oval foramina corresponding to the first and second pillars of the living chamber. Near the right-hand top corner part of the lid is broken away, showing the pits produced by the moniliform rays and the concentric shelly walls. Rather under one-half natural size. Author's collection.

- FIG. 2.—*Barrettia* cf. *monilifera*; Woodward. Same locality. A young specimen with the upper valve in place, partly crushed into the visceral cavity. Rather over one-third natural size. 2a. Top view; at the bottom of the figure is seen the embayment of the margin of the shell. 2b. Side view of both valves conjoined. The decoration of lid and sides is well seen on young examples such as this one. Same collection.

PLATE XX.

- FIG. 1.—*Barrettia* cf. *monilifera*; Woodward. Upper Cretaceous. Haughton Hall, near Green Island, Western Jamaica. Specimen of the lower or conical attached valve viewed from above. The lid is missing and the living chamber has been cleaned out. Around the living chamber are seen the pits of varying size and depth into which shelly processes from the under side of the top valve fitted. Near the left-hand side a portion of the top valve remains. Slightly over one-third natural size. Author's collection.
- FIG. 2.—Same species. Same locality. Specimen with both valves conjoined, the central part of the lid almost completely crushed into the living chamber, viewed partly from above and partly from the side. The top lid is very thin and is weathered away in places, especially near the right-hand top edge of the figure, where the moniliform rays like strings of beads can be seen. In other parts the saucer-like depressions on the surface of the top valve are visible. Towards the lower part of the figure the top lid is partly grown over by oysters. Slightly under one-third natural size. Same collection.
- FIG. 3.—*Barrettia* cf. *multilirata*; Whitfield; var. *cylindrica* nov. Same locality. Specimen with both valves conjoined, part of the lid broken away at the top right-hand edge. Rather over one-third natural size. Same collection.
- FIG. 4.—*Cardita* (*Venericardia*) cf. *subcomplanata*; d'Archiac. Same locality. Right valve. Natural size. Same collection.
- FIG. 5.—*Avellana* (*Eriptycha* ?) cf. *decurtata*; Zekeli. Same locality. Natural size. Same collection.

The Traprain Law Phonolite.

Part I: Nepheline, Analcite, Sodalite, and Olivine in the Traprain Law Phonolite.

By A. G. MACGREGOR, M.C., B.Sc.

Part II: Analysis of the Traprain Law Phonolite.

By F. R. ENNOS, B.A., B.Sc., A.I.C.

PART I.

A RE-EXAMINATION of the trachytoid phonolite of Traprain Law was undertaken on the suggestion of Mr. E. B. Bailey, in order to determine the characteristics and mode of occurrence of the nepheline contained in it. The slides examined were those of the Geological Survey collection and nine new ones specially cut from material recently obtained. During the course of the examination sodalite and olivine were detected in the rock. These minerals have not been mentioned in previous accounts of

1

5

4

3

2

C. T. T. photo.

BARRETTIA (about $\frac{1}{3}$ nat. size). GASTEROPOD AND LAMELLIBRANCH FROM THE
BARRETTIA BED (nat. size). Jamaica.

TOTAL 511

the petrography of Traprain Law, and sodalite seems to have been described in only one other rock from the British Isles (14).¹

In Traprain Law *all* the isotropic mineral content was previously taken for analcite. Now that some of it proves to be sodalite, the question must be faced, how far the analcite of other Scottish rocks will survive chemical investigation.

After Part I of this paper had been written Dr. Flett very kindly arranged for a re-analysis of the Traprain Law phonolite in the Geological Survey laboratory. Mr. Ennos undertook the work and his results furnish the material of Part II.

OPTICAL EXAMINATION.

Nepheline.—During the examination of the slides under the microscope a mineral was noticed to occur fairly abundantly, and with the following characteristics:—

1. *Very low polarization colours*.—Between crossed nicols the mineral had a pale indigo-blue-grey colour. This polarization colour was decidedly lower than that of the feldspars, and by means of it the larger patches of the mineral could be picked out fairly readily, after some practice, with the 1 inch objective. The smaller patches were located by a careful examination with the $\frac{1}{4}$ in. objective.

2. *Refractive Index*, as shown by the Becke test, decidedly higher than that of the surrounding alkali-feldspar laths of the groundmass in contact with it, and approximately the same as that of the balsam of the slide.

3. *Cleavage*.—Indications of cleavage were generally present, one fairly well defined, and another much less clear and approximately at right angles to the first. With reference to the better defined cleavage the mineral showed straight extinction and negative character.

4. *Decomposition*.—The feldspars of the groundmass were in general made cloudy by brown powdery decomposition products, but this was not the case as regards the mineral in question, which stood out, in ordinary light, clear, colourless, and transparent among the cloudy feldspar laths. Very occasionally isotropic material occurred in such a way that it might be interpreted as replacing this mineral (nepheline). Tiny very sporadic fibres (a zeolite?) could often be seen in the mineral.

5. *Habit*.—In nearly every case the mineral showed ophitic relations to the feldspar laths of the groundmass, and good idiomorphic outlines were never seen. Very occasionally the mineral was included as small irregular patches within the feldspar phenocrysts. Occasionally approximation to squarish rectangular outlines was seen, but idiomorphism was never complete. Exceptionally there was a doubtful suggestion of a feldspar lath moulded on the mineral.

6. *The size of the patches* ranged from those hardly determinable with a $\frac{1}{4}$ in. objective, to irregular patches about the order of 0.6 mm. The size varied greatly even in the same slide.

7. *Interference figure*.—Many attempts were made to get an interference figure from the mineral, but the best were very ill-defined, and it was even difficult to decide whether a biaxial or a uniaxial figure was being dealt with. In some cases the figure could be doubtfully interpreted as a very broad, ill-defined uniaxial black cross giving negative character with the gypsum plate. The mere failure to give a distinct figure, when combined with the very low double refraction, suggested a distinction between the mineral and a feldspar.

From the above characteristics it was suspected that the mineral was nepheline.

¹ Figures in parentheses refer to the Bibliography at the end.

Sodalite and Analcite.—There was also noticed under the microscope the abundant isotropic material previously referred to as analcite in descriptions of the rock. Its characteristics were:—

1. *Isotropic.*
2. *Refractive Index* much lower than that of the surrounding alkali felspar laths of the groundmass, and very much lower than that of the balsam of the slide.
3. *Cleavage*, when present, very ill-defined.
4. *Decomposition.*—Among the groundmass felspar laths, with their brown powder of decomposition products, the mineral stood out clear and colourless.
5. *Habit.*—Crystal outlines entirely absent. The isotropic material occurred typically wedged in between the felspar laths of the groundmass as abundant small patches, often of roughly triangular shape, owing to the straight bounding edges of the felspars: sometimes in larger roundish patches with ophitic relations to the felspars: exceptionally as a small vein cutting across the rock, moulded on the idiomorphic terminations of felspar laths. The general mode of occurrence did not suggest derivation from nepheline.
6. *Size of patches.*—The smaller were about 0.18 mm. by 0.08 mm. The larger roundish patches ranged up to about 0.5 mm. by 0.4 mm. The veins were about 0.4 mm. broad.

From the above characteristics the isotropic material might be analcite or sodalite, or it might be made up of both.

Olivine.—Besides the green pleochroic augite described by Dr. Hatch in his account of the rock (5), a mineral was noticed with the following characteristics:—

1. *High polarization colours.*—Blues, greens, and reds of the second order and higher.
2. *Refractive Index.*—High.
3. *Cleavage.*—One very pronounced somewhat irregular cleavage or parting, and sometimes another much less well defined but more regular and at right angles to the general direction of the first. Also irregular cracks. Extinction almost always parallel to the cleavages. The optical character of the more regular cleavage zone was positive.
4. *Decomposition.*—Often clear and undecomposed, colourless to very pale yellow in parallel polarized light, and not pleochroic. In other cases wholly or partly altered to a pale or olive-green serpentinous substance with very low polarization colours. Olivine-shaped pseudomorphs common, occasionally in a more decomposed part of the rock replaced by a red-brown or yellowish transparent mineral. Serpentinization started along the cracks and cleavages with some formation of iron ores. (The pleochroic green augite of the rock was almost invariably fresh and undecomposed.)
5. *Habit.*—The mineral occurred in two ways—(a) As small crystals and granules in the groundmass, always with slightly ophitic relations to the felspar laths, the majority with quite irregular outlines, but many showing the characteristic shape of olivine. (b) As larger scattered patches with ophitic relations to the felspars. The components of each large scattered patch were shown to be in optical continuity by the cleavages and extinction. The ophitic relations were as striking as those commonly shown by augite in dolerites.
6. *Size of crystals.*—Irregular grains up to about 1 mm. in length. Shaped olivines up to about 0.3 mm. by 0.18 mm. Ophitic patches extending through an area as large as 1.1 mm. by 0.9 mm.
7. *Interference figures* were biaxial and showed a very large optic axial angle, but in some cases it seemed possible to determine the optical character as definitely negative.
8. In the crystals with the characteristic shape of olivine there was a very well-defined but irregular parting more or less parallel to (001), and sometimes

a faint but irregular cleavage parallel to (010). Nearly all such crystals extinguished parallel to the cleavages.

From the above characteristics the mineral was suspected to be olivine in spite of the unusual ophitic mode of occurrence. The mineral occurred abundantly in the rock, but not so frequently as the pleochroic augite. In a few slides it was absent.

MICROCHEMICAL AND CHEMICAL EXAMINATION.¹

Nepheline.—In order to test the supposed nepheline, three slides were subjected to the same microchemical staining process employed by Dr. Hatch (4 and 5). Over twenty patches of the supposed nepheline were noted and their positions recorded both by sketches and by co-ordinates on the grid engraved on the fixed stage of a Dick microscope. Each slide was then cleaned with benzol and covered with a few drops of concentrated hydrochloric acid. Five minutes acid treatment was found to be quite sufficient. The slide was then carefully washed for about twenty minutes in a very gentle stream of running water in a flat dish, treated with a solution of fuchsine, and again carefully washed. *Every* marked patch of supposed nepheline was stained and stood out distinctly from the unaffected felspars. It was found that staining was unnecessary, as the gelatinized patches could be clearly seen after the acid treatment and washing. An *even cleaner* test was made in the case of two slides by more prolonged treatment with acid, when the nepheline was entirely removed and a hole left with the shape of the original nepheline patch.

This test confirmed the presence of nepheline.

Analcite and Sodalite.—Isotropic patches were observed to stain in the slides primarily used to test for nepheline, and some of the isotropic material was seen to be attacked by the acid much less readily than the nepheline. In order to test further the nature of the isotropic material, patches were marked as in the case of the nepheline, and the slide was covered with a few drops of pure dilute nitric acid and silver nitrate for about twenty minutes, and then carefully washed and exposed to sunlight. Under the microscope different patches of the marked isotropic material were now seen to present quite distinct characters. Some had been highly corroded and were crowded with small black grains, especially at the edges, and in consequence at once stood out and caught the eye. Others were much less corroded, but had acquired a very striking system of small reticulated cracks, quite independent of cleavage (when the latter could be made out). These cracks were just visible with the 1 in. objective. The cracked patches had no deposit of black grains. Further, with the naked eye the surface of the slide could be seen to be covered in parts with

¹ As explained above, the chemical analysis of the rock by Mr. Ennos is reserved for Part II, where it is accompanied by a discussion of mineral proportions.

a very finely granular purplish deposit, which became dark brown on exposure to bright sunlight. This fine powdery deposit was traceable to the highly corroded patches as a source. By treatment of the slide with aqueous ammonia, all the dark particles were removed. Hence it was concluded that silver chloride had been formed at the expense of some of the isotropic patches, which were thus shown to contain chlorine.

Two slides of ditroite were then cut from a hand-specimen with blue sodalite apparent to the naked eye, and were similarly treated. The sodalite patches were corroded and became crowded with dark grains, and there was seen on the slides a purple deposit, precisely the same as that already described, which darkened in sunlight. The spreading of this purple deposit from the large sodalite patches was actually observed with a hand lens during the action of the nitric acid and silver nitrate, and it was found impossible to prevent this taking place to some extent.

In contrast to the phenomena shown by the ditroite, slides of teschenite from the island of Inchcolm and from Crossall Hill, Dalmeny, when similarly treated with nitric acid and silver nitrate, gave no sign of a silver chloride precipitate. Instead, the large analcite patches of these rocks acquired the same reticulated pattern as was observed in some of the isotropic material of Traprain Law. Very dilute nitric acid and silver nitrate gave the best result.

A further test for chlorine in the Traprain Law rock was made as follows. A small fragment of the rock was crushed and repeatedly shaken up with cold distilled water. The filtrate did not react for chloride, thus proving water-soluble chlorine was not present in appreciable quantity. Another chip when powdered and treated with cold dilute nitric acid gave a dense precipitate of silver chloride on adding silver nitrate to the filtrate. This proved acid-soluble chlorine was present.¹

The only sources of acid-soluble chlorine in an igneous rock are the sodalite group of minerals and sometimes apatite. Only very minute apatite needles were present in the five slides cut from the hand-specimen used for crushing, and could not account for the dense silver chloride precipitate, even on the supposition that all the apatite was chlorine-bearing. (Occasionally larger very sporadic apatites are met with in the Traprain Law rock.) Hence part of the isotropic material was referred to a mineral of the sodalite group.

Because Hillebrand (6, p. 26) states that chlorine is an essential component of noselite (nosean), another rock chip was powdered and boiled with dilute hydrochloric acid. The filtrate when tested did not react for sulphate. This proved that part of the isotropic material was sodalite.

The Inchcolm teschenite, when crushed and tested for chloride, gave no appreciable precipitate of silver chloride. This test, when

¹ See also analysis, Part II.

coupled with the evidence of the peculiar reticulated cracks already mentioned, showed that part of the isotropic material of Traprain Law was analcite.

An especially good example of the joint occurrence of analcite and sodalite was afforded by a vein of isotropic material 0.4 mm. wide, which traversed one of the slides. The differential action of the nitric acid and silver nitrate here showed clearly that the vein consisted chiefly of analcite, but partly of sodalite. Before the microchemical test the presence of only one isotropic mineral was suspected.

It is hoped that the simple qualitative test for chlorine on the rock powder will prove a useful means of detecting the presence of sodalite in any rock, and that further work will show that the reticulated system of cracks is characteristic of analcite among isotropic minerals under the conditions specified above.

Olivine.—The optical characters of the supposed olivine left some slight doubt that the mineral might be an augite. This doubt was removed by marking and drawing as before about fifteen pieces of supposed olivine (crystals with olivine shape, irregular grains, and ophitic patches) in different slides and treating with concentrated hydrochloric acid for about ten to fifteen minutes. In every case the mineral was at first attacked and then entirely removed by the acid. This is characteristic of an olivine not rich in forsterite. The irregular cracks and cleavages were often left running across the space where the mineral had been, owing to the magnetite deposited in them on the commencement of serpentinization. The green augites were unaffected by the acid. The former mineral was thus proved to be an olivine fairly rich in iron.

Note.—For success in all the microchemical work it was found essential to locate carefully and to draw a sketch of each patch of the mineral under investigation, and the other minerals in its neighbourhood, after the cover-glass, but not the balsam, had been removed. Without these precautions it was found extremely difficult definitely to locate portions of the slide seen before the microchemical treatment, owing to movement during removal of the cover-glass, and the changes due to the action of the acid and the absence of the balsam. The stain of fuchsine is not stable in presence of hot balsam, so it is not convenient to replace cover-glasses on slides so stained.

APPENDIX I.

NOTES ON PREVIOUS WORK.

Nepheline.—Dr. Hatch, who discovered that Traprain Law was a phonolite, states in his description of the rock (4 and 5) that he had great trouble in determining the nepheline, but that Rosenbusch, who examined some of the slides, detected small four- and six-sided sections of that mineral.

Analcite.—Dr. Hatch (5) states that analcite and natrolite are present in Traprain Law as alteration products of the nepheline.

In Mr. Bailey's description of the Traprain Law rock (2) evidence is given that the isotropic material (described as analcite) is primary in origin.

Sodalite.—Mr. Player's analysis of Traprain Law, given in Dr. Hatch's Edinburgh Royal Society paper (5), does not record chlorine.

Rosenbusch states (13, p. 963) that in the phonolitic rocks the minerals of the haityne group (which includes sodalite) are always idiomorphic. The mode of occurrence of sodalite in Traprain Law constitutes an exception to this rule.

The only other known occurrence of sodalite in a rock from the British Isles is—as far as I am aware—that noted by Dr. Shand in his paper on borolanite and its associates in Assynt (14). Here, in a rock which he calls assyntite, he found idiomorphic sodalite, showing sections of the rhombic dodecahedron, and enclosed by all later minerals. He identified the mineral by its low refractive index and isotropism, and by the chlorine reaction of the rock. He says there is no evidence to justify calling the mineral haityne or nosean in preference to sodalite. The rock reacts strongly for chlorine and only very faintly for sulphuric acid. An analysis of assyntite has been published by Mr. A. Gemmell (3).

Olivine.—References to the occurrences of olivine in phonolites will be found in Rosenbusch's classical work (13, pages 968, 969, 974) and in the bibliography on pages 952 et seq. of the same volume. I have consulted the papers by A. von Lasaulx (7), by H. Möhl (10), and by P. Marshall (9) therein mentioned, but in no case could I find a record of ophitic olivine.

Lady McRobert (8) describes an augite-olivine-trachyte from the Mid Hill, Eildon Hills, where the olivine is represented by occasional yellow and red-brown pseudomorphs. She says the rock closely resembles that of Traprain Law, but although expecting to find nepheline in the Mid Hill rock, she could not detect it by optical or microchemical methods.

APPENDIX II.

THE HISTORICAL INTEREST OF THE TRAPRAIN LAW PHONOLITE.

Traprain Law has considerable interest in petrological history, as it was, I believe, the second instance in which nepheline was found in a "Palæozoic volcanic rock",¹ and it therefore formed one of the important links which strengthened the chain of evidence, proving that there is no essential difference between the so-called palæo-volcanic and neovolcanic rocks of the continental geologists. O. A. Derby (2) discovered in Brazil the first known occurrence of nepheline and leucite in palæozoic volcanic rocks.

Rosenbusch's examination of Derby's and Hatch's Palæozoic phonolites must have convinced him that he had been right in saying in the 1887 edition of his textbook (11), that to geological age there had previously been attributed a more important influence on the structural and mineralogical forms of eruptive rocks than was

¹ "Palæovulkanisches Gestein." The fact that the Traprain Law phonolite is actually an intrusion does not affect the argument.

its due. He had come to this conclusion although at that time palæovolcanic equivalents of the elæolite-syenites were unknown. Subsequent editions of his great work mention the Palæozoic phonolites of Brazil and Traprain Law, and he gradually discards the age factor in his classification, stating definitely in his 1896 edition (12) that he recognized that it had no real significance in classification. In the 1908 edition (13) he concludes that this fact is widely recognized because "it has occurred to no geologist to give a separate name to the palæozoic phonolites, leucitophyres, etc."

APPENDIX III.

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In conclusion I would like to thank my colleague Mr. E. B. Bailey, and Dr. R. Campbell, of Edinburgh University, for their help and advice in the preparation of this paper.

PART II.

The chemical analysis (I) of the Traprain Law phonolite was made in the laboratory of the Geological Survey. For purposes of comparison, the former analyses by J. H. Playter (II),¹ and the partial analysis by W. Pollard (III),² are also given.

¹ *Trans. Roy. Soc. Edin.*, vol. xxxvii, 1892, p. 125.

² "The Geology of East Lothian": *Mem. Geol. Surv.*, 1910, p. 130.

	I.	II.	III.
SiO ₂ . . .	56.89	56.8	—
TiO ₂ . . .	.33	.5	—
Al ₂ O ₃ . . .	19.11	19.7	—
Fe ₂ O ₃ . . .	2.04	2.2	—
Cr ₂ O ₃ . . .	nt. fd.	—	—
FeO . . .	3.44	3.5	—
MnO . . .	.18	.2	—
(CoNi)O . . .	nt. fd.	—	—
CaO . . .	2.15	2.2	—
BaO . . .	.01	—	—
MgO . . .	.35	.4	—
K ₂ O . . .	6.35	7.1	6.41
Na ₂ O . . .	6.88	4.3	6.79
Li ₂ O . . .	nt. fd.	—	—
H ₂ O at 105° C. .	.54	} 2.5 (loss on ignition)	—
H ₂ O above 105° C. .	1.68		—
P ₂ O ₅ . . .	.15	—	—
FeS ₂ . . .	.17	—	—
SO ₃ . . .	trace	—	—
CO ₂ . . .	nt. fd.	—	—
Cl . . .	.22	—	—
	100.49	—	—
Less O for Cl . .	.05	—	—
Total . . .	100.44	99.4	—

It will be seen that, with the exception of the alkalis, the new analysis agrees very closely with that of Player. The new figures for potash and soda, which confirm the partial analysis of Dr. Pollard, differ from those of Player, both in the total and in the relative proportions of the two oxides. The only other constituent in which any serious divergence occurs between the two analyses is the alumina, but, after making allowance for the phosphoric anhydride not determined by Player, the discrepancy amounts to only 0.4 per cent. Phosphoric anhydride and chlorine, of which no mention is made by Player, have been found in quite appreciable quantity. Special interest attaches to the determination of these constituents, owing to their importance in the calculation of the amount of sodalite. If the phosphoric anhydride is assumed to be present as chlorapatite, the 0.15 per cent of P₂O₅ found will require 0.02 per cent of chlorine to form 3Ca₃P₂O₈ · CaCl₂. The remaining 0.20 per cent of chlorine calculated to 3(Na₂O, Al₂O₃, 2SiO₂) 2NaCl gives 2.7 as the percentage of sodalite in the rock.

The mineral composition of the rock has been calculated from the chemical analysis in the following way and the results are appended below. After determining the amounts of ilmenite from the titania and chlorapatite from the phosphoric anhydride, the residual chlorine is allotted to sodalite. Total potash is calculated as orthoclase, and water above 105° C. as analcite. The soda remaining after allowing for that in sodalite and analcite is divided between albite and nepheline, the relative amounts of these being determined by the silica available after all other silicates have been satisfied. As

some alumina is still unaccounted for, this is given the requisite amounts of lime and silica to form anorthite. Ferric oxide is then combined with the corresponding amount of ferrous oxide for magnetite. The residual lime, together with ferrous and magnesium oxides in the proportion in which these two are left, yield the meta-silicate diopside, while the rest of the ferrous oxide and magnesia enter into combination with silica as the orthosilicate olivine.

By the above method a somewhat conventional representation of the mineral composition of the rock is obtained. It is probable that the figure for analcite is too high, owing to the presence of other hydrous minerals. Further, there is no soda available for the calculation of the amount of alkali-bearing pyroxene present. Diopside, as such, does not occur in the phonolite.

Orthoclase	. . .	$K_2O, Al_2O_3, 6SiO_2$	. . .	37.58
Albite	. . .	$Na_2O, Al_2O_3, 6SiO_2$	. . .	20.07
Anorthite	. . .	$CaO, Al_2O_3, 2SiO_2$	. . .	3.19
Nepheline	. . .	$Na_2O, Al_2O_3, 2SiO_2$	. . .	4.23
Analcite	. . .	$Na_2O, Al_2O_3, 4SiO_2, 2H_2O$	. . .	20.50
Sodalite	. . .	$3 (Na_2O, Al_2O_3, 2SiO_2), 2NaCl$	. . .	2.71
Diopside	. . .	$\{CaO, SiO_2$	$. . . 2.74\}$	5.69
		$\{MgO, SiO_2$	$. . . .50\}$	
		$\{FeO, SiO_2$	$. . . 2.45\}$	
Olivine	. . .	$\{2MgO, SiO_2$	$. . . .26\}$	1.80
		$\{2FeO, SiO_2$	$. . . 1.51\}$	
Magnetite	. . .	FeO, Fe_2O_3	. . .	2.97
Ilmenite	. . .	FeO, TiO_2	. . .	.62
Chlorapatite	. . .	$3Ca_3P_2O_8, CaCl_2$	. . .	.35
Pyrites	. . .	FeS_2	. . .	.17
Moisture	. . .	H_2O	. . .	.54
Total	. . .			100.42

The Lower Carboniferous Rocks of Cumberland.

By K. W. EARLE, M.Sc., F.G.S.

ON glancing over back numbers of the GEOLOGICAL MAGAZINE after eight months' residence abroad, I have been much interested to find a paper by Mr. C. Edmonds on the Carboniferous Limestone of West Cumberland.¹

I myself worked in this district in connexion with a more ambitious paper on the whole of the limestone series from Penrith via Caldbeck to Egremont, which paper formed the subject of a communication to the Geological Society last November. It is needless to say that at the time of my work I had no idea there was an independent observer in the field, or I should not have devoted much time to his area. Such duplication of field work, though regrettable, is perhaps, however, not entirely wasted if the second observer is able—as I am in the present case—to confirm the conclusions of the first by independent mapping.

¹ GEOL. MAG., Vol. LIX, 1922, pp. 74 and 117.