15) and Driefontein (461)[1] in the central portion of the Johannesburg–Pretoria boss; also in the Vredefort granite massif and in some localities of the Vryheid district; Dr. Voit[2] mentions a red variety in German South-West Africa, and I have found red and pink varieties in the Gordonia division of Cape Colony near the borders of German South-West Africa. Mr. H. Kynaston[3] mentions the occurrence of a coarse pink variety with large porphyritic felspars near the Swaziland border in the Komati Poort neighbourhood; also pegmatite veins of a pale-pink colour are found in the Old Granites.[4]

The Orange Grove granite is a dark-grey rock, characterized by large porphyritic crystals of plagioclase and orthoclase felspar, frequently corroded, measuring up to about 1½ inches in length by about half an inch in width, by rounded, lustrous blebs of quartz a quarter of an inch or more in diameter, and by the abundant presence of small particles of a dark-green biotite scattered throughout the mass, sometimes occurring in the felspar, which imparts a distinctly dark shade to the rock as a whole.

Dr. G. A. F. Molengraaff in his Annual Report for the year 1898, as State Geologist to the late South African Republic, in describing the Old Granite of the Transvaal at the same time drew a vivid comparison between it and the much more recent Red Granite.

In the light of subsequent investigations some slight alterations must now be made in this description, but for the most part it holds as good to-day as it did then, and it is the best general description which has so far been published, and I therefore reproduce it in full, as follows:—

Old Granite.	*Red Granite.*
"The Old Granite is invariably of a grey colour, seldom red.	"This granite is, as the name implies, usually of a red colour.
"The Old Granite is on most places a biotite, or two-mica granite; less frequently an amphibole-biotite granite or a muscovite granite, and seldom an amphibole granite.	"The Red Granite is on most places an amphibole-biotite granite and seldom biotite granite. Up to the present muscovite has never been observed in the Red Granite.
"The felspar in the Old Granite always consists in a great measure of plagioclase or microcline. Not	"The felspar in the Red Granite is almost exclusively orthoclase.

[1] *The Witwatersrand and Associated Beds*, by C. B. Horwood, 1905 (Esson and Perkins, Johannesburg), p. 67.

[2] "A Contribution to the Geology of German South-West Africa," by F. W. Voit: Trans. Geol. Soc. S.A., 1904, vol. vii, pt. ii, p. 84.

[3] "The Geology of the Neighbourhood of Komati Poort," by H. Kynaston: Trans. Geol. Soc. S.A., 1906, vol. ix, p. 21.

[4] A pink graphic granite was encountered 50 feet from the surface in sinking a well near the south-west corner of Illovo Township, about 5 miles north of Johannesburg. I have examined this in section under the microscope and find it consists entirely of a beautiful intergrowth of quartz and of water-clear microcline. Presumably the occurrence is that of a pegmatite vein in the Old Granite.

infrequently the rock is plagioclase granite or microcline granite.

"Granophyric structure has not yet been observed in the Old Granite.

"On most places granophyric structure is beautifully developed in the Red Granite, and is very characteristic of this rock.

"Pegmatite veins are to be found almost everywhere in the Old Granite; and it not infrequently presents a reticulated appearance, caused by the ramifications of thick and thin dykes and veins of pegmatite throughout its mass. There is an abundance of handsome graphic granite to be found in the pegmatite.

"Veins of pegmatite have not yet been found in the Red Granite.

"Syenite has not yet been found in the region of the Old Granite.

"Syenite occurs very frequently with the Red Granite, and often that rock is entirely or partly changed to pistacite-syenite.

"Passages of the Old Granite to quartz-porphyry or related rocks are not known, but here and there dykes of quartz-porphyry do break through the Old Granite.

"In many instances the Red Granite passes gradually over into porphyritic forms belonging to the quartz-porphyry and felsite-porphyry group. Sometimes we find then true quartz-porphyry where quartz and felspar both occur as phenocrysts in a dense ground - mass, more frequently felsite-porphyry with large porphyritic crystals (phenocrysts) of red felspar as Carlsbad twins.

"Effusive rocks and volcanic ejectamenta which might be considered as belonging to the granite family are never found in the region of the Old Granite.

"In connection with the Red Granite, and at its base, resting on the underlying older rocks of the Pretoria Series (for instance, on Mr. Pretorius' farm, Roodeplaat, No. 314), distinctly stratified eruptive rocks, tufts, and breccias, with numerous slag inclusions occur, which certainly may be considered as volcanic ejectamenta of the granite family. They lie intercalated with sheets of felsite-porphyry, which represent old lava streams.

"In the Old Granite segregations of the basic components from the granite magma occur on a very small scale and play an unimportant rôle.

"In the Red Granite the dark, most basic components are here and there segregated and separated out from the magma in large aggregates. Foremost of these occur

"The Old Granite is intimately connected with the schists. It not infrequently even possesses a more or less banded structure, and passing then over to gneissic or amphibolitic rocks; while in many places bands of schists are interbedded. In such cases the schists consist of amphibolite, especially actinolite schists, chlorite schist, sericitic schist, staurolite schist, andalusite schist, etc."

accumulations of the amphibole, whereby local rocks originate which may be designated hornblende rocks. Of much more importance, however, is the segregation of the most basic materials —the iron ores from norite—at the base of the Red Granite, which have conduced to the origin of important ore masses consisting of chrom-iron and magnetite. The norite and gabbro themselves, of which, among others, the range known as the Zwartkoppies consists, may not improbably again be considered as basic segregations from the Red Granite magma on a large scale, but up to the present the data are insufficient to enable one to decide with certainty on the matter.

"In the Red Granite region schists have never yet been met with."

From a more recent work we now know that muscovite does occur in the Red Granite.[1] From a specimen of Red Granite which I obtained from Balmoral I have had a section cut which contains microcline; the occurrence of this mineral in the Red Granite is, however, extremely rare. Granophyric structure is sometimes present in the Old Granite.[2] Also passages of the Old Granite into quartz-diorite and quartz-porphyry sometimes occur, and Mr. H. Kynaston[3] has called attention to their occurrence in places along the southern margin of the Johannesburg–Pretoria boss.

In view of our present more advanced knowledge I would suggest the following comparison between the Old Granite and the Newer Red Granite:—

[1] *The Witwatersrand and Associated Beds*, by C. B. Horwood, 1905, pp. 68, 69.

[2] Loc. cit., pp. 65, 68; also *vide* "The Geology of the Neighbourhood of Komati Poort", by H. Kynaston: Trans. Geol. Soc. S.A., 1906, vol. ix, p. 21.

[3] "The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg," by H. Kynaston: Trans. Geol. Soc. S.A., 1907, vol. x, pp. 56–8.

	Old Granites.	*New Granites.*
1. Origin.	Plutonic.	Volcanic (inasmuch as it represents the intra-liquid slowly-cooled portion of an enormous volcanic sheet).[1]
2. Age.	Primary or fundamental.	Later than the Pretoria Series, probably later than the Waterberg Series.[2]
3. Chief Macroscopical Characteristic.	Usually of a grey colour.	Red in colour.
4. Chief Microscopical Characteristic.	Very general presence of microcline.	Very general presence of granophyric structure.
5. Chief Field Characteristics.	Presence of quartz and pegmatite veins and diabase dykes. Marginal modifications; such as quartz-diorite, schists, and gneissic granite; association with amphibolite rocks, schists, and gneisses.	Association of three types— 1. Upper felsitic portion. 2. Hypidiomorphic granite, originally intermediately situated. 3. Panidiomorphic granite, originally centrally seated, or interior. Also presence of more basic rocks around its periphery, such as syenites, norites, gabbros, pyroxenites, etc.

Possibly some slight latitude must be allowed in this use of the term volcanic, to give greater antithesis to the above comparison of the two granites. It designates rocks which have consolidated at or near the surface,[3] and it is in this latter sense that it is here employed.

Dr. Molengraaff says:[4] "I consider the Red Granite, as forming a portion of an enormous sheet, although of a decidedly micropegmatitic structure, has much in common with that of the plutonic rocks, which is my justification for still retaining the name Granite.

[1] Geological Survey of the South African Republic, Annual Report for 1898, by Dr. G. A. F. Molengraaff, pp. 5, 6.

[2] Some of the Red Granite is certainly more recent than the Waterberg Series, *vide* "The Waterberg Sandstone Formation and its Relation to other Formations of the Transvaal", by E. T. Mellor (Trans. Geol. Soc. S.A., 1904, vol. vii, pt. i, p. 45); also "The Red Granite of Balmoral and its Relations to the Cobalt Lodes", by C. B. Horwood (Trans. Geol. Soc. S.A., 1904, vol. vii, pt. ii, p. 110).

[3] *British Petrography*, by J. J. Harris Teall, p. 451.

[4] Geol. Surv. of the S.A. Republic, Ann. Rep. for 1898, pp. 5, 6.

The apparent contradiction disappears if we take into consideration that we have here to deal with a stream of acid—probably very viscous—lava of enormous extent and thickness. This explains how the intra-liquid portion could cool only very slowly, and thus acquire the characteristic structure of plutonic rocks. We must assume that, after the decomposition of the Magaliesberg Beds in the area which is now the Bushveld, there followed a period of volcanic activity on a very large scale. . . . The bed of the Pienaars River on the farms Baviaanspoort (No. 470), Leeuwfontein (No. 320), Zeekoegat (No. 287), and Roodeplaat (No. 314) offers excellent opportunities for the study of the earlier results of the above-mentioned eruptive activity, followed by the outflow of a colossal stream of granite lava, which in its central and lower portions consolidated to a 'granite' with micropegmatitic structure, the portion nearer the surface, however, furnished rocks belonging to the quartz-porphyry and felsite-porphyry group." Later[1] he speaks of the intrusion of a magma, rich in soda, which might have been of the nature of a laccolite, intruded between the Waterberg and Pretoria Series. However, whether portion of an enormous sheet or of a laccolite, the origin of the granite, in either case, is the same.

This explanation of the origin of the Red Granite is not incompatible with modern ideas. Sir Archibald Geikie states[2] that granite may occur "connected with true volcanic rocks, and forming, perhaps, the lower portion of masses which flowed out at the surface as lavas. In the Tertiary volcanic region of the west of Scotland, masses of granite and granophyre have pierced the sheets of sub-aerial basalts, and must have risen near to, if they did not actually reach, the surface. They prove that granite is not necessarily, though usually an abysmal rock".

Returning now to the Old Granite, Mr. H. Kynaston[3] has described the granite at the old Half-way House between Pretoria and Johannesburg as a somewhat coarse rock of a pale pinkish-grey colour, with occasional large flesh-coloured felspars showing more conspicuously among the other constituents, and says that under the microscope it is seen to consist mainly of a somewhat coarse aggregate of microcline, plagioclase, and quartz, with a few small flakes of white mica. He states that the proportion of ferro-magnesian constituent is small, and consists of biotite, partially chloritized, and a very small quantity of green hornblende; also that apatite is accessory, and that a few small grains of epidote appear as a secondary constituent.

In this same granite boss, near the dynamite factory on the farm Modderfontein, I have found a reddish-grey granite, in which small particles of violet-coloured fluorspar were easily discernible in the hand specimen.

Dr. G. A. F. Molengraaff[4] has given such a very full and careful

[1] *Geology of the Transvaal*, 1904, pp. 57–60.

[2] *Text Book of Geology*, by Sir A. Geikie, 1903, vol. i, p. 208.

[3] "The Marginal Phenomena and Geological Relations of the Granite North of Johannesburg," by H. Kynaston: Trans. Geol. Soc. S.A., 1907, vol. x, p. 55.

[4] "Note on the Geology of a Portion of the Klerksdorp District, etc.," by Dr. G. A. F. Molengraaff: Trans. Geol. Soc. S.A., 1905, vol. viii, pp. 24, 25.

description of the Old Granite in the Klerksdorp District that I quote it in full—

"*Microcline Granite:*—Specimens from Haartebeestfontein (624), Oorbietjesfontein (201), and Rhenosterhoek (585). *Macroscopic:* a grey granite of medium grain. The lamellar twinned character of the triclinic feldspar is easily recognisable with a pocket lens.

"Under the microscope the rock shows a typical granitic hypidiomorphic structure. The primary constituents are microcline, plagioclase, orthoclase, quartz, muscovite, some iron ore, biotite, rutile, zircon, and tourmaline. The secondary constituents are chlorite and muscovite. Feldspar and quartz preponderate so much over the other minerals that the latter only occur in clusters here and there in the rock, or as enclosures in the quartz or feldspar. Iron ore is very sparingly represented by some crystals of magnetite and by some hydrated iron oxide, which may have been derived from hæmatite. Mica is chiefly represented by muscovite; part of the muscovite is altered into chlorite in such a way that each crystal of muscovite is altered into a chlorite crystal with the same crystallographic orientation. The chlorite is distinctly pleochroic and shows 'Höfe' with very strongly marked pleochroism, and those often contain in their centres minute grains of zircon.

"The muscovite enclosed in quartz is always quite undecomposed. Biotite occurs only in small quantities enclosed in quartz or in feldspar.

"Feldspar occurs chiefly as microcline, which forms, in fact, the bulk of the rock. With the exception of quartz, the microcline was the last mineral to crystallize in the rock, which is proved by the fact that numerous well-planed crystals of orthoclase — mostly Carlsbad twins—and also crystals of plagioclase are enveloped by microcline. The characteristic 'Gitterstructur' of the twinning is very fine. The microcline was found to be quite fresh and undecomposed in all the specimens, whereas both orthoclase and plagioclase was less pellucid and partly decomposed, numerous small flakes of secondary muscovite having been formed in them.

"Quartz fills the gaps left after the crystallization of all the other minerals, and also contains all these as enclosures; zircon, rutile, and tourmaline are found only as enclosures in the quartz. The rock shows signs of having been subjected to great pressure, which is revealed under the microscope by the undulatory extinction of the quartz, and by the numerous bends and cracks in the other minerals; this last phenomenon is, of course, most clearly shown in the lamellar plagioclase."

Dr. J. A. Leo Henderson,[1] referring to the Yokeskey River granite (in the Johannesburg–Pretoria massif), remarks that "a regular mutual intergrowth between biotite, muscovite, and green pleochroic chlorite was observed parallel to the cleavage traces, and it would appear that, as Molengraaff suggests, the chlorite has been derived from the primary biotite. A good deal of the muscovite is primary, containing tiny zircon inclusions, but much is secondarily derived from

[1] *Petrographical and Geological Investigations of certain Transvaal Norites, Gabbros, Pyroxenites, and other South African Rocks*, by Dr. J. A. Leo Henderson, 1899, p. 44, Dulau & Co., London.

the feldspar through decomposition. Broken needles of rutile in the quartz grains and contorted mica folia, as well as the bent and broken feldspars, combined with undulose extinction of the quartz and feldspars, indicate considerable cataclastic action. This probably explains, as Molengraaff observes, the cross-hatching structure of the microcline".

Dr. Voit,[1] speaking of the Old Granite of German South-West Africa, says that the frequent occurrence sometimes in veins and sometimes in great masses of pegmatite is characteristic. He states that mica occurs as large as a man's hand, and a red felspar (microcline) of gigantic size, like graphic granite, with quartz inclusions; that the mica is chiefly muscovite, accompanied sometimes by biotite in small flakes, sometimes, too, small flakes of a green mica occur in the graphic granite, in which the blow-pipe affords evidence of chromium; that tourmaline is a very common constituent of the granite, and occurs in both large and small individuals up to an arm's length and thickness; that clusters of small apatite crystals are often to be found in the red felspar; and that topazes and beryls are found as long as one's hand, the latter being of a completely opaque and dirty variety, the clear, bluish-green, glassy variety of aquamarine being seldom found. He also describes the gneiss-granite district as unusually rich in secondary minerals, the felspars near Ganab being frequently changed to zeolites.

Mr. A. W. Rogers,[2] Director of the Geological Survey of the Cape Colony, in describing the granite massif which stretches from St. Helena Bay to Klein Dassen Berg, a distance of about 70 miles, says that many varieties of granitic rock occur, the most abundant being, perhaps, a two-mica granite, with orthoclase as the chief felspar. He states that every gradation between a normal granite and a gneiss can be found, and that the massive granite is seen in the interior of the area and the foliated rock near the periphery, but that this rule has many exceptions. He says that large and small veins or dyke-like bodies of microgranite and quartz-porphyry, with a microgranite base, are found towards the edge of the area in many places; and tourmaline is often present in the rock near Darling. Also that in the hills to the south and west of Darling there are some remarkable rocks associated with the granite and gneiss; colourless augite, plagioclase, and sphene are added to the usual constituents of the granite, and mica is practically absent; the structure is that known as granulitic, the various minerals occurring in grains of a more uniform size than is the case with ordinary granite. These rocks often show a parallel structure, but have not the foliated or schistose planes seen in the gneiss. He adds that the nature and origin of the granulites of Darling are as yet unexplained, as is also their exact relationship to the surrounding granite and gneiss.

With regard to the Malmesbury granite boss, he says that it is mainly a rather coarse biotite granite with porphyritic orthoclase, but fine, grained granite, composed of the same minerals, and coarse pegmatites are not infrequent, and that there seems to be no gneiss.

[1] "A Contribution to the Geology of German South-West Africa," by Dr. F. W. Voit: Trans. Geol. Soc., vol. vii, pt. ii, pp. 84, 85.

[2] *The Geology of Cape Colony*, by A. W. Rogers, pp. 38–42.

Again, he describes the granite of Paarl Mountain as a biotite granite associated with dykes of quartz-porphyry but not with gneiss. Further, he remarks that "the granites of the Paarl and Stellenbosch districts contain a fair amount of microcline, a variety of felspar which is rare in the Saldanha Bay and Darling area, although it seems to be the chief felspathic constituent of the granites in the northern and north-western parts of the Colony. On the south-west edge of the Bottelary granite cassiterite or tin-stone occurs in a gneissose muscovite granite, together with tourmaline; wolframite has been found in the same neighbourhood".

In describing the smaller of the two granite masses near Somerset West, he says: "The main mass of the intrusion is a biotite granite with little muscovite, but the muscovite is very abundant in certain places and the felspar decreases in amount and may disappear completely, so that the rock becomes a greisen or quartz-muscovite rock. In other parts tourmaline is extremely abundant, sometimes giving rise to a schorl rock, composed of tourmaline and quartz only. At other places andalusite, showing a beautiful pink tint under the microscope, forms a large part of a rock composed of quartz, tourmaline, muscovite, andalusite, and apatite."

Professor E. Cohen,[1] of Greifswald, has recorded the presence of pinite (an alteration product of cordierite) in the biotite granite of Table Mountain. Mr. Rogers[2] describes the granite mass of George as containing both muscovite and biotite granites, with tourmaline and fluorspar; and associated with gneissose rocks.

With regard to the granite and gneiss of the Prieska district, he[3] observes that the foliation planes of the gneiss are in general parallel to the strike of the sedimentary rocks in its neighbourhood; he thinks it not unlikely that the intrusion and solidification of the granite and gneiss occupied a long period, and that we have in the gneiss the earlier, and consequently most altered, products of the acid magma; but he says that "whether any part of the granite is of much later date than the bulk of the intrusions is not yet settled. Some of the very fresh-looking granites on the farm Schalk's Puts might certainly be considered younger than the gneiss, but there are so many intermediate varieties that the evidence of a considerable difference in age between the extreme types must be clearly made out before that opinion can be accepted". He then proceeds—

"The chief constituents of the acid intrusions are quartz, orthoclase, microcline, albite, and an intergrowth of orthoclase or microcline, and a plagioclase felspar, black and white mica, the latter sometimes (e.g. Grenaat's Kop and Alicedale) in crystals up to 10 inches in width, but too frequently bent by the movements which the rock has undergone since its solidification; hornblende is not often met with; apatite and iron ores are not abundant; garnets occur, especially in certain gneisses, and in the rocks with the same

[1] "Geognostisch-petrographische Skizzen aus Süd Afrika:" Neues Jahrbuch für Min., etc., 1874, p. 460.

[2] *The Geology of Cape Colony*, by A. W. Rogers, p. 44.

[3] Loc. cit., pp. 79–83.

constituents as the granite but with granulitic structure. Tourmaline seems to be absent from the Prieska granites.

"Pegmatite or graphic granite, chiefly composed of an intergrowth of microcline and quartz, forms a large mass in the neighbourhood of Saft Sit Pan. Quartz-porphyries are rather restricted in their occurrence; they have been found only within the granite areas, and are not known to traverse the surrounding rocks in the manner of the quartz-porphyries near Paarl Berg.

"The granulites of Prieska are abundant and vary greatly in composition. They are fine-grained rocks, usually showing distinct banding on large weathered surfaces, but the banding is often unobservable on a freshly broken surface. They are usually dark in colour, but the more acid or siliceous types are light-coloured. In general appearance they look rather like even-grained quartzites. It is only under the microscope that the distinctive features of the granulites are seen. The most striking character is the uniformity in size of the grains of the various minerals composing the rocks; another important feature is the almost complete absence of crystalline faces in the minerals, which seem to have separated out in a different manner from that usual in igneous rocks; enclosures of one mineral by another are abundant, but the enclosed mineral is irregularly shaped, usually with a rounded outline. Garnet, which is an important constituent of most of the Prieska granulites, is the only mineral which sometimes shows crystal faces, and it very often contains small grains of more than one of the other minerals composing the rock. All the minerals in the granulites are remarkably fresh and free from alteration products. The rocks may be broadly divided into three groups—(1) Granulites made up of the same minerals as the granite and gneiss, viz., quartz, felspar (orthoclase and plagioclase), garnet, and biotite. This seems to be a less abundant rock than those belonging to the two other classes to be mentioned, but on account of its being rather closely related to much of the gneiss, into which it passes by the coming in of a pronounced foliation and the increase in size of some of the felspars, it is easy to overlook small outcrops in the gneiss areas. (2) Hornblende-granulites, composed of quartz, orthoclase, albite, hornblende, biotite, magnetite, garnet, and sphene. The hornblende is a pale, bluish-green variety, different from the hornblende of most of the hornblende schists. Garnet is a less abundant mineral constituent than in the next group. (3) Pyroxene-epidote-granulites, composed of plagioclase, augite, epidote, garnet, magnetite, sphene, and frequently hornblende. The pyroxene is a pale-green or bluish-green monoclinic variety, diopside, and is slightly pleochroic. The abundance of epidote, which often forms a large part of the rock, is very remarkable.

"The granulites form elongated outcrops in the granite and gneiss, with the longer axes of the areas parallel to the foliation planes of the gneiss; they have not been found as intrusions in the sedimentary rocks. The nature of their contact with the gneiss has not been made out, as the line of junction of the two rocks is almost invariably concealed under the red sandy soil that the granite and gneiss give rise to. The composition of the pyroxene-granulites must be very different from that of any of the gneissose or schistose rocks yet found in Prieska, and it is therefore impossible to consider them as local modifications of any of the latter, as the biotite-granulites may be with regard to the gneiss. The amount of lime and alumina in the pyroxene-granulites must be greater than is usual in igneous rocks containing the same varieties of plagioclase. The granulites give one the impression of being intrusive, but the question of their origin is quite unsettled."

I have quoted Mr. Rogers' description of these rocks in full because he has given such a clear and detailed account of them, and because there can be no doubt that the granulites of the Prieska district are genetically connected with the normal type of granite, and Mr. Rogers is evidently inclined to admit a difference in age between them and the normal granite. Mr. Rogers[1] also mentions the occurrence of peculiar types of well-foliated gneiss amongst the Southern Bushmanland granites and gneisses at the base of the Langeberg in Calvinia, which consist chiefly of quartz, plagioclase, enstatite, hornblende, and biotite, and occur in bands enclosed in gneiss of more normal character. He further states that garnetiferous granite and gneiss are abundant in that area.

A description of certain microcline gneisses of the Congo Free State, which are petrographically remarkably similar to some of the gneisses already mentioned, will be found further on.

Review of Work done during the Last Decade.

Some of the work already done has of necessity been mentioned under the last heading, but that which has not yet been alluded to I now propose to review.

In 1897[2] Mr. A. R. Sawyer drew attention to what he called the Rooi Kopjes mass of granite, situated south of Heidelberg between the upper and lower Rooi Kopjes. The granite is here overlain unconformably by a small outlier of Karroo Beds, and does not outcrop at the surface, but has been encountered in bore-holes. According to Mr. Sawyer's description it occurs at a considerable depth below the level of the Witwatersrand rocks which outcrop around it, and dip away from it along the margin of the Karroo Beds, which here form the South Rand Coal-field. He stated "that the gneissoid granite, forming the base of this coal-field, is part of the basement underlying the whole of South Africa, and is here, in the writer's opinion, distinctly anterior to the banket formation".

Later,[3] in 1903, he states, in referring to his previous description of this occurrence, that it appeared to him at that time "that the gneissoid granite formed part of a protrusion of the vast underlying deep-seated granite foundation which I have seen in so many parts of South Africa, from the coast in Cape Colony to beyond Salisbury in Mashonaland, and which I believe underlies the whole of South Africa, and that it

[1] Loc. cit., p. 91.

[2] "The South Rand Coal-field and its Connection with the Witwatersrand Banket Formation," by A. R. Sawyer: Trans. Inst. M.E., 1897, vol. xiv, p. 312.

[3] "Remarks on some Granite Masses or the Transvaal," by A. R. Sawyer: Trans. Geol. Soc. S.A., 1903, vol. vi, pt. iii, pp. 47–9.

produced a large flexure or anticline, and was not therefore posterior to the uplifted rocks". Then in the same paper he says, "since then I have found out by boring that the dip of the Witwatersrand and Hospital Hill Beds is steeper near the granite," and he suggests that the steep dip of the rocks east and west of the granite points to the granite being intrusive in them.

Thus, in his opinion, the Old Granite is the basement rock on which the Witwatersrand Beds were laid down, and which subsequently invaded them by after-intrusions. It is also of interest to note that in 1897 [1] he mentioned an occurrence of granite containing veins of white quartz on the farms Varkenskraal and Klerkskraal, which are traversed by the Mooi River, 35 miles north of Potchefstroom, and stated that banket reefs (Black Reef Series) containing glassy white quartz pebbles can be seen resting on the granite on these farms, and that the white quartz veins of the granite "can be seen passing through various gradations of decomposition until they reach the final stage of banket pebbles".

Dr. Molengraaff, in his report for the year 1897, as State Geologist of the South African Republic, under the term South African Primary Formation with Intrusive Granite Bosses, includes—

1. Granite and schists.
2. Hospital Hill Series and Barberton Beds.
3. Witwatersrand Series.

And he states that the beds of this formation have been much altered, both by dynamo-metamorphism and by contact-metamorphism, in the vicinity of the granite bosses. Also, he speaks of numerous granite masses which are found intrusive in this formation. Later, in the same report, he speaks of the granite as intrusive in the bottom part of this formation.

In his report for the following year he classes the Witwatersrand Series (our present Witwatersrand Beds) as the upper division of the Barberton Series, and in his table of the sequence of the various formations he puts the Barberton Series as conformable with the Old Granite and schists, but puts a query mark against the sign for conformability.

In a paper [2] read by him in June, 1903, on the tectonics of the Vredefort district he shows in a most convincing manner how the overtilting of the beds is there due to the intrusion of the granite. The chief arguments which he brings forward in support of this contention are that at a certain distance from the great central granite boss small enclosures of granite are found entirely surrounded by rocks of the South African Primary System, being apparently offshoots of the main granite boss; also that unmistakable signs of strong contact-metamorphism are found in the lowest portion of the sedimentary strata around the granite, the strata nearest to granite being entirely crystalline, and having the character of crystalline schists, especially actinolite schist; and up to some distance from

[1] Loc. cit., p. 13.

[2] "Remarks on the Vredefort Mountain-Land," by G. A. F. Molengraaff: Trans. Geol. Soc. S.A., vol. vi, pt. ii, pp. 20–6.

the granite the shaly and slaty rocks are charged with contact minerals. Of these he describes two chief types—(*a*) apparently porphyritic, more or less schistose rocks, composed mainly of corundum and biotite in fairly large crystalline grains, all interlarded by a kind of network of quartz; in some varieties phenocrysts of corundum are very conspicuous on the surface of the rock, having been so left by reason of their strong resistance to weathering; (*b*) highly ferruginous and magnetic banded slates, being identical with the well-known Hospital Hill Slates, but for their being charged with spherulites or bunches of actinolite. And further, he points out that the steep dip and overtilting of the beds surrounding the granite boss is not due to one main axis of dislocation at right-angles to which lateral pressure was exerted, but the axis of overtilting gradually changes in direction all round the granite boss, keeping tangental to it, so that evidently the pressure has been exerted in every instance from its centre towards the periphery. Since all the series of beds from the granite up to and including the Pretoria Series has been more or less overtilted, and since sandstones of the Karroo formation near Vredefort rest in a perfectly horizontal and undisturbed position on the granite, the intrusion must have taken place after the deposition of the Pretoria Series and before the deposition of the rocks of the Karroo System. Dr. Hatch,[1] in discussing this paper, stated that he thought it extremely probable that Dr. Molengraaff was correct in his view with regard to the overtilting of the Witwatersrand Beds.

Although Dr. Molengraaff had treated this occurrence in such a masterly way, and his conclusions were based on such sound premises, yet because one occurrence of the Old Granite was afterwards shown to be non-intrusive in the Lower Witwatersrand Beds in the Heidelberg district,[2] instead of realizing that his previous work in the Vredefort district had proved that the Old Granite was intrusive in places, even if not so everywhere, and therefore did not all belong to one and the same period of intrusion, he in August, 1904, says:[3] "the recent studies of Messrs. Dörffel and Corstorphine have led me to doubt the correctness of my opinion that the Old Granite is intrusive in the Lower Witwatersrand Beds (Hospital Hill Series), and I consider this question open to revision in the case of the granite of the Vredefort boss also."

In his *Geology of the Transvaal* (1904) he states that the whole of the South African Primary System represents one single series, of which the rocks are greatly modified in their structure by contact-metamorphism produced by granitic intrusions. He then states that in the districts where the South African Primary System has been well developed, as in the Barberton district and in the Witwatersrand, it is preferable to distinguish a lower series confined to the vicinity of the old intrusive granite, consisting of crystalline schists, and an upper series composed of rocks of clastic origin. He adds a footnote

[1] Trans. Geol. Soc. S.A., vol. vi, pt. iii, p. 30.

[2] "The Geological Relation of the Old Granite to the Witwatersrand Series," by G. S. Corstorphine: Trans. Geol. Soc. S.A., vol. vii, pt. i, pp. 9–12.

[3] Trans. Geol. Soc. S.A., 1904, vol. vii, pt. ii, p. 115.

to the effect that recent investigations tend to prove that in the Southern Transvaal the Witwatersrand System was deposited on the pre-existing Old Granite, and that for the time being he considers the question whether this granite must be regarded as intrusive in the oldest sedimentary rocks as doubtful, and as direct proofs of the granite being intrusive in Hospital Hill Series are wanting he suggests that possibly the upper and lower series of the South African Primary System are of different ages, the majority of the crystalline schists being segregations and alterations by pressure from the granite. Thus at first he was of the opinion that the Old Granite was intrusive in the Hospital Hill Series (our present Lower Witwatersrand Beds), but later felt doubt about this and reserved a final opinion. Moreover, in discussing Mr. Jorissen's paper,[1] which I refer to later, he says,[2] in reference to the relation existing between the Witwatersrand Series, Swaziland Series, and the Old Granite, "Possibly the granite is intrusive into both of these; possibly also the granite in different places may belong to separate intrusions of different ages." The recent investigations which he referred to were started by the late Mr. D. Dörffel[3] in December, 1903. Until then the Old Granite was generally considered intrusive in the Witwatersrand System.

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

V.—The Homotaxial Equivalents of the Culm of Western Germany.

By Dr. W. Hind, B.Sc. Lond., F.G.S., etc.

In the Geological Magazine, 1904, Dec. V, Vol. I, p. 403, I criticized the view put forward by Dr. Parkinson that the Culm beds in the neighbourhood of Marburg were of Lower Carboniferous or Tournaisian age. Last summer I had the advantage of being taken over the ground by Professor Kayser, of Marburg, and also of seeing his valuable and extensive collections from the Culm of various parts of Germany.

The view that the Culm of Germany is of Lower Carboniferous age has naturally arisen from the fact that it certainly forms the base of the Carboniferous rocks of Western Germany, and that these rocks rest on Upper Devonian beds with *Clymenia* without any apparent great unconformity. Unfortunately sections showing anything like a complete sequence are unknown, and the Culm seems to have been laid down in several small basins over a gradually sinking area of Upper Devonian rocks, themselves much moved and interrupted by volcanic outbursts, so that the lowest bed or beds of the Culm are not everywhere present.

By comparing the zonal fossils of the known sequence of the Culm or Pendleside Series in either Great Britain or Belgium with

[1] "Notes on some Intrusive Granites in the Transvaal, the Orange River Colony, and in Swaziland," by E. Jorissen: Trans. Geol. Soc. S.A., vol. vii, pt. iii, pp. 151–60.

[2] Proc. Geol. Soc. S.A., to accompany vol. viii of the Transactions, 1905, p. 32.

[3] "Note on the Geological Position of the Basement Granite," by D. Dörffel: Trans. Geol. Soc. S.A., vol. vi, pt. v, pp. 104–5.

those of the various Culm beds of Western Germany, a very definite and normal succession of zonal sequence can be made out. The fauna of the Culm, as exhibited in the Museum of the Geological Department of the University of Marburg, is typically that of the Pendleside Series and Culm of Great Britain; all the important zonal Cephalopoda are present, and I consider in normal succession.

It is practically unthinkable that similar successions of Cephalopod forms could be evolved at two distinct periods of geological time, which the view of the Tournaisian age of the Culm of Western Germany would necessitate. It is known that in Belgium and Great Britain the Pendleside or Culm fauna is always post-Viséan, and consequently the presence of the typical fauna in Germany determines the age of the German Culm to be also post-Viséan.

In Great Britain the faunal sequence which succeeds the Viséan subdivision of the Carboniferous Limestone is as follows:—

Zone of *Gastrioceras Listeri*	Millstone Grit.
Zone of *Glyphioceras bilingue*	Millstone Grit.
Zone of *Gl. spirale* and *Gl. diadema*	Pendleside Series.
Zone of *Gl. reticulatum* (maximum)	Pendleside Series.
Zone of *Nomismoceras rotiforme* and *Posidonomya Becheri* .	Pendleside Series.
Zone of *Prolecanites compressus* in upper part of *Cyathaxonia*-zone.	

Glyphioceras crenistria is common in the upper part of the Viséan or *Dibunophyllum*-zone.

The majority of these zonal forms are found in Belgium in the same sequence, and the fauna which is found in the Pendleside Series and its equivalent in Belgium is a Lower Carboniferous fauna, but post-Viséan.

In Germany the Culm beds lie on a diabase of Upper Devonian age, intrusive into the *Clymenia* beds, a sequence practically identical with that which obtains in North Devon. The lowest Culm fauna is obtained from lenticular patches of limestone at Breitscheid, and German authorities are agreed that this is the case. The following fauna has been obtained at Breitscheid:—

Prolecanites compressus.	*Trincoceras hibernicum.*
Glyphioceras crenistria.	*Dimorphoceras Gilbertsoni.*
G. mutabile.	*Orthoceras scalare.*
Pericyclus virgatus.	*Orthoceras* cf. *salvum*, de Kon.
Brancoceras ornatissimum.	Corals.

This is a fauna which is distinctly characteristic of the highest Viséan or *Dibunophyllum* horizon of Great Britain and Ireland, and contains the type or zone fossil of the passage beds between the *Dibunophyllum*-zone and the Pendleside Series. I am informed that a similar fauna has been found at Erdbach and Liebstein, but the beds are very local and not persistent, and are often entirely absent.

The so-called 'Mittel Kulm' is much more fossiliferous, and perhaps the best exposure is at Herborn, the fauna of which has been described by v. Koenen ("Die Kulmfauna von Herborn": Neuen Jahrebuch für Min., Geol., u. Pal., 1879, p. 311). At Herborn the series consists of calcareous shales, the 'Posidonien Schiefer', with small nodules, which rests on 7–8 metres of black chert; this, in turn, rests on a diabase of Upper Devonian age. The section is—

	Metres.
Grauwacke or grit	130–200
Posidonomya Becheri shales	20–25
Black chert	7–8
Upper Devonian diabase.	

The Herborn flora and fauna is typically that of the Lower Pendleside Series, with the exception that *Pterinopecten papyraceus* has not been found there. The fauna is rich, and the most important members are—

Adiantites antiquus.
Glyphioceras reticulatum.
G. diadema.
Nomismoceras rotiforme.
Orthoceras striolatum.
O. scalare, often called with us *O. Konincki.*
Aviculopecten Losseni.
Posidoniella lævis.
Posidonomya Becheri.
Actinopteria persulcata.
Camaropteria papyracea.
Listracanthus Beyrichi.
Trilobites.

I regret to say that I did not visit the Culm of Westphalia, but thanks to Professor Kayser I was able to study his fine collection of fossils from that area, and with his information as to the sequence have arrived at the following results.

Professor Kayser's collections were from two localities — Hagen and Aprath, near Elberfeld. The general sequence is as follows:—

	Metres.
Flotzeere Sandstein, with plants	2000
Culm Tonschiefer, with *Glyphioceras reticulatum*	200
Dark thin-bedded limestones, with Hagen fauna at base . .	200
Silicious limestone, with Goniatites	50
Cherts, with Aprath fauna	
Phtanites, with *Prolecanites compressus*	5
Devonian Rocks	

The Aprath fauna contains a fauna typical of the very lowest of the Pendleside Series—

Prolecanites compressus,
Nomismoceras rotiforme,
Trincoceras hibernicum,
Pleurodyctium Dechianum,
Productus plicatus, Sarres,

and, as might be expected, the oldest facies of any fauna in the sequence.

The fauna of Hagen also contains a number of late Viséan forms of Brachiopods, such as are found in and known to range throughout the Pendleside Series of England (Congleton Edge), together with Goniatites, which are known to be associated with *Posidonomya Becheri* in Devonshire.

Glyphioceras striatum.
G. sphæricum.
Glyphioceras crenistria.
Orthoceras Morrisianum.

At Scarlet, Isle of Man, and various localities in North Staffordshire, also near Cracoe in Yorkshire, and Black Hall near Chipping, these Goniatites abound in limestones immediately below the *Posidonomya Becheri* shales.

D. W. Wolterstorff has described the Culm of Magdeburg, and his figures of fossils show that the fauna is identical with that of Herborn. I suspect, however, that he has there also the fauna of a higher zone, for I think it probable that the Goniatite he figures as *Dimorphoceras Tornquisti* may be either *G. bilingue*, *G. Phillipsi*, or *G. reticulatum*.

The presence and persistence of the Pendleside or Culm fauna over Western Europe, and the fact that its zone fossils always succeed each other in normal sequence, affords most certain and definite evidence for the correlation of the Pendleside Series and the Culm of Devonshire with the Namurien of Belgium and the Culm of Germany, and that the view that the Culm beds of Germany are below the Viséan and are the homotaxial equivalents of the Tournaisian must, on palæontological grounds, be revised.

When discussing the question on the ground I found that the view that *Posidonomya Becheri* was a very unsatisfactory zonal form and that it occurred again and again at various horizons was strongly urged, and certain stratigraphical facts were also cited in support of the view that the German Culm-measures were of Tournaisian or ante-Viséan age.

In the first place it is known that *P. Becheri* occurs low down in the Yoredale Series of Wensleydale in black shale above the Hardraw Scar Limestone, but the associated fauna is a Viséan one and not a Pendleside or Culm fauna, and it may be said that *P. Becheri*, with the peculiar Cephalopods which constitute the Pendleside fauna, has a very narrow horizontal distribution indeed. But the case does not depend on this fossil at all. I rely absolutely on the Cephalopod succession and the fauna as a whole. It is most improbable that such highly organized forms as *Prolecanites compressus* or *Nomismoceras rotiforme*, with their peculiar sutures, genera which only existed for very brief periods as measured by vertical succession, should have characterized different series of rocks in the British–Belgian area and in Germany.

In 1904 (Geol. Mag., Dec. III, Vol. I, pp. 272–6) Dr. Parkinson, on palæontological grounds, definitely made out the Culm of South Germany to be below the horizon of the Viséan division of the Carboniferous Limestone. I was shown the stratigraphical evidence in the field by Professor Kayser, whom I beg to thank for his lucid explanations and for permission to study the whole of the palæontological material on which the views were based. In the neighbourhood of Königsberg, north of Giessen, are outcrops of a slaty breccia, with some limestones, which yield the following fauna :—

Productus giganteus.	*Cyathophyllum.*
P. punctatus.	*Cyathaxonia.*
P. semireticulatus.	*Spirifer* cf. *bisulcatus.*
Orthotetes crenistria.	*Chonetes papyraceus.*
Corals.	*Cyclophyllum.*

This is a fauna of a high Viséan phase, undoubtedly and totally distinct from any of the hitherto known Culm faunas of Germany. There is, however, no section which shows the relation of this fauna to the Culm faunas. The Königsberg Beds are underlain by a grauwacke or grit, and the Herborn Beds or Posidonien Schiefer are overlain by a similar rock, and it is therefore surmised that this grauwacke represents a definite horizon and demonstrates the relation of the Viséan beds of Königsberg to the *Posidonomya* shales of Herborn. The whole district is much disturbed, faulted, and overthrusts are many and on a grand scale, the Königsberg Beds are themselves much contorted and broken, and the exposures very small, that sufficient detail of stratigraphy does not obtain.

Near Königsberg, 400 yards east of the village, is a small section which shows the following succession:—

Posidonien Schiefer.
Cherts.
Diabase.
Upper Devonian.

A succession similar to that which exists at Herborn. These beds are cut off by a fault and then the section shows grauwacke, on which lies the slaty breccia containing the Viséan fauna.

In the absence of detailed stratigraphical evidence of the relation of the Königsberg Beds, it is argued that the beds with Viséan fauna cannot be below the *Posidonomya* cherts, because there is no room for them between the Devonian diabase and the chert. But it is forgotten that the lowest Culm fauna, the Breitscheid or *Prolecanites compressus* fauna, which is admitted to be below the *Posidonomya* beds, is absent at Königsberg. And further, this argument begs the whole question, because it assumes that there was no interval or unconformity between the outburst of the Devonian diabase and the deposit of the Posidonien Schiefer.

The question is not one that demands much imagination, however. The Viséan fauna found at Königsberg is that which is always found to immediately precede the *Prolecanites compressus* beds and normally should be only a few feet below it, and it is not therefore at all strange to find evidences of both faunas in very close proximity, but it is important to recognize that the Culm of Western Germany is late Carboniferous, and not Tournaisian, and the appeal to palæontology pronounces a very definite and certain verdict on this point. The solution of the question was impossible in Germany, on account of the absence of sections and the disturbance, contemporaneous and afterwards, due to volcanic activity and earth-movements. It is of the greatest interest to find that the questions of the relation of the Upper Devonian to the Culm are practically identical in Germany and Devonshire, and to know that the oldest Carboniferous rocks in Germany are late Viséan.

Recent work in Belgium by Dr. Purves,[1] M. Cornet,[2] and M. Renevier afford additional evidence for the views advanced in the above paper.

[1] Bull. l'Acad. Roy. Belg., ser. III, pt. ii, No. xii.
[2] Am. Soc. Géol. Belg., t. xxxii, pp. 139–52.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science, Seventy-ninth Annual Meeting, held at Winnipeg, August 26–31, 1909. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Address by the President (*Dr. Arthur Smith Woodward, F.R.S., F.G.S.*).—The Evolution of Vertebrate Animals as shown by Fossils (see Geol. Mag., September, p. 413).

J. B. Tyrrell.—The Geology of Western Canada.

Professor A. P. Coleman, Ph.D.—The Extent of the Ice Sheets in the Great Plains.

Warren Upham, D.Sc.—The Glacial Lake Agassiz. (See p. 475.)

Professor E. F. Chandler.—The Rainfall Run-off Ratio in the Prairies of Central North America.

Professor A. P. Coleman, Ph.D.—The Bearing of Pre-Cambrian Geology on Uniformitarianism.

Professor W. G. Miller.—The Pre-Cambrian Rocks of Canada.

A. R. Dwerryhouse, D.Sc.—An Outline of the Glacial Geology of Britain, illustrative of the Work of the Committee on Erratic Blocks.

Dr. Aubrey Strahan, M.A., D.Sc., F.R.S.—The Glacial Geology of South Wales.

David Woolacott, D.Sc.—On the Classification of the Permian of the North of England.

Herbert Bolton.—New Faunal Horizons in the Bristol Coalfield.

Professor S. H. Reynolds, M.A.—Description of the Avon Section, Bristol, in illustration of Dr. A. Vaughan's work on the English Carboniferous Limestone.

Professor S. H. Reynolds, M.A.—Lithology of the Carboniferous Limestone of Burrington Combe, Somerset.

Ernest Dixon, B.Sc.—On some Structures in Limestone Formations.

Professor W. G. Miller.—Gold and Silver Ore-deposits of Canada.

Professor A. P. Coleman, Ph.D.—Copper and Nickel Deposits of Canada.

Professor W. G. Miller.—Iron Ore-deposits of Canada.

J. B. Tyrrell, M.A.—Placer Mining in Canada.

Professor T. L. Walker, Ph.D.—Rare Metals found in Canada.

Professor J. W. Gregory, D.Sc., F.R.S.—Report of the Committee on South African Strata.

Charles F. Juritz, M.A., D.Sc.—Topographical and Geological Terms in South Africa.

Report of the Committee on Topographical and Geological Terms in South Africa.

Tempest Anderson, M.D.—The Volcano of Metavanu.

Professor J. W. Gregory, D.Sc., F.R.S.—Exhibition of the Material described as Geyserite from the Mount Morgan Mine, Queensland.

A. Smith Woodward, LL.D., F.R.S.—Discovery of Dinosaurs in the Cretaceous of Australia.

A. Smith Woodward, LL.D., F.R.S.—Discovery of a Dinosaurian Tooth in the Trias of Brazil.

Professor S. H. Reynolds, M.A.—Certain Aspects of British Scenery as illustrating the work of the Geological Photographs Committee.

Henry C. Beasley.—Report on Footprints found in the Trias of Great Britain.

Professor S. H. Reynolds, M.A.—Report of the Committee on the Geology of Glensaul, co. Galway.

E. S. Cobbold.—On some Further Excavations among the Cambrian Rocks of Comley, Shropshire, 1908.

Report of the Committee on the Drift Deposits of Kirmington, Lincolnshire, and the East Riding of Yorkshire.

Report on the Crystalline Rocks of Anglesey.

Report on the Chemical Composition of Charnwood Rocks.

Report on the Salt Lakes of Biskra, Algeria.

List of Titles of papers read in other Sections bearing upon Geology:—

Section A.—Mathematical and Physical Science.

F. Napier Denison.—Effects of Atmospheric Pressure on the Earth's Surface.

Professor A. E. H. Love, F.R.S.—Discussion of "Earth Tides".

Section D.—Zoology.

E. S. Goodrich, F.R.S. (Oxford).—The Origin of Vertebrates.

Professor A. B. Macallum, F.R.S. (Toronto).—Palæobiology and the Age of the Earth.

J. Stanley Gardiner, F.R.S. (Cambridge).—Coral Reefs.

Section E.—Geography.

A. O. Wheeler.—Some Characteristics of the Canadian Rockies.

J. Stanley Gardiner, F.R.S.—The Seychelles.

Professor Hobbs (Michigan).—Cycle of Alpine Glaciation.

Miss L. A. Owen.—Floods in the Great Interior Valley of America.

Professor A. P. Coleman.—The Yellowhead Pass and Mount Robson.

Professor Dodge.—The Formation of Arroyos in Adobe-filled Valleys in the South-Western United States.

Professor D. W. Johnson.—The Development of Nantasket Beach near Boston.

M. Allorge.—The Eastern (Tunisian) Atlas Mountains; their Main Structural and Morphological Features.

Section G.—Engineering.

J. B. Porter.—An Outline of an Investigation now being conducted for the Dominion Government on the Coals of Canada.

Section H.—Anthropology.

Report of the Committee to investigate the Lake Villages at Glastonbury.

Report of the Committee to conduct explorations with the object of ascertaining the age of Stone Circles.

Report of the Committee to investigate Neolithic Sites in Northern Greece.

Report of the Committee to conduct Archæological Investigations in British East Africa.

Professor E. Guthrie Perry.—On a Recent Find of Copper Implements in Manitoba.

C. Hill-Tout.—Report on the Ethnology of the Okanagan.

Dr. G. B. Gordon.—Ethnological Researches in Alaska.

Professor H. Montgomery.—Archæology of Ontario and Manitoba.

Section K.—Botany.

J. Parkin.—The Evolution of Inflorescence.

Dr. Kidston, F.R.S., & Professor D. T. Gwynne-Vaughan.—The Ancestry of the Osmundaceæ.

II.—The Glacial Lake Agassiz.[1] By Warren Upham, A.M., D.Sc., St. Paul, Minn.

During the final melting of the North American ice-sheet a glacial lake, held by its barrier in the basin of the Red River and Lake Winnipeg, extended from Lake Traverse, on the west side of Minnesota, northward to the Saskatchewan and Nelson Rivers, and eastward on the international boundary to and somewhat beyond Rainy Lake. It attained thus an area of about 110,000 square miles, exceeding the combined areas of the five great lakes tributary to the St. Lawrence River. This glacial lake, named in 1879 Lake Agassiz, had a southwardly flowing outlet, called the Glacial River Warren, which took the course of the present Minnesota River, joining the Mississippi at Fort Snelling.

Beach ridges of sand and gravel, a few feet high, traced by levelling along about 800 miles of the highest shore of Lake Agassiz, mark its stage of greatest extent, and other similar beaches, at many successive lower levels, record later stages of the lake, reduced in height by erosion of a deep channel along the course of the outflowing river. After the recession of the ice-sheet permitted drainage from the glacial lake north-eastward into Hudson Bay, still lower beaches were formed, until the complete uncovering of the area crossed by the Nelson River reduced Lake Agassiz finally to its present representative, Lake Winnipeg.

In its earliest and highest stage, Lake Agassiz was nearly 200 feet deep above Moorhead and Fargo; a little more than 300 feet deep above Grand Forks and Crookston; about 450 feet above Pembia, St. Vincent, and Emerson; more than 500 feet above the site of the city of Winnipeg; and about 500 and 600 feet respectively above Lakes Manitoba and Winnipeg. The length of Lake Agassiz is estimated to have been nearly 700 miles, and its greatest width more than 200 miles.

Reports on the explorations of this ancient lake have been published by the Geological Surveys of Minnesota, the United States, and Canada. In the present paper the latest explanations are reviewed to account for the northward ascent of its beaches.

[1] Paper read before British Association, Section C (Geology), Winnipeg, 1909.

The highest and earliest beach or shore-line has an ascent of about a foot per mile toward the north-north-east; the lower and later shores ascend less; and the lowest shore, marked by beaches only 60 to 70 feet above Lake Winnipeg, are almost perfectly horizontal. It is thus known that the land was being uplifted differentially while Lake Agassiz existed, and that the uplift was nearly completed before the ice-sheet was wholly melted away.

The chief cause of the uplift is thought to be the unburdening of the land by the removal of the vast weight of the ice-sheet, this part of the earth-crust being restored to equilibrium or isostasy by an inflow of the plastic magma at a great depth within the earth, which took place during the time of departure of the ice.

Measures of the shore erosion and beach accumulation indicate that the duration of Lake Agassiz was only about 1000 years; and from the rate of recession of the Falls of St. Anthony, forming the gorge of the Mississippi River between Fort Snelling and Minneapolis, the length of the Post-Glacial period is estimated to be between 6000 and 10,000 years.

REVIEWS.

I.—An Egyptian Oasis: an account of the Oasis of Kharga in the Libyan Desert, with special reference to its History, Physical Geography, and Water-Supply. By H. J. Llewellyn Beadnell, F.G.S., etc. 8vo; pp. xiv, 248, with 28 pictorial plates and 4 maps and sections. London: John Murray, 1909. Price 10*s.* 6*d.* net.

A VERY interesting account of the "Flowing Wells and Sub-Surface Water in Kharga Oasis", accompanied by map, section, and view of one of the wells, was contributed by Mr. Beadnell to the Geological Magazine for February and March of last year. The author has now published in full his researches on the history and physical features of this extensive and remarkable oasis.

The oases of the Libyan Desert appear to have been inhabited from early prehistoric times, as flint implements of Palæolithic type occur on the margins of the plateaus that border the oases, and also within the depressions. Although at Kharga no natural outflow of water now occurs on the floor of the oasis, the author considers it probable that in those early times there may have been some natural springs, which escaped through fissures and attracted attention. Many ancient wells 120 metres in depth continue to flow now, though for the most part the yield has diminished. It is not known when the flowing wells were first made, but it has been ascertained that during their occupation of the country the Romans largely developed the water-supply, cutting underground tunnels of great length in solid rock with numerous air-shafts in the 'surface-water sandstone'.

As the author dealt with the geological structure of the region in the article before mentioned, we need not further refer to this part of the subject. With regard to the origin of the oasis, he finds no evidence of fluviatile erosion, nor of local subsidence. Tectonic movements have affected the shape of the ground by bringing rock-masses of varying hardness and composition under the influence of subaerial agents of destruction; and thus deep and broad hollows in the softer strata have been excavated nearly to sea-level out of a plateau that rises in places to an elevation of 400 metres or more. Changes in temperature have facilitated the crumbling of the rocks, but the main agent in erosion is that of the sand-blast.

The Kharga Oasis is described as one of the most windy places in the country, and the sand which is drifted appears to be derived mainly from strata newer than the Middle Eocene, which "are exposed on the surface of the country between the Mediterranean Sea and latitude 29° N." The sands are not wholly siliceous, but contain also grains of white limestone.

The extreme length of the Kharga Oasis is stated to be about 185 kilometres, or 115 miles, and the breadth to vary from 20 to 80 kilometres.

Of particular interest is the evidence, obtained by the author, that the depression had at an early period been the site of an immense lake. He points out that thick deposits of calcareous tufa are found on the escarpments bordering the oasis and on the face of the cliffs. "The tufas frequently contain large numbers of freshwater shells and an abundance of fossil vegetation, and, from the presence of casts of the leaves of such trees as the oak, one is led to refer the deposit to the more humid period which preceded the incoming of the modern desert conditions." These tufas may have been formed on the margin of the lake.

The floor of the depression is occupied by large isolated patches of "horizontal finely-bedded alternations of sand and clay, or more frequently of an intimate mixture of the two", lacustrine strata, probably of Pleistocene age, which have been subjected to considerable erosion. The discovery of fragments of pottery proves "that the lake was contemporaneous with man". It appears to have extended over a distance of 136 kilometres, or 85 miles, and to have attained a height of from 70 to 85 metres above sea-level. It probably "existed well into the historic period", to about 500 B.C., but "when the country became a Roman province, the lake had very much contracted, and probably only existed as a marshy swamp occupying the lower portions of the depression".

In the author's opinion there is good reason to believe that the oasis was inhabited prior to the formation of the lake; and he remarks, "we must not forget the possibility that it was formed by artificial means during one or other of the Egyptian dynasties between 3000 and 1000 B.C." Wells may then have been dug, and the escape of water from a previously untapped artesian basin may have been on a much larger scale than it is now; or it is possible that "If one or other of the porous beds, charged with water under pressure, should, through the action of denudation on the overlying beds, become exposed at the surface, the waters would escape through natural springs in very large quantities". Thus the higher water-bearing strata, known as the 'surface-water sandstone', may have been covered by impervious clays, so as to contain water under pressure, as is the case with the lower 'artesian-water sandstone' at the present day.

In the articles to which reference has been made, the author dealt with the probable sources of the artesian waters, their saline ingredients, the amount of discharge, etc. In the present work he has amplified the information on the wells and borings, and has given the results of experiments to show the mutual interference of one well or boring on another. The data show that the shutting down of a flowing well or the opening of a closed one may produce a marked effect within an hour, when the distance is more than 500 metres.

The author discusses the drifting of the sands, and the various economic aspects of the Kharga Oasis, adding a few notes on sport and natural history. To geologists, and especially to those interested in the problems of water-supply, the work contains a great deal of important practical as well as scientific information; while to the general reader the story of the wonderful work achieved in ancient times by means of artesian wells and irrigation in the desert regions of Upper Egypt will be found both fascinating and impressive.

II.—Geological Survey of New Zealand.

"THE Geology of the Mikonui Subdivision in North Westland," by Mr. P. G. Morgan, forms the subject of Bulletin No. 6 (New Series), 1908. The country here described borders the Wanganui River and the Tasman Sea to near Hokitika, on the coast of the Southern Island, north-west of Christchurch. The oldest rocks, comprising schists and grauwackes, form an intensely folded and altered complex of sedimentary and igneous rocks, including serpentine. They are grouped as the Arahura Series, and regarded as probably Palæozoic. A newer set of rocks, somewhat less altered and perhaps of Carboniferous age, is known as the Greenland Series, and into this bosses of granite have been intruded. A great gap succeeds, for the next group is Eocene-Oligocene, and includes the local coal-bearing strata, followed by some Miocene deposits. Then come the Glacial drifts of Pliocene and Pleistocene age, and the Recent fluviatile and marine deposits. The various sedimentary formations and the igneous rocks are described in detail.

The physiography of the area, the mountains and snowfields, the rivers, lakes, gorges, hanging-valleys, plains, and other features are also described and illustrated.

The mineral resources appear to be limited; alluvial gold has been obtained in the Totara and Ross districts, and from black sands on the sea-beach, and some auriferous quartz-mining has been carried on. For the most part, however, the metalliferous deposits have not proved to be extensive, the gold placers have largely been worked out, and the coal-mining has not been satisfactory. It is remarked, however, that in respect to water-power Westland is richly gifted.

The work is illustrated by many excellent pictorial views, as well as by neat colour-printed topographical and geological maps and sections.

III.—Brief Notices.

Changes of Level in the Nile Valley.—In an article on "Elevation and Depression in the Nile Valley" (*Cairo Scientific Journal*, April, 1909), Dr. W. F. Hume summarizes the conclusions at which he has arrived as follows:—

1. Elevation due to folding that resulted in fracture (not necessarily accompanied by faulting), and gave rise to the Nile Valley cleft.

2. Depression to at least 250 feet in late Pliocene times, admitting the sea up the Nile Valley at least as far as Sidmant, determining a chain of lakes in the valley, and the accumulation in them of thick deposits of rain-eroded materials.

3. Elevation to at least 600 feet, involving the drainage of the lakes, the cutting back of the cataracts, and the deepening of the river valley.

Cotteswold Naturalists' Field Club.—The Proceedings, vol. xvi, pt. iii, June, 1909, contains a short article "On the occurrence of *Chara*-nucules in the Forest Marble of Tarlton, near Kemble, Gloucestershire", by Mr. Charles Upton, who names the new species *Chara lævigata.* Mr. T. S. Ellis deals with the origin of "The Lower Severn Valley, River, and Estuary from the Warwickshire Avon to the Bristol Avon", and combats the notion that the Lower Severn was cut backwards so as to behead a stream which was formerly connected with the river-system of the Thames. Mr. L. Richardson contributes a "Note on *Pollicipes aalensis*, Richardson" (described in the Geological Magazine for August, 1908), and also a short article on "The Dorset and Hampshire Coasts, with particular reference to the Forest Marble Beds near Langton Herring".

CORRESPONDENCE.

THE OLD AND NEW THEORIES OF IGNEOUS ROCKS.

Sir,—Your review of Mr. Harker's *Natural History of Igneous Rocks* inferentially gives judgment against my two 1903 papers in the Geological Magazine on all points. So I crave a word of explanation.

After General McMahon's reply, in November, 1903, to my "Crystallization of Granite" appeared, I learned to my regret how ill he was, and that the controversy had troubled him. I at once wrote to express my regret, and received a most friendly answer. There, so far as the Magazine is concerned, the matter dropped, leaving me apparently crushed.

I subsequently submitted my paper to two physicists and to Dr. Sorby, with a view to clearing up outstanding doubts, if possible. Dr. Sorby gave me a general permission to use his letters, and I got all the leave I asked for from the physicists. I subsequently reviewed the whole controversy in the Transactions of the Devonshire Association. The dispute thus remains at a loose end, with no attempt by the petrologists to settle it.

To give you an idea how loose the ends are, I may say that in October, 1903, a physicist wrote as follows:—"My best thanks for the copy of your paper and letter accompanying it. I should not wonder if the petrologists are all adrift."

I see that your reviewer considers that the old doctrine of the permeability of rocks by overhead waters has been finally disposed of. Now geologists always rely on the explosive or expansive action of steam to repel any invasion of water; but they seem to overlook the fact that when once the critical *pressure* of water is attained, there will either be no steam, or the steam will be compressed to the same volume as the liquid water at the critical temperature. If the critical pressure be exceeded, the steam will be still more compressed.

As the critical pressure of water is only 200 atmospheres, the moderate ocean depth of 1100 fathoms will suffice to overcome any expansive force that water or steam may exert; and at the greater oceanic depths, fire and water would be impotent to resist the pressure-control.

One thing I notice is that though petrologists reject the penetration of rocks by water under tremendous pressure, they gaily assume the free penetration of 'country rocks' by gases and liquids! They obviously will not allow the sauce for the goose being used for the more powerful gander. A. R. Hunt.

Southwood, Torquay.
September 9, 1909.

OBITUARY.

WILLIAM FORD STANLEY, F.G.S.

Born 1828. Died August 14, 1909.

Mr. Stanley, who died at his residence, South Norwood, at the age of 81 years, was the head of the firm of W. S. Stanley, manufacturers of surveying and drawing instruments. Well versed in all branches of physical science, he also took considerable interest in geology, and became a Fellow of the Geological Society in 1884. In that year he communicated a note—"A Correction in the assumed Amount of Energy developed by the Secular Cooling of the Earth as stated in two Papers by the late Robert Mallet." In 1887 he brought before the same Society some observations on the "Probable Amount of former Glaciation of Norway". Before the British Association at the Montreal Meeting in 1884, he criticized Dr. Croll's views in a paper "Upon the Improbability of the Theory that Former Glacial Periods in the Northern Hemisphere were due to Eccentricity of the Earth's Orbit, and to its Winter Perihelion in the North" (see Geol. Mag., 1884, p. 518). He was also author of a work on *The Nebular Theory in relation to Stellar, Solar, Planetary, Cometary, and Geological Phenomena* (1895).

MISCELLANEOUS.

Victoria University, Manchester.

Professor W. Boyd Dawkins, F.R.S., has resigned the Chair of Geology and Palæontology in the Victoria University of Manchester, and he is succeeded by Sir Thomas H. Holland, K.C.I.E., F.R.S., who has for some years been Director of the Geological Survey of India. Professor Dawkins, after serving from 1861 to 1869 on the Geological Survey in England, was in 1870 appointed Curator of the Manchester Museum and lecturer in geology at Owens College; and since the foundation of the University he has been Professor of Geology and Palæontology.

No. 545. Decade V.—Vol. VI.—No. XI. Price 1s. 6d. net.

THE

GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

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NOVEMBER, 1909.

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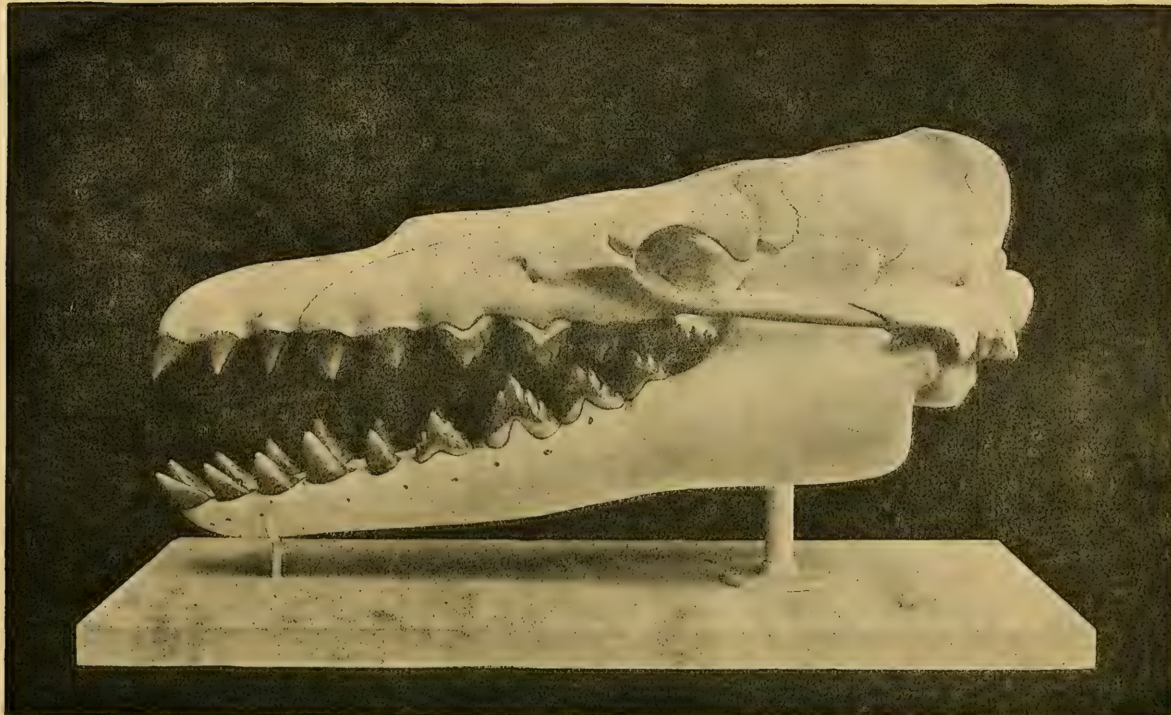
LONDON: DULAU & CO., LTD., 37, SOHO SQUARE, W.



Restored model of the Skull and Mandible of *Prozeuglodon atrox*, Andrews. About $\frac{1}{6}$ nat. size. Middle Eocene : Fayûm, Egypt. As supplied by

THE

GEOLOGICAL MAGAZINE.

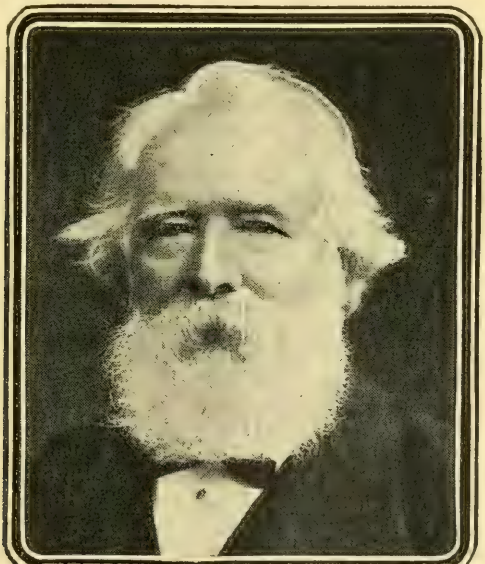
NEW SERIES. DECADE V. VOL. VI.

No. XI.—NOVEMBER, 1909.

ORIGINAL ARTICLES.

I.—Rev. Osmond Fisher, M.A., F.G.S.[1] (November 17, 1817). Professor T. Rupert Jones, F.R.S., F.G.S.[2] (October 1, 1819).

WE offer warmest congratulations to two dear and valued friends connected with the Geological Magazine since its commencement, both having been constant contributors, and Professor Rupert Jones in addition one of the Editors during the first year of the journal's existence.



Professor T. Rupert Jones, F.R.S., F.G.S.
From a photograph by Maull & Fox (ex "Graphic", October 5, 1907).

If living illustrations were needed of the value of geology as a health-giving pursuit, the two eminent men here cited—one 92, the other

[1] For life and portrait of Rev. O. Fisher, see Geol. Mag., 1900, pp. 49–54.
[2] For life and portrait of Professor T. Rupert Jones, see Geol. Mag., 1893, pp. 1–3.

90 years of age—both in the enjoyment of good health, and still interested in their favourite studies, would afford the strongest recommendation to all, not already enrolled, to join at once the noble brotherhood of the hammer.

It is hoped that this note may convey to these fathers of science in their peaceful retirement not only our own earnest good wishes, but those of many other of their geological friends and admirers.

II.—Notes on Fossil Plants from the Witteberg Series of Cape Colony.

By A. C. Seward, F.R.S., Cambridge.

(PLATE XXVIII.)

THE specimens described below were sent to me for examination by Professor Schwarz from the Albany Museum, Grahamstown; they were collected from a thin seam of shale in the Grahamstown district in the Witteberg Series. This series, so named from the Wittebergen in the south of the Karroo, consists of a group of shales, sandstones, and quartzites, which are placed at the summit of the Cape Series below the plant-bearing and glacial beds of the Lower Karroo system. The Witteberg Series have afforded a very few fossils; these include imperfectly preserved fragments of Lepidodendroid plants and an abundance of the fossil known as *Spirophyton*, referred by some authors to the vegetable kingdom and by others regarded as probably inorganic.[1]

In a paper published in the Records of the Albany Museum, Professor Schwarz[2] has described the following new species based on material which does not admit of satisfactory diagnosis: *Lepidodendron albanense*, *L. kowiense*, *Bothrodendron irregulare*, *B. cæspitosum*, *Didymophyllum* (*Stigmaria*) *expansum*. So far as it is possible to base an opinion on his published drawings, I am disposed to regard the specimens as possibly referable to a single type. The fossils sent to me are larger and apparently in a better state of preservation than those described by Schwarz.

Bothrodendron irregulare, Schwarz. Pl. XXVIII, Figs. 1–4.

Under this name Mr. Schwarz has described "a common species occurring in the quartzites and intercalated shales of the Witteberg Series at Port Alfred, near Grahamstown".[3] As the small specimen which he figures as the type of *Bothrodendron irregulare* is no doubt identical with some at least of those described below, I have adopted his designation. The fossils which I refer to *Bothrodendron irregulare* include two fairly distinct forms: (1) impressions and casts of small branches characterized by crowded scars or tubercles and showing in a few cases portions of acicular leaves; (2) larger branches characterized

[1] Seward, Annals S. African Museum, 1903, vol. iv, p. 103.
[2] Records of the Albany Museum, 1906, vol. i, p. 347.
[3] Schwarz, loc. cit., p. 356, pl. vi, fig. 4.

by oval or circular depressions, or, in the casts, by rather broad truncated ridges. These two forms, shown in Figs. 1–4, I regard as specifically identical, a conclusion which receives support from an examination of the much richer material described by Nathorst from the Devonian of Bear Island.[1]

Fig. 4. This is a good example of the smaller form of branch in which the axis, 1·2 cm. wide, is dichotomously branched, and the surface bears numerous small oval or circular scars. This specimen is probably identical with one previously figured[2] from the Port Alfred range, and now in the British Museum collection, and with some of the specimens figured by Schwarz. A similar form has been figured by Nathorst as *Bothrodendron Carneggianum* (Heer)[3] from Bear Island, and some of the examples of *B. brevifolium* and *B. kiltorkense*,[4] described by the same author, bear a striking resemblance to the African fossils.

The material hardly justifies a decided opinion as to the specific identity of the northern and southern plants, but it is at least clear that they represent closely allied types.

The specimen represented in Fig. 3 shows more clearly the small scars which are disposed spirally and in horizontal rows. The horizontal arrangement is a conspicuous feature of several of the Bear Island examples of *Bothrodendron*. Several acicular leaves are seen on the left-hand side of this specimen The larger form is illustrated by the specimens shown in Figs. 1 and 2.

In the example shown in Fig. 2 the upper surface bears slightly raised ridges terminating in scars. On the lower surface, that is the impression of the cast, the scars are clearly seen as depressions. The smaller specimen shown in Fig. 1 suggests at first sight a comparison with *Sigillaria* owing to the prominence of the rounded ribs. There is a close resemblance between this specimen and some of those figured by Nathorst as *Bothrodendron kiltorkense* in the *Knorria* condition from Bear Island. Some of the casts are those of branches in a partially decorticated condition; the scars are not the actual leaf-scars as they appeared on the surface of the living plant, but casts of gaps in the more external cortex. These gaps were formed by the decay of a sheath of delicate tissue which surrounded each leaf-trace as it passed through the cortex of the branch on its way to a leaf. The uneven surface of the scars as seen in Fig. 1 is the result of fracture of the slender argillaceous casts of the leaf-trace gaps.

None of the specimens examined retain the original surface characters; all are more or less decorticated. It is therefore impossible to say whether the surface of the branches exhibited the fine sculpturing characteristic of *Bothrodendron* or the delicate reticulum which distinguishes Weiss's genus *Pinakodendron*.[5] None of the

[1] Nathorst, *Kongl. Svenska Vetenskaps-Akad. Hand.*, 1894, Bd. xxvi, No. 4; ibid., 1902, Bd. xxxvi, No. 3.

[2] Seward, loc. cit., p. 89, fig. 8.

[3] *Kongl. Vetenskaps-Akad. Hand.*, Bd. xxvi, pl. xiv, fig. 10.

[4] Ibid., Bd. xxxvi, pls. xi, xii.

[5] Kidston, Trans. R. Soc. Edinburgh, 1903, vol. xl, pt. iv, p. 797, pl. i, figs. 9–11.

actual leaf-scars are preserved with the surface-features intact, and it is therefore not possible to describe the position of the leaf-trace scars or the parichnos. Some of the smaller branches have probably lost less of the cortical tissues than the larger impressions, which represent the *Knorria* form of the species. In spite of the imperfection of the material there cannot be any serious doubt as to the generic nature of the specimens.

It is impossible to say whether *Bothrodendron irregulare* is identical with *B. kiltorkense* or with other previously described species, but the additional specimens from the Albany Museum are interesting from the point of view of the wide geographical distribution of this generic type in Lower Carboniferous or Devonian strata. An Australian specimen described by Feistmantel as *Cyclostigma* sp.[1] may be compared with *B. irregulare*, and the species *C. hercynianum*, figured by Weiss and by Potonié from Devonian rocks of the Hartz,[2] is another example of a closely allied or even identical type of stem. The species *B. Leslii*[3] from the Lower Karroo sandstones of Vereeniging may also be compared with the Witteberg species.

Hastimima sp. Pl. XXVIII, Figs. 5, 6.

In an account of the fossil flora of the Coal-measures of Brazil, recently published by Dr. David White,[4] some problematical fossils are described from a plant-bed north-east of Minas, Santa Catharina, under a new generic name *Hastimima*. Some at least of the specimens referred to *Hastimima Whitei* exhibit a close resemblance to the fossil from Cape Colony shown in Figs. 5 and 6, which I propose to designate *Hastimima* sp., without being able to adduce any conclusive evidence as to the nature of the genus.

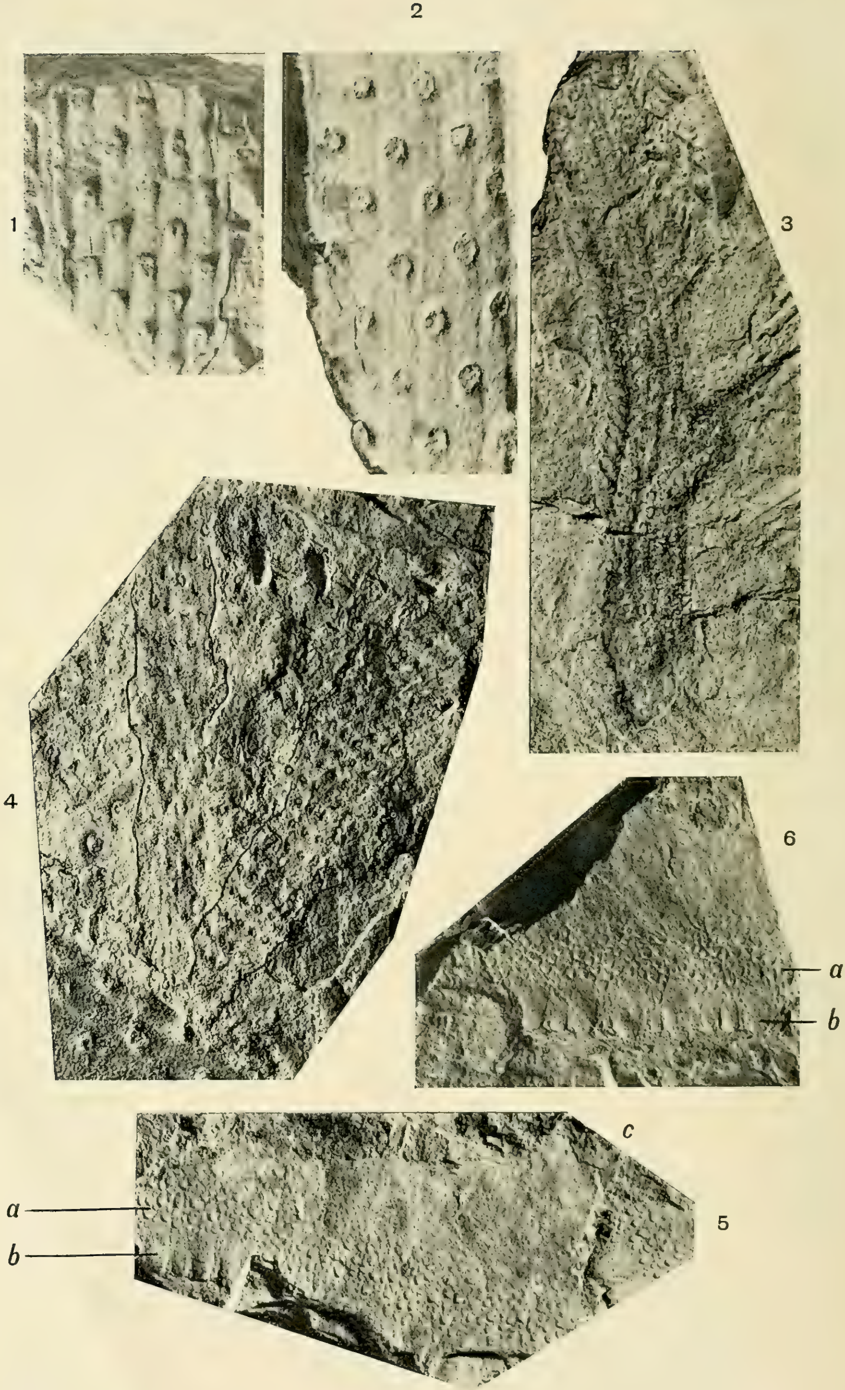
The specimen represented in Figs. 5, 6 consists of a flat surface with an ill-defined boundary on the left-hand side, and prolonged at the top in Fig. 5, *c, a*, for a short distance as a narrow branch. Towards the upper margin the surface of the impression presents on slight magnification a fine scaly appearance, and this becomes gradually more obvious towards the lower edge; the scaly appearance is caused by numerous slightly projecting elevations terminated distally by a free rounded edge. These scale-like projections are not distributed with any regularity, and in none of them can I detect any indication of a pit such as would be formed by a vascular bundle. At the lower edge, where the impression is more complete, the scales are succeeded rather suddenly by a row of larger rounded ridges (Fig. 5, *b*), beyond and slightly below which is a narrow strip of shale showing discontinuous vertical ridges and small tubercles. The larger ridges are shown also in Fig. 6, *b*, which represents the reverse of the specimen shown on Fig. 5. In this view the scale-like

[1] Feistmantel, Mem. Geol. Survey, New South Wales, Palæontology, No. 3, 1890, pl. ii, fig. 7.

[2] Weiss, *Jahrb. k. preuss. geolog. Landesanstalt*, 1885, p. 175, pl. vii; Potonié, *Abh. k. preuss. geol. Land.* (Neue Folge), 1901, Heft xxxvi, p. 32.

[3] Seward, Ann. S. African Museum, 1903, vol. iv, p. 87, pl. xi.

[4] Commissão dos Estudos das Minas de Carvão de Pedra do Brasil. Final report by I. C. White, Rio de Janeiro, 1908, p. 589, pls. x, xi.



D. Elliott phot.

Figs. 1–4. *Bothrodendron.* Figs. 5, 6. *Hastimima.*

appearance is more clearly seen, but in the form of depressions. The depressions vary in size and exhibit no regularity of arrangement.

Dr. White expresses the opinion that he is strongly inclined to regard the fossils as not vegetable, but, he adds, if *Hastimima* is a plant, "it would seem that the tubercles [scales] should be interpreted as sporangia or sporangiferous, as cushions giving rise to some appendages, or as glands." With this suggested interpretation I am unable to agree. The idea occurred to Dr. White as to myself, before I read his description, that the tuberculate impression might belong to some animal, but "a number of eminent American specialists in vertebrate palæontology", to whom Dr. White showed the material, were unwilling to accept the fossils as coming within their province. The author of the genus expresses the opinion that it will probably be found later in other Lower Gondwana areas, a prophecy which appears to be now partly fulfilled. The Indian fossils described originally by Feistmantel,[1] and more recently by Zeiller,[2] as *Dictyopteris* are compared by White with his specimens, but I agree with him that the two are not generically identical.

At first sight the row of rounded ridges shown in Figs. 5, 6, *b*, reminded me of the strips of secondary wood separated by medullary rays which are seen in some longitudinally split examples of *Stigmaria* such as that figured by Williamson[3] in his monograph of the genus, but it would seem impossible to explain on this comparison the irregularly arranged smaller scales. *The view which seems to me most hopeful is that this fossil represents part of a body-segment of a Eurypterid.* A comparison of Figs. 5, 6 with several of the drawings given in Dr. Woodward's monograph of the British Fossil Crustaceans belonging to the order Merostomata[4] leads me to think that it is far from improbable that the impression has been produced by some Eurypterid. This comparison has, however, but little claim to be considered more than a guess, and we must wait for further discoveries to decide the nature of the Mexican and African specimens.

EXPLANATION OF PLATE XXVIII.

Figs. 1–4. *Bothrodendron irregulare*, Schwarz. (Nat. size.)
,, 5, 6. *Hastimima* sp. (Nat. size.)

P.S.—Since the above notes were written I have had the benefit of Dr. Woodward's opinion on the specimen represented in Figs. 5 and 6. This he has now stated in a "Note on the genus *Hastimima*"; his conclusions convert my 'guess' as to the Eurypterid nature of the fossil into an identification which is unlikely to be seriously questioned. Dr. Woodward, by his ready response to my request to examine the specimens, has contributed a valuable piece of evidence in regard to the geological age of the Witteberg Series of Cape Colony.

[1] Feistmantel, Mem. Geol. Surv. India, 1881, vol. iii, pl. xxiiiA, figs. 4–6, 14.
[2] Zeiller, ibid., 1902, vol. ii (New Series), p. 24, pl. iv, fig. 8.
[3] Palæontographical Society, 1887, pl. xiv, fig. 68.
[4] Ibid., 1866–78.

III.—Note on the genus *Hastimima* from Brazil and the Cape.

By Henry Woodward, LL.D., F.R.S.

Professor Seward has called my attention to Figs. 5 and 6 on Plate XXVIII, which accompanies his notes on Fossil Plants from Cape Colony. These fragmentary impressions of organic remains have been compared by him with similar doubtful plant-remains figured by Dr. David White from the Coal-measures of Brazil (see *Commissao dos Estudos das Minas de Carvão de Pedra do Brasil*, Estampa x and xi. Final Report by J. C. White, Rio de Janeiro, 1908, p. 589.) Dr. White had already doubted the vegetable nature of the specimens from Brazil, which doubt is shared by Professor Seward, but the latter expresses himself more definitely against the plant-nature of Figs. 5 and 6, Pl. XXVIII, from the Witteberg Series of Cape Colony. He has, in fact, suggested that they "represent part of a body-segment of a Eurypterid." In this opinion I cordially agree. I also wish to add a word about the specimens figured under the name of *Hastimima* by Dr. David White from the Coal-measures of Brazil.

In this Memoir, on pl. x, five figures are referred to as *Hastimima Whitei*, namely, figs. 1 and 2, which appear to represent, *probably*, the impression and counterpart of an imperfect thoracic segment of an Arthropod, the lateral and posterior margins of which are readily to be seen, and the latero-posterior angle which they form is slightly produced and falcate as shown in the body-segments of *Pterygotus anglicus*, drawn on pls. i and ii, fig. 1, of my monograph on the Merostomata (Pal. Soc. Mon., 1865). The usual scale-like markings, however, are only seen near the margins of fig. 1, and are represented enlarged four times in fig. 1*a* of Dr. White's plate. The rest of the segment is ornamented by a series of small, short, bluntly-rounded spines, sparsely distributed over the surface and pointing towards the posterior border. They are shown in relief in fig. 1 and as depressions on the surface in fig. 2 of pl. x. Figs. 3 and 4 on the same plate also represent the impression and counterpart of another portion, most probably of the same animal, as the scabrous surface-ornamentation is of the same kind, being in relievo on one half (fig. 3) and in intaglio on the other (fig. 4). This specimen, which is rather acutely hastate in form, may represent the 'telson' or tail-spine of a *Pterygotus*, the margins, as far as preserved, are bilaterally symmetrical, and there is a median ridge on fig. 3 and a corresponding depression on fig. 4. It is too regular and pointed to have been the spatulate extremity of one of the swimming-paddles, and cannot be a leaf, although no doubt at first supposed to be one. The scabrous ornamentation on these specimens agrees very closely with that of *Eurypterus punctatus*, Salter, sp., from the Lower Ludlow Beds, Church Hill, Leintwardine.[1] A similar ornamentation is observed on the segments of a large form referred to *Echinocaris Wrightiana*, Dawson, sp. (Jones & Woodward, Geol. Mag., 1884, p. 393, Pl. XIII, Figs. 1*a*, 1*b*. Woodcuts of

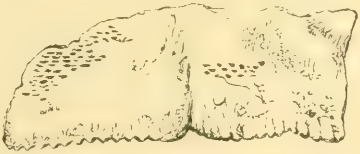
[1] For drawings of *E. punctatus*, Salter, sp., see H. Woodward's Monograph on the Merostomata, 1872, pt. iv, p. 153, fig. 51; p. 157, etc.

ornamentation, drawn by Professor Jas. Hall, are given (see A and B, op. cit., p. 395), from the Portage Group (Upper Erian), New York).

Turning now to pl. xi, also from the Coal-measures of Brazil, Dr. White gives on this plate ten figures, referred to *Hastimima Whitei*: these are mostly small fragments, and having been considered when drawn to be plants, they were nearly all figured with the posterior border upwards; the plate has, consequently, to be turned upside down in order to see the objects properly in their natural position. It is pretty certain that figs. 1–5, 7–9 on this plate (pl. xi) are referable to the same Arthropod as are figs. 1–4, pl. x, already noticed. Figs. 1 and 2 may be parts of appendages, but are very obscure: 2*a* shows distinct scale-markings, and traces of an obscure appendage, possibly part of a swimming-foot, like fig. 1. Fig. 3 shows impressions of obtuse spines on one part and scale-markings clearly visible on the other part.

The surface of fig. 4 is entirely covered with very minute elongate tubercles, like those seen on *Eurypterus punctatus*, Salter, sp.; fig. 5 is no doubt of the same nature as fig. 3, having impressions of obtuse spines on its surface; figs. 6–8 are small portions of the posterior borders of body-segments of *Eurypterus*, showing rounded (in fig. 6) or pointed (in figs. 7 and 8) marginal serrations, and the surface covered by scale-markings. The margin of fig. 9 resembles those in the specimen from the Witteberg Series of Cape Colony, figured on Professor Seward's plate (Pl. XXVIII, Figs. 5 and 6), in not being so deeply and strongly scalloped along the posterior border, but the surface is also scale-marked and has two spots indicative of two short bluntly-rounded spines. Fig. 10 is too obscure to define with accuracy, but may probably be of the same Eurypterid nature as the others.

1



2

Fig. 1. Part of one of the body-segments of *Eurypterus hibernicus*, Baily.
,, 2. Part of the margin of same (enlarged) from the Devonian of Kiltorcan, Ireland.[1]

The Cape specimens—kindly sent to me to examine by Professor Seward—present, like the Brazil coal-shale specimens, clear evidence of being portions of segments of Eurypterids (see Pl. XXVIII, Figs. 5 and 6). The surface anteriorly is nearly smooth, that

[1] Reproduced from woodcut (Fig. 45) of *Eurypterus hibernicus*, Baily, from the Devonian rocks of Kiltorcan, Pal. Soc. Mon. Brit. Foss. Crustacea, Order *Merostomata*, by H. Woodward, 1872, pt. iv, p. 150.

portion having been overlapped by another and more anterior body-segment; this is succeeded by a band covered by scale-markings (*a*), about six rows deep, and next these follows the posterior crenulated border (*b*). (The specimens are numbered 2910 and 2911.) The first of these shows a piece of a body-segment, 75 mm. long by 40 mm. deep; only 20 mm. of the margin is preserved. There is a trace of another segment which underlies the above, also showing scale-markings and a small part of the scalloped margin. No. 2911 measures 60 mm. in length, by 40 in depth; 50 mm. of the posterior crenulated margin is preserved.

Like the remains of the Merostomata from British and Irish localities, those from Brazil and the Cape are also associated with plant-remains, and may have been of lacustrine origin. It is highly probable that, although based only upon fragmentary remains, *Hastimima* includes specimens of more than one species, if not of more than one genus. It is not my intention, however, to suggest fresh names for these fragmentary Arthropods; but their presence in such widely separated localities is a matter of extreme interest, and may prove useful as a means of marking synchronous or homotaxial horizons over very large areas. Similar fragments (see woodcut, Fig. 1) were observed by the late Mr. W. H. Baily in the Devonian rocks of Kiltorcan, as well as those already referred to in the Upper Ludlow of Shropshire.

IV.—Note on the Langkofl Thrust-mass.

By Mrs. Maria M. Ogilvie Gordon, D.Sc., Ph.D., F.L.S.

IT will be remembered that two years ago, in 1907, I pointed out the occurrence of important planes of overthrust at the base of the Dolomite Mountain-massive of Langkofl and Plattkofl in South Tyrol, which explained its apparent ‘reef-like’ form, and its curious position above Wengen lavas in some places and Muschelkalk at others. I showed that at Langkofl the Upper Werfen Strata and Muschelkalk form a shear-slice above which the Schlern Dolomite rocks of the Langkofl Mountain have been overthrust, and below which the Wengen lavas and tuffs of the Ciampinoi meadowland are present; also that the planes above and below this shear-slice are crush-planes of extremely low inclination.

Last autumn I continued my researches in this district, but unfortunately, owing to the pressure of other business, it is only now that I have had an opportunity of preparing my work for publication.

In mapping the Ciampinoi and Wolkenstein hill area that descends from Langkofl to Gröden Valley, I traced an important thrust-plane northward across the Gröden Valley to the Sorasass Alpe and Pitsch-Berg on the north side. Disturbed strata are present in the Ciampinoi and Wolkenstein hill area, belonging to the Wengen, Buchenstein, Muschelkalk, and Werfen horizons, and they continue the same E.N.E.–W.S.W. strike as the thrust-band below the Langkofl. They are overthrust above the Wengen lavas and tuffs of the valley segment. Where the fault-plane is exposed on the western slope of the Ciampinoi hill it strikes N. 10 E. and dips *ca.* 20 E., but the surface is waved and bent, and the outcrop of the plane is frequently interrupted by small cross-faults. The plane is essentially a crush-plane, at which the older group of rocks has been thrust westward.

On the north side of the Gröden Valley the thrust-plane continues through the Pitsch-Berg, where the Werfen or Lower Triassic Strata have been overthrust westward above the Middle Trias. Further north rise the Dolomite peaks of the Geissler group, whose geological relations and 'reef-like' form Mojsisovics compared closely with those of the Langkofl Massive (*Dolomit-Riffe*, 1879, pp. 210–11). The band of Muschelkalk Rock at the base of the Dolomite in both these Massives reaches the height of 2200 met. contour, whereas in the Triassic succession of the Gröden Valley below St. Christina it is exposed at the 1400–1500 met. contours. The explanation, however, is provided in this important overthrust of the rocks of the Upper Gröden area, and the subsequent flexures and faults which the thrust-mass has undergone.

Near St. Christina, I detected in three of the stream-cuttings on the south side of Gröden Valley the same thrust-plane, almost horizontal, passing through the Wengen lavas and tuffs, and duplicating that horizon and the Buchenstein Strata; and I traced it westward where it underlies the Seiser Alpe. Thus the Langkofl or Schlern Dolomite thrust-mass simply rests upon another thrust-mass on the west. At a still lower level another thrust-plane is present, passing through the Buchenstein and Mendola Dolomite horizons, and with overthrust again of Augite, Porphyrite, and Buchenstein rocks.

The Upper Gröden thrust-mass is therefore composed of subjacent thrust-slices of varying thickness and importance. The thin shear-slice of portions of Werfen, Muschelkalk, Buchenstein, Porphyrite, and Wengen tuffs emerging from below Langkofl on the north side owes its position to an east–west dislocation within the thrust-mass. The thrust-planes below and above it are apparently the same as those above and below the lower segment of Schlern Dolomite and Wengen-Cassian Strata in Sella Massive. This thin shear-slice underlies the thick development of Schlern Dolomite in both Massives, which represents the main thrust-segment. In the Sella Massive it is succeeded by another thrust-slice at the Boe summit, where Raibl and Dachstein horizons have been overthrust above Upper Trias and fragments of Jurassic and Cretaceous Strata. The conformable succession of Schlern Dolomite upon Upper Cassian horizons belonging to the thrust-mass is well preserved on the southern and eastern flanks of the Langkofl Massive.

The similarity of the geological relations in the Langkofl and Sella Massives proves the essential continuity of the important thrust-plane at the base of the Schlern Dolomite. The varying dip of the plane to north or south or in other directions, both in Sella and Langkofl, is due to superimposed plicational and dislocational effects; while the position of the overthrust Cassian Strata and Schlern Dolomite relatively to different stratigraphical horizons in the underlying shear-slice indicates the previous existence of folds in the rock-masses cut by the thrust-plane. The observations at Langkofl confirm the results I obtained for the district generally that the earliest folds had an east–west strike, while the overthrusts took place during a more advanced period of strong cross-compression.

At Langkofl the complex of thrust-slices has been segmented by several north–south 'step' faults of slight throw, the effect of which has been to lower the segments on the east side towards the north–south fault in Sella Pass with upthrow on the east. In former papers I have shown that this is also the case in Sella Massive, and has shattered the eastern aspect of that mountain as compared with the western; and that it also holds good for the Enneberg and Sett Sass area where the step faults lower the Valparola exposures of Raibl and Dachstein Strata on the east of Sett Sass. The dolomitic rock in these mountain-massives and in the Ampezzo and Gader Thal district is part of the same thrust-mass as Sella and Langkofl.

The Wengen Strata of the underlying or St. Christina and Seiser Alpe thrust-mass may be traced continuously from the north of Langkofl round the west of Plattkofl to the Duron Valley slopes on the south of the Dolomite Massive. There the thrust-mass of Langkofl and Sella Massive is downthrown, and the underlying mass upraised, on the north and south respectively of that leading east–west fault which I called the Rodella-Buchenstein fault.

The thrust-planes in the group of Lower and Middle Trias reappear in the south or Duron Valley slopes, and have the same effect as at St. Christina of duplicating or cutting out various horizons. The chief thrust-plane of the Duron Valley slopes occurs at 1700–1800 met. contour and continues as a well-marked plane of overthrust throughout the Mt. Donna and Bufaure Mountains. Above it are sheared slices of Werfen, Muschelkalk, Buchenstein Strata, and the Wengen lavas and tuffs; below it is a succession of Lower and Middle Trias which exhibits the petrographical and palæontological characteristics of the so-called northern and southern, or 'Rand' facies of the Dolomites, i.e. with well-defined Upper Werfen fossiliferous zones and the Middle Trias developed for the most part as a homogeneous calcareous or calcareo-dolomitic mass. According to my mapping of the thrust-planes in Fassa this calcareous facies exposed in the Vallaccia, Costabella, Marmolata, and other Massives represents the basal mass above which the thrust-slices with the porphyritic, tufaceous, and dolomitic facies have been driven.

Subsequent folds and faults have lowered the rocks of the overthrust slices in some places between portions of the basal mass, so that in the Fassa and Contrin region the one facies suddenly gives place to the other and the complication of detail is very great.

V.—Some Glacial Features at Aberedw in the Wye Valley, near Builth Wells.

By L. Richardson, F.R.S.E., F.G.S.

(PLATE XXIX.)

WHILE pioneering for an excursion of the Cotteswold Naturalists' Field Club at Aberedw in the Wye Valley, between Builth Wells and Hay, certain very interesting physiographic features,

Phot. P. B. Abery, Builth Wells.

View of the mouth of the Aberedw Valley and its junction with that of the Wye. From left to right the features are: the wooded hill-side (Aberedw Rocks); post-Glacial gorge of the Edw; the bailey-castle-crowned tump; the level ground formed by the morainic matter filling up the pre-Glacial channel of the Edw; and the slope of the hill-side. The Wye enters the view by the valley on the right and leaves it by that on the left, the hills in the background being on the right (west) bank of the Wye.

obviously connected with Glacial action, were observed which appear worthy of record.

Aberedw is situated near the mouth of a lateral valley of the Wye (Text-fig. 1). The Wye here pursues an approximately north and south course through a deeply excavated valley in Wenlock, Ludlow, and, further south, Old Red Sandstone rocks. Viewed from the commanding height of the Carneddau it appears very similar to the Chalford Valley, Stroud. At Aberedw it unites with the Aberedw Valley, which joins it almost at right angles. In pre-Glacial times the Wye flowed through this gorge, and then, as now, was joined at Aberedw by the Edw River; but instead of the subsequent Edw affecting its junction with the consequent Wye by way of the deep-cleft cut to the south of the bailey-castle-crowned tump south-west of the church (see Plate XXIX), it doubtless flowed Wyewards to the north. In other words, I think that this deep gorge of the Edw has been cut by the Edw River since Glacial times, that the valley to the north of the crag referred to was its pre-Glacial channel, and that this to the south is its post-Glacial one.

This change of channel was probably due to the ice that occupied the Wye Valley depositing debris from its lateral moraine across the mouth of the Aberedw Valley. To this heap was added terminal moraine matter from the Edw Glacier. While the ice was moving, the terminal moraine matter from the Edw Glacier would combine with that of the lateral moraine of the Wye, and trail southwards as the left-bank lateral moraine of that glacier. But a time would come when the southward movement of the ice would no longer continue, and Wye lateral moraine matter, *plus* the terminal moraine debris of the Edw Glacier, would accumulate in the mouth of the Aberedw Valley. As the rigorous climate of the Glacial Epoch ameliorated the ice thawed, and the moraine-blocked Aberedw Valley passed into the lake phase. The waters of the lake would become augmented by the melting ice and snow of the more elevated tracts, and the moraine dam would be overflowed. Such lakes as a rule evolve an overflow channel between the morainic material and the solid rock bank, and generally, rather naturally, on the downstream side.

Morainic material must thus be pictured stretching across the mouth of the Aberedw Valley. The water escaping over the southern end of the dam soon commenced cutting into the flaggy rocks of the Silurian, the purely erosive action of the swift-flowing water being accelerated by the filing action of the torrent-driven stones.

When the Glacial Epoch closed, a passage having been established, the River Edw did not attempt to revert to its pre-Glacial channel, but persisted in its cleft-like gorge and soon graded with the Wye.

Differential denudation has now lowered that part of the mouth of the Aberedw Valley, where the morainic matter occurs more than the crags along the right bank of the present Edw Gorge (Plate XXIX).

Standing on the summit of the old bailey-castle and looking down into the deep Edw Gorge, with its rocky banks and swift-flowing river, one cannot restrain feelings of admiration at this excellent illustration of how much work has been accomplished since the rigorous Glacial conditions drew to a close in these parts.

The photograph reproduced with this paper will convey a good idea of the flat ground occupied by the moraine-matter ; the bailey-castle-crowned tump of Silurian rocks on the north side of the Edw Gorge, and the steep, wooded Aberedw rocks on the south side.

The material of which the moraine-deposit that occupies the mouth of the Aberedw Valley and stretches some way up the valley eastwards is composed is excellently exposed in a pit close by the Wye and in the lane-sides near the village school. Well-smoothed boulders of diabase - porphyrite and andesite from the craggy Carneddau and of Caban conglomerate from the neighbourhood of Rhayader are easily identifiable rocks amid the preponderating element of fissile and less-travelled slabs of Wenlock and Ludlow rocks. Small fragments and large are confusedly intermixed in characteristically morainic fashion in a matrix of finer material.

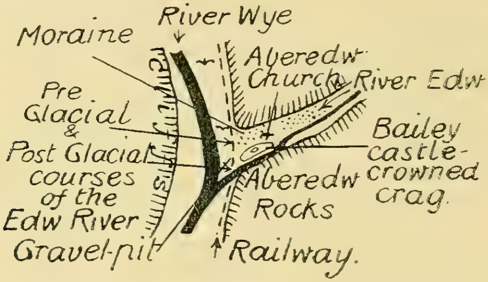


FIG. 1. Diagrammatic sketch of the country around Aberedw, near Builth Wells.

All down the Wye Valley between Aberedw and Boughrood well-defined patches of gravel form interrupted terraces, but at Boughrood there is a considerable spread rendered all the more apparent by an extensive pit at Boughrood Station. The railway traverses this bank of gravel and negotiates it by means of a steep gradient between the station and the Wye bridge, while the Wye escapes between the gravel patch and the steep western valley side, subsequently proceeding to describe the most noticeable horseshoe bend that there is in many miles of its course. Probably this gravel-deposit is one of several terminal moraines that mark the recession of the Wye Glacier.

The valley and tributary combs of the Upper Wye are rich in the products of the ice-action of the Glacial Epoch, and it is hoped that the phenomena described in the present paper will lend stimulus to their systematic investigation, which should result in the piecing together of a chapter of Glacial History no less instructive and valuable than that contributed by those who have studied the glacial phenomena of the Yorkshire moors.

VI.—The Diamond Matrices of Australia.

By J. Allan Thomson, B.A. (Oxon), B.Sc. (N.Z.), A.O.S.M., F.G.S.

SINCE the exhibition of the diamond in a dolerite at York and Mexico by Professor Edgeworth David, great interest has been aroused in the Copeton occurrence. Specimens of the rock and concentrates washed from it were forwarded by the prospector, Mr. Pike, to several gentlemen who had expressed their desire to examine them, and amongst others to Professor Miers. It was my privilege, whilst at Oxford, to examine these specimens, and the results of this examination were conveyed in a letter to Mr. Pike. As he has published part of its contents in the *Australian Mining Standard*, it is desirable to place before British readers a more connected account, and at the same time to give an outline of the not very easily accessible Australian literature.

The rock in which the diamonds have been found comes from Oakey Creek, Copeton, about 18 miles south-west of Inverell, New South Wales. Diamantiferous alluvial of late Tertiary age is abundant in the district, and has been long worked. The matrix itself has been discovered in a tunnel driven in the granite floor of the alluvial. It was first described by the Government Geologist and identified by Mr. G. W. Card as a dolerite.[1] So far, only two diamonds have been obtained, as the prospectors are unable to obtain water to wash the decomposed rock that has been mined. Both these diamonds were exhibited by Professor David at York and Mexico, and no doubt has been expressed as to the genuineness of the discovery.

The geological occurrence of the dolerite has not yet been fully cleared up; probably it is a dyke, but Mr. Pittman was inclined to believe that it might be a small pipe. In one direction a drive reached granite after passing through 26 ft. 6 in. of dolerite, but in a direction at right angles to this it has a much greater extent. The rock shows excellent spheroidal weathering.

Professor David refers to the rock as a hornblende diabase,[2] but the two specimens examined by me agreed in containing only pyroxene as an original ferromagnesian mineral. Sections show the rock to consist for the most part of elongate quadrate prisms of felspar, on which are moulded ophitically a colourless or pale bistre augite, a little ilmenite and a greenish-yellow chloritic material. The felspar is twinned both according to the Carlsbad and albite laws, and is determined by Levy's method as a labradorite of medium basicity. The yellow chloritic material is resolved, between crossed nicols, into minute imperfect sphærocrystals, with positive elongation of the fibres and a moderately high birefringence. It includes rare octahedra of magnetite, more commonly minute globules of a yellow, isotropic iron-hydrate and rod-like growths of iron-oxide, but in the majority of cases it is entirely free from ferruginous inclusions. It generally occurs in larger patches than the augite, but its relation to the felspar is the same. The augite appears so fresh that some difficulty is found in explaining the chlorite as arising from its decomposition, and it appears equally probable that it represents an altered glassy base. It would be remarkable if large ophitic plates of hornblende were entirely decomposed to a chlorite free of ferruginous materials, while the pyroxene escaped alteration. Possibly the specimens supplied to Professor David were of a different nature to those here described,

[1] E. F. Pittman, Ann. Rep. Dept. Mines, N.S.W., for 1904, p. 137 (1905).
[2] T. E. David, *Sydney Morning Herald*, January 19 and 26, 1907.

and if so, it is desirable that a full microscopic description should be published. Under the circumstances, the rock will be here referred to as a dolerite, the term 'diabase' being discarded because of its ambiguity.

The following analysis, made by Mr. Mingaye in the New South Wales Geological Survey Laboratory, accompanied the specimens sent by Mr. Pike. In using this analysis it must be remembered that some of the minerals described below in the concentrates may possibly have been included. Thus the presence of Cr_2O_3 is probably explained by the inclusion of chrome-diopside.

			89·78
SiO_2	50·43	K_2O	1·23
TiO_2	0·82	H_2O-	3·82
Al_2O_3	14·72	H_2O+	3·89
Cr_2O_3	0·02	CO_2	1·67
Fe_2O_3	2·90	P_2O_5	0·22
FeO	4·59	SO_3	0·01
MnO	0·03	V_2O_5	0·03
MgO	6·67		
CaO	7·13		100·65
Na_2O	2·47		
	89·78		

Sp. gr., 2·58. Traces of SrO, ZrO_2, and Cl.
F, S, NiO, CoO, BaO, and LiO_2 absent.

The concentrates consisted of the following minerals, all previously recorded by Mr. Card:—plagioclase felspar, iron-ores, a pale bistre augite, calcite, pyrite, quartz, tourmaline, a pale-green augite and garnet. The first three minerals are doubtless constituents of the rock, while calcite and pyrite may be considered as arising from their alteration. The presence of quartz and tourmaline is, in all probability, to be explained by the inclusion of fragments of the granite through which the granite is intrusive. There remain the green augite and the garnet to account for.

According to Mr. Pike's account,[1] the abundance of small red garnets in the rock is a very striking feature, and he surmises that eclogite inclusions may be present. He also quotes Mr. André Levy Strauss for the inclusion of contact-altered mica schist, limestone, and shale, but the descriptions given are hardly convincing.

The principles which guided Messrs. Pike and O'Donnell in searching for the matrix seem well founded, and justify the hope that other matrices may be discovered. They remarked that the diamonds found in neighbouring claims often showed considerable variations in form and colour, and they concluded that this could arise only if the matrix were near. Waterworn boulders of a decomposed yellow rock were the only constituents of the gravels that seemed likely to be the home of diamonds (arguing from analogies with the yellow ground of Kimberley), and these led them up to the dolerite. Mr. Pike appears still convinced that his matrix is comparable to the blue ground of Kimberley.

Another supposed matrix of the diamond occurs at Ruby Hill, about

[1] A. R. Pike, "The Copeton Diamonds, New South Wales. In Matrix and Notes on the Alluvial Deposits": *The Australian Mining Standard*, January 27, p. 93, and February 3, p. 119, 1909.

12 miles south of Bingara, New South Wales, and has also been described by Mr. Pittman.[1] Ruby Hill, so named from the abundance of garnets, is a small eminence of about 80 feet in height, formed on one side by Carboniferous claystones and a quartz felsite dyke intrusive into them, and on the other by a volcanic agglomerate penetrated by several basalt dykes. The map accompanying the description might almost serve for one of the necks of East Fife. Both the agglomerate and the dykes contain nodules of a rock consisting of garnet, anorthite, and chrome-diopside, identified by Messrs. Card and Woolnough as eclogite. Mr. Pittman draws an analogy between the agglomerate and the blue ground of Kimberley, but instead of following Professor Bonney in ascribing the eclogite to waterworn fragments derived from a floor of crystalline schists, suggests that it may be "the deep-seated representative of the eruptives which found their way to the surface in volcanic pipes at both these places".

Ten small diamonds were said to have been derived from Ruby Hill, but latterly some doubt has been thrown on the genuineness of this statement, since washing operations have not been successful in bringing fresh specimens to light.[2]

Still another supposed matrix is now being prospected at Snodgrass, about 20 miles south-west of Delegate, New South Wales, close to the Victorian border.[3] This rock, of which a poor exposure is found at the contact of Silurian slates and sandstones and a granite intrusive into them, is supposed to resemble blue ground in being composed of angular fragments of various rocks lying in a serpentinous matrix, and especially in the presence of eclogite nodules. As no diamonds have yet been found in the rock or in any alluvial deposits in the district, Mr. Pittman is justly doubtful of the probability of success in the present explorations, but as will be shown in the sequel, his argument that "in view of the authentic occurrence at Oakey Creek, near Inverell, it seems more logical to search for diamonds, in this country, in hornblende diabase" may need modification.

It will be seen from the above account that Australian diamond prospectors are inclined to attach much importance on the discovery of blue ground, and further consider the presence of eclogite as an important indicator. The latter predilection is owing to the well-known discovery by Professor Bonney of diamond crystals within the garnet of the 'eclogites' of the Kimberley pipes. Messrs. Hatch and Corstorphine[4] do not share Professor Bonney's view as to the importance of these pyroxene-garnet nodules, and they, moreover, consider them as related to the basic secretions of plutonic rocks, and not as true eclogites. But even if diamonds are not plentiful in these nodules, Professor Bonney's descriptions leave no doubt that they do occur in them.

I have already suggested that the nodules of crystalline rocks found

[1] E. F. Pittman, "The Mineral Resources of New South Wales": Geol. Surv. N.S.W., 1901, pp. 392–5.

[2] E. F. Pittman, "Supposed Diamond-bearing Volcanic Pipe, Snodgrass, N.S.W.": *Australian Mining Standard*, April 7, 1909, p. 359.

[3] Loc. cit.

[4] F. H. Hatch & S. S. Corstorphine, *The Geology of South Africa*, 1905, p. 299.

in the blue ground may prove to be homogeneous inclusions of volcanic rocks, which are analogous to, but hardly the same as the basic secretions of plutonic rocks.[1] The apparent reason that this explanation has not been earlier put forward must lie in the comparative rarity of garnetiferous homogeneous inclusions. A brief survey of the known examples may be of interest. Lacroix describes a few occurring in alkaline rocks when these themselves contain melanite.[2] Zirkel describes certain garnet-wollastonite nodules in the basalts of the Rhine Valley, but explains them as inclusions of limestone which have undergone thermal metamorphism by the action of the magma (accidental xenoliths).[3] These two kinds of garnet nodules are hardly germane to this discussion, and there remain only three instances known to me which have a bearing on the so-called eclogites. Zirkel in the same paper[4] gives adequate reasons for regarding other garnet-felspar-augite nodules as early segregations from the basalt magma. I have described garnetiferous olivine, augite and hornblende nodules in the limburgite breccia of Kakanui. Finally it is almost certain that similar nodules occur in the necks of the Fife coast, for at Elie Ness, where hornblendic, augitic, biotitic, and felspathic nodules are abundant, garnets may occasionally be picked up in the agglomerate and on the beach. It is worthy of note that the two latter occurrences are in the agglomerates of limburgites, although felspathic basalts are present in both localities. From the descriptions already given, the so-called eclogites of Ruby Hill and Snodgrass appear to come under this category, and it is not improbable that the other eclogite occurrences of New South Wales, cited by Mr. Pittman,[5] may prove to be similar.

The presence of chrome diopside and garnet in the Oakey Creek dolerite is strongly suggestive of the occurrence of garnet-pyroxene nodules in this rock. The occurrence would not then differ so greatly from those of South Africa as has been supposed. The importance of this case is that we have direct evidence of the nature of the magma from which the nodules segregated.

These views are largely conjectural, but this paper will serve its purpose if it secures an adequate consideration of them when the full history of the Australian diamond matrices comes to be written. Should they be confirmed, instead of comparing the Australian occurrences to the South African, the reverse process may take place, and one may see in the diamond 'pipes' of the latter continent the necks of volcanic rocks such as limburgites, in which the accidental xenoliths and homogeneous inclusions have escaped excessive alteration, while the ultrabasic volcanic material has been completely serpentinised. The discovery of necks of mellilite-basalt already points in this direction.[6]

[1] J. A. Thomson, "Inclusions in some Volcanic Rocks": Geol. Mag., 1907, Dec. V, Vol. IV, p. 500.

[2] A. Lacroix, *Les Enclaves des Roches volcaniques*, Maçon, 1893.

[3] F. Zirkel, "Über Urausscheidungen in rheinischen Basalten": Abh. Königl. Sächs. Ges. d. Wiss., 1903, xxviii, p. 103.

[4] Loc. cit., p. 497. [5] Loc. cit.

[6] A. W. Rogers & A. L. du Toit, "The Sutherland Volcanic Pipes and their Relationship to other Vents in South Africa": Trans. S.A. Phil. Soc., 1904, xv, p. 61.

Although only one undoubted matrix is known in Australia, the wide distribution of diamonds in the alluvial deposits suggests that many others are present. The erosion of a dolerite dyke must of necessity be slow, and seems inadequate to supply the quantity already recovered from the gravels. Volcanic agglomerates seem more suited to explain this wide distribution, from their easy destruction by surface agencies. Moreover, in such aggregates diamonds are more likely to be plentiful, if one may argue from the distribution of other minerals of homogeneous nodules. For instance, both at Kakanui and Elie Ness large hornblende crystals may occasionally be found in the dykes traversing the agglomerates, but they are much more abundant by themselves as fragments in the agglomerate, and this is true of the minerals of most crystalline tuffs.

VII.—The Old Granites of the Transvaal and of South and Central Africa, by Cuthbert Baring Horwood, A.R.S.M., Assoc. M.Inst.C.E., F.G.S., with a Petrographical Description of the Orange Grove Occurrence, by Arthur Wade, B.Sc. (Lond.), A.R.C.S., F.G.S.

(*Continued from the October Number, p.* 468.)

Mr. J. Hays Hammond in his paper, "Gold-mining in the Transvaal, South Africa," read at the Richmond meeting of the American Institute of Mining Engineers in February, 1901, referring to this Old Granite, states: "There are at places intrusions from this enveloping granitic mass into the younger formations."

Mr. Dörffel called attention to the fact that it had never been proved to be intrusive in the Witwatersrand System, and expressed his opinion that it was not, although this assumed the existence of an Archæan formation, which apparently was wanting in the Transvaal yet existed in Cape Colony as the Malmesbury Beds.

In January of the following year, in supporting Mr. Dörffel's views, I showed [1] that in the case of the Orange Grove occurrence all the evidence indicated that there the granite is not intrusive in the Witwatersrand System. [2]

In March of the same year Dr. Corstorphine [3] described the exposure of Witwatersrand quartzite resting directly on the Old Granite on the farm Uitkyk in the Heidelberg district, where no veins are to be seen passing upward into it from the granite, and in the closest proximity to the granite the quartzite presents the same petrographical characteristics as elsewhere. Where the surface of the granite can be seen below the escarpment it gives the impression of a rounded and worn mass. From the evidence afforded from this occurrence he

[1] "Contribution to the Discussion on Mr. Dörffel's Paper, 'Note on the Geological Position of the Basement Granite,'" by C. B. Horwood: Trans. Geol. Soc. S.A., vol. vi, pt. vi, pp. 114, 115.

[2] The Witwatersrand System consists of the Upper and Lower Witwatersrand Beds; this division is purely an arbitrary one, and is placed at the base of the Main Reef Series.

[3] "The Geological Relation of the Old Granite to the Witwatersrand Series," by G. S. Corstorphine: Trans. Geol. Soc. S.A., vol. vii, pt. i, pp. 9–12.

maintained that the Old Granite is not intrusive in the Witwatersrand System; but that the latter was laid down on the granite.

Again, in December of the same year, Mr. E. Jorissen[1] described occurrences in the Central, Western, and Northern Transvaal, and just over the eastern border in Swaziland; and also in the Vredefort district of the Orange River Colony, where he maintained the Old Granite is intrusive into either schists or quartzites, as the case may be, older than the Witwatersrand System. He suggested that these quartzites and crystalline schists must be considered as the remnants of an Archæan formation in the Transvaal, the existence of which Mr. Dörffel had already assumed.

Simultaneously with Mr. Jorissen's paper another appeared by Dr. F. H. Hatch,[2] in which he pointed to the existence of sedimentary rocks, composing the hill range of Mount Marais, near Marasbastad, 8 miles south of Pietersburg, which have suffered great contact-metamorphism from the presence of the Old Granite, which has been intruded into them. He argued that these sediments are therefore older than the Witwatersrand System, since the latter was shown by Dr. Corstorphine to rest unconformably on the Old Granite. The author stated that his investigation of the Mount Marais rocks and a comparison of them with those of Barberton had led him to the conviction that these beds, for which he proposed the name of Swaziland Series,[3] are well represented in the Transvaal by the great series of schists comprising the rolling uplands of Swaziland, by the Moodies and Sheba Ranges at Barberton, and by the hill country near Marabastad. He also pointed out[4] that the pebbles of which the conglomerates of the Witwatersrand System are composed are derived from just such rocks as occur in this Swaziland Series.

Mr. H. Kynaston, Director of the Transvaal Geological Survey, in discussing these last two papers,[5] said he had a few months ago paid a flying visit to the rocks of Mount Marais; and went on to say that "the two papers had certainly conclusively proved that the Older Granite was intrusive in an older series of altered sedimentary rocks. One of the chief arguments of the author against the Mount Marais rocks being of Lower Witwatersrand age was that the Older Granite was not intrusive in these latter beds. This fact he did not feel quite satisfied in his mind as having been as yet conclusively proved, and further, there was always the possibility of separate masses of the Older Granite belonging to slightly different periods of intrusion. A short visit last year to the Venterskroon district had left the decided impression in his mind that the Vredefort granite was intrusive in the surrounding strata of Lower Witwatersrand age, and he had particularly noticed the corundum bearing and other

[1] "Notes on some Intrusive Granites in the Transvaal, the Orange River Colony, and in Swaziland," by E. Jorissen: Trans. Geol. Soc. S.A., vol. vii, pt. iii, pp. 151–60.

[2] "The Oldest Sedimentary Rocks of the Transvaal," by F. H. Hatch: Trans. Geol. Soc. S.A., vol. vii, pt. iii, pp. 147–50.

[3] This name has since been generally adopted.

[4] Loc. cit., p. 148.

[5] Proc. Geol. Soc. S.A., 1904, to accompany vol. vii of the Transactions, p. 62.

spotted and altered rocks described by Molengraaff, and he considered them as typical hornfels due to the contact action of the granite ".

I notice that Mr. Jorissen [1] in dealing with the Vredefort occurrence shows the granite intrusive in certain schists, but does not prove that here it is not also intrusive in the overlying beds, and does not attempt to dispute Dr. Molengraaff's statement of the contact-metamorphism of the Hospital Hill Slates, or to criticize his explanation of the cause of the over-tilting of the strata in this district.

In March, 1906, Mr. H. Kynaston, Director of the Geological Survey of the Transvaal, in a paper entitled "The Geology of the Neighbourhood of Komati Poort ", [2] states that in the Old Granite intrusions of igneous rock occur, the majority of which may be classed as dolerites, in the sense in which Teall employs the term, and that they are usually in a well-preserved condition, and constitute a distinct group from the far older basic intrusions, usually referred to as diabases, so common in some of the other formations, such as the Pretoria Series. He says they must be referred to the final stages of the period of volcanic action which marked the close of Karroo times.

In his paper of the following year, "The Marginal Phenomena and Geological Relations of the Granite north of Johannesburg," he says [3]—

"An interesting modification is found along the slopes of the north face of the Rand between Orange Grove and Bedford. This is the only locality along the Rand, so far as I am aware, where an actual contact can be seen between the granite and the base of the Lower Witwatersrand Series. In one or two other localities further west the granite, or rather its dioritic modification, can be seen within a few yards of the basement quartzites, but in the section between Orange Grove and Bedford we have a clear and well-defined contact exposed for a distance of about a quarter of a mile.

"This contact is perhaps best seen a short distance west of the western boundary fence of Bedford Farm, and 1½ miles east of Orange Grove. The normal coarse acid type of the granite crops out on the lower slopes of the escarpment, but within 2 or 3 yards of the contact it gradually assumes a foliated structure, which becomes more and more marked up to the actual contact, where the uppermost few inches of the granite are usually in a highly schistose condition. The line of junction is remarkably sharp, and the base of the quartzite presents a well-defined and smooth under-surface resting at an angle of about 35 degrees upon the granite. There is not the slightest indication of any intrusive behaviour on the part of the granite, such as characterizes its relation to the basic schists and the older sediments of the Moodies Series. There are no signs of any intrusive veins or pegmatites in the quartzite, or of the granite breaking across from one horizon to another. The whole appearance of the section is that of a younger series of sediments resting upon an older mass of granite. Moreover, the lowest few inches of the quartzite

[1] "Notes on some Intrusive Granites in the Transvaal, the Orange River Colony, and in Swaziland," by E. Jorissen: Trans. Geol. Soc. S.A., vol. vii, pt. iii, pp. 156, 157.

[2] Trans. Geol. Soc. S.A., vol. ix, 1906, p. 28.

[3] Trans. Geol. Soc. S.A., vol. x, 1907, pp. 51–61.

frequently contain small rounded pebbles, sometimes almost in sufficient quantity to constitute a 'banket', and occasional pebbles are also sometimes found at slightly higher horizons. The pebbles are of vein-quartz and quartzite; granitic fragments could not be detected with certainty.

"Apart from the presence of these pebbles, the basal portion of the quartzite is usually fine-grained and uniform in texture, though along a certain portion of the section it was seen to become coarse and gritty. These features recall those so often found at the base of the Black Reef quartzites, where they rest upon similar granite, and tend to the conclusion that the base of the Witwatersrand quartzite here constitutes a true basement bed, which has been deposited upon the granite."

On the other hand, he points out that the intensely foliated character of the granite along the junction is similar to the foliated marginal facies which is intrusive in the Swaziland System, and that its petrographical features tend to strengthen the resemblance. Also the planes of foliation usually, although not always, strike in a direction parallel to the strike of the overlying quartzites. Further, he says: "the porphyry-like facies of the granite along the line of contact is certainly suggestive of intrusive behaviour, but one cannot accept this fact alone as good evidence of intrusion without more definite and confirmatory indications in the field; whereas, as already pointed out, the field evidence leads distinctly to the conclusion that the quartzites were deposited upon the granite. Further, the large quartz grains in the coarse grit, sometimes found at the base of the quartzite, are seen under the microscope to consist of aggregates of quartz showing strain shadows, and resembling the quartz blebs seen in the foliated granite beneath, a fact which strongly suggests their source of supply, and further favours the conclusion of the later age of the quartzites." Personally, I think the foliation and porphyry-like facies alluded to suggest close proximity to the contact with beds belonging to the Swaziland System, the junction being hidden by the overlying and unconformable quartzites.

He also describes two small outliers of the Moodies Series, consisting of shales and quartzites, with associated basic schists and serpentines, and also quartz-felsites, some 3 miles west of Mulder's Drift, in which the granite is intrusive; and shows that the basic schists to the south and south-west of the granite mass form a sort of peripheral basic zone.

He calls attention to the foliated character of the granite along its contact with the older basic schists and quartz-felsites of the Swaziland System, also to the variations of the granite itself. Thus we have biotite-granites, hornblende-granites, and quartz-diorites; to the development either of biotite or hornblende, the one at the expense of the other; to the local development of foliated quartz-diorite along its margin, due to the magmatic segregation of the more basic minerals towards the cooler portions; to dyke-like intrusions of diabase; and to the occurrence of lines of crush in the granite, forming conspicuous ridge-like features, having a general north and south trend, along which foliated and crushed granite of an acid type is found well developed.

With reference to these lines of crush he says: "they consist mainly of reefs of massive vein-quartz, which forms their central portion, and this is usually flanked on either side by a narrow zone of crushed and highly-sheared vein-quartz and granite, both kinds of rock being often brecciated and crushed together. The central portions have also frequently been fractured and brecciated, the fragments having been recemented by a secondary deposition of siliceous material." He instances one which extends for a distance of 12 miles and occurs about half-way between the eastern and western boundaries of the granite mass. This sheared and crushed nature of the granite along its marginal portions and along the edges of the quartz reefs he attributes to earth-movements subsequent to the consolidation of the granite.

In September, 1905, Dr. F. W. Voit[1] briefly described the occurrence of various gneisses, such as mica, hornblende, protogine, augen, flaser, epidote, and garnet gneisses, granulites, eclogites, and similar rocks, which occupy vast areas in the Northern Transvaal, including the Limpopo Flats. He suggested that all the phenomena, including petrographical character of the rocks, their monotony, and enormous extension probably indicated that they represented a Fundamental Formation; perhaps a vast area of original granite which had been converted into gneiss as a result of enormous pressure. The following month, in a paper entitled "Gneiss Formation on the Limpopo",[2] he points out that in such an old and large continent we have reason to expect that there should exist a Fundamental Gneiss Formation, and that the petrographical character of the rocks of the Swaziland Series, in which the Old or Basement Granite is intrusive, is such that we cannot class them among those rocks which elsewhere are considered as constituting the basement or fundamental rocks on which the others have been laid down. That, in fact, this Swaziland formation very largely consists of arenaceous and argillaceous rocks, which must have been derived from a still older formation.

He then shows that such a formation, consisting of granite and gneiss, actually occurs and covers an area of at least 800 square miles in the Limpopo Basin. He tells us that the formation for the greater part consists of different varieties of gneisses and schists, among which also occur hornblende and pyroxene rocks, crystalline limestones, quartzites, hæmatites, and magnetites. The gneiss, he says, shades off into a non-foliated rock, which occurs in alternating bands, but is structurally a granite, and is only sparsely developed in comparison with the foliated rocks, and evidently belongs to the period and process of the granite formation, and cannot be looked upon as a later intrusion. He describes the gneissoid rock as being an aggregate of flesh-red orthoclase, quartz, and a greenish somewhat decomposed hornblende, the minerals occurring in long, stretched, alternating individuals, with a strictly banded arrangement, and sometimes showing evidence of having undergone much pressure;

[1] "Preliminary Notes on 'Fundamental Gneiss Formation' in South Africa," by Dr. Voit: Trans. Geol. Soc. S. A., 1905, vol. viii, pp. 106–7.

[2] Trans. Geol. Soc., 1905, vol. viii, pp. 141–6.

they, especially the hornblende, being bent, and even broken, while minute fault-planes run right across the cleavage. Among the various varieties he mentions the occurrence of corderite-gneiss, and also directs attention to the frequent occurrence of highly-crystalline limestone as well-defined layers in the gneisses,[1] and of thin beds of hæmatite and magnetite, which are often interbedded with the gneisses.

He lays stress on the fact that geologists who have made a special study of the origin of gneisses are inclined to look upon them as being of magmatic origin, as being, in fact, original granite foliated and turned into gneissoid rocks by enormous pressure caused by the contraction of the earth's crust. Also that northern geologists who have studied the old crystalline schists assume the existence of a granite older than all crystalline schists—forming the basement whereon the geological formations began to be built up, whilst they, during a long period of denudation, furnished by their detritus the material from which the sedimentary rocks could be formed. Two years later he states[2] that in the Limpopo district granite resembling that which is intrusive in the Swaziland Series also occurs and is intrusive in the gneiss formation, and that its intrusive nature can often be observed along the steep banks of the Limpopo River. Also that inclusions of crystalline, well-foliated rocks, such as coarsely-crystalline well-foliated hornblende rock containing very little felspar, augen-gneiss, etc., which certainly do not belong to the Swaziland Series, and which are apparently in no way related to the granite, occur as metamorphosed masses in the Old, intrusive, Granite. In the Vryheid district, for example, he found such a rock and also augen-gneiss occurring as metamorphosed masses in the Old Granite, which had evidently been caught up in it at the time of its intrusion. Rounded masses of hornblendic and augen-gneisses also occur in the granite between Melmoth and Eshowe in Zululand.[3]

In this connexion I might mention, that dark inclusions consisting of amphibolite or closely allied rocks, occur abundantly in the granite-gneiss of the Laurentian System of Eastern Canada, and that there is positive proof that some, and possibly all, of these are remnants of the walls or roof of the granite bathyliths which have fallen into the granite-magma, and have partaken of its subsequent movements.[4] Also the black inclusions in the granite-gneisses of the Adirondacks are considered to be broken masses of an older rock caught up by the granite-gneiss when the latter was still in a molten condition.[5]

[1] He gives an occurrence of calcite rock, which is interbedded between the schists near Zand River, as an example of a highly altered igneous rock. Probably the crystalline limestones in the gneisses have also originated from the alteration of igneous rocks.

[2] "Gneiss Formation in Africa," by Dr. F. W. Voit: Trans. Geol. Soc. S.A., vol. x, pp. 90-4.

[3] Loc. cit., p. 93.

[4] "On the Structure and Relations of the Laurentian System in Eastern Canada," by Frank Dawson Adams, D.Sc., F.R.S.: Quart. Journ. Geol. Soc., vol. lxiv, No. ccliv, pp. 133–5.

[5] "Report on the Crystalline Rocks of St. Lawrence County," by C. H. Smyth, jun.: N.Y. State Mus. 49th Ann. Rep., 1895, vol. ii (1898), p. 490.

In order to show the widespread areas covered by this gneiss formation, he points out that Dantz[1] maps the central and northern parts of German East Africa as an enormous area of gneiss, in which he distinguishes between the peripheral zones of gneiss of particularly well-foliated character and the central part of granitic character; and that Tornau noticed gneisses of every variety in the Uluguru Mountains, but that generally in other parts of the Colony through which he travelled coarsely-grained granite prevails, showing throughout the same uniform composition and character, without any signs of foliation, and this he called typical granite, which is probably identical with our Old, intrusive, Granite.

Mr. Tornau states that the gneisses are older than the granite; for instance, he found, towards the south of the Nyassa, rounded gneiss fragments of all varieties, with sharp contours, in the granite. Dr. Voit[2] says he found a similar gneiss formation in the interior of Angola, which he put down as Fundamental Formation, consisting of granite and coarse-grained gneisses, in which the granite was intrusive, and that these gneisses showed a remarkable resemblance to the foliated gneisses of the Limpopo. He further says that it appears that certain gneisses south of the Gansberg in German South-West Africa ought to be separated from the intrusive granites, and classed as an independent formation. He says it is interesting to the geologist who has seen more of Africa than the South to observe that the Swaziland Series with intrusive granite seem to prevail in the South of Africa, while proceeding towards Rhodesia and Central Africa the gneisses with intrusive granites predominate.[3]

Dr. Voit[4] also found the Old Granite intrusive in the gneisses of the Engoye Mountains in Zululand; and also correlates the gneiss formation (in which the Old Grey Granite is intrusive) of the 'Nkandhla district of Zululand with the granite-gneiss formation of the Limpopo. The Swaziland Series also occurs in the 'Nkandhla bush.

He concludes by stating that we therefore have two distinct formations in which the Old Granite is intrusive—a coarse-grained, highly-crystalline rock of well-foliated character, similar to the very oldest gneiss of Laurentian age, and of undoubted igneous origin; and the Swaziland Series, of undoubtedly sedimentary origin, with igneous sheets of diabasic rocks.

In discussing Dr. Voit's first paper on this gneiss formation of the Limpopo Flats, Mr. H. S. Harger[5] stated that he had been over this ground in the Limpopo region and that he had also come across a similar formation, consisting of hornblende-gneiss, garnet-gneiss,

[1] Paper read by Mr. Tornau before the Deutsche Geologische Gesellschaft, Berlin, March 6, 1907.

[2] "Preliminary Notes on 'Fundamental Gneiss Formation' in South Africa," by Dr. F. W. Voit (Trans. Geol. Soc. S.A., 1905, vol. viii, p. 107), and "Gneiss Formation in Africa", by Dr. F. W. Voit (Trans. Geol. Soc. S.A., 1907, vol. x, p. 92).

[3] "Gneiss Formation in Africa," by F. W. Voit: Trans. Geol. Soc. S.A., 1907, vol. x, p. 92.

[4] Loc. cit., p. 93.

[5] Proceedings of the Geol. Soc. of South Africa (to accompany vol. viii of the Transactions), 1906, pp. 57, 58.

magnetite-gneiss, mica-schist, and talcose-schist, on the borders of Natal and Zululand, near Krantzkop.

With reference to Dr. Voit's remark that the gneisses and granite are more predominant as one travels northwards towards Central Africa, a paper by Messrs. Preumont & Howe[1] on the Geology of Uelle and Lado Enclave (the north-easternmost provinces of the Congo Free State, and including the eastern portion of the basin of the Upper Nile, covering in all an area of some 80,000 square miles) is of great interest. Granite, well-foliated gneisses, mica-schists, and other metamorphic rocks greatly predominate, and are classed as primary rocks. In fact, post-Primary rocks occur only in the extreme western part of the region, about Buta on the River Rubi. The granite is intrusive in the gneisses, quartzites, and mica-schists. Remarkable deposits of hæmatite and magnetite also occur. From Howe's petrological description of the rocks, the granite and gneisses bear a marked resemblance to the gneisses and Old Granites of the Transvaal.

The following is his description of microcline-gneiss from the Lado Enclave:—" A cream-coloured, medium-grained, banded rock. The texture, as seen in the section, is granitic; there is no sign of foliation. Quartz occurs in fair-sized plates, also in blebs within the felspar (corrosion-quartz). Streaks of dusty inclusions are common. The felspars comprise abundant microcline, orthoclase, and plagioclase (oligoclase); albitic and periclinic twinning frequently occur together. Some of the felspars have schiller-structure, produced by rows of negative crystals. Micrographic intergrowths of felspar and quartz appear sporadically in small patches. A curious, dark-green, pleochroic variety of hornblende occurs in a few patches. Biotite is present, but is sparingly represented; it is often greenish in colour. A little sphene is associated with the mica. A few small rounded crystals of zircon are present, also short prisms of apatite."

A microcline-gneiss from between the Rivers Kwado and Aro he described thus: "Microcline in abundant large plates is the predominant felspar; there is also some plagioclase. Quartz occurs in irregular grains and as bleb-like inclusions in the microcline; fluid-inclusions are common in the quartz. Both a colourless and a dark-brown mica are present. Epidote is plentiful in rather large pale masses. Zircon and sphene are present, also small patches of chlorite in association with the mica. The foliation is well marked, even in the slide, and is accompanied by an approach to granulation and a sort of mortar-structure."

From these two descriptions the granites appear to be remarkably similar in petrographical habit to the Old Granites of the Transvaal. The prevalence of microcline-granite-gneisses and microcline-gneiss also suggests great similarity to the Old, Grey, Microcline Granites of South Africa.

Along the boundary of the Congo State and the Bahr-el-Ghazel a series of very coarse, pegmatoid, gneisses occurs, with large mica,

[1] "The Geology and Petrology of part of the Congo Free State," by G. F. J. Preumont & J. A. Howe: Quart. Journ. Geol. Soc., 1905, vol. lxi, pp. 641–66.

felspar, and quartz elements, and local developments rich in tourmaline, kyanite, and garnet. The authors state that the crystalline rocks of the eastern portion of the area described appear to be analogous in every way to the rocks of the same age in Uganda, British East Africa.

In the discussion on this paper Mr. Walcot Gibson stated that some of the rocks described recalled a sequence in Griqualand West. In this same connexion, some recent papers by Mr. J. Parkinson on the Geology of Southern Nigeria and Western Liberia are also instructive. Mr. Parkinson,[1] in describing the geology of Southern Nigeria, speaks of a basement-platform of crystalline rocks, and again of a basement-platform of gneiss and schists; and he divides the crystalline rocks into (1) foliated acid orthogneisses, which tend to lose their foliation and pass into granites, and when coarsely-crystalline have a pegmatoidal habit; and (2) unfoliated rocks consisting of many varieties of granite, of tourmaliniferous pegmatites, and of aplite-dykes. The petrographical characters of the schists suggest that they were originally sediments. The gneisses are said to be intrusive in them, but I suspect that later work will show that it is a younger granite which is intrusive in both schists and gneisses.

Dr. J. W. Evans, in discussing Mr. Parkinson's papers, said that these crystalline rocks showed considerable resemblance to those of Central Africa.

Dealing with Western Liberia, Mr. Parkinson[2] finds that most of the rocks consist of acid-gneisses (in which biotite is usually the sole ferro-magnesian mineral and microcline is common), garnet-schists, garnet-biotite-gneisses, granitic-orthogneisses, and foliated hornblende-schists, garnet-hornblende-quartz rock, magnetite-hypersthene rock, and chlorite-schists, etc. He states that the probable igneous origin of many of the gneisses and associated rocks is suggested by an exposure at Von on the St. Paul River, where a coarse quartz-felspar vein of pegmatoidal habit cuts clearly across the foliation of the biotite-gneiss, but is apparently an integral part of the complex. He maintains that here also the gneisses are intrusive in the schists.

As in the Congo Free State Preumont[3] found hæmatite and magnetite deposits associated with the old crystalline primary rock, so here, in Western Liberia, Parkinson found hæmatite-schists associated with the gneisses. As already noted, Voit[4] also found thin beds of hæmatite and magnetite interbedded between the gneisses on the Limpopo.

Messrs. Chalmers and Hatch,[5] in describing the geology of

[1] "The Post-Cretaceous Stratigraphy of Southern Nigeria," "The Geology of the Oban Hills (Southern Nigeria)," "The Crystalline Rocks of the Kukuruku Hills (Southern Nigeria)," all by J. Parkinson: Quart. Journ. Geol. Soc., 1907, vol. lxiii, No. ccli, pp. 308–17.

[2] "A Note on the Petrology and Physiography of Western Liberia," by John Parkinson: Quart. Journ. Geol. Soc., 1908, vol. lxiv, No. ccliv, pp. 313–16.

[3] Loc. cit.

[4] "Gneiss Formation on the Limpopo," by F. W. Voit: Trans. Geol. Soc. S.A., 1905, vol. viii, p. 145.

[5] "Notes on the Geology of Mashonaland and Matabeleland," by J. A. Chalmers and F. H. Hatch: Geol. Mag., 1895, Dec. IV, Vol. II, No. ccclxxi, pp. 193–203.

Mashonaland and Matabeleland, show that the bulk of the country consists of granite, and the remainder chiefly of metamorphic rocks, chiefly chlorite- and hornblende-schists, epidiorites, actinolite rocks, diabases, dolerites, and other igneous rocks. It is their opinion that the schists are, at all events for the most part, derived from basic igneous rocks which have invaded the granite, and do not represent ancient sediments deposited on a granite floor. They consider the granite and schists constitute a portion of that ancient floor of granite and metamorphic rocks that elsewhere underlie the subsequent sedimentary or igneous accumulations.

As illustrating the widespread distribution of Old Granites and Gneiss in Southern Africa, Mr. J. Kuntz,[1] speaking of Little Namaqualand, says: "Like everywhere else in South Africa, the base of all stratified rocks is formed by granite and gneiss with its varieties and developments into the old crystalline schists."

With reference to the southern part of Great Namaqualand he states that towards the north the Archæan rocks become more covered by younger strata, and the zone of granite-gneiss is confined to a narrower strip along the coast; and also that in the northern part of Great Namaqualand almost the whole country consists of old schists, varying from the gneiss to mica-schists, amphibolite-schists, quartzites, and chlorite-schists. He says that in the granite zone of the Swakop River, situated to the north and north-west of the schistose zone of the Kuisib Valley, the granite is intrusive in the old schists, but only near the basal granite-gneiss, in which the granite is also intrusive. He remarks that it appears as if formerly, when the crust of the earth was very thin, the folding movement, such as that which tilted up the old schists, caused outbreaks of the underlying granitic magma.

Dr. F. W. Voit,[2] in describing the geology of German South-West Africa, divides the whole country into a gneiss and schist zone and a gneiss-granite zone, pointing out that there are intrusive masses of granite, especially frequent in the western half of the country, containing large fragments of gneiss and schist, which undoubtedly belong to the gneiss and schist zone. In the gneiss-granite area there is a strong predominance of granite. He points out that certain coarse-veined gneiss is merely a structural variety of the granite, and also that a special feature of the district is the occurrence of crystalline limestones, some of which are interbedded in the schists, and which he regards as true members of the schist formation.

With regard to the gneiss-schist area, he remarks that the gneisses and mica-schists appear to be connected with each other by almost imperceptible gradations, and that, moreover, a certain sequence is apparent, which he illustrates by an ideal cross-section from Jakalswater to Gansberg, a distance of about 85 miles, in which from below upwards we have—

[1] "Copper Ore in South-West Africa," by J. Kuntz: Trans. Geol. Soc. S.A., 1904, vol. vii, pt. ii, p. 70.

[2] "A Contribution to the Geology of German South-West Africa," by Dr. F. W. Voit: Trans. Geol. Soc. S.A., 1904, vol. vii, pt. ii, pp. 77–94.

(1) *Granite*, intrusive in the gneisses and schists.
(2) *Schistose gneisses*, with an interstratified calcium-silicate-hornfels rock.
(3) *Mica-schists*, with highly crystalline limestones and clay slates interbedded.
(4) *Amphibolites*, with graphite-quartzite-schists and mica-schists.
(5) *Chloritic and sericitic schists.*

He also says that varieties of granite frequently penetrate one into the other.

Mr. A. W. Rogers,[1] Director of the Geological Survey of Cape Colony, has described the masses of granite and gneiss of Griqualand West and of the Cape Colony, by far the greater proportion of which occurs in the north-west of the Colony, but so far he had found no evidence of a difference in age between the granite and gneiss. As already stated, he is, however, inclined to admit a difference in age between the granulites of the Prieska district and the normal granite and schists; this will be referred to again later.

He mentions the occurrence in the south-western districts of rocks of more basic composition than granite as being intrusive in both the granite and Malmesburg Beds. Here the granite is intrusive in the Malmesbury Series and the Namaqualand Schists, which are both correlated with the Swaziland Series of the Transvaal.

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

VIII.—Notes on the Pre-Glacial Rock-Platform on the Wexford Coast.

By F. R. Cowper Reed, M.A., F.G.S.

The occurrence of a pre-Glacial marine terrace and raised beach along the coast of the south of Ireland was described by Messrs. Wright & Muff in 1904,[2] and its development in the eastern part of co. Waterford was the subject of two short papers by the author in 1907[3] in this Magazine. Messrs. Wright & Muff (op. cit.) observed the same raised beach only in the south-eastern portion of co. Wexford, so that its recognition this summer by the author further north along the east coast of Ireland deserves recording, for it has been traced for several miles to the north and south of Courtown Harbour, and its height, characters, and relations to the overlying deposits show that it is a continuation of the same feature. The first locality to be mentioned is about 3 miles to the south of the village of Courtown, where relics of it are preserved between Roney Point and Salt Rock; it is still more distinct as a rock-terrace a little further north at Pollshone Head and Breanoge Head, but in the bays between these points the conditions are not favourable for its exposure, as there are no rocky cliffs, only extensive sand-dunes stretching

[1] *An Introduction to the Geology of Cape Colony*, by A. W. Rogers, 1905 (Longmans, Green, & Co., London).
[2] Wright & Muff, Proc. R. Dublin Soc., 1904, vol. x, pt. ii, pp. 250–324.
[3] Reed, Geol. Mag., 1907, Dec. V, Vol. IV, pp. 17, 549.

along the shore. From Courtown Harbour northwards for about 2 miles to Duffcarrig Rocks sand-dunes are similarly developed, forming a nearly continuous line of ridges rising to heights of over 50 feet. Thick drift deposits occur behind them, but no pre-Glacial cliff or platform is exposed. At Duffcarrig Rocks solid rock again appears forming the headland, and we can recognize remnants of the rock-cut shelf in a much eroded and fissured condition. From here onwards to Ballymoney, about 1½ miles to the north, fragments of it may be detected in the reefs running across the foreshore, but in no place here is it continuously or well preserved, having been much dissected by later marine erosion. It is on the north side of Ballymoney, where the cliffs and foreshore are largely composed of solid rock, that we find it in the most perfect condition. Especially is this the case near the mouth of Kildermot Glen, where it forms a distinct shelf or platform 10–30 feet wide, and is cut across the edges of the steeply inclined Lower Palæozoic sedimentary and igneous beds. On this platform rest patches of the old beach deposit, the shingle being cemented together into a hard conglomerate and adhering in places firmly to the platform itself. The pebbles in it are mostly rounded and small, but a few are subangular and measure as much as 6–8 inches in length. The platform ends abruptly at the cliffs behind, the upper portion of which is composed of boulder-clay and glacial gravel; but it can be proved to pass in below these deposits which rest upon its surface. The pre-Glacial cliff is not exposed. When followed further north beyond Kildermot Glen, the rock-platform attains a general width of 25–30 feet, forming an almost horizontal terrace, 10–15 feet above high-water mark, with a gentle slope seawards, and it has been planed down to a remarkably uniform level across the edges of the steeply dipping and highly cleaved Ordovician calcareous flags, etc. A few large transported boulders of non-local rocks are found resting on the surface of the platform, either partly embedded in the drift of the cliffs or weathered out and lying loose on its surface. One such large subangular mass of diorite measured 6 × 3 × 2 feet, and another block of coarse grey granite measured 3 ft. 6 in. × 3 ft. × 2 ft. 6 in. in size, both of them being typical erratics. The pre-Glacial platform has been completely worn away further north towards Kilmichael, where the softer purple and green laminated slates set in, the cliffs composed of these beds rising up nearly vertically from the present beach-level. In Kinahan's *Geology of Ireland* (1878), p. 253, there is a statement that the "12 ft. beach" is seen in many places between Bray Head and Carnsore, and it is probable that he here refers to the above described pre-Glacial platform.

IX.—On River Development in Mid-South Wales.

By L. Richardson, F.R.S.E., F.G.S.

The Lower Severn Valley has been classic ground to students of river-development ever since Professor W. M. Davis visited and applied those principles of river-development which he had found so illuminating in his own country. Recorded in print, and developed by Mr. S. S. Buckman and others, these views have met with much support, and certainly have the advantage of explaining many otherwise unintelligible phenomena.

In brief, as far as the Lower Severn Valley is concerned, the exponents of this theory hold that the valley of the Lower Severn was once non-existent; that the beds now terminating in the Cotteswold escarpment once extended much further west, up to, if not beyond, the borderland of the Palæozoic rocks. And not only did these rocks extend much further west and fill up the present Lower Severn Valley, but other deposits of great thickness also passed westwards above them. These Neozoic rocks were doubtlessly uplifted to form a great coastal plain gently sloping to the south-east. Over it the initial drainage ran in channels, usually, as one would expect, with an approximate direction from north-west to south-east. These original consequent-streams followed the ordinary course of river-development, deepening their channels, developing subsequents, capturing, and being captured.

Slowly and surely, however, whilst this development was proceeding, the theory has it that the Severn was cutting its way backwards from the south-west, capturing the transfluent consequent-streams one after the other, diverting the waters to the west of the elbows of capture into its own channel, and causing the beheaded streams to take their rise at some point to the east of the place of capture. In this way a divide was initiated between the capturing river and the beheaded streams. Thus had the Cotteswold escarpment its genesis, and as obsequent-streams were developed in the old consequent notches immediately to the east of the points of capture, it was caused to proportionately retreat. Further development has produced the mature valley of the Lower Severn, with its fault-block hills of Bredon and Woolston, the butte-like Churchdown Hill, the conical Robins'-Wood Hill, and the cuesta of the Cotteswolds. Away to the south-east, clearly visible from many of the eminences of the Cotteswold Hills, stretches the white Chalk escarpment.

In the heart of Wales, centred round Builth Wells, the present river-systems are in a prior phase of development of a subsequent cycle to that which has been reached in Gloucestershire and the adjacent counties. In many parts of Wales, as is so well seen from the Arans and Cader Idris, the rejuvenated rivers are actively engaged in dissecting the well-known peneplain. The case is not absolutely parallel, of course, although it sufficiently approximates to merit comparison. Standing on such a hill as Y Foel, north of Llanwrtyd Wells, and looking toward the south-east, one sees the channelled escarpment of the Wenlock and Ludlows, capped with the basement-beds of the Old Red Sandstone, which has been pictured so well by Murchison. The combes are not much more than storm-channels. They are not like the more mature combes of the Mid-Cotteswolds, for they are in a prior phase of development. From the Mynydd Bwlch-Y-Groes flows the Dulas River north-westward to the Irfon, which continues to flow in the same direction along the foot of the great Mynydd Eppynt to join the Wye near Builth. The Mynydd Eppynt declines to the south-east, and is drained by a number of beheaded consequent-brooks that flow into the east- and west-running River Usk. The Usk runs eastwards, from the foot of the dark towering Carmarthen Fan, past the Fans of Brecon, and so into its broader valley at Crickhowel and Abergavenny.

Sketch-map to show the river-distribution in Mid-South Wales. The Towy-Bran system is that about Llandovery. (For Llandridod read Llandrindod; and for Aberdew Hill, Aberedw Hill.)

The River Wye, that flows south-eastwards from lone Plinlimmon, past Builth Wells, and down the deep Erwood Gorge, is suggestive of what the early Severn-to-Coln river was like when its course was by way of Upton-on-Severn, Tewkesbury, the line of the Swilgate, and so through the Chelt Valley and into the present Coln. With Newbridge-on-Wye occupying a corresponding site to Tewkesbury it is not hard to picture in the Ithon the subsequent Stratford-on-Avon.

Builth Wells corresponds in position to Dowdeswell in the Chelt

Valley; the hills that are grouped around the Carneddau to the Cleeve-Hill plateau; the Llansaintfread Valley to that of Sevenhampton; and the Aberedw Hill and its northern prolongation to the hills that form the east side of the Sevenhampton Valley.

Such was probably the state of the river-distribution in the Vale of Gloucester before the River Severn cut its way back.

The Severn captured the consequent that flowed from Upton to Andoversford at Tewkesbury, and brought about that river-distribution which has not greatly changed at the present time.

The River Bran, the north-easterly directed tributary of the Towy, will effect in time in the Vale of Llangamarch changes similar to those that the Severn has in the Lower Severn Valley. It is not difficult to see that a further backward development will bring about the capture of the Upper Wye; the diversion of that portion of the Wye which is above Newbridge into the capturing Towy-Bran River; the resultant beheading of that portion of the Wye to the south-east of the elbow of capture; to be followed by the initiation of an obsequent-stream up the Builth-Wells Valley, and the recession of the source of the beheaded Wye. The comparison could be carried further, but it will be easy for those who know about the state of river-development in the neighbourhood of Andoversford, near Cheltenham, to institute the few minor comparisons that remain.

The undulating ground that separates the progressing Bran from the receding Cledan and Dulas tributaries of the Irfon is excellently viewed from the lofty summit Y-Foel above Llanwrtyd Wells. On the south side the ground falls steeply towards Llandovery.

The Towy River has obviously effected an important capture at Llandovery. Once no doubt the River Usk commenced its course considerably further west, flowed across the then non-existent Towy Valley at Llandovery, and *via* the deep Cwm Dwr found its way past the site of the present Brecon. Westwards through the greater length of the Cwm Dwr now flows the obsequent Gwydderig, and eastwards a tributary of the consequent Usk that is gradually diminishing in length. In this neighbourhood there are in progress some very pretty examples of river-capture. Southerly and south-easterly directed tributaries of the Usk are being encroached upon by the growing Gwydderig, and abrupt elbows of capture are seen comparable with those observable in the Stroud area, where the obsequent Frome, developed from the Severn, has captured such original south-easterly directed tributary-streams of the Thames as that which flows down the Edgeworth Valley.

The way in which the comparatively broad valeland around Cilmery has originated through the development of the subsequents Irfon and Ithon may possibly suggest an explanation for the somewhat broad valeland expanse around Churchdown, Cheltenham, and Tewkesbury, and its contraction to the south towards Berkeley. When the Towy has overcome the intervening undulating ground in the neighbourhood of Cefn Llwydlo it will make comparatively rapid development, for it will capture the head-waters of the Irfon and invade the ready-excavated valley of Llangamarch. At first, as in the Lower Severn Valley near Berkeley Road Junction, the Towy Valley will be constricted, but after that it will open out again like the Vale of Gloucester does in the neighbourhood of Churchdown, Cheltenham, and Tewkesbury.

Further details of the development of the rivers in Mid-South Wales must be left for local observers to work, but there is one broad feature to which passing reference may be made. It is the noticeable crescentic sweep of all those important rivers, that, working their way backwards, are effecting such radical changes in the river-distribution of Wales and the neighbouring counties of England. Starting down in the south-west they work their way north-eastwards and then gradually curve round north-westwards.

The Shannon in its crescentic course has nearly traversed Western Ireland. The Teify has almost isolated with the lower reaches of the Ystwyth a somewhat Ireland-shaped mass of Wales. The Towy seems engaged on developing a similar crescentic course, and the great Severn seems bent on making Wales another Ireland. With water stretching from Dee to Severn there would be the replica of the waters that now part Wales from Ireland.

X.—Optical Peculiarities in Phlogopite.

By T. Crook, Assoc.R.C.S., F.G.S.

It frequently happens that micas exhibit small basal cleavage rifts of roughly circular shape, and these may be so numerous as to render opaque or feebly translucent a plate which would be otherwise quite transparent. The so-called silver-amber mica of the mica trade, a variety of phlogopite which is highly prized for its low conductivity, apparently owes its silvery sheen to the presence of these cleavage rifts, which overlap each other to a considerable extent, and reflect the light copiously. The presence of these basal cleavage rifts in silvery phlogopite is rendered quite obvious when a plate is examined under the microscope in ordinary light, by the interference rings seen round the borders of the rifts. Such a plate of silvery phlogopite exhibits a peculiar phenomenon in consequence of the presence of these rifts.

If a plate of suitable thickness, say 0·5 mm. or so, be taken, it will be found to be opaque or only feebly translucent when examined in ordinary light in such a way that the plate is normal to the line of vision. If the plate be now turned about a horizontal line, so that it slopes towards the observer, it will gradually become more transparent, the degree of transparency reaching its maximum at an angle of about 45°, and diminishing as the plate approaches the horizontal position. This greater degree of transparency in an oblique position, in spite of the apparently greater thickness of the plate which the light has to traverse, is a rather puzzling feature, and one which would scarcely be anticipated. It only occurs in those pronounced silvery types in which the rifts are exceedingly numerous and overlap extensively. The phenomenon seems to be due to the fact that, in consequence of the overlapping rifts, light can only be transmitted through the plate by a series of oblique internal reflections; hence rays cannot emerge freely at right angles to the plate.

Further, if a plate of brown phlogopite be rotated in its own plane when in an oblique position, it exhibits axis-pleochroism, the axial colours being the same as those observed when the plate is examined with a nicols prism or a dichroscope. The varieties which show this axis-pleochroism in ordinary light to best advantage are the rich brown phlogopites, which show the pronounced axial tints on the base.

A plate of coloured muscovite or ordinary biotite, if examined in the manner here described, shows no pleochroism.

A basal cleavage plate of brown phlogopite therefore provides an instance of a mineral which exhibits axis-pleochroism when examined in ordinary light, without the use of a polarizer or a dichroscope.

NOTICES OF MEMOIRS.

I.—Preliminary Note on the Classification of the Permian of the North-East of England.[1] By David Woolacott, D.Sc., F.G.S.

SEDGWICK, Howse, and King classified the Permian according to the nature of its stratification or of the structures occurring in it; but as the bedding of the different divisions is often alike, and as the structures—whether concretionary, brecciated, pseudobrecciated, or cellular — are not confined to particular horizons, divisions named on this basis are misleading and unsatisfactory. The use of the term 'fossiliferous' to mark off a division is also inadmissible. In the following classification the limestone is typically developed at the place the name of which is used to designate a group of strata. The divisions in descending order are—

Middlesbrough Red Beds with Salt.—Red marls, marly sandstones and lenticular beds of salt, anhydrite, and gypsum with fœtid fossiliferous magnesian limestones. 300 feet.

Roker Limestone.—Yellow limestone, regularly bedded; some beds compact, others formed of minute hollow spheres. 100 feet.

Fulwell Rocks.—Bedded yellowish and brownish concretionary (of various types) and non-concretionary limestones, in places highly fractured and brecciated; cemented crush breccia occurs locally. Base often much disturbed by beds from below being forced into it, and by falling of lower layers into fissures and gashes. Irregular beds of amorphous marl are associated with these beds. Two fossiliferous horizons occur: one of fish remains at Fulwell, and the other of invertebrata at Byers Quarry. 150 to 200 feet.

Marsden Rocks.—Bedded yellow and brown limestones, slightly concretionary in places. Irregular masses of white limestone resembling Mountain Limestone occur. Brecciated beds (cemented crush breccias) occur at different horizons. In places highly folded and fractured, but sometimes little disturbed. Breccia-fissures and breccia-gashes

[1] Abstract of Paper read at British Association Meeting, Winnipeg, in Section (C) Geology, August, 1909.

are found principally in this division. It is sometimes 'cellular', due to solution of fragments out of cementing material of brecciated beds. This horizon has been a zone of thrusting, the amount of brecciation being determined by the relative compressive strength and rigidity of the strata. A flexible limestone occurs near the top of this division. 150 to 200 feet.

Claxheugh Limestone.—Yellow, earthy, friable, and crystalline limestone. Generally unbedded, in places very fossiliferous, sometimes brecciated (crush breccia) and highly fractured. Its upper surface is very irregular. Some of the brecciated beds between Frenchman's Bay and Marsden, on Tynemouth Cliff, and at Blackhall Rocks are included in this division. Outcrops roughly parallel to coast as a continuous band. Brachiopods and most of the other genera of Permian fossils stop at this horizon in Durham. 50 feet.

Houghton Limestone.—Regularly bedded, thinly at base, more coarsely above. Top layers often highly displaced and tilted up; in one or two places it is entirely thrust out of position. Thickens greatly from north to south of county, and width of outcrop increases. Often full of geodes. 10 to 400 feet (?).

(The total thickness of magnesian limestone proved by boring is about 800 feet.)

Marl Slate.—Greyish, yellowish-brownish, and blackish arenaceous and argillaceous laminated limestone. Numerous fish remains. 3 or 4 feet thick.

Thin band of calcareous clay a few inches thick.

Yellow Sands.—An incoherent sandstone generally yellow along outcrop, occasionally variegated (iron oxides and manganese dioxide). In pit sections often greyish or bluish. Very variable in thickness. Top originally regular, but floor on which it rests irregular. Generally false-bedded, although in places, especially near the top, it is regularly bedded. Grains rounded. 0 to 150 feet.

II.—Limestone Unconformities, and their Contemporaneous Pipes and Swallow-holes.[1] By E. E. L. Dixon, B.Sc., F.G.S.

Calcareous rocks differ from other commonly occurring types in being appreciably soluble in atmospheric waters, and, in consequence, being eroded along underground channels where situated above saturation-level. Thus it is that one of their most striking physiographic characteristics is the occurrence in them of numerous caves and swallow-holes, of all sizes and shapes, often containing either debris of overlying rocks or deposits formed in them *in situ*. It is the purpose of this note to draw attention to the way in which this characteristic is reflected in the nature of certain unconformable junctions of limestones with younger rocks.

Unconformities may be divided, for our purpose, into two groups. In the first the underlying rocks have an approximately plane upper

[1] Abstract of Paper read at British Association Meeting, Winnipeg, in Section (C) Geology, August, 1909.

surface, the plane of the unconformity, and have evidently been base-levelled, by either marine denudation or peneplanization, before the deposition of the upper set upon them. With this group any limestones which occur below the unconformity appear to be devoid of pipes or swallow-holes contemporaneous in origin with the plane of the unconformity. Example : the junction of the Carboniferous Limestone with Triassic or Jurassic formations at most places, such as Upper Vobster, in the Bristol district, already described by many authors.

In the second group the rocks below the unconformity have not been maturely eroded before the deposition of those above, and the junction may in consequence be very uneven. Where the underlying rock is limestone the unevenness becomes most marked, for there the junction is complicated by pipes and swallow-holes contemporaneous with the unconformity and filled with material similar to that of the overlying formation, which has been deposited in them *in situ*. An example in which the unconformity, and consequently the piping, has been but slight is afforded by the junction of the upper and lower subzones of the *Syringothyris*-zone of the Carboniferous Limestone—i.e. by the mid-Avonian unconformity—at West Williamston, in Pembrokeshire.[1] There the basement-bed of the upper subzone fills pipes, up to 8 feet deep, in the upper part of the Caninia-oolite (the top of the lower subzone) below, the evidently undisturbed state of both the in-filling and the rest of the basement-bed above showing that the pipes have been formed before the deposition of the upper subzone. At a short distance from West Williamston the pipes in the oolite disappear as we approach the area characterized by continuous deposition of the Avonian; but at Pendine,[2] in the opposite direction, where the unconformity in the middle of this formation is greater than at West Williamston, the piping has extended for a greater depth into the limestones below.

A still more advanced stage of solution-erosion is shown by the Carboniferous Limestone at Ifton, in Monmouthshire, near Severn Tunnel Junction. The unconformity in this case occurs between the Carboniferous Limestone and the Millstone Grit; in the former have been eroded large steep-sided cavities, comparable only with swallow-holes, as well as small pipes resembling those at West Williamston, and both swallow-holes and pipes have been filled with an original deposit of Millstone Grit. This occurrence is the more interesting because the Carboniferous Limestone and the Millstone Grit have subsequently been covered up with Trias, but the junctions of both with the latter form an even surface, evidently a base-levelled plane, below which there are no contemporaneous—i.e. Triassic—pipes in the limestone.

Finally, an extreme case of solution-erosion preceding unconformable deposition on limestone is afforded by huge breccia-filled cavities in the Carboniferous Limestone of Pembrokeshire.[3] These cavities

[1] *Summary of Progress for* 1906, Mem. Geol. Surv., 1907, p. 55.

[2] *Summary of Progress for* 1902 (p. 43), 1904 (p. 44), and 1905 (p. 55); and "The Country around Carmarthen" (in the press), Mems. Geol. Surv.

[3] *Summary of Progress for* 1904, Mem. Geol. Surv., 1905, pp. 46–7.

often extend from top to bottom of cliffs ranging up to more than 100 feet in height, and in some cases continue horizontally for over 100 yards. They are almost completely filled with blocks of limestone, of all sizes up to masses weighing hundreds of tons, which have fallen from the roof and sides, but also contain a little interstitial Triassic material *in situ*. The formation of the cavities, therefore, preceded the deposition of the Trias, and took place during the long period represented by the great unconformity between the latter and Carboniferous rocks. In this district, most, if not all, of the succeeding younger formation (the Trias), deposited on the upper surface of the limestone, has been removed, but there is evidence that that surface was a base-levelled plane. This belief, however, does not invalidate the conclusion that such planes are devoid of contemporaneous swallow-holes, because the plane which is believed to have existed in this case must have truncated some of the breccia-filled cavities, and therefore have been of later origin.

III.—Investigation of the Igneous and Associated Rocks of the Glensaul and Lough Nafooey Areas, Co. Galway.[1] By C. I. Gardiner.[2]

Mr. C. I. GARDINER and the Secretary visited Connemara in April and completed their field work on the Glensaul district, commencing, in addition, to map the Lough Nafooey district.

The Glensaul district is a small one, measuring only about 2 × 1 miles. It is about 3 miles south-west of the southern extremity of the Tourmakeady district, recently described,[3] of which it is clearly a continuation, the type of sedimentary rock met with in the two being practically identical. The general succession is:—

III. ?*Bala Beds*—conglomerate and sandstone. These have not been studied.

II. *Llandeilo Beds.*

(5) Calcareous gritty tuff, passing in places into fairly pure limestone, and enclosing bands and patches of limestone breccia and bands of highly fossiliferous limestone, which in some cases has been shattered by earth movement . . .	Thickness doubtful.
(4) Very coarse tuff or breccia mainly composed of felsite fragments	750 feet.
(3) Tuff coarse and fine with occasional patches of calcareous beds	150 feet.
(2) Great felsite sill of Tonaglanna and Greenaun .	1200 feet.
(1) Tuff with some grit	600 feet.

I. *Arenig Beds.*

(4) Coarse grit	150 feet.
(3) Fine grit and tuff associated with black chert, graptolitic shale, and a prominent band of breccia 30 feet thick	Thickness doubtful.
(2) Coarse grit	110 feet.
(1) Coarse conglomerate	About 600 feet seen.

[1] Abstract of Paper read at British Association Meeting, Winnipeg, in Section (C) Geology, August, 1909.

[2] Report of the Committee, consisting of Professor W. W. Watts (Chairman), Professor S. H. Reynolds (Secretary), Mr. H. B. Muff, and Mr. C. I. Gardiner. (Drawn up by Mr. C. I. Gardiner and the Secretary.)

[3] Quart. Journ. Geol. Soc., 1909, vol. lxv, pp. 104–53.

The black shales have yielded the following considerable series of graptolites, which have been kindly determined by Miss G. L. Elles, D.Sc., and indicate the zone of *Didymograptus extensus*. The associated cherts contain radiolaria :—

Graptolites from the Arenig Beds of Glensaul.

Dictyonema, sp.	*Thamnograptus*, sp.
A Dendrograptid.	*Didymograptus extensus*, Hall (common).
Tetragraptus pendens, Elles.	*D. filiformis*, Tullberg.
T. Amii, Lapworth M.S.	*D. fasciculatus*, Nich.
T. quadribrachiatus, Hall.	*D. bifidus*, Hall.
Clonograptus Lapworthi, Rued.	*D. gracilis*, Törnquist.

In the Llandeilo rocks, both limestone and tuff, a large number of generally rather fragmentary fossils was found, which are being determined by Mr. F. R. Cowper Reed.

The crystalline igneous rocks, all of which we believe to be intrusive, are by no means so varied as in the Tourmakeady district, and are practically limited to one broad band of felsite, which is noteworthy from the fact that it almost everywhere contains pyroxene.

The district is much faulted, large faults bound it on the east and west, a somewhat complicated system of faults approximately parallel to these bounding faults intersects it, and there are other dislocations of importance.

REVIEWS.

I.—Life and Letters of Peter and Susan Lesley. Edited by their daughter, Mary Lesley Ames. 2 vols. 8vo; pp. xii, 526, and v, 562, with 16 portraits, 17 sketch illustrations, and geological map. New York and London: The Knickerbocker Press (G. P. Putnam's Sons), 1909.

PETER LESLEY, the fourth in succession of that name, was born in Philadelphia on September 17, 1819, and died at Milton, near Boston, on June 1, 1903, in his 84th year. His great-grandfather belonged to Scotland, and was known as the "Miller of Fifeshire". His grandfather (Peter the second) settled in Boston, U.S.A., as a cabinet-maker, and his father (Peter the third) succeeded to this business. Peter the fourth, however, did not like his Christian name, and while during his father's lifetime he signed his name "Peter Lesley, Jr.", he subsequently transferred the J to the front, and became J. P. Lesley, in which form his name has been familiar to geologists.

In an interesting and appreciative obituary memoir, which formed part of the anniversary address delivered by Sir Archibald Geikie as Vice-President of the Geological Society in 1904, J. P. Lesley was described as "one of the most distinguished and lovable men of science in the United States"; and in the two volumes before us ample testimony is given of the justice of those words.

In early years Lesley received from his father, who was a man of high principle and wide culture, a valuable training in mechanics, in perspective and machine drawing; he was sent to the best schools, acquired a knowledge of Latin, Greek, French, and German, and in 1838 graduated in the University of Pennsylvania. It was his intention to enter the ministry, and to complete his studies in divinity at Princeton. His health, however, gave cause for anxiety, and it was suggested that he should take a season of outdoor work on the geological survey that had been established in 1836 under the direction of Henry D. Rogers. Lesley was well qualified to start as a surveyor and draughtsman. Thus it came to pass that, in 1839, he was appointed a sub-assistant on the First Geological Survey of Pennsylvania, and his very diversified career commenced from that date.

In her preface to the first volume, Mrs. Ames remarks—"I have not attempted to write of my father's scientific life, not being competent to do so; but in the Appendix will be found several of the obituary notices written by scientific friends, which will to some extent supply this omission." Lesley's claim to scientific distinction, apart from his Professorial work, rests on his able and original surveys of the coal regions of Pennsylvania; on the maps and reports which he prepared, first as assistant to Rogers, and finally as Director of the Second Geological Survey of the State; on his *Manual of Coal and its Topography*, his *Iron Manufacturers' Guide*, and other works and papers, of which a list is given.

Nevertheless, in the two volumes of biography we learn from letters and diaries a good deal of geological interest about Lesley, his methods of work, his many journeys to Europe, and of men of science he met; and we are impressed not only by his unflagging industry, interrupted though it was by periods of illness, but likewise by the happy home life and general interests of both Lesley and his wife. After serving about three years with Rogers he resigned his official appointment, and completed his theological training. He then laboured for the American Tract Society, became pastor of a Congregational Church, and finally was converted to Unitarianism. During this period of about ten years he was occasionally employed by Rogers in field-work and in preparing maps and sections for the Report of the First Geological Survey. After its publication in 1852 a coolness arose in the friendship between Rogers and Lesley owing to the unfortunate omission on the part of the Director to acknowledge adequately the large share of work performed by his various assistants. Mrs. Ames remarks—"Very possibly this fact was not due to an ungenerous intention, but to the theory that, since the responsibility of a survey rested on the head of that survey, to him also was due the credit of the work done." Lesley put the matter right in a subsequent publication, and Rogers never spoke to him again.

The records of his many journeys to this country and various parts of Europe, also to Egypt, are full of interesting observations and reminiscences. In his first journey in 1844 he met Elie de Beaumont and von Buch, and on subsequent expeditions he saw much of Desor, whose acquaintance he made in America in 1851, and whose genial company, as he remarked, was "enough to keep a dozen men in humour". Later on, at Desor's chalet at Combe Varin, near Neuchâtel, he had many "jolly times"; and it is mentioned that the road leading to the house was bordered by tall trees of various kinds on which names of distinguished visitors were from time to time inscribed.[1]

We read of Barrande, who in 1851 had "been able to throw 20 species and 12 genera into *one*", and wish that such a process could be continued; and we find many memoranda about Lesquereux, the distinguished botanist. He was son of a watchmaker at Neuchâtel, and early in his career was professor in the University of Stuttgart, but becoming stone-deaf he had to abandon his post, and his health was for a time broken. It is touching to learn that his wife "laid aside all the prejudices of her early education, and with astonishing perseverance learned a branch of the watch-making trade, and supported her husband and five children for nearly three years". Lesquereux recovered his health, but not his hearing, and settled for the sake of his family in the United States, where he became renowned for his researches on fossil plants.

An interesting account is given by Lesley of a dinner with the Royal Society Club in 1863, in which year also he met Dr. Percy, who "was waiting for me in his study, and at once made me at home with cheroots and a glass of sherry". They had much to discuss concerning iron-ores.

He saw the *Archæopteryx* from Solenhofen with Owen, who thought that the remains included "the front jaws of some fish which the bird has eaten".

There are reminiscences also of Sir Henry Holland, of Ramsay, and Sir William Hooker, as well as of a visit to Lyell when he had a children's party in 1863, and there were present Leonard Horner, Darwin, and Bishop Colenso.

Lesley dined with the Geological Society Club in 1864, meeting Murchison, Lyell, Lord Enniskillen, Ramsay, and others; but it is noted that W. J. Hamilton was "perpetual Secretary" and Smyth "Clerk", whereas both were Secretaries for the time being.[2]

Again, we find Lesley at the International Geological Congress in Paris in 1878, and he mentions that at one meeting when Hébert presided, "Everybody talked all at once. Three sometimes spoke vehemently without listening to each other. Total absence of parliamentary rules." There are reminiscences also of meetings with Gosselet, Heim, Barrois, and others.

During many years Lesley was very fully occupied in making reports for companies and private individuals on coal, iron-ore, and petroleum. In 1872 he was appointed to the Chair of Geology in the School of Mines at the University of Pennsylvania, and in 1874 he became State Geologist. Of his great work in connexion with the Second Pennsylvanian Survey, Mr. J. J. Stevenson has remarked—"He was

[1] It is to be regretted that no obituary notice of Desor appeared either in the Quarterly Journal of the Geological Society or in the GEOLOGICAL MAGAZINE.

[2] We have noticed few other mistakes; but in vol. i, on p. 244, the "Dean of York" should be Dean of Westminster (Buckland), on p. 445 "Leyme" should be Swanage, on p. 446 "Riggs" should be Trenham Reeks, and in vol. ii on p. 74 "Hapley" should be Huxley. Mrs. Ames was evidently in doubt about some of these names, owing to difficulty in reading the MS.; but her work bears evidence of scrupulous care.

head rather than director. An assistant once appointed was left practically to his own devices; but there was something about the personality of the director that impelled each one to do faithful work, that made the unambitious man ambitious." Lesley did all he could to encourage his men to work well and accurately, and spared no pains to make the published maps and reports worthy of the State. It was observed by one of his assistants, Dr. H. M. Chance, that "probably no public organization was ever less bound by the red-tape of officialism".

More than 120 volumes of Survey Reports passed through Lesley's hands, and eventually he undertook a "Final Summary Report", publishing two volumes and preparing a portion of the third and last volume, embracing in all more than 1800 octavo pages; but failing strength forbade the completion of the concluding chapters, the writing of which was delegated to others.

In an autobiographical letter written by Lesley to a friend in February, 1882, he modestly remarks—"The only original ideas in geology for which I could venture to claim credit are, (1) the determinations of the present system of surface drainage by the dimpled form of the plicated original surface; and (2) the production of all modern topography chiefly by the underground dissolution of limestone strata, of all ages." These remarks, which we presume were based on his Pennsylvanian work, will be of interest to those who in recent years have given attention to the subject.

The very ample record which Mrs. Ames has given in these two volumes is sufficiently varied to attract many readers interested in art, theology, and politics, as well as science. There are memoranda relating to the Civil War and other momentous matters; but the chief interest is the biographical study of two high-minded individuals. While it is pleasant to read of Lesley's "intense interest in his profession, his real love of and satisfaction in hard work, his delight in nature", it is pleasant also to read of his charming helpmate, and of the closing tranquil years which they spent together in their country home at Milton.

H. B. W.

II.—What is a Mineral?

THIS question forms the title of an interesting essay by Professor J. W. Gregory (Trans. Inst. Mining Eng., read February 10, 1909). The subject is one that has for many years proved attractive to lawyers and scientific witnesses; it was referred to in the Geological Magazine for December last (p. 564) under the heading "Is China Clay a Mineral?" and it is of special concern in connexion with the present Parliamentary Budget and the question of "ungotten minerals".

Professor Gregory has entered very fully into the definitions given by various authorities, and shows that all the explanations of what is meant by a mineral fail from a scientific point of view, whether we speak of simple minerals or mineral species as distinguished from rocks. Thus physical properties, chemical composition, and crystalline structure cannot be relied upon when we consider opal, serpentine, and wad, the felspars, apatite, and tourmaline, as in geometric form or composition they afford no support to precise definitions.

The question of most importance at the present day is what is a mineral from the commercial point of view. In regard to mineral rights, "coal, ironstone, slate, or other minerals" are usually specified in legal documents, and, as Professor Gregory remarks, none of these are really mineral species. In official publications, in the Mining Statistics formerly issued by the Geological Survey (see pt. ii for 1858), various clays, as well as chalk, building-stones, sand, etc., were included under "Earthy Minerals"; and in the present reports issued by the Mining Inspectors of the Home Office practically everything mined or quarried is included under the heading of "Mineral Products".

The result is that every geological formation, and practically the whole of the British Islands, might be considered to contain "ungotten minerals" at a greater or less depth. A common-sense list of all such minerals seems impossible, and therefore in the case of legal documents it would seem necessary in future to specify every mineral of which the right of working was reserved, and to omit the vague reference to "other minerals". In the new Parliamentary Budget (as it stands at present) sand, gravel, chalk, and common brick-clay are to be exempted from duty. As remarked by Professor H. Louis, it is possible that common clay may some day be utilized as a source of aluminium; moreover, in some places it may be difficult to separate "common brick-clay" from terra-cotta clay, or other clay that may be put to special use. Seams of coal that cannot now be worked with profit may be mined in the course of time.

Professor Gregory concludes that "A mineral of commercial value may be defined as a constituent of the earth's crust which, if organic in origin, has been altered by fossilization, and which has a value of its own apart from its value as a soil or as a support"; and that the question "when a surface-material acquires such economic value that it should be included in the category of commercial minerals must be determined for each case as it arises, but should occasion no serious difficulty".

III.—The Seventy-fifth Anniversary of the Mining Journal.

THE *Mining Journal*, which claims to be "the oldest Mining Paper and the Pioneer of the Technical and Trade Press of the World", has issued a seventy-fifth Anniversary Number, August, 1909. We take it that it is the oldest existing paper devoted to the subject, inasmuch as it absorbed at an early date *The Mining Review*, which had before been published quarterly. The career of the present journal coincides practically with the history of modern mining. The opinion is expressed that "the mining output of the past ten years is equal to that of the whole previous history of the world". Coal, iron, copper, zinc, and gold, as well as manganese, aluminium, nickel, oil, nitrates, and phosphates, are included in the estimate.

Some unfavourable comparisons are made between the economic work done by the United States Geological Survey and by that of Great Britain, "so far as regards metalliferous work at any rate"; but since the time of De la Beche a good deal of economic work has been done by the Survey in this country, notably on iron-ores, and more recently on the metalliferous regions of West Cornwall, while many memoirs relating to coal and coal-measures, water-supply, building-stones, etc., have been published. In fact as much has been done as possible with the meagre financial support accorded to the Geological Surveys in Britain.

The present anniversary number of *The Mining Journal* contains, in addition to sundry trade reports, particulars of mining in various parts of the world, together with interesting articles on "Mining Engineers Past and Present", by J. D. Kendall; on the "History of Mining in Australia", by F. D. Johnson; and the "History of Mining in New Zealand", by Professor James Park.

IV.—The Battle of Land and Sea on the Lancashire, Cheshire, and North Wales Coasts, with special reference to the origin of the Lancashire Sandhills. By William Ashton. Second edition. 8vo; pp. vi, 217. Southport: William Ashton and Sons, 1909. Price 1*s*. 6*d*. net.

THE first edition of this work was issued in May of the present year, and the second edition, revised and with additions, in July. It has had the advantage of following the Report of the Royal Commission on Coast Erosion (1907), and the author acknowledges help received from T. Mellard Reade and Joseph Lomas, whose deaths we have had so recently to deplore. Mr. Ashton gives full particulars of the losses of land and other changes along the north-western coasts, and has illustrated his subject with numerous maps. Cheshire has suffered more by coast erosion than other counties dealt with. The author maintains that the chief source of the Lancashire sand-dunes is the river-borne sedimentary matter brought from the Millstone Grit of the Pennine Range, and he was supported in this view by microscopic examinations of the sands made by Lomas. An index would have added greatly to the usefulness of this little book, which bears evidence of much painstaking research.

V.—Brief Notices.

1. A Century of Geological Maps of New York.—Mr. Henry Leighton has written an article on "One Hundred Years of New York State Geologic Maps, 1809–1909" (reprinted from the Fifth Report of the Director for 1908, New York State Museum Bulletin No. 133, 1909). A list of 329 maps, with index, is given, commencing with McClure's map of the United States coloured geologically in 1809. The first independent geological map of the State was that of Amos Eaton, 1830, of which a colour-printed copy is inserted.

2. Geology of the Country around Londonderry.—We have omitted to notice that the Geological Survey of Ireland, under the Department

of Agriculture and Technical Instruction, issued in 1908 a special colour-printed map and memoir of the geology of the country around Londonderry, the work of Messrs. S. B. Wilkinson, A. McHenry, J. R. Kilroe, and H. J. Seymour, under the direction of Professor G. A. J. Cole. In mapping the Drifts it was found necessary also to map (on the six-inch scale) the Igneous, Metamorphic, and Lower Carboniferous rocks. The memoir is well illustrated with photographic plates and text-figures, and contains much of scientific interest as well as accounts of soils, water-supply, and other economic matters.

3. The Queensland Geological Survey has issued a second report on "The Etheridge Goldfield", by Mr. W. E. Cameron (publication No. 219, 1909). This goldfield occupies an area of more than 13,000 square miles, the centre of the field being about 200 miles south-west of Cairns. The rocks consist of granite, quartz-porphyry, and diorite, together with altered sedimentary rocks, comprising massive white quartzites, schists, and slates, with which are associated numerous mineral veins carrying gold, silver, lead, and copper. The gold-bearing quartz veins occur, however, mainly in the granite, and the yearly average yield of reef gold since 1900 has been 9000 ounces.

4. Permian Footprints.—In an essay on "British Permian Footprints" (Mem. Manchester Lit. and Phil. Soc., 1909, liii), Mr. George Hickling endeavours to show that footprints may be used to distinguish Permian from Triassic deposits. Judging by the footprints from definite Permian strata at Mansfield and Penrith, he would group the footprint-bearing rocks of Corncockle Muir and other localities in Dumfriesshire, and those of Cummingstone in Elgin, as Permian.

5. Erosive Action of Snowfall.—In an essay entitled "Physiographical Notes, No. 1" (*Geographical Journal*, July, 1909), Mr. G. W. Lamplugh discusses the erosive conditions resulting from snowfall. He has been impressed by the great discrepancy between the effects of erosion on contiguous tracts in various parts of Ireland and in the north of England, where drumlins of boulder-clay, esher-ridges and kame-mounds of sand and gravel, and moraines of incoherent rubble, show little or no evidence of subærial denudation, while neighbouring streams have cut trenches through a great thickness of drift into the underlying bed-rock. In explanation he has been led to conclude that there was much winter precipitation of snow during the waning phases of the Glacial epoch, and that during the warmer season the gradual melting of the snow caused a gentle flow of water over the slopes, but led to powerful torrential action along the stream-channels. This explanation is well worthy of consideration, apart from other evidence that would apply in some localities, of erosion due to flood-waters resulting from the melting of ice in earlier times, or of the re-excavation of ancient buried channels.

6. Dew-Ponds.—Mr. E. A. Martin has further dealt with the subject of Dew-Ponds (*Geographical Journal*, August, 1909), and gives some analyses of the waters. The presence of sodium chloride is interesting as an indication that much of the aqueous vapour came from the sea. In the course of discussion Dr. H. R. Mill referred to

the ponds on Mill Hill and the high ground of Totteridge, which have a very restricted drainage-area, and must owe their replenishment to the same cause as the dew-ponds of the South Downs.

7. Land Forms.—Another important communication, bearing on Geology and Geography has been brought before the Geographical Society by Professor W. M. Davis (*Geographical Journal*, September, 1909). He has, in a discourse on "The Systematic Description of Land Forms", sought to persuade geographers to introduce concise methods of description and to employ precise terms for types of feature. For this purpose a knowledge of geological structure as well as the forces of erosion is necessary.

8. A New Jurassic Ammonite.—A description of a new species of Ammonite, of the genus *Stepheoceras*, was contributed by the late Dr. J. F. Whiteaves to *The Ottawa Naturalist* (May, 1909). The specimen was obtained from rocks, presumably of Jurassic age, in the Nicola Valley, British Columbia.

9. Tin Deposits in the Malay Peninsula.—In a paper on "The Origin of Tin Deposits", read by Mr. J. B. Scrivenor, before the Perak Chamber of Mines, 1909, the author concluded that the tin deposits in the Malay Peninsula conform with tin deposits elsewhere in having as their source a mass of igneous rock containing a high percentage of silica. The importance of fluorine as a reagent in the processes that led to the formation of cassiterite was emphasized, while, on the other hand, it appeared that boron was not essential in those reactions.

10. Tin Mining and Water Supply, Federated Malay States.—We have received the Annual Report for 1908, of Mr. Scrivenor, Geologist to the Federated Malay States. He deals with the question of water supply, and with the expectation that at a depth beneath the alluvial mangrove mud of the Perak River there might be found sand saturated by springs from the bed-rock of the valley. A trial-bore at Bagan Datoh has, however, encountered brackish water at a depth of 150 feet. The tin-mining receives special attention, and the Lahat 'pipe' is described as an instance of a lode-deposit which is being converted *in situ* into a detrital-deposit. The alluvial ore-deposits are likewise dealt with.

CORRESPONDENCE.

ON THE USE OF THE TERM 'LATERITE'.

Sir,—In the September number of the Geological Magazine, p. 431, Mr. J. B. Scrivenor has written objecting to the restricted and definite use of the term laterite as advocated in the *Bulletin of the Imperial Institute*, 1909, vol. vii, p. 134. Mr. Scrivenor claims that the word laterite "has been used in the Malay Peninsula for many years by a large body of engineers for what are essentially masses of iron oxide replacing portions of weathered rocks, and filling fissures in such rocks near the surface". He also claims that "laterite is an engineer's rather than a geologist's term, covering rocks of varying composition". The word has, however, been consistently used as a scientific term, and its meaning, at least so far as geologists are concerned, should be decided not by the loose usages of engineers, but by the way in which it was first defined and subsequently used by the best authorities.

The term laterite was introduced in 1807 by F. Buchanan in his *Journey from Madras, through Mysore, Canara, and Malabar.* He describes the occurrence of iron ore at Angadapuram in the hills west of Calicut on the Malabar coast, and in vol. ii, p. 436, remarks as follows:—"In all the hills of the country the ore is found forming beds, veins, or detached masses in the stratum of indurated clay, that is to be afterwards described, and of which the greater part of the hills of Malabar consists."

It will be seen that Buchanan clearly regarded the indurated clay as distinct from the iron ores. On p. 440 he continues: "What I have called indurated clay . . . is one of the most valuable materials for building. It is diffused in immense masses, without any appearance of stratification, and is placed over the granite which forms the basis of Malayala. It is full of cavities and pores and contains a very large quantity of iron in the form of red and yellow ochres. In the mass, while excluded from the air, it is so soft, that any iron instrument readily cuts it, and is dug up in square masses with a pickaxe, and immediately cut into the shape wanted with a trowel, or large knife. It very soon after becomes as hard as a brick, and resists the air and water much better than any bricks I have seen in India. . . . As it is usually cut into the form of bricks for building, in several of the native dialects it is called the brick stone (*Itica cullu*). . . . The most proper English name would be Laterite, from Lateritis, the appellation that may be given to it in science."

The laterite thus described by Buchanan is the clay-like material which occurs extensively in India as the product of one type of tropical or subtropical weathering of crystalline rocks, containing aluminous silicates, and which is essentially characterized by the presence of hydrated alumina. It has, as Buchanan says, the power of hardening on exposure, and for that reason it has been extensively used as road metal. It is to this material that the word laterite has been for many years mainly applied in India, not only by geologists, but also by engineers.

The recognition of the fact that laterite is essentially characterized by the presence of free hydrated alumina is due to Professor Max Bauer, who worked on the laterite of the Seychelles (*Jahrbuch für Min.*, etc., 1898, vol. ii, pp. 192–219).

The conclusions arrived at by Max Bauer were confirmed and amplified by Sir Thomas Holland, late Director of the Geological Survey of India, in a paper "On the Constitution and Dehydration of Laterite", published in this Magazine (Decade IV, Vol. X, 1903, p. 59), and have been almost universally adopted among Continental geologists.

We find, therefore, that Buchanan, who introduced the term laterite, attached to it a significance which is in strict agreement with modern scientific usage; and the loose application of the term to ordinary ferruginous clays, iron ores, etc., is wholly unwarranted.

From a scientific standpoint, Mr. Scrivenor's suggestion that the term bauxite should be applied to laterite in the sense here defined is not justifiable. Bauxite is a mineral name, signifying a hydrated alumina of fairly definite composition. Laterite is properly a rock name, signifying the product of a special kind of weathering; it is a complex product, essentially characterized by the presence of free hydrated alumina, but usually containing also notable amounts of titanium and iron oxides, whilst free silica is generally present, and hydrated silicate of aluminium is not necessarily absent. The amount of iron oxide is very variable; but when it becomes excessive it usually separates out in the form of concretionary iron ore. In defining the word laterite, however, Buchanan, as we have already seen, clearly distinguished such iron ore from the laterite in which it occurred; and in no case did he apply the term to material resembling that referred to by Mr. Scrivenor as "masses of iron ore".

The term laterite is used in a loose way not merely for material which is essentially iron ore and which should be described as such; it is also used by some people as a name for any ferruginous clay, sand, or gravel which may occur at or near the surface in tropical and subtropical countries. Such uses of the term are unscientific, and cannot properly be adopted by geologists, any more than they can adopt the engineers' use of the term granite to cover all holocrystalline igneous rocks, including syenite, diorite, and gabbro.

T. Crook.

Imperial Institute,
London, S.W.

"AN EGYPTIAN OASIS."

Sir,—In your review of this work (p. 477) you call special attention to Mr. Beadnell's suggestion, that a lake in the Kharga district may have been due to the letting loose of artesian waters through denudation of the once overlying impervious beds. This interested me much, as I had attributed to the same cause the formation of swallow-holes and valleys. (See "Ightham", Homeland Association, 1907, pp. 127–30, and also more fully in *Geographical Journal*, September, 1908.) It is, therefore, gratifying to have my views independently confirmed by one who has had such intimate experience of flowing artesian wells as Mr. Beadnell.[1]

I may say that before my views were published I put them forth in correspondence with some leading geologists, and they were strongly contested by some and not really accepted by any. Those who attended the Loose Valley Excursion this year of the Geologists' Association in July saw an area near Maidstone where, as I consider, this suggested method of valley formation is particularly well shown.

F. J. Bennett.

West Malling.
October 7, 1909.

[1] See also Capt. H. G. Lyons, Quart. Journ. Geol. Soc., 1894, vol. l, p. 541.

OBITUARY.

DR. FELIX ANTON DOHRN,

FOR. MEMB. R. S.

BORN DECEMBER 29, 1840. DIED SEPTEMBER 26, 1909.

It is with deep regret we have to record the death of an old and valued friend and fellow-worker, Dr. Anton Dohrn, Founder and Director of the famous Zoological Station at Naples, an institution for the study of marine organisms, the existence and maintenance of which were largely due to his genius and energy, and upon which he must have expended a considerable amount of his own private means. Born at Stettin in 1840, son of the well-known entomologist Carl August Dohrn, and brother of Dr. Heinrich Dohrn, who devoted himself to the study of malacology, Anton Dohrn was educated at Königsberg, Bonn, Jena, and Berlin, and paid especial attention to invertebrate zoology, having at the age of 27 established himself as a private teacher of zoology at Jena.

As early as 1858–60 Anton Dohrn had published various short treatises on the Hemiptera, and took his degree as a Doctor in science in 1865 by a work on the anatomy of foreign Hemiptera, published in 1866–8. During his residence at Jena, Dr. Anton Dohrn also paid considerable attention to fossil insects, and published important papers on them and upon other Arthropoda, particularly on the development of *Limulus polyphemus*, etc.—

"*Eugereon boekingi*, eine neue Insectenform aus dem Todtliegenden" (*Palæontographica*, vol. xiii, pp. 333–40, Taf.), 4to, Cassel, 1866.

"*Eugereon boekingi* und die Genealogie der Arthropodon" (*Stett. entom. Zeit.*, Bd. xxviii, pp. 145–53, pl. i [xli]), 8vo, Stettin, 1867.

"Zur Kentniss der Insecten in den Primarformationen" (*Palæontographica*, vol. xvi, pp. 129–34, Taf. viii), 4to, Cassel, 1867.

"Die embryonale Entwickelung des *Asellus aquaticus*" (*Zeitschr. Wissensch. Zool.*, xvii, 1867, xvii, pp. 221–77).

"Zur Embryologie und Morphologie des *Limulus polyphemus*" (*Jenaischen Zeitschrift*, Bd. vi, Heft iv, p. 639), Jena, 1871.

In 1870 he visited Naples and shortly afterwards founded the Zoological Station, in which he received the aid of the leading zoologists in Germany and England, and later the powerful support of the then Crown Prince of Germany, the Berlin Academy of Sciences, the British Association, and afterwards by the German Government itself. The lasting services rendered to Biological Science by Dohrn through the establishment of the Naples Zoological Station are well known. He dedicated all the best energies of his life to this work, and had in these last years been energetically supported by the German Emperor.

As the Zoological Station became more and more widely known, and the work carried on as a research laboratory for biological students better understood, the greater became the number of visitors, and the institution received considerable support from American as well as from European Universities and men of science.

In 1875 Dr. Dohrn published a work *On the Origin of Vertebrate Animals* and *On the Morphology of the Pantopoda of the Gulf of*

Naples. From 1881 to 1907 he published, in twenty-four parts, a primæval history of the Vertebrata (*Studien zur Urgeschichte des Wirbelthier Körpers*). Besides these he wrote various reports and essays on zoological stations, particularly upon that of Naples. The Royal Society's Catalogue gives the titles of fifty-nine papers by Dr. Dohrn up to 1883.

In addition to the valuable observations and records published by the Zoological Station at Naples, and the unrivalled opportunities afforded to students from colleges and universities, to whom tables for special work have been granted from time to time, the skilled scientific staff of the station have been engaged for years in the preparation and preservation of all the most delicate, difficult, and rare forms of invertebrata, such as the Cœlenterata, the pelagic forms of Mollusca, Starfishes, and Crinoidea, the Jelly-fish, Corals, Sponges, etc.; these and an infinite number of other exquisite forms of marine life have been mounted and elaborately arranged, expanded as in life, in glass jars suitable for exhibition in museums. These are some of the services to science which for nearly forty years Dr. Dohrn and his staff have carried out at Naples Zoological Station.

Numerous honours were bestowed upon Dr. Dohrn, especially by the various Scientific Societies, of many of which he was made a foreign member. The city of Naples created him an Honorary Citizen. Honorary degrees of Doctor in Science and Laws were conferred upon him from Halle, Breslau, and Cambridge. Professor von Hildebrand had just executed a bas-relief portrait of Dr. Dohrn, which his friends had intended to present to him on his 70th birthday (December, 1910).

Dr. Dohrn's health had been in a very precarious state during the past year from heart trouble. He died at Munich on September 26, and was buried at Jena on October 3. The Emperor and many of the German Princes have sent personal messages of sympathy to Dr. Dohrn's family, who have also received numerous addresses from scientific bodies in all parts of the world. We are glad to learn that his son, Dr. Reinhard Dohrn, who has represented him there during the last two years, will succeed his father in the direction of the Zoological Station at Naples. Dr. Anton Dohrn's life has been one of strenuous labour, but we may say of him, now that he has concluded his life's work, *Palmam qui meruit ferat.*

[Partly supplied by Dr. Paul Mayer and in part by a translation from the Munich *Neuste Nachrichten*, September 30, 1909.]

MISCELLANEOUS.

Addendum.—In Mr. Donald MacAlister's paper, "Association of Cassiterite and Specular Iron in the lodes of Dartmoor" (see September number, 1909, pp. 402–9), on p. 406, to legend to text-illustration, "Fig. 3.—Microphotograph of Specular Iron-Tinstone from Birch Tor," *add* magnified 28 times.

No. 546. Decade V.—Vol. VI.—No. XII. Price 1s. 6d. net.

THE GEOLOGICAL MAGAZINE

OR

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

THE GEOLOGIST.

EDITED BY

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

ASSISTED BY

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DECEMBER, 1909.

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With this Number is presented an Extra Sheet, containing Index and Title for Decade V, Vol. VI, 1909.

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

Yours truly

W. Boyd Dawkins

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. VI.

No. XII.—DECEMBER, 1909.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

William Boyd Dawkins, M.A., D.Sc., F.R.S., F.S.A., F.G.S.

(WITH A PORTRAIT, PLATE XXX.)

WILLIAM BOYD DAWKINS, who has recently resigned the Professorship of Geology and Palæontology at the Manchester University, belongs to the comparatively rare, and now dwindling, group of naturalists who have extended their energies across the borderlands of their main subjects, and have become recognized as authorities also in neighbouring territories. If Boyd Dawkins had not been famous in the realm of Geology, he would still have been a prominent figure among anthropologists and archæologists; and if he had not established for himself a name among those whose researches have enriched the data and philosophy of science, he would still have been prominent as a teacher, an organizer, and a public-spirited citizen. Forty years ago, when there were two small collections of natural-history objects in Manchester, the late Professor Huxley nominated young Dawkins as the man with the requisite amount of energy, business capacity, and scientific knowledge to organize a central institution, which now, under the control of the new University of Manchester, is an institution of importance as much to the student who requires reference materials as to the general public. Although the Manchester Museum has now attained dimensions requiring the superintendence by specialists in the three main branches of Natural History, the organization is the direct outcome of its first Curator, through whose influence mainly the money required for buildings has been obtained, and through whose attraction unique collections of materials have been secured.

In 1874 Dawkins was elected to the Chair of Geology in the then young College founded by the munificence of John Owens. Here he soon proved an attractive and inspiring teacher, supplementing the college lectures by practical demonstrations in the field. He imbued a long series of students with enthusiasm for geological work, and among them are many who have subsequently advanced the science by original research. His summer courses of field-excursions were open to others besides his ordinary students, and thus drew to Geology many amateurs who were members of the local societies. Although he resigned the Professorship last year, Dawkins still remains an active member of the controlling Committee of the

Museum, and his popular lectures in the institution attract the public as before.

Although so prominent in the world of science, Dawkins distinguished himself as a student at Oxford in classics, and became diverted to geological interests by the inspiring personality of Professor Phillips at a time when the Natural Sciences were not generally worshipped at our most ancient University. Dawkins, nevertheless, went through the honours' school with distinction, and secured the first Burdett-Coutts scholarship.

As the outcome of an agreement between two College companions and subsequent lifelong friends, the world has been enriched by two well-known works that were intended to supplement one another, namely, *A Short History of the English People*, by John Richard Green, and *Early Man in Britain*, by the subject of this note.

In 1861 Dawkins was appointed to the Geological Survey of Great Britain, and until 1869, when he was secured by the city of Manchester, was occupied in mapping the Wealden and associated formations in Kent and the Thames Valley, when he became interested in the rich mammalian contents of the cave-earths and gravels. For his work on the Pleistocene Mammalia Dawkins was elected in 1867, at the early age of 28, to the Fellowship of the Royal Society. His subsequent work followed this line of research downwards among the mammalian remains of earlier Tertiary times and upwards to the overlapping historical records, paying especial attention to the "central figure of the Pleistocene mammalia", Man. In 1882 he was elected President of the Anthropological Section of the British Association, and six years later President of the Geological Section, while in 1889 his services to Geology were recognized by the Geological Society of London with the Lyell Medal. He has also been elected an Honorary Member of societies like the Berlin Anthropological, the Academy of Philadelphia, the Natural History Society of Boston, and the Geological Society of Belgium. On retirement from the Chair at Manchester, Dawkins was elected an Honorary Professor in the University, and has since received the Honorary Degree of D.Sc.

Dawkins' papers on Tertiary Mammalia are marked not only by detailed and accurate descriptions of forms, but by a clear appreciation of the ways in which the materials described bear on palæontological science. His descriptive work cleared up the confusion into which the British Pleistocene rhinoceroses had previously fallen, he showed that the lion and hyæna found in the cave deposits belonged to living species, and he added greatly to our record of Pleistocene Cervidæ and Bovidæ. His work in conjunction with Sanford on the lion from the materials preserved in the Taunton Museum is still one of the most detailed osteological monographs of any mammal, recent or fossil. In clearing up the confusion then existing regarding the Miocene and Pliocene deer, Dawkins pointed out the gradual increase in the complexity of the antlers in phylogeny, and thus indicated the resemblance between this development and the changes which take place during the life of a modern deer.

Dawkins' interest in the deeper problems of palæontology is shown especially by his paper on the distribution of the mammoth in space and time, and by the discussions prefixed to many of his descriptive papers on Pleistocene mammals. His paper on the classification of the Tertiary Period by means of the mammalian fossils demonstrated the principle that successions of stratified deposits may be divided on the evidence obtained by a study of the gradual evolution of structure displayed by some marked group which is *en plein évolution.* The principles established in this paper were published in a more expanded form in *Early Man in Britain.*

Dawkins was the first to point out the evidence indicating the existence of two Pleistocene cave faunæ—a lower with *E. antiquus*, *Hippopotamus*, and *Rhinoceros hemitoechus*, and an upper with *E. primigenius* and *R. tichorhinus*, the two occurring sometimes in the same cave. He showed, also, that the fauna of the Forest-bed passes on to the former of these two periods, and so established for the Pleistocene records in Britain three separated divisions. He pointed out the composite character of the British Pleistocene mammals, and indicated the elements derived from the 'Arctic', 'Southern', and 'Temperate' or 'Eastern' groups, drawing on the known facts of migration to explain the apparent commingling of species following changes of climate. The long-continued researches on cave faunæ were fittingly crowned by the discovery at Doveholes in 1903 of cave mammals of Pliocene age.

The bearing of the Pleistocene data on anthropological problems is not the least important of the work done by Dawkins. His suggestions that the Eskimos are the descendants of the cave men, and that the Iberians are descended from the Neolithic people, have assisted the complicated problems of the European anthropologist, while the data gathered regarding prehistoric trade-routes and the relationship of the Mykenæan culture to that of Northern Europe during the Bronze Age are of extreme interest to the archæologist. *Early Man in Britain* became the foundation stone of researches which have since developed along many lines of thought, and this remarkable work has consequently become, not merely a popular presentation of a wide group of related subjects of human interest, but a classic to the archæologist and anthropologist.

LIST OF PUBLICATIONS BY PROFESSOR W. BOYD DAWKINS.

(Compiled by D. M. S. Watson.)

1862. "On a Hyæna Den at Wookey Hole, near Wells": Quart. Journ. Geol. Soc., vol. xviii, pp. 115–25.

1863. "On the Molar Series of *Rhinoceros tichorhinus*": Nat. Hist. Rev., vol. iii, pp. 525–38.

1864. "On the Rhætic and White Lias of Western and Central Somerset; and on the Discovery of a new Mammal in the Gray Marlstones beneath the Bone Bed": Quart. Journ. Geol. Soc., vol. xx, pp. 396–412.

1865. "On the Dentition of *Hyæna spelæa* and its Varieties, with notes on the Recent Species": Nat. Hist. Rev., n.s., vol. v, pp. 80–96.

"On the Dentition of *Rhinoceros megarhinus*, I. de Christol": ibid., p. 399, figs. 1–15.

"On the Mammalian Remains found by E. Wood, Esq., near Richmond, Yorkshire": Quart. Journ. Geol. Soc., vol. xxi, pp. 493–5.

1866. "On the Fossil British Oxen."—Part I: *Bos Urus*, Cæsar: ibid., vol. xxii, pp. 391–401.

"On the Dentition of *Rhinoceros leptorhinus*, Owen": Proc. Roy. Soc. vol. xv, p. 106.

1867. "On the Age of the Lower Brick Earths of the Thames Valley": Quart. Journ. Geol. Soc., vol. xxiii, pp. 91–109.
"On the British Fossil Oxen."—Part II: *Bos longifrons*, Owen: ibid., pp. 176–84.
"On the Dentition of *Rhinoceros leptorhinus*, Owen": ibid., pp. 213–27, pl. x.
"*Ovibos moschatus*": Proc. Roy. Soc., vol. xv, p. 516.

1868. "On the Dentition of *Rhinoceros Etruscus*, Falc.": Quart. Journ. Geol. Soc., vol. xxiv, pp. 207–17, pls. vii and viii.
"On a New Species of Fossil Deer from Clacton": ibid., pp. 511–16, pls. xvii and xviii.
"On a New Species of Deer from the Norwich Crag": ibid., pp. 516–18, pl. xviii.

1869. "On the Distribution of the British Post-Glacial Mammals": ibid., vol. xxv, pp. 192–217.

1870. "The Denbighshire Caves": Trans. Manch. Geol. Soc., vol. ix, pp. 31–7.
"On the Discovery of Flint and Chert under a Submerged Forest in West Somerset": Journ. Eth. Soc., N.S., vol. ii, pp. 141–5.
"On the Discovery of Platycnemic Men in Denbighshire": ibid., pp. 440–68, figs. and pl. xxxi.

1871. "On the Formation of Caves around Ingleborough": Trans. Manch. Geol. Soc., vol. x, pp. 106–12, figs.
"Report on the Results obtained by the Settle Cave Exploration Committee out of Victoria Cave in 1870": Journ. Anthrop. Inst., vol. i, pp. 60–70, figs. and pls. i and ii.
"On the Discovery of the Glutton, *Gulo luscus*, in Britain": Quart. Journ. Geol. Soc., vol. xxvii, pp. 406–10.

1872. "The Climate of the Pleistocene Age": Trans. Manch. Geol. Soc., vol. xi, pp. 45–52.
"On the Cervidæ of the Forest-bed of Norfolk and Suffolk": Quart. Journ. Geol. Soc., vol. xxviii, pp. 405–10.
"The Classification of the Pleistocene Strata of Britain and the Continent by means of the Mammalia": ibid., pp. 410–46.

1874. *Cave Hunting: Researches on the evidence of Caves respecting the Early Inhabitants of Europe;* London, Macmillan.
"The Limits of our Knowledge of the Earth": Owens College Essays, pp. 129–60.

1875. "On the Stone Mining Tools from Alderley Edge, Cheshire": Journ. Anthrop. Inst., vol. v, pp. 2–5, pl. i.
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II.—On a Palæolithic Implement found *in situ* in the Cambridgeshire Gravels.

By J. E. Marr, Sc.D., F.R.S.

(PLATE XXXI.)

DURING the Long Vacation of 1909, I was fortunate enough, when examining some gravel-pits in the company of Messrs. Rastall, Romanes, and Gandy, of Christ's College, to discover a Palæolithic implement, *in situ*, near Hildersham, Cambridgeshire.

As the recorded examples of implements of this age in the county are extremely few, and as the specimen which I discovered was extracted from a deposit the relationship of which to the other Pleistocene gravels is uncertain, a deposit, moreover, which is at a considerable height above the river in its vicinity, I am induced to record briefly the conditions of occurrence of the implement.

Notices of previous discoveries, with references to the original records, will be found in Mr. F. R. C. Reed's *Handbook to the Geology of Cambridgeshire* (1897), pp. 237–9, and in an article by Dr. Duckworth in the *Handbook to the Natural History of Cambridgeshire* (1904), p. 248. One of these discoveries (made by Mrs. Hughes near Upper Hare Park) must be noticed more fully. In a paper printed in the *Journal of the British Archæological Association* for 1899, Professor Hughes writes: "I know of only one authenticated case of a Palæolithic implement found *in situ*. That was dug out of the gravel on the top of Allington Hill by Mrs. Hughes. The height of this gravel above sea-level is about 150 feet." The discovery of the specimen was first recorded in *Nature* for 1884 (vol. xxx, p. 632), and it is figured in the *Archæological Journal* for 1897 (pl. iv, fig. B 9, facing p. 372).

As Messrs. Rastall and Romanes are at present engaged in the study of the Cambridgeshire gravels, I do not propose to say more concerning them than is sufficient for my purpose.

In the Geological Survey Memoir of the neighbourhood of Cambridge will be found an account of the distribution of the various gravels; those with which we are concerned are spoken of therein as "Marine Gravels and Loam" and "Gravels of the Ancient River System" respectively; the former are frequently termed the "Plateau Gravels", which name will be subsequently used in this paper.

On the Geological Survey Map the plateau gravels (coloured pink) are represented as extending in patches from the Gog Magog Hills on the north-west to Barrington Hill on the south-east, lying in the intervening tract a little to the north-east of the villages of Babraham, Little Abington, and Hildersham. The later gravels (coloured brown) extend on either side of the course of the present stream, and at no great height above it, in a continuous band, parallel with and lying to the south-west of the stretch of plateau gravels.

The plateau gravels at Barrington Hill are at a height of over 350 feet above sea-level, those on the Gog Magog Hills about 225 feet above the same level. In the Survey Memoir they are described as occurring at a lower level to the north-west of Barrington Hill, falling to their lowest point east of Babraham, and gradually rising again to the top of the Gog Magog Hills. It is in the tract where the gravels are at a lower level that the implement was found, and the fall of level between the gravels capping Barrington Hill and those which yielded the implement occurs in a comparatively short horizontal distance.

There is more than one view as to the origin of the plateau gravels, but whichever we accept it seems improbable that these gravels should contain implements, and I think that at any rate part of the gravel patch north-east of Hildersham and part of the spread of similar gravels north-east of Little Abington do not belong to the plateau gravels but consist of gravels of the Ancient River System. They are found flanking the ridge some distance below its summit, whereas the plateau gravels on Barrington Hill and the Gog Magog Hills cap the hill-summits. I believe, therefore, that further work will prove that two distinct gravels have been mapped as plateau gravels, and that the implement-bearing gravels will be found to have been deposited against the older plateau gravels.

Before visiting the pit in which the implement was found we examined two pits close to "Sand Pit Plantation" (see 6-inch map), half a mile north-north-east of Lay Rectory Farm, Little Abington, and situated about the level of the 200-foot contour-line. One of these pits contained chalky drift with many foreign boulders; the other, only a few yards away, showed coarse angular gravel and beds of angular flints with finely laminated red-brown and yellow-grey sand. The gravel here preponderated over the sand. The relationship between the deposits in the two pits was unfortunately not seen. The beds in the latter pit strongly resemble those of other exposures of river gravels.

The implement which forms the subject of this communication was found in a pit on the west side of Furze Hill, north-east of Hildersham, about 200 yards north-east of the road flanking the south-west side of the hill. This pit is also situated about the level of the 200-foot contour-line. The section seen in it was as follows:—

6. About 10 feet of angular flint gravel with seams of bedded sand.
5. About 4 feet of bedded brownish-red sand with scattered flints.
4. 6 inches of sand with small flints.
3. 2 feet of bedded brown sand.
2. 6 inches of sand with small flints. (The implement was close to the top of this bed.)
1. 3 feet seen of bedded brown sand, the beds below this being concealed by talus.

There is little doubt that these sands and gravels were once continuous with the similar deposits in the gravel-pit north-north-east of Lay Rectory Farm. The two deposits are quite similar in every respect save that in the Hildersham pit the proportion of sand to gravel is somewhat greater than in the farm pit.

The face of the pit was extremely steep, and the implement could not have fallen from above and rested where it lay, namely, on a sloping ledge about 4 inches wide, with the face of the gravel above and below nearly vertical. The greater part of one face of the implement was exposed on the ledge, and on removing the flint its 'mould' remained in semi-coherent sand. Some of this sand still remains firmly cemented in one or two little depressions of the implement. There is no doubt, therefore, as to its occurrence *in situ*.

The implement itself is well fashioned, of ovoid shape, formed of brown flint, and but little worn. The point has apparently been broken off during manufacture or when in use, for the patina on the fracture is similar to that over the dressed surface. It measures $3\frac{7}{10}$ inches in length by $2\frac{3}{5}$ in breadth at the widest part. I have deposited it in the Sedgwick Museum.

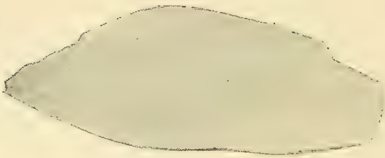
Its occurrence about 100 feet above the present river level at Hildersham is of interest, but is not contrary to what might reasonably be expected. Some 5 miles in a northerly direction lie the elephant-bearing gravels near Lark's Hall, at a height about that of the gravels we are considering. They there occur in a valley, and are traceable from thence almost continuously (save where cut through by the modern Cam near Cambridge), along the ridge of Wilbraham and Quy Church past the Observatory and away northward into the Fenland. Were it not for subsequent denudation by the Granta, the Hildersham gravels might be traceable in the same way past Babraham and Shelford, and so northward to join the gravels mentioned above, near Cambridge.

Although the implement found by Mrs. Hughes near Upper Hare Park was associated with gravels which are not inserted on the Geological Survey Map, and the views of the surveyors as to their age are therefore unrecorded, their position would suggest that they might belong to the period of formation of the Quy Church and Wilbraham gravel. It is desirable that further search should be made in these high-level gravels in various parts of the county, as was indeed long ago suggested by the late Sir John Evans (see Dr. Bonney's *Cambridgeshire Geology*, p. 56).

The Cam has eroded its valley at Cambridge to a depth of nearly 50 feet below the level of the Observatory gravels: there is, therefore, little cause for surprise if erosion has taken place to about double that amount at Hildersham. In fact (even allowing for a larger volume of water), a grade steeper than that of the present Cam, which falls about 80 feet between Little Abington and Cambridge, is probably necessary to account for the transport of the coarse flint pebbles which largely compose many beds of the Observatory gravel. The fall from 200 feet to 60 feet (which is the difference in height between the Palæolithic gravels of Hildersham and the Observatory gravels) in a distance of about 12 miles measured in a straight line, or, allowing for sinuosities, say a fall of 10 feet per mile, does not appear too much to allow for the transport of these flints.

The mere existence of an implement of the type found in the Hildersham gravel renders it unlikely that the gravel belongs to the 'plateau series', and points to its assignment to one of the older river

3



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R. H. Rastall, M.A., Photo.

Palæolithic Implement: Hildersham, Cambs.

gravels. In suggesting that it belongs to the period of the Wilbraham–Quy gravels I do not desire to hint at their strict contemporaneity. I would only submit that if separable from the plateau gravels the evidence is in favour of its being grouped with the deposits referred to by the Geological Surveyors rather under the title "Gravels of the Ancient River System" than to those which they describe under the heading of "Gravels of the Present River System."

EXPLANATION OF PLATE XXXI.

Palæolithic Implement from near Hildersham, Cambridgeshire. The view of the face, Fig. 1, is about $\frac{3}{4}$ nat. size; that of the edge, Fig. 2, about $\frac{4}{5}$ nat. size; Fig. 3, ideal section.

III.—Post-Glacial Time and Ancient Egypt.

By Edward Greenly, F.G.S.

PERPLEXING as are all problems connected with geological time, there has naturally appeared much more hope of determining the length of the period that has elapsed since the close of the great Glacial episode in the Northern Hemisphere, the period in which, indeed, we may be said to live, seeing that many processes that can be observed in action may be supposed to have gone on without interruption from the disappearance of the ice to the present day. It has proved, however, scarcely less difficult than the other problems of geological chronology. Many methods have been applied, and the results reached have been hardly less varied than the methods.

In the last few years a group of investigators, applying anew the method of Bakewell, Lyell, and others, the measurement, that is, of the rate of recession of Niagara and other waterfalls, have arrived at estimates that are surprisingly short, some of them even restricting Post-Glacial time to not more than about 6000 years.

Has it been perceived, however, that such estimates as these must of necessity bring the matter into touch with another series of chronological measurements, derived from totally distinct data, and by a quite independent group of investigators?

At a time when all the mountain-ranges of the northern shores of the Mediterranean basin were heavily glaciated, when the Alps sent out gigantic glaciers into the Plain of Lombardy, it is certain that the whole Mediterranean region must have been, in varying degrees, affected by such conditions. Not for a long time after they had passed away—after, that is, what we call the "close of the Glacial Period", when the ice had disappeared from Northern and Central Europe—can the countries along the southern shores of the Mediterranean have settled down to climatic conditions approximately like those that obtain in them to-day.

Now, the monuments of the First Dynasty in Egypt carry us back considerably more than 4000 years before the Christian era—that is to say, more than 6000 years before the present time—and these monuments are those of a thoroughly settled and civilized people. But behind this time lies the period of the prehistoric culture, which, in the opinion of the best authorities such as Professor Flinders Petrie, must have extended not less than some 2000 or 3000 years further back still — that is, to some 8000 or 9000 years from now. And Professor Flinders Petrie informs me that neither in the remains of the historic nor of the prehistoric period can he find any evidence of a climate that was appreciably different from that of Egypt at the present time. If, then, the estimates of Post-Glacial time that are under consideration can be accepted, we must suppose that large, civilized, agricultural populations lived and moved and had their being, built the monuments and left the legible inscriptions that have come down to us to-day, utterly unaffected, during a period of some 3000 or 4000 years, by the gigantic changes of climate that were in progress no further away than the northern shores of the Mediterranean!

During the past thirty or forty years we have been told so many times that this or that consideration, generally a physical one, imposed an absolute limit on some piece of geological chronology, that geologists may well pause before insisting that archæology can impose a limit of another kind. The history of speculation upon geological time may well serve to sober the boldest of calculators. Nevertheless, there does seem reason to think that the records so wonderfully brought to light from Ancient Egypt may aid us in the solution of a vexed question in geology, even as they are now doing with regard to vexed questions in other subjects of research.

IV.—On some Dry Chalk Valley Features.

By R. H. Chandler.

THE existence of a 'wind gap' or 'pass' at the head of a dry dip valley clearly points to the former extension of that valley beyond the present escarpment; and the depth of the gap is a measure of the size of the valley before being beheaded by the recession of the escarpment. Thus the gap at Merstham is about 300 feet deep, and the valley would probably have continued south some miles on to the Wealden uplands; the floor of this valley falls regularly north, and presents all the features due to a stream flowing in that direction previous to the formation of the Gault strike valley. As an instance of a less developed beheaded valley, the Maplescombe valley, which joins the Darent valley on the right bank at Farningham, may be instanced. The Maplescombe valley has a 'wind gap' of possibly 100 feet deep, and so its former southward extension would not have continued into the Wealden area as far as the Merstham valley; moreover, the floor does not slope regularly to the Darent, but is steepest at the head, the distance between each contour-line increasing as one descends the valley, viz.—

600 to 500 in 1700 feet, or fall of 1 in 17.
500 to 400 in 3000 feet, or fall of 1 in 30.
400 to 300 in 5300 feet, or fall of 1 in 53.
300 to 200 in 7200 feet, or fall of 1 in 72.

The present valley floor, particularly the upper part, is evidently not the one down which a stream from the Weald would have flowed, for at the above noted rate of increased slope the valley would 'run out' (or become extinct) at a very few hundred yards south of the present Chalk escarpment, and this short length is not compatible with the excavation of a valley 100 feet deep, such as the present wind gap.

A feature that appears to have been overlooked, by the various geologists who have written about this subject, is that the beheading of 'dry' Chalk dip valleys, by the formation of strike Gault valleys behind them, would cause a lowering of the saturation level of the Chalk; and as the Gault would probably be rapidly excavated, the lowering of the saturation line of the Chalk would be proportionately rapid.[1]

Now the early dip stream initiating the 'dry' valley system would doubtless flow at about the level and the gradient of the line of saturation in the Chalk at that time, so that when the valley was beheaded, and the saturation level lowered (owing to the Gault Stream), the springs in the 'dry' valley would be thrown out at successively lower levels, and by the upper parts of the valley being dry earlier than the lower, and the well-known action of springs in cutting backward, thus forming a steep bank behind, it is here proposed that the present progressive increased steepness of the valley floor upward may be explained.

The characteristic deposits of gravel, consisting of angular and little-worn flints, few Tertiary pebbles, and occasional pieces of Lower Greensand chert and ironstone, in a clayey matrix, found on the floors of these valleys, seem to show that very little of it was formed by ordinary river action, but that the deposit was due to the dissolution of the chalk from around the flints by a stream of water without much transporting power, such as might take place by a flow parallel to and below the valley floor,[2] and each such flow by lowering the chalk and leaving the unworn flints would deepen the deposit of 'dry valley gravel' found in these situations; added to which the occasional existence of a 'bourne' would account for the presence of bedding rarely shown by this gravel.

Anything more unlike ordinary river gravel than this 'dry' valley gravel it is difficult to imagine, and as bournes do occasionally break out it seems reasonable to suppose that when the bourne is not visible at the surface it is flowing some distance underneath, dissolving the chalk and leaving the insoluble constituents. The Lower Greensand and other water-worn material are the relics of the early stream (or they may be from the immediate 'plateau'), and the clayey part of the drift is the insoluble residue of the chalk and the rainwash from the slopes on either side.

Features due to the early river action (as distinguished from the later or bourne features) may be found in the general configuration of the valley, and more especially in the upper (and older) parts of the sides where steep banks occur alternately on either hand, due to the river cutting into its banks on the outer part of its curves.

[1] The saturation line consisting of two curves meeting at some distance in from the escarpment on the dip side, a gentle slope down the dip, and a steeper one falling towards the escarpment. It is the lowering of the point of intersection of these two curves, and the movement of this point in the direction of the dip, that is here spoken of as the lowering of the saturation level in the Chalk.

[2] *Vide* Prestwich, *Water-bearing Strata of London*, 1851, p. 132.

V.—On some Middle and Upper-Lias Sections near Batcombe, Somerset.

By L. Richardson, F.R.S.E., F.G.S.

IN 1906 I described, in this Magazine,[1] a section at Maes Down, between Evercreech and Doulting, in which the Marlstone of the Middle Lias and certain Upper-Lias beds were exposed. The main interest of this section lay in the fact that the beds exposed occurred in a tract that had been mapped as Inferior Oolite resting upon Midford Sands, and these in turn directly upon the Lower Lias without the intervention of any Middle Lias. Naturally it was wondered what had become of the Middle Lias. This Maes-Down section therefore proved the presence of typical Marlstone and certain basal Upper-Lias beds (consisting of thin alternating layers of clay and limestone), while on the higher ground, above the level of the quarry, are unmistakable signs of Midford Sands.

Although I have inspected the hill-slopes between Maes Down and Chelynch (on the slopes of the Mendips), I have failed to find any exposure that throws light upon the probable northerly extension of the Middle Lias, or the relations of that stage to the Lower Lias.

The Midford Sands, however, are very fairly exposed at the top of the bank on the south side of the road, close to the south-eastern corner of the Doulting Sheep Sleight; and ammonites indicative of *striatuli* hemera have been procured from a limestone-bed in the bank by the side of the main-road, where it climbs the hill between Shepton Mallet and Doulting.[2]

In the hills between Maes Down and Bruton it is probable that the sequence is everywhere in ascending order: (1) Marlstone; (2) Upper-Lias clays and limestones; and (3) Upper-Lias Sands. The Marlstone and basal Upper-Lias clays and limestones are excellently displayed in the quarry at Small Down, and in that in Westcombe village, near Batcombe; while the Sands are deeply-incised by the lane that descends Lamyat Beacon in the direction of Week Champflower.

Sir Henry de la Beche assigned a thickness of 21 feet to the Marlstone at Scale Hill, near Batcombe, and estimated the thickness of the Upper-Lias deposits at 66 feet.[3] Commenting upon Sir H. de la Beche's estimates, Mr. H. B. Woodward, F.R.S., writes that the "Marlstone, although present, does not appear to comprise a mass of strata 21 feet thick, as stated by him".[4] It may be too liberal an estimate (if it does not include the underlying "sandy beds" of the Middle Lias), but still the Marlstone is very well-developed in this neighbourhood, as the two sections I am about to record demonstrate.

The first section to notice is that on the western slope of the camp-crowned hill, about half-a-mile to the south-east of Chesterblade. Locally, it is called the "Small-Down Quarry". It is a little difficult to indicate on the one-inch Geological Survey Map, sheet xix,

[1] Geol. Mag., Dec. V, Vol. III, 1906, pp. 368–9.
[2] Quart. Journ. Geol. Soc., 1907, vol. lxiii, p. 391; Geol. Mag., 1908, p. 510 (footnote).
[3] Mem. Geol. Surv., 1846, vol. i, p. 280 (footnote).
[4] Mem. Geol. Surv., 1893, vol. iii, p. 207: "The Jurassic Rocks of Britain: The Lias of England and Wales (Yorkshire excepted)."

its precise position, because the topographical information is none too detailed, but it certainly comes within the area mapped as Upper Lias, if not actually on the Inferior Oolite. I have not investigated the hill above Small Down with a view to mapping the distribution of the various beds, but it appears as though the deposits mapped as Midford Sands are really the "sandy beds" of the Middle Lias; the Inferior Oolite, the Marlstone; the Lower Fuller's Earth, the Upper Lias (clays and limestones and sands); and the Fuller's-Earth Rock, Inferior Oolite. The beds on the top of the hill have a north-north-easterly inclination, dipping down towards the great fault that has so conspicuously depressed the beds to the north of it, and whose westerly continuation is the probable cause of the Marlstone of Maes Down being on about the same level as the Inferior Oolite to the north.

SMALL-DOWN QUARRY.

				Thickness in ft.	in.	
Toarcian.	*Lilli*	1	Limestone, rubbly, earthy, brownish, with dark-brown iron-specks: seen	1	0	*Hildoceras semipolitum*, S. Buckman, *Rhynchonella* cf. *Moorei*, Davidson, *Belemnites* spp.
		2	Parting	0	0½	
	Bifrontis	3*a*	Limestone, bluish-grey and brownish, with dark-brown ferruginous granules	1	10	*Hildoceras hildense*, (Young & Bird), *Nautilus* sp., *Belemnites* spp., *Astarte* sp., *Hinnites velatus*, Goldfuss.
		3*b*	Parting	0	0½	
	Falciferi	3*c*	Limestone, similar to 3*a* .	0	8	*Harpoceras elegans* (J. Sowerby), *Dactylioceras* cf. *vermis* (Simpson), *Belemnites.*
		4	Clay, dark-purplish, with rolled fragments of ammonites common at the top: 3 to 7 inches	0	5	*Harpoceras* cf. *exaratum* (Y. & B.), *H.* cf. *falciferum* (J. Sow.), *Rhynchonella jurensis* (Quenstedt).
	?Falciferi	5	Limestone, brownish-grey, somewhat sparsely iron-shot, in lenticular nodule-shaped masses, and often in two layers fitting into the irregularities of the Marlstone	0	6	*Dactylioceras gracile*? (Simpson)
		6	Clay: 0 to 1 inch . .	0	1	
Pliensbachian		7	Marlstone: seen . .	5	0	*Belemnites*, very common in the top layer: usual fossils.

A comparison of this section with that at Maes Down will show the similarity of the deposits; the dark-purplish clay-bed being an easily-identifiable horizon. At Small Down there is a higher bed exposed than any at Maes Down, and the ammonite *Hildoceras semipolitum*, S. Buckman, shows that it is of *Lilli* hemera.

The quarry at Westcombe displays a long face of Marlstone capped with a few feet of Upper Lias. Probably it was from here that the rock-specimen of Marlstone which is preserved in the Jermyn Street Museum was obtained.[1]

WESTCOMBE QUARRY, NEAR BATCOMBE.

				Thickness in ft.	in.	
TOARCIAN.	*Bifrontis* and ?part *falciferi*	3	Limestone, much disturbed, grey-brown, with yellowish iron-granules, full of specimens of *Hildoceras hildense* (Y. & B.), shell-fragments and belemnites: seen	1	3	*Pseudolioceras elegantulum* (Y. & B.), *Hildoceras hildense* (Y. & B.), *Dactylioceras holandrei* (d'Orb.), *Peronoceras desplacei*? (d'Orb.), *Cincta Lycetti* (Davidson), *Rhynchonella jurensis* (Quenstedt), *Terebratula* sp. (probably new), *Syncyclonema* sp.
	Falciferi	4	Clay, bluish-grey: 4 to 6 inches	0	5	
		5	Limestone, greyish-blue .	0	3	*Harpoceras* sp.
		6	Clay, bluish-grey: 0 to 1 inch	0	0½	
Pliensbachian		7	Marlstone, top layer full of specimens of *Terebratula punctata*, Sow., and belemnites: seen	5	0	*Amaltheus* (fragment), *Paltopleuroceras* sp., *Rhynchonella amalthei* (Quenstedt), *Rh. tetrahedra* (Sow.), *Terebratula punctata*, Sow., *Ornithella indentata* (Sow.), *Ostrea sportella* (E. Dumortier), *Protocardia truncata* (Sow.), *Syncyclonema* sp., *Pseudopecten æquivalvis* (Sow.), *Chlamys Humberti* (Dum.), *Pleuromya Jauberti*, Dum.,[2] *Plicatula pectinoides* (Lamarck),[3] *Cryptænia expansa*, Sow.

Summary.—In the neighbourhood of Batcombe the Marlstone of the Middle Lias is typically developed, and is succeeded by thin alternating layers of clay and limestone, which are in turn followed by pale-yellow fine-grained sands—near Bruton, of considerable thickness.

VI.—ON THE TYPE-SPECIMEN OF *PSEUDOMELANIA VITTATA* (PHILLIPS).

By J. WILFRID JACKSON, F.G.S., Assistant Keeper of the Manchester Museum.

I HAVE recently had the good fortune to come across the lost type-specimen of Phillips' *Melania vittata* in the course of going through the contents of one of the reserve cabinets in the Manchester

[1] Mem. Geol. Surv., 1893, vol. iii, p. 207: "The Jurassic Rocks of Britain: The Lias of England and Wales (Yorkshire excepted)."

[2] *Études Pal. sur les Dépôts Jurassiques du Bassin du Rhone*, 1869, 3ième pt., pl. xxix, fig. 8.

[3] Ibid., pl. xl, fig. 7.

Museum. The specimen was along with a number of others which formed part of the late Professor Williamson's collection, and my attention was drawn to it being the type by seeing a label attached bearing the following inscription: "This specimen is figured in Phillips' *Geol. York.*, pl. 7, fig. 15." A comparison with Phillips' figure confirmed this fact.

On referring to the second edition (1835) of the above work, pp. 116 and 181, it will be seen that the species was founded on a specimen from the Cornbrash of Scarborough, in Mr. Williamson's collection, i.e. John Williamson, the Professor's father. The species, Mr. B. B. Woodward tells me, is also figured in the first edition of the *Geology of Yorkshire* (1829), on pl. 7, fig. 15, and is given among the Cornbrash fossils on p. 145, and in the list of plates, p. 189, but is nowhere actually described.

Phillips, in his explanation of the plates (2nd ed., p. 177) says the specimens in the Williamson collection figured by him in his work have since been transferred to the Scarborough Museum. It would appear, however, that the type-specimen of *Melania vittata* was, for some unknown reason, not transferred along with the others.

The late Rev. J. F. Blake, in his description of the species,[1] appears to have noticed the absence of a type-specimen in the Scarborough Museum, as he states: "Type is constituted by Phillips' figure only." It would thus appear that Blake came to the conclusion that no actual type-specimen existed.

The present is a good opportunity to call attention to a mistake made by both Blake[2] and Hudleston[3] in the date of Lycett's[4] description of this species. Both authors give 1853, whereas date should be 1863, otherwise the "Supplement" reads as if published before the "Monograph" of 1854. It is evident from the similarity of the mistakes that Blake copied Hudleston.

VII.—The Old Granites of the Transvaal and of South and Central Africa, by Cuthbert Baring Horwood, A.R.S.M., Assoc. M.Inst.C.E., F.G.S., with a Petrographical Description of the Orange Grove Occurrence, by Arthur Wade, B.Sc. (Lond.), A.R.C.S., F.G.S.

(*Concluded from the November Number, p.* 507.)

MR. GEO. G. HOLMES[5] and others have observed the remarkable and highly suggestive fact that not only do the schists (which contain in many places interlaminated beds of quartzites and massive crystalline limestone, e.g. in the Dwarsberg on the Magalakwin River in the Northern Transvaal) appear interbedded in the gneisses, but that the strike foliation and planes of schistosity of these old schists and of the gneisses seem invariably to be parallel.

This in itself appears to me to be strong evidence that these old

[1] *Fauna of the Cornbrash* (Pal. Soc.), 1905, p. 77. [2] Loc. cit., p. 77.

[3] Geol. Mag., 1882, p. 244.

[4] "Suppl. G. O. Mollusca" (Pal. Soc.), 1863, p. 14.

[5] Personally communicated. Also *vide* "Some Notes on the Geology of the Northern Transvaal", by Geo. G. Holmes (Trans. Geol. Soc. S.A., 1904, vol. vii, pt. i, p. 52), and A. W. Rogers, loc. cit., p. 41.

schistose rocks were laid down on an old fundamental basement granite before the earth-movements occurred which induced the gneissoid structure of the granite; and it is therefore to the same causes which produce this gneissoid character that the schistose and foliated nature of these rocks is due.[1] Further, that the gneiss and schists have been so fractured, crumpled, and tilted, that a pseudo-stratification or interlamination of gneiss and schists has been produced.

Mr. Holmes has shown that these earth-movements have certainly extended up to later times than the Pretoria period. Thus, with reference to the South-Western Transvaal, he writes[2]—

"The most noticeable feature in the structure of this part of the country is a folding of the formations, the axis of which has a general north and south direction, due to pressure acting east and west. The main axis passes near Schweizer-Reneke northwards to the Kunana Reserve, along which line we find exposures of the primary granite. This line also divides the two great synclines of Dolomite and Pretoria Beds, one of which extends over the Kaap Plateau in Bechuanaland and the other over the North-Western Transvaal in the Marico and Rustenburg districts.

"It is noticeable that this axis is coincident with the lamination of the gneiss, and that the pressure was prolonged in the same direction for a long period, acting most intensely on the oldest rocks; thus, whereas the quartzites immediately beneath the diabase at Schweizer-Reneke show comparatively gentle folding, the shales of Abelskop are crushed and folded to a great degree in the same direction."

I find that Mr. A. W. Rogers,[3] in describing the 'Keis Series[4] of Cape Colony, has given expression to a similar opinion with reference to the granite and gneiss and the quartzites and mica-schists which compose the 'Keis Series. He says—

"Along the greater part of their course the 'Keis Beds are flanked on either side by granite or gneiss, and areas of these rocks also occur in the heart of the series at Kaboom, Brakbosch Poort, and probably other places. At Boschiesman's Berg and Van Wyk's Pan tongue-shaped masses of gneiss project into the series from the great granitic area. These tracts of igneous rock are elongated in the direction of the strike of the 'Keis Beds, and the foliation and planes of schistosity of the two rocks are parallel.

"On Grenaat's Kop there is an inlier of 'Keis Beds surrounded by the Dwyka conglomerate, and a comparatively narrow dyke of granite traverses the inlier in a direction at right angles to the strike of the latter. The Grenaat's Kop dyke is the only clear case of intrusion of the granite in the 'Keis Series seen in the district. In other parts the contact of the igneous and sedimentary rocks has not been seen, owing to the thick covering of sand, and it would be possible to account

[1] It would seem probable that the later granitic intrusions were due to these same earth-movements.

[2] "The Geology of the South-Western Transvaal," by Geo. G. Holmes: Trans. Geol. Soc. S.A., 1906, vol. ix, p. 95.

[3] *The Geology of South Africa*, by A. W. Rogers, 1905 (Longmans, Green, & Co., London), p. 67.

[4] The geological horizon of these beds is above the Namaqualand schists, from which they are probably separated by an unconformity.

for many of the facts observed on the supposition that the 'Keis Series was deposited upon a floor of granite, and that at some subsequent period the rocks were intensely folded, so that on the one hand ridges of gneissose granite were formed projecting into the quartzites and schists, and on the other steeply folded synclines of the sediments went down into the granite."[1]

Mr. William Anderson, late Government Geologist of Natal, divided the Old Granites of Natal and Zululand into (1) fundamental granites, with gneisses and schists, and (2) newer intrusive granites.[2] The old crystalline schists, hornblendic, and other varieties, relics of a metamorphosed sedimentary formation, with interlaminated, coarsely crystalline limestones, he correlates with the Swaziland Series,[3] and thinks that the metamorphism of the limestone[4] is due to the intrusion of the granite. The gneisses he regards as probably sheared portions of the granite.[5]

The following is taken verbatim from his second report on the geology of Natal and Zululand:[6]—

"The granites, with their accompanying gneisses, schists, and less altered quartzites, conglomerates, etc., which are so well developed in the sub-coastal areas of Natal, the Engoye Mountains, and the Melmoth district of Zululand, present characters which are well worthy of mention. In these localities the occurrence of the granite among the gneisses and schists is remarkable, in that it is of a most erratic character. In the Engoye Mountains to the north-east of Eshowe it is present as a more or less distinct axis to the range, where it is flanked on either side by gneisses and schists. The less metamorphosed rocks of this series to the east and west of the range are not often visible, being covered by the newer formations; but at the Matikulu River mouth in Zululand a small outcrop of granite occurs, and to the north-west, after crossing the Umhlatuzi River, the large area of the Melmouth district is formed of similar granitic and metamorphic gneisses and schists. Here the granite is not of the ordinary character of a simple intrusion, but is present on the outcrops as local areas among the gneisses and schists.

"In the Inchanga and Inanda districts of Natal the porphyritic granite there shows far more evidences of having been a locally intruded granite, while in the Engoye Range this feature appears to a less degree.

"The gneisses and schists associated so intimately with the local areas of granite seem to be quite distinct from the metamorphic slates,

[1] The origin of the Witwatersrand syncline can be explained in a similar manner.

[2] Second Report of the Geological Survey of Natal and Zululand, by Wm. Anderson, F.R.S.E., Government Geologist, 1904 (West, Newman, & Co., London), p. 13.

[3] Third and Final Report of the Geological Survey of Natal and Zululand, by Wm. Anderson, F.R.S.E., Government Geologist, 1907 (West, Newman, & Co., London), pp. 108–13.

[4] He says this limestone has undoubtedly originated as a sedimentary deposit, loc. cit., p. 111.

[5] Loc. cit., pp. 109, 113.

[6] Second Report of the Geological Survey of Natal and Zululand, by Wm. Anderson, F.R.S.E., Government Geologist, 1904 (West, Newman, & Co., London), pp. 11, 12.

quartzites, jasperoid rocks, and conglomerates which are present in the west of Zululand in the Nkandhla and Tugela Valley districts. The petrological character and mineralogical composition of the granites forming these erratically disposed areas usually vary much, and there seems little doubt that the gneissic and schistose series of rocks is of a much greater age than the metamorphic rocks, quartzites, jasperoid rocks, etc., above mentioned, and probably represents the oldest rocks of the Continent, the original basal series of this part of the world, which formed the backbone of Africa upon and around which all the younger sedimentary formations have been deposited."

He then says: "Whether this most ancient series of granites, gneisses, and schists are the same as the Namaqualand gneisses and schists I cannot yet say, but my friend Dr. Corstorphine informs me that lately he has identified a similar series of granitic gneisses and schists on the Limpopo River, to the north of Pietersburg. His description of the occurrence and character of these rocks on the Limpopo tallies exactly with this series on the East Coast which I have just mentioned."

Having now passed in review the most important work done on the Old Granites of South Africa during the last ten or eleven years, before summarizing the chief deductions which may be drawn from it, I will, very briefly, say a few words on the scenic and economic aspects of the gneiss and granite areas.

Scenic and Economic Aspects.

In describing the pre-Cape rocks of the south and west of Cape Colony, Mr. Rogers[1] states that the masses of granite and gneiss form the highest ground, with the exception of outliers of Table Mountain sandstone. In Griqualand West and Prieska they form most of the lower-lying country, seldom rising far above the generally sandy ground in hills or 'tors' as the granitic rocks do in Bushmanland and in the south-west districts of the Colony.[2] I have also noticed this feature of the granite country in the Prieska district, and have observed that as one travels further east the granites of Upington and of Southern Gordonia, generally near the borders of German South-West Africa, frequently rise into 'tors' or bare rugged hills, especially the more massive varieties.

In the Congo territory described by Preumont and Howe[3] the country is, of course, mostly covered with equatorial forest and the ground with a heavy layer of surface soil, so that outcrops are few and far between. The greatest elevations (3300 to 4000 feet) are attained in the Nile–Congo watershed. In the south-east and north-east the country is hilly or even mountainous; westwards it gradually becomes lower and monotonous, with broad undulations, out of which rise in places groups of isolated hills. A large extent of the Uelle district is very densely wooded; to the north of this forest area it consists of vast plains covered with grass and scrub, pierced by broad valleys covered with forest growth following the watercourses.

[1] *The Geology of Cape Colony*, by A. W. Rogers, 1905 (Longmans, Green, & Co.), p. 38.

[2] Loc. cit., p. 64.

[3] Loc. cit., p. 643.

Messrs. Chalmers and Hatch [1] have shown how very noticeably in Mashonaland and Matabeleland the physical features are largely dependent on the geology of the country. Thus the bulk of the country is granite, the remainder consists chiefly of schists, and the areas covered by granite present a bare, rocky, rugged aspect, which is remarkable for its uniformity over large areas, or else broad expanses of flat or rolling veld, from which rise here and there masses of immense boulders and rugged kopjes. At intervals the granite rises into wild mountain ranges. The schists occur as broad patches in the granite and form the gold belts of the country. Instead of the sandy sterile soil of much of the granite areas, the schists give rise to a clayey fertile soil, produce softer, less rugged, scenery, more undulating and hilly, with fertile valleys and well-wooded hills, owing to the more variable nature of the rocks and also to the fact that they are tilted at high angles so that they are more easily weathered.

Dr. F. W. Voit,[2] in describing the geology of German South-West Africa, says: "It is so easy to see at a glance the difference in the character of the landscape between a schistose and granite area." He speaks of the schist districts as presenting a very undulating land surface, from which rise hills to a height of from 1300 to 1600 feet, culminating in serrated kopjes and flat-topped ridges, and covered with thick bush and grass. In the granite area, on the other hand, rocks, like islands, rise out of a coarse-grained sandy floor with startling abruptness, or form characteristic half-coned hills or gigantic granite cones, almost completely barren of vegetation.

The copper deposits of this region occur in the schists and gneiss zones and not in the granite proper.[3] However, granite areas may also be undulating and fertile, as, for example, the granite boss between Johannesburg and Pretoria, which is only sparingly wooded.

Mr. W. Anderson [4] has pointed out that in metamorphic and granitic areas, where the rocks are more or less crystalline and contain chiefly quartz, felspar, hornblende, mica, etc., the soils resulting from the former (gneisses, schists, etc.) are generally of a decidedly clayey nature, while those derived from the latter are of a more sandy character, though still containing much clayey material from the decomposition of the felspars. Also that the chemical constituents of the ordinary minerals in these rocks—potash, alumina, silica, lime, magnesia, etc.—are such as are necessary for the formation of a good soil; and that the reason why granitic areas are not, except in rare cases, much used for agricultural purposes is a physical geological one, surface denudation of these rocks generally producing a very rugged country, which is always against the preservation of the soils for agricultural use; but where it happens

[1] "Notes on the Geology of Mashonaland and Matabeleland," by J. A. Chalmers and Hatch: Geol. Mag., 1895, Dec. IV, Vol. II, No. ccclxxi, p. 193 et seq.

[2] "A Contribution to the Geology of German South-West Africa," by Dr. F. W. Voit: Trans. Geol. Soc. S.A., vol. vii, pt. ii, p. 84.

[3] Loc. cit., pp. 77–94. Also *vide* "Copper Ore in South-West Africa", by J. Kuntz: Trans. Geol. Soc. S.A., vol. vii, pt. ii, pp. 70–6.

[4] Second Report of the Geological Survey of Natal and Zululand, by Wm. Anderson, F.R.S.E., Government Geologist, 1904, p. 23.

that any extensive area of moderate slope is covered with granitic soil, its quality is beyond dispute. He points out that the high angles of the slopes in a rugged granitic country accelerates the drainage from the soils, where they are present, of all the alkalies in solution, as well as the other soluble chemical ingredients, which are necessary to the formation of a productive soil; also that in some parts of the world granitic soils are of extreme richness from the presence in the granite of apatite, a mineral which is a natural phosphate.

These granitic areas are generally well watered, as, for example, in Natal and Zululand, the Johannesburg–Pretoria boss, the Limpopo region, and the Uelle and Lado Enclave provinces of the Congo Free State. Gold occurs in quartz-veins in the Old Granite in the Zoutpansberg district. At the Ayrshire mine[1] in Rhodesia gold occurs in an augite-diorite dyke traversing the granite. Tin occurs in pegmatite dykes in the Old Granite in Swaziland, at Embabaan; also in veins in the granite at Kuils River, near Cape Town. Probably payable deposits of kaolin, derived from the decomposition of the Old Granite, will in time be discovered.

Conclusions.

From the foregoing the following conclusions are derived:—

(1) In South and Central Africa there exists a Fundamental Granite-Gneiss Formation, which formed the nucleus or core of the continent, the base of the geological column on and around which the younger formations have been built up, and although later portions are intrusive in the Swaziland Series, nevertheless it underlies and supports it in much the same way that the Fundamental or Laurentian Gneiss of Canada is intrusive in and yet underlies and supports the Grenville Series.[2] In Eastern Canada, however, the original basement upon which the first sediments were laid down has nowhere been discovered, having been everywhere torn to pieces by the Laurentian Granite intrusions;[3] whereas in South Africa later portions of the Old Granite are intrusive in both the Fundamental Gneiss and also in the oldest existing sediments, and there is no reason to assume the pre-existence of still older sediments; but, as we have seen, there is good reason to regard the Old Gneiss as the original basement on which the oldest existing sediments were built up. This Fundamental Granite-Gneiss Formation is especially well developed in the region of the Limpopo, in German South-West Africa, in German East Africa, in parts of the Congo Free State and of the Nile Basin, in Mashonaland and Matabeleland, and also in Natal and Zululand.

(2) It follows from (1) that the Old Granites of South Africa, although all derived from similar, probably the same, magma, are not all of exactly the same age. Thus it would seem that the Old Granite

[1] *The Geology of South Africa*, by Hatch & Corstorphine, 1905 (Macmillan & Co.), p. 105.

[2] "On the Structure and Relations of the Laurentian System in Eastern Canada," by Professor F. D. Adams, D.Sc., F.R.S.: Quart. Journ. Geol. Soc., vol. lxiv, No. ccliv, p. 146.

[3] Loc. cit., p. 147.

is intrusive in the Swaziland Series by after-protrusions due to the fracturing and crumpling of the old granitic crust produced by secular cooling. These intrusions have occurred at various intervals extending over vast geological time. For example, Dr. Molengraaff[1] has shown that the Old Granite boss of Vredefort is probably more recent than the Pretoria Formation.

(3) The increasing prevalence of granite and gneiss as one travels northwards towards Central Africa has already been noted. To the south and south-east the sediments are well developed. The elevation of the more northern portion and the progressive subsidence of that to south and south-east (and consequent depositions and building-up of the sediments of these latter areas) may probably be due to the same causes as those recently suggested by Dr. Adams[2] to explain the progressive uplifting of the Laurentian Highlands of Eastern Canada and sinking of the great plains to the south, namely, the uprising of the granite-magma from the depths accompanied by its withdrawal from below the subsiding areas.

(4) The gneisses of this formation are of igneous origin, and are probably granites altered chiefly by regional metamorphism. Possibly, however, some of the later gneisses, intimately associated with the crystalline schists of the Swaziland Series, are paragneisses, that is to say, are of sedimentary origin.

(5) The sediments of the Swaziland Series are derived from this Old Fundamental Formation, and possibly also in part from ocean-borne detritus.

(6) The Witwatersrand System has been derived from the Swaziland Series and the Old Granite which is intrusive in it, but probably to only a very small extent, if any, from the further removed Fundamental Granite-Gneiss Formation.

The Granite of Orange Grove.

By Arthur Wade, B.Sc. (Lond.), F.G.S., A.R.C.S.

(PLATE XXVII.)

The rock consists essentially of quartz, albite, microcline, orthoclase, biotite, and sphene, with apatite as a prominent accessory mineral; epidote, chlorite, sericite, and fluor are more or less common minerals of secondary origin. It is a biotite-granite, somewhat rich in soda. Under the microscope the rock is seen to be holocrystalline, hypidiomorphic, somewhat porphyritic, and coarse-grained. A tendency to graphic and micrographic structures are sometimes to be noted. Felspars, either orthoclase or plagioclase, are the most abundant minerals, the latter type being most frequent. The orthoclase is practically confined to an early generation of large porphyritic crystals. Microcline is very abundant in some sections and curiously rare in others.

[1] "Remarks on the Vredefort Mountain-Land," by G. A. F. Molengraaff: Trans. Geol. Soc. S.A., vol. vi, pt. ii, pp. 20–6.

[2] Loc. cit., p. 145. In Great Britain the sequence from the very oldest to the most recent rocks as one travels from the north-west of Scotland to the south-east shores of England is very marked.

The extinction angles show that albite is the dominant form, though a little lime-soda felspar is present. It is frequently idiomorphic with regard to microcline and orthoclase felspars. The mineral is usually very much altered, so much so that the twin lamellation is frequently obscured. The secondary products include the colourless micaceous mineral sericite, which is often included in minute flakes in the turbid interior of the crystals, or is present along cracks, probably developed by crushing, both in the plagioclase and in the microcline. Small greenish flakes of biotite are sometimes similarly included, whilst lemon-yellow grains of epidote are fairly abundant in the plagioclase.

A feature to be noted is the presence of clear, fresh, secondary soda-felspar bordering the altered plagioclase in places, practically in optical continuity with the original felspar lamellation (Pl. XXVII, Fig. 3), though occasionally the secondary material shows no such lamellation. The microcline contrasts markedly with the other plagioclase felspars by reason of its comparative freshness. It is sometimes quartz-like in its clearness. The typical cross-hatching is frequently beautifully shown. It contains idiomorphic crystals of the other felspars, as well as elongated blebs of quartz and flakes of biotite as inclusions. Sericitization has taken place along strain cracks in the mineral.

Quartz occurs in colourless irregular grains, sometimes enclosing flakes of biotite, sometimes wrapping round the felspars. Its occurrence inside the microcline simulates graphic structure, whilst micrographic intergrowths with orthoclase felspar are sometimes seen. The grains frequently tail off into or are partly bordered by crushed material. This, accompanied by undulose extinction in both quartz and felspars, shows that the rock has been subjected to severe crushing strains.

The biotite varies from pale yellow green to green in colour. Longitudinal sections are extremely dichroic: a pale yellowish brown, β and γ green, in unaltered sections. Pleochroic haloes are also common. The mineral has a strong birefringence. It encloses sphene, and sometimes a little sericite is intergrown with it. Epidote is frequently seen in large grains, very intimately associated with the biotite flakes. Chloritization is often seen to have been partly or wholly effected in some of the biotite, with a consequent weakening of the polarization effects. It is mostly seen running through the rock in strings or as groups of flakes enclosing the altered plagioclase crystals. Sometimes it occurs in tiny greenish scales scattered through the much altered felspars. These modes of occurrence, together with its constant association with epidote (Pl. XXVII, Fig. 1), suggest that the mineral is in part or even wholly of secondary origin.

Sphene is unusually abundant. It is reddish brown in colour, distinctly pleochroic, with high refractive index, strong birefringence, and strong dispersion of the optic axes ($\rho > v$). Double wedge-shaped crystals are characteristic, though curiously elongated forms are also present (Pl. XXVII, Fig. 2). It belongs to the earlier (porphyritic) generation of minerals present in the rock. Small colourless grains, with high refractive index, are sometimes present, and can be identified as sphene by their strong dispersion. Apatite also belongs to this early generation of minerals, and is a common accessory. It is present as tiny needles, included chiefly in the felspars and biotites. Sometimes small aggregates occur, and these are especially associated with the biotite flakes. Large crystals, giving well-defined hexagonal basal sections (Pl. XXVII, Fig. 1), are also present. Epidote occurs in quite large grains and aggregates, sometimes forming a fairly large proportion of the section under consideration. It is of the pale lemon-coloured variety, distinctly pleochroic, and possessing strong birefringence. The large size and idiomorphic character of some of the grains give a first impression that the mineral may be primary. It is, however, always closely associated with much altered felspars, and is occasionally seen as small grains enclosed in them. It is therefore much more likely to be a secondary produce. Some colourless grains enclosed in the micas suggest the mineral zoisite, whilst others, exceedingly scarce, had two sets of cleavages at 70° with one another, and extremely weak birefringence. The characters suggest fluor, though on account of the very small size of the grains and the thinness of the section confirmation by chemical tests could not be obtained. The rock is a *Biotite Granite*, somewhat rich in soda, with much sphene and epidote.

An analysis of the rock, with a comparison with those of some of the best known British soda granites, and with that of the New Red Bushveld Granite of the Transvaal, may prove instructive—

	I.	II.	III.	IV.	V.	VI.
$Si O_2$ . .	78·61	70·48	63·34	72·084	80·24	75·84
$Ti O_2$ . .	—	—	—	—	—	—
$Al_2 O_3$ . .	7·76	14·24	15·28	14·459	12·24	11·14
$Fe_2 O_2$ . .	4·51	3·72	6·88	2·399	0·72	4·68
$Fe O$ . .	1·69	—	—	—	—	0·01
$Mn O$ . .	—	—	—	—	—	tr.
$Ca O$ . .	2·60	1·48	4·34	1·762	0·89	1·04
$Mg O$ . .	0·90	0·40	2·48	0·105	tr.	0·27
$K_2 O$ . .	1·74	4·26	2·67	4·803	0·40	3·92
$Na_2 O$ . .	2·10	3·66	3·68	3·014	5·58	2·69
$P_2 O_5$ . .	tr.	—	—	—	—	tr.
Co_2 . . .	—	—	—	—	—	tr.
Li . . .	—	—	—	—	—	tr.
Moisture .	—	1·59	1·01	0·906	—	0·02
Loss . .	—	—	—	—	—	0·64
Totals . .	99·91	99·83	99·68	99·532	100·07	100·25
Spec. Grav.	2·712	2·593	2·713	2·634	2·629	2·626

		Age.
I.[1]	Orange Grove Granite, Transvaal. (Fresh.)	Pre-Carboniferous.
II.[2]	Grey Granite of Slieve-na-Glogh, Carlingford . . .	Post-Carboniferous.
III.[2]	Soda Granite, Newry. (Mean of two analyses.) . . .	,,
IV.[2]	Soda Granites of S.E. Ireland. (Mean of nine analyses.)	Pre-Carboniferous.
V.[2]	Soda Granite, Croghan Kinshela, S.E. Ireland . . .	,,
VI.[3]	Bushveld Granite, Roodepoortje (149), Transvaal. (Fresh.)	,,

[1] *The Witwatersrand and Associated Beds*, by C. B. Horwood, 1905 (Esson and Perkins, Johannesburg), pp. 70–1.

[2] Analyses quoted by Teall, *Brit. Petrog.*, 1888, pp. 310–50.

[3] C. B. Horwood, loc. cit., pp. 70–1.

A most interesting description of a rock very similar to that of Orange Grove will be found in the Memoirs of the Geological Survey of the United Kingdom, *Silurian Rocks of Britain*, 1899, vol. i, Scotland, ch. xxvi.

It will be seen that in all these cases the low percentage of alumina presents a close comparison with the Orange Grove rock, but some varieties of the rocks furnishing the means given in Columns III and IV approximate more closely to it in composition. A granite from Teufelsmauer, near Krems, mentioned by Zirkel in his *Handbuch*, has a similar low percentage of alumina accompanied by a high silica percentage.

On the whole the analysis bears out the observations made by means of the microscope. The abundance of sphene, however, in the rocks would lead one to expect some small quantity of oxide of titanium. The rock has one or two other peculiarities besides its low percentage of alumina. It is very acid, and yet has rather higher percentages of lime and iron than are usual in granites. The abundance of epidote accounts for the lime, and this, together with the presence of secondary albite, is somewhat significant. It suggests that oligoclase was originally one of the felspathic constituents, and this suggestion finds support in the presence of oligoclase in the more basic fresher varieties of this Old Grey Granite of the Transvaal as found at Rietfontein and Driefontein.

The peculiarities in the composition of the rock lead one to examine its position with regard to the classification of igneous rocks by quantitative methods lately proposed by distinguished American petrologists. Whilst not entirely accepting this American system and its elaborate nomenclature, the author feels bound to recommend it to the notice of all interested in petrology, as a step in the right direction; a foundation for a more perfect system of rock classification, which will enable us to comprehend more clearly their relationships and the laws which govern the origin of rocks. For further details with regard to the system and the methods and nomenclature used in the following calculations, the works on the subject published by the originators are recommended.[1] One or two words only can be spared here. Starting from the chemical composition of the rock as obtained by an actual analysis, the molecular proportions of the various oxides present in the rock are first worked out. From these the 'norm' or standard mineral composition of the rock, as contrasted with the 'mode' or actual mineral composition, is obtained by allotting the various oxides in molecular proportions to form certain 'normal' minerals. The allotment is performed according to certain fixed rules. Now by reason of the fixed set of minerals so obtained we are able to compare all rocks with a great amount of accuracy. These minerals are grouped as 'Salic' or 'Ferric' according as they are acid or basic in composition. The final classification is based primarily upon the ratios between these two groups of minerals, and, secondly, between the minerals of the 'norm'.

[1] *Quantitative Classification of Igneous Rocks*, by Cross, Iddings, Pirsson, and Washington, 1903 (University of Chicago Press).

MINERALS OF THE NORM.

	Percentage Composition.	Molecular Proportions.	Pyrite.	Ilmenite.	Magnetite.	Apatite.	Orthoclase.	Albite.	Anorthite.	Diopside.	Hypersthene.	Quartz.
SiO_2	78·61	1·310					108	204	48	44	51	855
Al_2O_3	7·76	·076					18	34	24			
Fe_2O_3	4·51	·028	} ·051							15	36	
FeO	1·69	·023										
MgO	0·90	·022								7	15	
CaO	2·60	·046							24	22		
Na_2O	2·10	·034						34				
K_2O	1·74	·018					18					
H_2O												
TiO_2												
P_2O_5	tr.											
	99·91											

Formulæ.	Molecular Proportions.		Molecular Weight.	Norm.			
SiO_2	855	×	60	Quartz	51·30	Q. 51·30	Salic.
$K_2O\ Al_2O_3\ 6\ SiO_2$	18	×	556	Orthoclase	10·01	F. 34·50	
$Na_2O\ Al_2O_3\ 6\ SiO_2$	34	×	524	Albite	17·82		
$CaO\ Al_2O_3\ 2\ SiO_2$	24	×	278	Anorthite	6·67		
$CaO\ SiO_2$	22	×	116	Diopside	5·23	P. 11·48	Ferric.
$MgO\ SiO_2$	7	×	100				
$FeO\ SiO_2$	15	×	132				
$FeO\ SiO_2$	36	×	132	Hypersthene	6·25		
$MgO\ SiO_2$	15	×	100				

$\frac{\text{Sal}}{\text{Ferr}}$	$= \frac{85 \cdot 80}{11 \cdot 48} > \frac{7}{1}$	. . . .	Class I	Persalane.
$\frac{\text{Q.F.}}{\text{C}}$	$= \frac{85 \cdot 80}{0} > \frac{7}{1}$	. . . . .	Sub-class I	Persalane.
$\frac{\text{Q}}{\text{F}}$	$= \frac{51 \cdot 30}{34 \cdot 50} < \frac{5}{3} > \frac{3}{5}$	. . . . .	Order	Columbare.
$\frac{K_2O + Na_2O}{CaO}$	$= \frac{52}{46} < \frac{5}{3} > \frac{3}{5}$	. . . . .	Rang	Alkalicalcic.

Name of Rang—**Riesenase.**[1]

$\frac{K_2O}{Na_2O}$	$= \frac{18}{34} < \frac{3}{5} > \frac{1}{7}$	. . . . .	Sub-rang	Dosodic.

Name of Sub-rang—**X.**

The American authors suggest no name for this Sub-rang, since no rock of importance known to them seems to come here, though they are aware of analyses of rocks which would fill the blank. The Orange Grove Granite appears to be of sufficient importance to warrant us in assigning the name of *Orangose* to the sub-rang.

Rather significant, and showing to some extent the value of the system, is the fact that a similar rock from the Transvaal with minerals in similar proportions, with the exception of a large percentage of the basic constituents, is described by the American writers as *Vaalose*.[2]

DESCRIPTION OF PLATE XXVII.

FIG. 1. Biotite, with pleochroic haloes, associated with yellow epidote. Small flakes of green mica in the turbid plagioclase to the right. To the left, near the base, is a large hexagonal section of an apatite crystal. Power, ½″. Ordinary light.

,, 2. Large reddish-brown crystal of sphene, showing its unusually deep colour and elongated form. The turbid felspars contain unaltered patches, together with small grains of epidote and flakes of mica. Chloritic patches are shown. Power, ½″. Ordinary light.

,, 3. Turbid crystal of plagioclase, with clear secondary felspar in optical continuity. Microcline and micrographic intergrowth of quartz and felspar are shown. Sericite is shown in its usual form of development. Power, ½″. Crossed nicols.

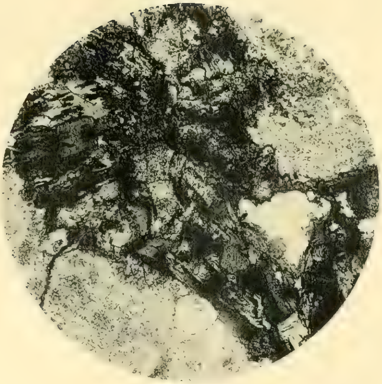
VIII.—Calc-Silicate Limestones of Donegal.

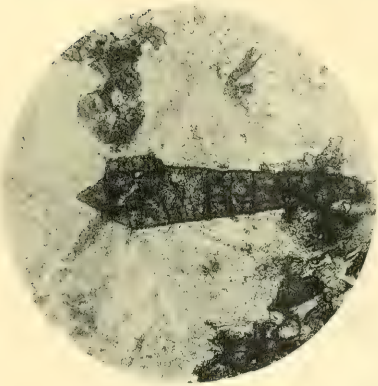
By Arthur E. V. Zealley, A.R.C.S. (Geologist and Curator of the Rhodesia Museum).

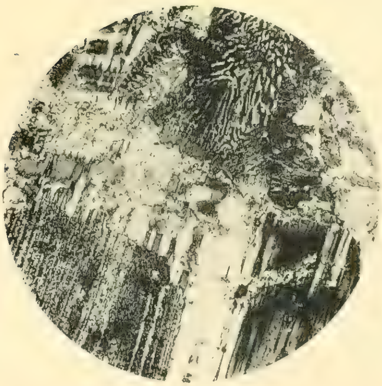
During the summer of 1908 I examined in the field the contact metamorphosed limestones of the county Donegal, my attention being mainly confined to those masses of limestone occurring as xenoliths in the granite. These strongly metamorphosed limestones frequently contain the interesting rock named by Dr. R. H. Scott 'Sphene-rock', which ("Granitic Rocks of Donegal": Journal of the

[1] "Alkalicalcic Rang of Columbare, the quarfelic order of Persalane, Class I, from the Granites of the Riesengebirge, Silesia": Milch. Neu. Jb., 1899, B. Bd. xii, pp. 152–222.

[2] "Dosodic Sub-rang of Vaalose, the Alkalicalcic Rang of Vaalare, the quardofelic order of Salfemane, Class III, Cohen": Neu. Jb., 1887, B. Bd. v, pp. 233–47.

1  x 30

2  x 30

3  x 30

H.A.B., Photo-Micro. *Bemrose, Collo., Derby*

SECTIONS OF THE ORANGE GROVE GRANITES.

Geological Society of Dublin, 1861, vol. ix, p. 288) he describes as "occurring in actual contact with garnet limestones wherever we find these rocks". This Sphene-rock consists of allotriomorphic and hypidiomorphic felspars, with quartz, idiomorphic diopside and sphene, and in some localities zoisite, scapolite, etc.

It is my experience that the Sphene-rock always occurs *in* the limestone, and never represents the mixed rock at the margin of the limestone xenoliths. It generally takes the form of regular and definite granite veins intrusive in the metamorphosed limestone, the veins having absorbed material from that rock by their intrusion to considerably modify their original nature. The formation of this Sphene-rock is interesting, and has been studied by me in considerable detail. In practically every instance where the metamorphosed limestones contain granite veins the latter are of the nature of Sphene-rock, and this rock was not found to occur under any other conditions.

In a few localities the enveloping granite for an inch or so at the contact with the limestone contains sphene and a trace of pyroxene. At Annagary, a few feet of pyroxenic granulitic rock, also containing sphene, is developed at the junction of the limestone xenoliths with the enclosing granite.

It is my intention in the near future to describe at length elsewhere the Sphene-rock and its mode of occurrence, as well as the various types of metamorphosed limestone, which, for the sake of convenience in describing, I have arranged under several headings indicated by their mineralogical constitution, namely—

Garnet-calcite-pyroxene rock,
Garnet-Wollastonite rock,
Idocrase-calcite rock,
Epidote-actinolite-quartz rock,
Scapolite rock,
Actinolite-calcite rock,

as well as calc-silicate hornfels, pyroxene granulites, etc.

The chief localities examined were the following: Barnes Gap, Glen, Sessiagh Bay, Bunbeg, Annagary, Loughanure, Lough Atirrive, Poisoned Glen, Ardmeen, near Anure Lough, Dunlewy, Doochary Bridge, Glenleghan, Lough Nambraddan, Fintown, and Toberkeen.

The minerals noted in the calc-silicate limestones in addition to calcite are: Garnet, idocrase, pyroxenes, Wollastonite, tremolite, actinolite, pistacite, quartz, scapolite, zoisite, apatite, fluorite, and mica. Some of these minerals are particularly well formed, and have found place in most of the chief museums of Great Britain and Ireland.

IX.—Sedgwick Museum Notes.

On the Age of the Creechbarrow Limestone.

By Henry Keeping.

ON the north side of the outcrop of the Chalk in the Isle o Purbeck, there is an outlier of Tertiary beds the exact age of which has given rise to some discussion. There must be some reason for the form of Creechbarrow Hill, and the outline suggests that it is due to some hard bed near the top, which we find on close examination to be a tough limestone, a considerable portion of which is hard and porcellaneous. The upper beds of this conical hill, which rises to a height of 637 feet above sea-level, are cut off from the adjoining masses, and therefore no continuous section can be traced to the well-known formations on the south or on the north. The section is further complicated by the occurrence of faults on both the north and south sides. We have, therefore, only the lithological character and fossil contents to depend upon for the correlation of the beds occurring in this outlier.

Mr. W. H. Hudleston has described the section at some detail in this Magazine,[1] and although he admits that the Creechbarrow Limestone resembles the Bembridge Limestone in some respects, he comes to the conclusion that it belongs to the Bagshot Series. Mr. Strahan[2] suggests the possibility that it may be the equivalent of the Bembridge Limestone. Mr. Hudleston speaks of the "thoroughly exceptional character of Creechbarrow in relation to the rest of the Tertiary beds in the neighbourhood", and quotes a workman who said "that Creechbarrow bulges all these beds and throws them out of line". But in his summing up he states "we cannot say what the hill itself consists of".

As I have stated above, the Survey has drawn faults on the north and on the south side of the outlier, and an overthrust is known to occur in close association, also there is room for unconformities between the Lower Tertiary and the Freshwater Series. I do not propose to discuss the structure, or to choose between faults, overthrusts, and unconformities. I merely wish to express the opinion that however it got there this limestone of Creechbarrow Hill is the equivalent of the Bembridge Limestone, and not of any part of the Bagshot Series, upon which it must rest discordantly.

After over sixty years of practical experience of this formation I hope it will be considered that I should know a piece of Bembridge Limestone, having worked it at the following places — Headon Hill, Cliff End, Sconce, Hampstead Point, Gurnet Bay, Binstead Quarries, St. Helens, Bembridge, and Whitecliff Bay. I know of no limestone in the Bagshot beds agreeing with the Creechbarrow Limestone in lithological character or fossil contents, but in the Bembridge Limestone we have the same kind of rock passing down in the same way through nodular concretionary beds into the underlying clay series.

In the Bagshot beds I know nothing resembling the lime-coated *Paludina* or *Melanopsis*, to whatever genus and species the Creechbarrow specimens may be referred. The remarkable fossil which has long been referred to as a cocoon, or the egg, first of turtle, and later of *Bulimus*, occurs at Creechbarrow, and if the shell of *Bulimus* could have been found I think the identity of the Creechbarrow and Bembridge Limestones might be considered proved. Seeing, therefore,

[1] New Ser., Dec. IV, Vol. IX, June, 1902, p. 241; Vol. X, April and May, 1903, pp. 149, 197. Proc. Dorset Field Club, vol. xxii, p. liv.

[2] "Guide to the Geological Model of the Isle of Purbeck": Mem. Geol. Survey.

that the interpretation of the geological structure of the district depends upon the correct determination of the age of this limestone, and we seem so near obtaining what would be regarded a crucial test, I am glad to announce that Professor Hughes has instructed me to carry out some not very extensive excavations which we hope may yield important results.

I would like here to thank Mr. A. H. Bloomfield for the valuable assistance he gave me during my recent visit to Creechbarrow, and I strongly recommend anyone who is visiting Dorsetshire for the purpose of studying its geology and collecting fossils to secure his services.

NOTICES OF MEMOIRS.

I.—New Faunal Horizons in the Bristol Coal-field.[1] By Herbert Bolton, F.R.S.E., F.G.S.

The well-known rarity of animal remains in the Bristol coal-field is proving to be due rather to the concealment of the measures beneath newer rocks than to any actual absence of fossils.

In 1906–7 the writer determined the existence of four horizons each possessing a marine fauna, between the top of the Millstone Grit and the lowest workable seam in the Ashton district; and further work upon the beds lying above the Bedminster seam at South Liberty Colliery, Bedminster, and at Coalpit Heath in the north of the basin, has proved the occurrence of others. A section at South Liberty Colliery is as follows:—

Strata	127·4
Black Shale with *Anthracomya*	4·11
Strata	337·8
Grey Shale with *Anthracomya*	3·7
Strata	2·0
Dark grey Shale with shells	2·8
Strata	150·0
Black shell-bearing Shale	3·6
Strata	134·4
Bedminster Seam	3·0

At Coalpit Heath, a black shale forming the roof of the High Vein (Hollybush Vein of Parkfield) has proved exceptionally rich in specimens of *Leaia Leidyi*, var. *Salteriana*, whilst *Estheria* cf. *tenella* and *Anthracomya Phillipsi* also occur.

II.—Studies on the Structure and Affinities of Cretaceous Plants.[2] By Marie C. Stopes, Ph.D., D.Sc., F.L.S., Lecturer in Palæobotany, Manchester University, and K. Fujii, Ph.D., Assistant Professor of Botany, Imperial University, Tokio.

The authors comment on the importance of the work done on the flora of the Palæozoic period, and the botanical interest that would attach to similar petrifactions of plants from all ages of the

[1] Abstract of paper read at British Association Meeting, Winnipeg, in Section C (Geology), August, 1909.

[2] Abstract of paper read before the Royal Society, May 27, 1909; communicated by Dr. D. H. Scott, F.R.S.

Mesozoic period. They have had the good fortune to find excellently preserved material from the Cretaceous of Northern Japan.

In the present paper they describe eighteen plants from this material, which is extraordinarily rich. As hitherto there has been very little known from anatomical material of plants of this age, the present paper is by no means final, but is in the nature of a pioneer chart of the ground.

The petrifaction of the cells of the plants is often extremely good, though the fragments are not so complete as could be desired. The plant-structures include stems, roots, leaves, cones, fern sporangia, and even an Angiospermic flower, the first petrifaction of a flower to be described. The débris lie together in the nodules in much the same way that the débris lie in the Coal-balls of the Palæozoic, though they are mixed with fragments of shells. The latter are largely Ammonites, and serve to determine the age of the petrifactions.

The flora as a whole represents an interesting mixed flora such as has not hitherto come to light among petrifactions.

Roughly speaking, the flora seems to have consisted of about one-third Angiosperms, slightly more than one-third Gymnosperms, and the rest of ferns and lower plants. The anatomy of the early Angiosperms being such a desideratum in botany, their presence in the petrifactions renders them doubly interesting, and particularly when they are found in so evenly balanced a mixed flora.

All the specimens described in this paper were cut in Tokio in the botanical department by the authors.

The plants described are as follows:—

Petrosphæria japonica, gen. et sp. nov. A fungus which has numerous microsclerotia, in the periderm of one of the Angiosperms, *Saururopsis*.

Schizæopteris Tansleii, gen. et sp. nov. The sorus and sporangia of a Schizæaceous fern.

Fasciostelopteris mesozoica, gen. et sp. nov. The stem and petiole of a fern with a dictyostelic anatomy. Probably allied to the *Dicksoniaceæ*.

Fern rootlets, in excellent state of preservation, showing the diarch stele of the leptosporangiate ferns.

Niponophyllum cordaitiforme, gen. et sp. nov. The leaf of what appears to be some plant of Cycadean affinity, the anatomy bearing considerable resemblance to that of *Cordaites*.

Yezonia vulgaris, gen. et sp. nov. A Gymnosperm, of which stems, unthickened twigs, leafy axes, are all very plentiful. It is the commonest plant in the material, and at the same time the most unique. In the anatomy of both main axis and foliage it is not like any known type.

Yezostrobus Oliverii, gen. et sp. nov. The fructification of a Gymnosperm, the cone bearing simple scales with seeds, one on each, which are like those of Cycads in some respects, but have a nucellus standing up entirely free from the integument with a well-marked epidermis between.

Though continuity is lacking between these two plants, there seems considerable ground for suspecting them of belonging to the same plant from anatomical points of likeness.

Araucarioxylon tankoensis, sp. nov. Secondary wood, showing remarkably clear pittings in the transverse sections.

Cedroxylon Matsumurii, sp. nov. Well-preserved secondary wood.

Cedroxylon Yendoii, sp. nov. Secondary wood, with traumatic resin canals.

Cunninghamiostrobus yubariensis, gen. et sp. nov. A cone, as its name implies, belonging to the family of the Cunninghamias, with its external appearance partly preserved and the cone scales and axis fairly well petrified. The seeds have apparently been scattered.

Cryptomeriopsis antiqua, gen. et sp. nov. Stem with leaves attached, the foliage very like that of a *Cryptomeria*.

Saururopsis niponensis, gen. et sp. nov. The stem and attached roots of an Angiosperm, probably to be included in the Saururaceæ.

Jugloxylon Hamaoanum, gen. et sp. nov. The secondary wood of an Angiosperm.

Populocaulis yezoensis, gen. et sp. nov. The stems of an Angiosperm, with cortical tissue.

Fagoxylon hokkaidense, gen. et sp. nov. The secondary wood of an Angiosperm.

Sabiocaulis Sakurii, gen. et sp. nov. Minute stems and older twigs of an Angiosperm, with cortex, and well-preserved and characteristic anatomy.

Cretovarium japonicum, gen. et sp. nov. The flower of an Angiosperm, of which there are several specimens.

Of this list of plants, the commonest, i.e. those which have yielded the greatest number of specimens in the course of the work, are *Yezonia*, *Sabiocaulis*, and *Cretovarium*. It is noteworthy that these are among the most unusual and the most interesting of the plants.[1]

REVIEWS.

I.—Igneous Rocks: Composition, Texture, and Classification; Description and Occurrence. By Joseph P. Iddings. In two volumes. Vol. I[2]: Composition, Texture, and Classification. 8vo; xi+464 pages, 130 figures, and 1 coloured plate. Cloth. New York, John Wiley and Sons; London, Chapman & Hall, Limited; 1909. $5 (21*s.*) net.

THIS is the first part of a new textbook of the petrology of Igneous Rocks, and is meant to serve as an introduction to an exposition of the 'quantitative' classification. For this reason special prominence

[1] The authors acknowledge much assistance in the work from the Royal Society Government Grant Committee, which made it possible for one of them (M. C. S.) to attempt the work; and from the various departments of the Imperial Government of Japan in the course of collecting and preparing the material.

[2] Vol. II: Description and Occurrence (in preparation).

is given to the chemical aspects of the subject. The earlier chapters are devoted to a brief account of the chemical characters of magmas and the principal means of representing these by diagrams. We then pass to a classification of the elements according to the periodic law, and the rock-minerals are considered according to their dominant components. It is difficult to see that anything is gained by this grouping, and it certainly leads to a good deal of repetition; the amphiboles, for example, are discussed under calcium, magnesium, iron, aluminium, and sodium. As regards the constitution of the silicates the views of Clarke are followed, but graphic formulæ are not used, probably because there is still too much uncertainty in applying them.

With the third chapter we begin the consideration of the application of the principles of physics and chemistry to magmas, and this portion of the work is entirely satisfactory, both in matter and in style. The exposition is lucid, though the treatment is brief; and for the benefit of those students who have not had a special training in physical chemistry the elementary principles of the subject are carefully expounded. No better introduction to the theory of the crystallization of rock magmas, regarded as solutions, could be provided for the use of students.

Some years ago a new descriptive terminology for rock structures was proposed by the author and a group of American petrographers. Without doubt greater variety and definiteness are needed in the language of descriptive petrology, and many of the terms proposed have already received general acceptance. This nomenclature is used here in the account of the texture of igneous rocks; much of it is excellent (for example, the suggestion that granophyres should be called graphophyres), and there are other kinds that are by no means unexceptionable. Thus mediophyric and mediiphyric, minophyric and miniphyric, as descriptive of porphyritic structures of different coarseness are more likely to cause confusion than to lead to clearness.

The book closes with a tabular statement of the 'qualitative' classification generally recognized in textbooks, and a condensed account of the principles of the new quantitative classification. This, and the chapter on the history of classification, have already appeared in print, and to English readers are likely to prove the least interesting part of the volume, as the space allotted to either system is too brief for any but a perfunctory treatment.

One of the most pleasing features of the book is the effort made to avoid the conventional methods of handling the subject, and to place new aspects and new examples before the reader. The author draws largely on the results of field-work among volcanic rocks in Western North America; and as the petrography of that region has been studied with extraordinary care, and it embraces a remarkable variety of igneous rocks, the instances cited to illustrate the general principles have a freshness and point which impress them on the memory.

J. S. F.

II.—An Introduction to the Geology of Cape Colony. By A. W. Rogers, D.Sc., F.G.S., and A. L. Du Toit, B.A., F.G.S.; with a chapter on the Fossil Reptiles of the Karroo Formation, by Professor R. Broom, M.D. Second Edition. 8vo; pp. xiii, 491, with geological map, 25 plates, and 29 text-illustrations. London: Longmans, Green, & Co., 1909. Price 9*s.* net.

We welcome a second edition of this excellent handbook, the first issue of which, by Dr. Rogers, was reviewed in the Geological Magazine for 1905 (p. 135). Mr. Du Toit, of the Geological Survey of Cape Colony, is now associated with Dr. Rogers in the authorship. A new, clearly printed, and brightly coloured geological map has been prepared of the Colony, with bordering tracts of Natal, Basutoland, the Orange River Colony, and the Transvaal. Several new illustrations are given, but the size of the volume has been increased only by twenty-eight pages. The work has been carefully brought up to date, and some details of minor importance in the first edition have been reduced or omitted in order to keep the work within moderate limits. Attention was previously called to the somewhat meagre index, and in the new volume no references are given to any of the authorities quoted, an omission which, from a bibliographical point of view, is to be regretted.

The oldest known formations grouped under the name Pre-Cape rocks comprise "a heterogeneous collection of sediments and igneous rocks both extrusive and intrusive", all older than Devonian, but otherwise of uncertain age. They include the Campbell Rand Series, mainly blue dolomitic limestones, reckoned to be from 2000 to 3000 feet thick. Some of these beds are oolitic, some contain chert; there are also occasional altered sandstones or quartzites in the series, as well as dolomitic limestones that have been changed into rocks having the appearance and composition of quartzites.

The Table Mountain Series, which forms the base of the Cape System, is grouped with the Devonian, and appears to have been formed under desert conditions with fluviatile and lacustrine deposits. The succeeding Bokkeveld Series has yielded a fauna most nearly related to that of the Devonian of South America, and having relationship with the Middle Devonian of North America and with the Lower Devonian of Europe. The still newer Witteberg Series has yielded a number of plants, all the genera of which occur in the Carboniferous of Europe. Quite recently, however, the first traces of animal remains in the Witteberg Series have been recognized by Dr. H. Woodward (Geol. Mag., November, 1909, p. 486), the remains being portions of segments of Eurypterids, probably of the genus *Pterygotus*.

The Karroo System, with its basement Dwyka Series, includes representatives of strata belonging to Permo-Carboniferous, Permian, Triassic, and Jurassic ages. The term 'tillite', suggested by Professor Penck, is used for the Dwyka glacial conglomerate, which is a hardened form of boulder-clay. It has yielded remains of *Gangamopteris*. The shales above the tillite appear to be definitely of Permian age. At a higher horizon in the Ecca Series remains of

Glossopteris and other plants, as well as reptilia, occur. The Beaufort Series contains the well-known and remarkable series of reptilia, including *Pareiasaurus* and numerous other genera, as well as amphibia, fishes, freshwater mollusca, plants, etc. Dr. Broom, who contributes a chapter on the reptiles, remarks, "In probably no part of the world is there a formation of greater interest to the palæontologist, for here in the 14,000 feet or so of strata we have beds which when fully studied will yield us a continuous history of the land animals of one part of the world during a period of possibly over 2,000,000 years." The Stormberg Series, with its great series of volcanic beds, closes the record of Jurassic events.

The Uitenhage Series is separated from earlier strata by evidence of unconformity, and the latest researches on the molluscan fauna by Dr. F. L. Kitchin render it probable that the entire series is of Neocomian age. Higher Cretaceous strata are represented in the Pondoland Series, which includes Senonian and possibly also Danian.

The volcanic pipes and the occurrence of diamonds, the traces of possible Tertiary (thick sands with layers of clay and lignite), and the various Pleistocene and recent deposits are duly described, but we find no references to any discoveries of ancient stone implements. The discovery of *Mastodon* in gravels of the Vaal River is noted, and regarded as of Pleistocene age. Interesting observations are made on natural saltpans, on hot springs, water supply, and economic geology in general. There is also a chapter giving a summary of the geological history of the Colony, including reference to Professor Penck's view that the land is a bent surface of denudation, and that the position of the coast roughly marks the axis about which the bending has taken place.

In conclusion we may remark that the progress of geological knowledge is greatly aided by works like the one before us, and we wish that the geology of all countries, so far as known, could be dealt with in an equally judicious manner.

III.—The Guadalupian Fauna. By G. H. Girty, United States Geol. Surv. Prof. Paper 58, 1908.

In this comprehensive work we find much that is of interest to palæontologists generally. Three new families—Guadalupiidæ, Cystothalamiidæ, and Polysiphonidæ of the order Sycones, and seven new genera—*Anthracosycon* [order Lithistida, sub-order Tetracladina], *Virgula* [sub-order Tetracladina], *Pseudovirgula* [sub-order Tetracladina], *Stromatidium* [order Hexactinellida, sub-order Dictyonina], *Guadalupia* [order Sycones], *Polysiphon* [order Sycones], *Cystothalamia* [order Sycones]—are founded among the Spongidæ. The family Guadalupiidæ contains but one genus, and is distinguished by the mode of growth, "usually in lamellar expansions," and by the construction of the walls, "which are composed of tubes having a direction normal to the two surfaces, the superficial layers being reticulated and apparently formed of large, mutually consolidated spicules." The Cystothalamiidæ includes only one species and is separated from the Sphærosiphoniidæ and the Sphærocœliidæ by the fact, among others, that the cysts are not separated into rings or segments, and from the Guadalupiidæ by not being composed of 'separate-walled' tubes and the want (?) of an outer fibrous layer. The Polysiphonidæ also includes one species and comes nearest to the Cystothalamiidæ. It differs from this latter in the possession of a solid instead of a perforated outer wall, in the absence of ostia, and "in having a definite and peculiar arrangement of the internal tubular structures, the tubes in *Cystothalamia* being more numerous, imperfect, chiefly radial in direction, and without any definite order of arrangement".

Among the Cœlenterata *Cladopora*, Hall, is recorded, apparently for the first time, from the Carboniferous. Several new forms of *Lindstroemia* are described. In a discussion of the first new species of this genus Girty treats of its relationship with *Lophophyllum*. Carruthers has more recently given a revised diagnosis of the latter and has shown that the type *L. konincki* is a young form of '*Cyathaxonia*' *tortuosa*, Mich., a form which cannot be a true *Cyathaxonia* on account of the presence of a well-marked dissepimental zone in mature growth-stages.

A new Cystid—*Cœnocystis*, n.gen.—has certain affinities with the Blastoidea, but is placed with the Cystoidea "because of the absence of large, regular, ambulacral areas and the presence of a large eccentric anal pore".

The section on the Brachiopoda is of more than usual interest. A new classification is submitted for the Orthotetinæ of the Strophomenidæ. *Streptorhynchus* and *Schuchertella* have neither septa nor dental lamellæ in the ventral valve. The former genus includes non-plicated forms which mostly have a high, distorted, ventral valve, "sometimes, possibly generally, attached by cementation." The dorsal valve is without an area and has a large cardinal process and well-developed socket plates. This genus would correspond to Waagen's 'Simplices'. Plicated forms which agree with the foregoing genus in other respects are so far without a generic designation. *Schuchertella* includes those shells which have a low, regular, ventral valve, peduncular attachment, a narrow distinct dorsal area, and a cardinal process, usually small. Plicated species are unknown. *Derbya*, *Orthotetes*, and *Geyerella* would be placed by Waagen in the 'Septati' and 'Camerati' divisions of his *Derbya*. Girty restricts the application of *Derbya* to non-plicated shells which possess a well-developed median septum in the ventral valve and have "the dental lamellæ more or less completely atrophied and discrete from the septum except at the apex" (= 'Septati' Waagen). Waagen's type of *Derbya* (*Derbya regularis*) belonged to this section. Plicated forms, of which only one species is known, have not yet been separated from the preceding. *Orthotetes* and *Geyerella* are included in the 'Camerati' division. The ventral valve possesses moderately developed dental plates which converge and unite and, with the pseudodeltidium, enclose a triangular pyramidal chamber. At their junction with one another the dental lamellæ also unite with the median septum, forming a triradiate figure. *Orthotetes* is restricted to the non-plicated forms, *Geyerella* being applied to the plicated shells. Another group of Orthotetinæ is composed of species in which the ventral valve is provided "with two more or less parallel dental plates without median septum. The plates are prolonged to meet the anterior or convex wall of the shell". When the dental plates are long and parallel and the shells non-plicated, we have the genus *Orthothetina*. Plicated forms are placed under *Meekella*. Shells with short and diverging dental plates are without a distinctive designation.

The question might naturally be raised as to the value of septal development, external plications, areas, etc., in generic classification. It is probable that some workers, with Jakowlew, would minimize in any detailed subdivision the value of areas, or, with Scupin in "Die Spiriferen Deutschlands", the importance of septal division. Jaekel in his paper on phylogenetic development considers external characters to be only valuable for specific distinction. Presence or absence of external plications would, on this view, be insufficient for generic definition. Girty expresses a doubt as to whether all the features used for distinction are of equal taxonomic value, and applies the doubt particularly to the generic separation of *Orthotetes* and *Geyerella*, *Orthothetina* and *Meekella*. He would consider as appropriate for recognition *Streptorhynchus*, *Schuchertella*, *Derbya*, *Orthotetes*, and *Orthothetina*, but uses *Meekella* and *Geyerella* as genera in the monograph under consideration.

In discussing the cardinal process of *Streptorhynchus hallianum* as figured by Hall and Clarke, Girty suggests the probability that the cardinal process, like other areas of muscular attachment, "is subjected in old age to excessive shell secretion, not only increasing its size, but by strengthening its muscular features, also modifying its shape, so that the process varies much in both particulars, owing to difference in age." A somewhat similar opinion has been expressed by other palæontologists, e.g. Drevermann in his treatment of the *Spirifer* casts of the Devonian. Schellwien considered that the median septum was a development from the dental plates, a view which the author of the present work is inclined to dispute. He considers the median septum and dental plates to be independent structures, "though all converge and unite at the apex of the ventral valves, where they often merge in a solid shelly mass." It is interesting in the same connexion to note Jakowlew's opinion that a plate developed adjacent to the spondylium in *Cyrtina carbonaria* corresponds to a pseudodeltidium.

Martinia is based on the peculiarity of external configuration together with the absence of septal plates. The outer layer, when preserved, is assumed to be punctate. *Reticularia* is regarded as possessing well-developed dental plates and median septum. Some of the recent descriptions of *Reticularia* by Vaughan, Sibly, and others contain no reference to the presence of a median septum. Lee, therefore, makes the interesting suggestion, in his recent paper on the Nova Zembla Carboniferous Fauna, that there may be *Reticularia*-like forms possessing dental plates without median septum. Shells so characterized would probably be entitled to specific if not sub-generic value. McCoy's original diagnosis of *Reticularia* emphasizes the presence of both dental plates and median septum. *Squamularia* includes forms which appear to bear the same relation to *Reticularia* in surface ornamentation as *Athyris* does to *Cleiothyridina*. It is further distinguished from *Reticularia* by the absence of dental plates and median septum. Gemmellaro originally established *Squamularia* on certain peculiarities of the brachia and the possession of flexuous lamellose expansions externally.

Heterelasma, a new genus of the Terebratulidæ, is based on peculiarities of internal structure. The names *Leptodus*, *Composita*, and *Cleiothyridina* are employed in accordance with Buckman's usage instead of *Lyttonia*, *Seminula*, and *Cleiothyris*.

A new lamellibranch genus is described under the name *Protrete*. It bears a certain resemblance to *Pleurophorella*, from which it differs in having a tubular perforation under the umbones. This perforation is supposed to be a real opening into the interior of the shell. Other distinguishing features are the absence of radial ribs and papillæ. The general shape suggests *Lithodomus*, but the possession of the anterior opening distinguishes it from this as well as other genera which it outwardly approaches.

Peritrochia is a new Cephalopod belonging to the Pronoritidæ. "The most closely related genus is *Pronorites*. The suture of *Pronorites* is almost exactly that of *Peritrochia*, save that there is a tendency in the lobes toward a pointed, linguiform shape. The shape of the shell in *Pronorites*, however, is discoidal and the whorl section elongate and subquadrate, while the shell in *Peritrochia* is globose and the whorl section transverse and lunate. The umbilicus in one is wide and in the other closed."

Finally a new trilobite genus, *Anisopyge*, is described as belonging to the Proetidæ. It comes nearest to *Phillipsia*, but differs from that genus as typically found, in having a more pyriform glabella, smaller fixed cheeks, and also in other respects. One of the most marked features, however, is the presence in *Anisopyge* of thirty pygidial segments together with "a very striking discrepancy between the segments of the axis and those of the pleural regions, a discrepancy emphasized by the presence of an unsegmented band along either side of the axis".

Thirty-one excellent plates illustrate this valuable monograph.

Ivor Thomas.

IV.—The Geology of Ore Deposits. By H. H. Thomas, M.A., B.Sc., and D. A. MacAlister, Assoc. R.S.M. Illustrated. Crown 8vo; pp. xi and 416. London: Edward Arnold. Price 7*s*. 6*d*. net.

THIS work is the second of a series to be published under the editorship of Professor J. E. Marr, and intended chiefly for students of economic geology, but also for students of general geology, miners, surveyors, and others who are concerned with the practical applications of the science. To those who are familiar with ore deposits, the task of catering for such a wide range of readers within the limits of one small volume appears tremendous, and our heartiest sympathy goes out to the authors when they say that they have found it fraught with much difficulty. But the work has been placed in good hands, and although others perhaps, under the same circumstances, might have sacrificed the numerous short notices of illustrative examples for more detailed descriptions of a few occurrences of ore, and abundant references to original works, the volume under review contains a wealth of information; and if, on closing it, we feel inclined to "ask for more", we may be sure that had the authors had greater space at their disposal, full justice would have been done to the subject.

The first chapter is an Introduction of twenty pages, that contain matter capable of expansion to four times the space. Then follow eight chapters, in which the authors classify ore deposits according to their mode of origin, under the following headings:—

Ores due to the differentiation of igneous magmas.
Pneumatolysis.
Hydatognesis—deposits formed by after-eruptive actions which are not pneumatolytic.
Ores due to metasomatic replacement.
Bedded ores due to precipitation.
Metamorphic ore deposits.
Secondary changes in ore deposits apart from metamorphism.
Detrital and alluvial deposits.

As the authors point out, any classification of ore deposits can only be arbitrary, and they themselves mention one objection to the above that will instantly occur to the reader, the difficulty of separating deposits formed by pneumatolysis from those formed by metasomatism, which is surmounted in this case by restricting metasomatism to aqueous solutions only. Nevertheless, this classification is easily followed and therefore good.

The best chapters in the book are, we think, that on ores due to the differentiation of igneous magmas and that on secondary changes. The illustrations are fair; but the index, which gives no names of localities, leaves much to be desired.

It would be unkind to the authors of this work to dwell on certain defects in the matter of clearness of statement, such, for instance, as that on p. 301, where precipitation is asserted to be dependent in all cases on the liquid being in a state of supersaturation with regard to the substance undergoing precipitation; or that on p. 14, where we are told that practically all tin-lodes are characterized by 'greisenization' of their walls. The former is logically correct, but requires explanation, while the second demands a very wide interpretation for the term 'greisen' before it can be accepted. However, such defects are perhaps difficult to avoid where 'boiling-down' is imperative, although a slight want of care in some quotations cannot be similarly excused. Again, detailed discussions on debatable points are, we know, out of the question, but we doubt whether every reader will agree with the authors in their treatment of the Witwatersrand conglomerates. In such a work as this it is surely better to state the arguments for and against, and leave the reader to form his own conclusion.

The account of the Bolivian tin deposits might have been improved by a reference to recent literature, even if its appearance was too late to enable the authors to modify the text; and again, the statement that the percentage of thoria in monazite occasionally rises to 6·5 is hardly in accordance with published analyses.

There is one defect in this book, however, that it is impossible to pass by without protest, and that is the frequent and totally unnecessary use of a termination that results in the terms 'acidic', 'sulphidic', 'oxidic', and 'satellitic'. We know that this hideous terminology did not originate with either of the authors; and when, some time ago, we saw it employed in an American magazine by one of them, we thought it due to editing. But that was a mistaken view, and we find now that we are expected to face with equanimity the phrase "oxidic and sulphidic compounds". Why not "oxides and sulphides"? On the other hand we are glad to see that the term 'vadose' occurs only once, and that as a quotation.

J. B. S.

V.—Journeys through Korea. By Dr. Bundjiro Kotô, Professor of Geology in Tokyo. Journ. Coll. Sci., Imp. Univ., Tokyo, 1909, vol. xxvi, article 2.

SIX years ago attention was called in the Geological Magazine (for 1903, p. 324) to "An Orographical Sketch of Korea" by Dr. Kotô. The present memoir gives the results of further studies and traverses of the country, and is accompanied by coloured geological sections and map of South Korea, and by 33 pictorial plates. The author refers to the pioneer work of Gottsche and Von Richthofen, the former of whom has quite recently been lost to science (see p. 575 *infra*).

The geological formations met with are arranged in sequence as follows:—

Alluvium.
Diluvium and younger effusives.
Tertiary.
Felsophyre and its allies.
Kyöng-sang formation (Mesozoic).
Great granitoid series.
Phyllite schist (Metamorphic Mesozoic).
Kang-jin mica-schist.
Basal gneiss.

Korea is described as a land of granite and gneiss, and it is to be remarked that the age of the Phyllite schist has not been actually determined to be Mesozoic; it may, indeed, be very much older. Great intrusions of granite took place subsequently, "shattering the crust into diverse patches, and metamorphosing the sediments and ancient lava-flows and dykes into schistose and foliated rocks."

The lower portion of the Kyöng-sang formation consists of red and grey sandstones, and red, green, and black marls; and the upper part of marls, shales, and breccia, all composed largely of igneous materials, with a covering of green porphyrite accompanied by felsophyre. Remains of plants, regarded as indicating the Malm-Dogger epoch of the Jurassic, have been found in the lower strata in Korea; but the Kyöng-sang formation is more fully developed in Japan, where it includes representatives also of Rhætic beds and Lias.

Dr. Kotô gives particular descriptions of the igneous rocks, which were erupted at the close of the Kyöng-sang period (Mesozoic). The land was afterwards "dislocated and uplifted, depressed and remodelled, and the general outline of the peninsula was then complete. Since then, as in the case of China, the land of Korea has remained long in the Continental Period, and has been degraded from Alpine altitudes to hilly tracts; the materials from the ruined mountains forming in the meantime the Tertiary deposits near the seashore", on the east coast. Basalt was erupted during Tertiary times, but a much greater outpouring seems to have taken place during the Diluvial Period in North Korea. Otherwise this later epoch appears to have been "a lost period in the record of the deposits of the peninsula", owing to the fact that there was "intense sub-aerial degradation, and the wash has been carried down to the sea as fast as it has been formed". Much of the ground now remains a semi-desert and desolate, but the beginning of the Recent Period was marked by much snow and rain, by evidence of ice-action and of floods, which led to accumulations of debris along the slopes of the Piedmont Hills and choked the valleys with boulder gravel.

VI.—Geologists' Association.

In the Geological Magazine for February last (p. 96) we called attention to the Jubilee of the Association, and mentioned that arrangements had been made to commemorate the occasion by the issue of a volume that should deal with the geology of the districts of England and Wales to which excursions had been made since 1858, the subjects to be treated from the standpoint of our present knowledge. In the meanwhile there has been printed the very interesting presidential address by Professor W. W. Watts (Proc. Geol. Assoc., xxi, p. 119) on "The Jubilee of the Geologists' Association", wherein it is noted that the actual date of birth was December 17, 1858. Professor Watts has also given a short memoir, with portrait, of the first President of the Association, Toulmin Smith, who was a zealous worker on chalk sponges and flints.

We have now received Part I of the Jubilee volume, entitled *Geology in the Field*, edited by Messrs. H. W. Monckton & R. S. Herries. The size of the volume has proved to be much larger than was anticipated, and three further parts are promised. It is to be presumed that they will be continuously paged, and be supplied with an index. The present part, however, fills 209 pages, it contains seven articles, and is illustrated by four plates.

Middlesex and Hertfordshire are dealt with by Mr. J. Hopkinson; Essex by Mr. T. V. Holmes; Cambridgeshire, Bedfordshire, and West Norfolk by Mr. R. H. Rastall; Buckinghamshire by Dr. A. Morley Davies; and the Oxford and Banbury District by Mr. J. A. Douglas. These articles have been written generally on the plan previously noted. There are two other articles, by Mr. F. W. Harmer, on the Pliocene Deposits of the Eastern Counties of England, and on the Pleistocene Period in the same area, the subjects being dealt with more purely from a stratigraphical and physical point of view, and without special reference to excursions made by the Geologists' Association. The second article, on the Pleistocene Period, is especially valuable in giving the matured views of Mr. Harmer on the glacial phenomena of East Anglia. He attributes the Contorted Drift (Lower Glacial) to the invasion of the land by ice coming directly from the North Sea, and the Chalky Boulder-clay (Upper Glacial) to the subsequent action of an inland glacier fed by ice which had crossed the Lincolnshire Wolds. His essay should do much to remove any scepticism that still remains with regard to the agency of land-ice in Britain during the Glacial Period.

VII.—Brief Notices.

1. British Pleistocene Canidæ.—Professor S. H. Reynolds read a paper before the Winnipeg Meeting of the British Association on the British Pleistocene Canidæ. Three species are found—the wolf, the fox, and the Arctic fox. There is no evidence of the existence in Britain in Pleistocene times of any animal that could be called a dog. The jaw described as *Lycaon anglicus* is thought by the author to be better regarded as a somewhat abnormal wolf. While, apart from any difference in size, the skull of a fox is readily distinguished from that of a wolf or dog by the depressions in the post-orbital processes of the frontals, it is extremely difficult, if not impossible, to find any valid distinctive character between dogs and wolves. The most useful character, for which we are indebted to Studer, is the orbito-frontal angle. He regards as belonging to wolves, skulls in which this angle measures 40°–45°; and as belonging to dogs, skulls in which the angle is greater than 45°. The author's measurements, while confirming Studer's contention that the angle in question tends to be decidedly less in the wolf than in the dog, show that the distinction is not absolute, and cannot be relied on in all cases.—*Nature*, October 21, 1909.

2. Norfolk and Norwich Naturalists' Society.—A general index to the Transactions of this Society, vols. i–viii, 1869–1909, has been prepared by Mr. C. D. Sherborn, and is issued with the concluding part 5 of vol. viii.

3. Plesiosaurs.—An article by Dr. C. W. Andrews, "On some new Plesiosauria from the Oxford Clay of Peterborough" (Ann. Nat. Hist., November, 1909), contains preliminary notes on some new types of Plesiosaurs and Pliosaurs, for which the generic names *Tricleidus*, *Picrocleidus*, and *Simolestes* are given.

4. Index for the London Library.—A comprehensive Subject-Index of the London Library, which contains more than 220,000 volumes, has been prepared by Dr. C. T. Hagberg Wright (1909). It is a quarto volume of 1254 pages, arranged alphabetically, with many

cross-references. The contents of proceedings of some of the learned societies and academies have been indexed fully under subjects, including the Kaiserliche Akademie der Wissenschaften zu Wien, the Palæontographical and Ray Societies, Smithsonian Institution, etc. A list of these is given, as well as lists of those proceedings partly catalogued in detail and others catalogued collectively. The work will be of the greatest value to students in art, literature, and science.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 3, 1909.—Professor W. J. Sollas, LL.D., Sc.D., F.R.S., President, in the Chair.

The following communications were read:—

1. "Certain Jurassic (Lias–Oolite) Strata of South Dorset, and their Correlation." By S. S. Buckman, F.G.S.

(1) Descriptions are given of certain strata (Lower Bathonian to Pliensbachian) on the Dorset coast—Chideock and Burton Bradstock.

(2) Comparison is made with similar strata inland—with a summary of beds at Stoke Knap; with certain North Dorset strata; with Toarcian beds of Yorkshire and Northamptonshire.

(3) The strata described are classified according to what may be called the 'multizonal' or 'polyhemeral' system in the main, according to the scheme introduced for these strata in 1893 (5); but further divisions due to other investigators and to the author are dealt with.

(4) The strata described are arranged among thirty-six zonal (hemeral) divisions—a greater number of divisions than Oppel used in 1856 for all the Jurassic rocks, of which these beds form but a small part.

(5) The Upper Lias part of the Junction Bed of Down Cliffs, Chideock (Lower or pre-*striatulus* Toarcian) is a very condensed, imperfect epitome in 20 inches of about 80 feet of strata on the Yorkshire coast, and of very much more, allowing for gaps.

(6) Between the *bifrons*-layer and the *striatulus*-layer of the Junction Bed there is occasionally a 2 inch layer which is all that represents some 250 feet of deposit in the Cotteswolds—so that about 2 feet of Junction Bed were formed while some 550 feet were being deposited elsewhere.

(7) The Upper Toarcian (*moorei-dumortieriæ* hemeræ) makes a great show at Burton Bradstock and Down Cliffs as the Down Cliffs Clay and Bridport Sands (*pars*)—the greatest thickness of rocks of these dates in the country.

(8) The sequence of *aalensis*-strata above *moorei*-beds is demonstrated at Chideock Quarry Hill, in the upper part of the Bridport Sands.

(9) The Inferior Oolite (Aalenian, Bajocian, Bathonian *pars*) strata of Burton and Chideock are not counterparts of one another: they

supplement each other to a certain extent; both are incomplete, and much epitomized representatives of thicker deposits elsewhere.

(10) Mr. Thompson's zonal scheme for the Upper Lias is considered, and a table of Upper Lias zones for future work is presented.

2. "Certain Jurassic ('Inferior Oolite') Ammonites and Brachiopoda." By S. S. Buckman, F.G.S.

This paper is presented as a palæontological appendix, partly to the author's accompanying communication, partly to his previous stratigraphical work. In a short introduction the author, remarking on the fecundity of the 'Inferior Oolite' in the matter of species, makes the suggestion that this is due to the relatively great length of time taken up in its deposition; and he adduces data for supposing that the time thus occupied was from one-fifth to one-fourth of that for the whole Jurassic System.

The paper describes certain species of Ammonites and Brachiopoda which are important for the identification, the correlation, or the dating of Inferior Oolite deposits, and certain other notable species which, having frequently attracted attention in the field, require naming in the interest of future workers.

3. "The Granite Ridges of Kharga Oasis: Intrusive or Tectonic?" By William Fraser Hume, D.Sc., A.R.S.M., F.G.S.

The author quotes the detailed records given by Mr. Beadnell in his paper published in the Quarterly Journal for February, 1909 (vol. lxv, p. 41), and although in entire agreement with the facts there stated, differs with regard to the interpretation of those facts. Whereas Mr. Beadnell regards the granite as intrusive, on account of the high dip of the sedimentaries, and the changes which they exhibit as regards colour and hardness, near the granite, the author considers that the dips are due to fold-movements almost at right angles to one another, since they lie on the same line as the crater-like basins, the rims of which are formed of the compact and steeply-dipping limestones of the Lower Eocene, and he adduces as further evidence the fact that dykes and quartz-veins penetrating the crystalline rocks cease abruptly at the edge of the sandstone. He attributes the bright hues and silicification found near the contact to gases and heated waters acting along the boundary between the dissimilar rock-masses.

4. "The Cretaceous and Eocene Strata of Egypt." By William Fraser Hume, D.Sc., A.R.S.M., F.G.S., Superintendent, Geological Survey of Egypt.

The author divides the fossiliferous Cretaceous strata into three series—

(1) A northern Antonian type, marked by Cenomanian species, including typical Turonian strata.

(2) A central Egyptian or Hammama type, Cenomanian strata being absent, Campanian marked by abundance of *Ostrea villei* and *Trigonarca multidentata*, and phosphatic beds; the Danian portion having an eastern facies in which *Pecten*-marls are a characteristic

feature, and a western chalky limestone indicating a close affinity with the white chalk of Northern Europe.

(3) A southern or Dungul type, having close affinities with 2, but in the Campanian the phosphatic beds are inconspicuous, and the fauna consists of a group of specialized sea-urchins and of Gasteropods among which *Turritellæ* are very prominent.

The author emphasizes the uniformity of the Lower Eocene throughout Egypt, its triple subdivision being recognizable over vast areas. In the Middle Eocene this uniformity is replaced by differentiation, the well-known regions of the Fayûm and the Moqattam Hill differing from the succession in the area selected as typical in this paper. In the latter, five zones have been recognized in the lower division, while in the Upper Moqattam the *Turritella*-beds and the strata rich in *Carolia placunoides* and *Plicatula polymorpha* are of zonal importance. The Lower Moqattam is considered as beginning with the *Nummulites gizehensis* zone and closing with the *Gistortia*-bed, to the significance and extent of which attention is especially directed.

The author discusses the relation between the Cretaceous and Eocene beds, and points out that they differ lithologically, limestones being dominant in the Lower Eocene and shales in the Upper Cretaceous.

Palæontologically, great groups such as the Ammonites still abundant in the Upper Cretaceous disappear in the Eocene and are replaced by the characteristic nummulinid Foraminifera. On the other hand, both periods bear a strong resemblance to each other in the dominance of oysters and sea-urchins over other forms. A notable feature is the comparative rarity of Brachiopoda in Egypt throughout both periods, nor have Belemnites been recorded from the Egyptian Cretaceous.

Among post-Eocene formations the calcareous grits are shown to have a wide extension; but in the desert they differ in character from the mammal-yielding beds of the Fayûm. The question as to the Upper Eocene or Oligocene age of these beds is left over.

The quartz-chert gravels appear to be closely related to the calcareous grits, but are unconformable upon them. This continental phase is accompanied by volcanic and geyser activity.

The Cretaceous Period in Egypt was therefore one, in the main, marked by the gain of sea over land, the Eocene was one of rest, while at the close of the Eocene and during the Oligocene the approach of a continental phase is clearly indicated.

II.—Mineralogical Society.

November 16.—Professor W. J. Lewis, F.R.S., President, in the Chair.

(1) On an occurrence of Native Copper with Tin Ore in the Federated Malay States; by Mr. J. B. Scrivenor. In concentrates obtained in the final washing of the tin ore from the Rotan Dahan mine, in the district of Kinta Perak, the cassiterite was found to be mixed with a reddish mineral, which could not be separated from it. This proved to be

native copper in minute and beautifully sharp crystals. The tin ore is obtained from a mass of partially decomposed soft schists overlying limestone, and the copper was probably the result of reduction in situ of a copper salt held in solution by water percolating through the schists. — (2) On a Meteoric Stone from Simondium, Cape Colony; by Dr. G. T. Prior. Two or three masses of a meteoric stone were discovered in 1907, 100 yards apart and a foot below the surface, in gravel near Simondium Station, on the Paarl to French Hoek line, in Cape Colony. The masses, of which the largest was not more than a foot in diameter, were broken up by the finders, who supposed the particles of nickel iron seen on the fractured surfaces to be native silver. Six of these fragments, which were preserved, have been presented to the British Museum collection by Mr. R. T. Hancock and Mr. R. H. Stanley, one of the prospectors who discovered the masses. The meteorite belongs to the less common class of aerolites which show no chondritic structure; it consists of enstatite, olivine, and felspar, with nickel-iron, magnetite, and some troilite.—(3) On the occurrence of Alstonite and Ullmannite (a species new to Britain) in a Barytes-Witherite vein in the New Brancepeth Colliery, near Durham; by Mr. L. J. Spencer. A large vein of barytes coinciding with a fault in the New Brancepeth Colliery is worked commercially on a large scale for barytes, and has yielded many finely crystallized mineral specimens. These include barytes and witherite in large crystals, and the rare species alstonite and ullmannite (Ni Sb S, with 28 per cent. of nickel), the latter of which has not been previously recorded in the British Isles. Galena, blende, copper-pyrites, iron-pyrites, and melanterite are also present in small amount. The order of formation of the non-metallic minerals is (1) barytes, (2) witherite, and (3) alstonite, the two last having been derived from the barytes. The ullmannite is found as cubes of considerable size and as *octahedra*, and it sometimes forms a parallel intergrowth with galena.—(4) On Sartorite and other Minerals from the Binnenthal; by Professor W. J. Lewis. A crystal of sartorite showing twin lamellæ was described.—A pocket sclerometer was exhibited by Mr. C. J. Woodward.

III.—Zoological Society of London.

November 9, 1909.—S. F. Harmer, Esq., M.A., F.R.S., Vice-President, in the Chair.

A paper was read by Sir Henry H. Howorth, D.C.L., F.R.S., F.Z.S., on "Some Living Shells, their Recent Biology, and the Light they throw on the Latest Physical Changes in the Earth.—I. *Mya arenaria*". He stated that *Mya arenaria*, or the Clam-shell, is widely distributed in the North Boreal, European, and North American seas, and claimed to prove that it is a recent migrant into the former, and has probably not been there more than 300 years. The notion that it is an Arctic shell is a mistake. In the Arctic lists *Mya truncata*, var. *oblonga*, has been mistaken for it, and the glacial character of the beds in which it has occurred, which has been postulated from its occurrence there, has accordingly been a wrong inference. Brögger has argued that it migrated from America. It was abundant in the Crag seas, and occurs in derivative fragments in the Drift beds, but it does not occur in the estuarine deposits or raised beaches, proving that after the period of the Crag it became extinct in Europe and has since been reintroduced. He regarded the cause of its extinction as a mystery, since the group of estuarine shells with which it is found has lived continuously in Europe since later Crag times.

In the course of his paper the author gave some interesting information on the changes known to have taken place in the Baltic, which at one time was a freshwater lake; afterwards it became freely open to the North Sea, and possessed an abundance of marine shells, with *Ostrea* and *Balani*, of large size. Lastly, so restricted became its supply of salt water, and so largely affected by the fresh waters of the great rivers which flow into it, that its marine fauna had gradually been killed off, or had become so dwarfed and malformed as to be hardly recognizable.[1]

CORRESPONDENCE.

THE USE OF THE TERM 'LATERITE'.

Sir,—Since writing to you on the use of the term *laterite*, two papers have appeared that illustrate the confusion surrounding the name at the present day. One of these is Mr. Mennell's "Note on Rhodesian Laterite" (Geol. Mag., August, 1909), and I shall be glad if you will permit a few further remarks in connexion with it.

Mr. Mennell agrees with Dr. Maclaren in considering that an essential condition to the formation of laterite is the alternation of perfectly distinct wet and dry seasons; in fact, Mr. Mennell says that this is the essential condition. Now, although throughout the Federated Malay States the rock called 'laterite' by engineers is, as far as I am aware, ironstone deposited in weathered rocks, there is in the State of Malacca an occurrence of rock that agrees with Dr. Francis Buchanan's definition of laterite; and in that it can be dressed with an axe, and hardens on exposure to the atmosphere, has proved of great utility in buildings, as can be seen in the old Portuguese church that crowns the hill in Malacca Town. This Malacca rock would, I believe, be accepted by all as laterite, and carries with it the idea of 'brick', on which the name was founded.

When Dr. Maclaren's paper appeared in 1906 I was struck by his remark on the necessity of alternating wet and dry seasons, since my impression was that no such alternation exists in Malacca; and when I saw the point emphasized by Mr. Mennell, I wrote to the Medical Officer in Malacca asking for the figures of monthly rainfall for any

[1] See H. H. Howorth, "The Recent Geological History of the Baltic": Geol. Mag., 1905, pp. 311, 337, 407, 454, 550.

three consecutive years, and received figures for 1906, 1907, and 1908, as follows:—

	1906.	1907.	1908.
	Inches.	Inches.	Inches.
January	3·12	2·57	2·27
February	4·19	1·99	3·62
March	4·63	3·53	3·48
April	6·65	5·55	5·53
May	6·61	7·30	4·23
June	6·71	6·57	3·49
July	6·42	6·32	4·22
August	10·82	4·92	9·12
September	5·97	5·65	10·75
October	10·60	9·32	6·69
November	3·81	8·35	6·86
December	11·03	9·28	4·66

I think it will puzzle anyone to find evidence in the above for alternating and perfectly distinct wet and dry seasons. Mr. Kilroe doubts the necessity of tropical conditions for the formation of laterite, and as there is no reason whatever for supposing that the Malacca laterite was formed under conditions of rainfall differing from those that obtain now, it appears that alternating wet and dry seasons are not necessary either. J. B. Scrivenor.

Geological Department, Kuala Lumpur,
Batu Gajah, Federated Malay States.
October, 1909.

OBITUARY.

CARL GOTTSCHE, Ph.D.

Born 1855. Died October 11, 1909.

We regret to record the death of Professor Dr. Carl Gottsche, Director of the Mineralogical–Geological Institute at Hamburg. Born at Altona in Schleswig-Holstein, he early gave attention to geology, and in 1875 described a boulder of sandy limestone found at Eimsbüttel near Hamburg, which contained *Paludina lenta*, *Planorbis euomphalus*, and *Unio Solanderi*, characteristic of the Headon Beds. In 1878 he published papers on the Miocene Mollusca of Reinbeck, and on some Jurassic fossils from the Argentine Cordilleras; and in 1883 he issued a little work, *Die sedimentare Geschiebe der Provinz Schleswig-Holstein*, which was published at Yokohama. At that date Dr. Gottsche was engaged in a geological study of Korea, and in addition to other papers on the results of his work, he communicated to the Berlin Academy in 1886 a Geological Sketch of Korea, with the first geological map that had been made of the country.[1] Dr. Gottsche attended the London meeting of the International Geological Congress in 1888, and was also present at the British Association meeting at Bath in the same year. Those who attended some of the geological excursions in the west country will remember his keen interest and buoyant spirits in the field; and all will lament his decease at the age of 54. H. B. W.

[1] Dr. Gottsche obtained a recent specimen of *Pleurotomaria Beyrichii* at Enoshima, Japan, described by H. Woodward, Geol. Mag., 1885, pp. 433–9, Pl. XI, Fig. 1.

THOMAS ROXBURGH POLWHELE, J.P., D.L., M.A., F.G.S.

BORN 1831. DIED SEPTEMBER 2, 1909.

MR. POLWHELE, who graduated at Cambridge, joined the Geological Survey under Murchison in July, 1857, and in the following year became a Fellow of the Geological Society. He was engaged in the mapping of parts of Oxfordshire and Buckinghamshire, and drew boundary-lines, which have proved to be substantially correct, for the clayey equivalents of the Corallian rocks between Wheatley and Quainton. He also surveyed areas of the Bagshot Series and other formations on the borders of Hampshire and Surrey. His geological notes were published in memoirs by his colleagues Mr. Whitaker and the late Professor A. H. Green.

Having succeeded to an estate at Polwhele, near Truro, he resigned his post on the Geological Survey on March 3, 1862. He was chosen President of the Geological Society of Cornwall in 1896 and 1897, and delivered addresses on "The Relation of other Sciences to Geology" and on "The Physical Geology of the Earth". He died at his Cornish home, aged 78.

MISCELLANEOUS.

RETIREMENT OF MR. W. A. E. USSHER, F.G.S., OF THE GEOLOGICAL SURVEY OF ENGLAND.—Mr. W. A. E. Ussher, who joined the staff of the Geological Survey early in 1868, retired on September 30, after a service of more than forty-one years. Commencing work on the borders of the Mendip Hills, he has surveyed and mastered the geological structure over a continuous tract of ground extending from that region through Bridgwater to the Quantock Hills, and through the vales of Taunton, Honiton, and Exeter to Plymouth and the Cornish borderland. Although the main features in the geology had been represented on the old one-inch maps of De la Beche, the re-survey was to all intents and purposes a new one as regards details of the strata and tectonic features. To Mr. Ussher we owe the recognition and mapping of the subdivisions of the New Red rocks from West Somerset to the south coast of Devon, the first account of which was published in the GEOLOGICAL MAGAZINE for April, 1875. To him also our knowledge of the subdivisions, the palæontology, and the foreign equivalents of the Devonian rocks of South Devon is most largely due. His strenuous and long-continued labours on the geology of that intricate district demanded not merely enthusiasm but an amount of physical energy unsurpassed. In other regions he was occupied for shorter periods, among the Jurassic rocks and drifts of North Lincolnshire, and in the survey of the superficial deposits on the borders of Greater London and in parts of the south-east of England.

CHANGE OF NAME.—Bibliographers should take note that Mr. H. B. Muff, F.G.S., of the Geological Survey of Scotland, has changed his name to Maufe.

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