

27. *The BASIC INTRUSION of BARTESTREE, near HEREFORD.* By Prof. SIDNEY HUGH REYNOLDS, M.A., F.G.S. (Read June 17th, 1908.)

[PLATE LII—MICROSCOPE-SECTIONS.]

CONTENTS.

	Page
I. Introduction, and Field-Relations	501
II. The Altered Rocks	501
III. General Relations of the Intrusive Rocks	503
IV. Description of the Intrusive Rocks	503
V. Conclusion	510

I. INTRODUCTION, AND FIELD-RELATIONS.

THE field-relations of the basic intrusion of Lowe's-Hill Quarry near Bartestree were fully described by Murchison,¹ but, although the dyke has been several times mentioned by later geologists² no detailed account has yet been given of its structure. The dyke is of considerable interest, both from its own character and from the alteration to which it gives rise in the Old Red Sandstone. It has a thickness of about 35 feet, and strikes in an east-north-easterly direction through the Old Red marls and sandstones which here lie almost horizontally. As represented in the 1-inch Geological-Survey map, the dyke has a length of about half a mile, striking across the road which leads southwestwards from Bartestree, and extending from about the middle of Tidnor Wood on the southwest to near Bartestree Convent on the north-east. At present, however, the only exposures are at Lowe's-Hill Quarry and for a short space immediately to the south-west. No trace of trap could be found west of the road; and, although fairly abundant *débris* occurs in Tidnor Wood, it appears to be derived entirely from Old-Red-Sandstone rocks.

The Lowe's-Hill rock, though not now worked, has formerly been largely quarried; and a long cutting has resulted, the sides of which are formed by Old Red sandstone and marl, while the trap is exposed at the end.

II. THE ALTERED ROCKS.

(a) North of the trap.—On the northern side of the cutting, an undulating line, fairly easily followed up the face of the cliff, marks the edge of the intrusion. Against this strikes the Old Red, consisting of alternating bands of sandstone and shale, both

¹ 'Silurian System' 1839, pp. 185-86.

² J. Phillips, *Mem. Geol. Surv.* vol. ii, pt. i (1848) p. 180; H. E. Strickland, *Quart. Journ. Geol. Soc.* vol. viii (1852) p. 384; R. Dixon, *Trans. Woolhope Nat. Field-Club*, 1867 (1868) p. 180; & J. D. La Touche, *ibid.* 1891 (1892) pp. 166-68.

considerably metamorphosed. At a distance of a few feet, however, from the edge of the intrusion, a fault passes obliquely up the quarry-face and is marked by a band of breccia. The presence of this fault does not interrupt the progressive metamorphism of the Old Red, this probably indicating that it is of earlier date than the intrusion. The fault-plane apparently forms the northern face of the quarry for some 40 yards, but the exposures are very bad here, the rocks being much obscured by talus and brambles. At the end of this ill-exposed portion the northern face of the quarry has been cut back some 10 feet from the fault-line, exposing a section of Old Red marl and sandstone, the lower beds of the marl being thrown into slight undulations. The rock seen at this portion of the quarry-face (which, owing to the cutting-back, lies at a distance of some 18 feet from the edge of the dyke) is unaltered, except that the prevalent red colour of the marl is more than usually mottled with yellow. A few feet nearer the dyke, however, the marls begin to show signs of alteration; the red coloration disappears; and the rock becomes at first in places pale yellow, but in the main hard and purplish-grey with yellow spots and patches, the appearance of which was suggestive of dolomite. They proved, however, on chemical examination to be of not very definite mineralogical composition, consisting mainly of silicate of alumina and carbonate of lime, with only a subordinate quantity of carbonate of magnesia.¹ Were it not for its softness, a hand-specimen of the prevalent grey rock might, as was noticed by Murchison, at first sight be taken for an igneous rock. Microscopical examination of the altered marls showed small grains of quartz and flakes of mica with much iron-staining, but did not disclose any facts of importance. The sandstone does not commence to show signs of alteration at so great a distance from the dyke as does the marl; but, as the line of contact with the trap is approached, the sandstone and marl are strongly metamorphosed, the marl becoming very hard and splintery, while the sandstone loses its red colour and is rendered very hard and grey. Microscopical examination of this altered sandstone shows some interesting contact-phenomena (Pl. LII, fig. 6), the quartz-grains being corroded and the feldspars recrystallized. Mr. Harker informs me that he is familiar with this type of metamorphism in the Torridon Sandstone of Rum, and has described it in the Geological-Survey memoir on the 'Geology of the Small Isles of Inverness-shire'² now in the press.³

(b) South of the trap.—On the southern side of the quarry, where a thickness of about 12 feet of altered rock is exposed, the contact-phenomena differ somewhat from those on the northern side, as the sandstone is far less in evidence than the marl. The latter rock, however shows alteration into a hard grey material

¹ I am indebted to my colleague, Mr. O. C. M. Davis, B.Sc., for this information.

² P. 13.

³ Published subsequently to the reading of this paper.

with pale spots and patches, which partly consist of epidote and, as was noted by Murchison, have a superficial resemblance to amygdulæ. The alteration is strongly marked, right up to the edge of the cutting at the south-western end near the trap; but farther north-eastwards, where the cutting widens somewhat, unaltered red sandstone is exposed.

Phillips (*loc. jam cit.*) noticed the occurrence of rude columnar jointing in the sedimentary rocks adjacent to the dyke—the columns being arranged at right angles to the margin of the trap, and extending for a distance of several feet. This is scarcely noticeable at the present time.

III. GENERAL RELATIONS OF THE INTRUSIVE ROCKS.

As regards the nature of the intrusion, the earlier writers refer to the rock as a greenstone; Murchison states that it is composed of hornblende, olivine, and felspar. The Rev. J. D. La Touche, who gives a full account of its field-relations, describes it as a greenstone or diorite. A microscopical examination, however, shows that the rock is clearly basic. It is not, however, a simple uniform intrusion, but is composed of several allied though differing types of dolerite and basalt. A comparatively slight examination soon shows that, while the main part of the dyke is a compact fine-grained basalt, doleritic material prevails near the southern margin and to a less extent near the northern.¹ There is often some difficulty in distinguishing between the two rock-types in the field, especially as the basalt when weathered tends to resemble the dolerite; and a more detailed examination, while confirming the fact that the central part of the dyke is predominantly basaltic and the marginal part predominantly doleritic, made it clear that the two rock-types are intimately intermingled, patches of basalt occurring in the predominantly-doleritic portion and *vice versa*.

IV. DESCRIPTION OF THE INTRUSIVE ROCKS.

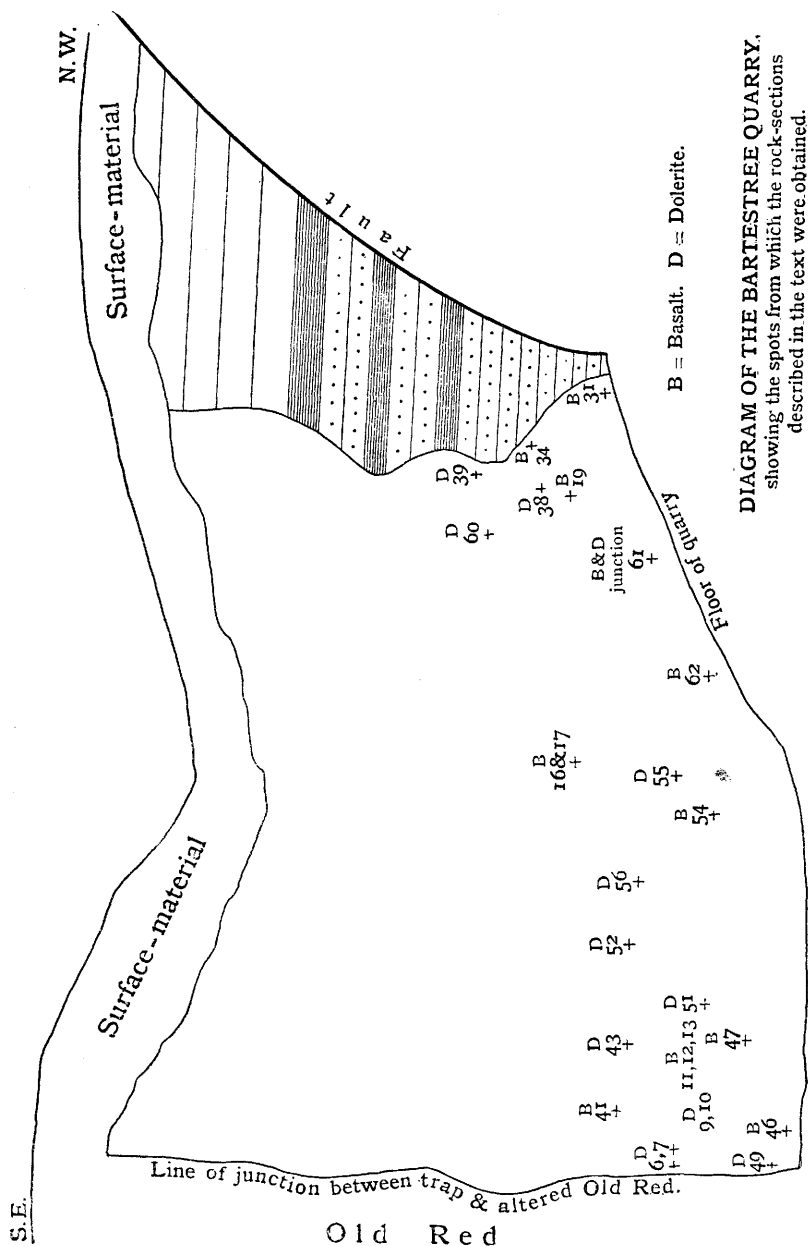
Owing to the very considerable amount of variation in the character of the rock in different parts of the intrusion, a somewhat detailed description will be necessary.

(A) The Dolerites.

Two distinct types may be recognized:—

(1) Along the southern margin of the intrusion a rather fine-grained dark yellowish-green doleritic rock, having the low specific gravity of 2.65 and containing 45.45 per cent. of silica, prevails. Excellent junction-specimens with the Old Red Sandstone are readily obtainable from a thin layer of dolerite which covers the Old Red forming the southern wall of the quarry nearest the trap.

¹ The Rev. J. D. La Touche (*Trans. Woolhope Nat. F.-C.* 1891, p. 167) says that the central part is more coarsely crystalline than the marginal part.



Two sections of this rock were examined. The first (6),¹ passing through the actual junction with the Old Red, consists mainly of fair-sized labradorite-crystals and augite completely altered into a yellow, apparently serpentinous mineral, which wraps round and encloses the felspars. No olivine occurs. Magnetite and leucogenized ilmenite are both abundant, the latter occurring in small irregular patches, the former in rather long crystals. The last quarter-inch of the section in immediate contact with the Old Red contains a fair amount of calcite in irregular patches, and a little quartz which was no doubt picked up from the Old Red; the felspars too are larger, fresher, and more abundant than in other parts of the section. A section (7) taken 3 inches from the junction with the Old Red, while agreeing with that just described in consisting mainly of labradorite and serpentinized augite, differs in the following respects:—there is no ilmenite, and the abundant magnetite occurs chiefly in irregular grains instead of elongated crystals; needles of apatite are plentiful; and pseudomorphs in carbonate after olivine are abundant: these are of no great size, about .5 millimetre being the maximum diameter. A third section (49), taken from close to the junction with the Old Red near the floor of the quarry, shows further differences. No olivine, either fresh or altered, occurs, a little biotite is present, small apatite-needles are very abundant, and the iron-ore is chiefly ilmenite. In addition to the presence, as in the two previous slides, of patches of serpentinized augite, this mineral occurs abundantly in small, fresh, brightly-polarizing grains, and forms also a few relatively-large twinned crystals.

(2) The prevalent type of doleritic rock is, however, a coarser-grained dark-green rock, occurring principally near the southern margin of the dyke, but also at various points near the centre and the northern margin. It is a heavy rock, specimens from near the southern margin giving a specific gravity of 2.84 to 2.88 and a silica-percentage of 43.03. In sections from two neighbouring spots (9 and 10) near the southern margin, olivine in a completely serpentinized state, but sometimes showing good crystal-outlines, is one of the most abundant minerals. These crystals are of considerable size, sections sometimes showing a length of $1\frac{1}{2}$ mm. The augite is all very fresh and polarizes brilliantly, being partly 'granulitic,' partly in fair-sized non-ophitic crystals which do not show any sign of pleochroism. The augite and olivine are by far the most abundant minerals, the olivine in one section forming at least one-third of the bulk of the rock. Small augite-granules polarizing with the greatest brilliance are gathered together into nests, and in one case form a band 2 to 3 millimetres broad stretching across the section. Fairly fresh labradorite is plentiful, but does not play so important a part as in the doleritic rocks previously described. Magnetite is

¹ The spots from which the sections indicated by the numerals in parentheses were obtained are shown in the accompanying diagram of the quarry-face (p. 504).

abundant, but ilmenite is not present. Plentiful apatite-needles penetrate all the other constituents. The most interesting fact about the rock is, however, the occurrence of analcime, the presence of which was first recognized by Mr. Harker. This mineral has already been described in British dolerites from the following localities :—Titterstone Cleve¹; Car Craig² and Gullane Hill,³ in the Edinburgh district; Spalefield⁴ near Anstruther; Bathgate⁵ in Linlithgowshire, and Kidlaw in Haddingtonshire; Dippin⁶ (Arran); and Hendre Quarry, Berwyns.⁷

In the Bartestree rocks the analcime is usually fresh, but sometimes converted into some other zeolite in bundles of fibres. It forms patches, frequently with a length of about half a millimetre; while in the Gullane-Hill rock they measure as much as 3 mm. in diameter, and are not very much smaller in the rock from Cloughland Point (Arran). These patches fill up the gaps between the felspar-laths, and their relations to the other constituents closely resemble those in the Dippin rock figured by Mr. Harker,⁸ and that from Spalefield described by Dr. Flett.

There is nothing in the Bartestree dolerite to suggest the former presence of nepheline, and the general freshness of the felspars and the absence of varieties rich in soda make it improbable that the analcime is due to the alteration of felspar, as is suggested by Mr. Young in the case of the Gullane-Hill rock. It seems probable, then, that the analcime is of primary origin, as is maintained by Mr. Harker with regard to the Dippin rock. Owing to the presence of analcime, this rock may be grouped with the teschenites.

Sections showed the occurrence of doleritic rocks at a number of points (see diagram, p. 504) farther towards the centre and the northern margin of the dyke. Thus rocks from the spots 43, 51, & 52 are of the same general type as that just described, the serpentinized olivine being extremely abundant. Analcime is especially plentiful at 51 (Pl. LII, fig. 1) and 52. A rock from the spot numbered 56, still farther towards the centre of the dyke, and an identical rock from 60, near the northern margin, are also well-marked dolerites but of a rather different type: the serpentinized olivine, which shows good crystal-outlines, is not so abundant as in the rocks just described, and analcime does not occur. Augite, both

¹ S. Allport, *Quart. Journ. Geol. Soc.* vol. xxx (1874) p. 550.

² J. J. H. Teall, 'British Petrography' 1888, p. 191 & pl. xxii, fig. 1.

³ J. Young, *Trans. Edin. Geol. Soc.* vol. viii (1903-1905) pp. 326-35.

⁴ J. S. Flett, *Mem. Geol. Surv. Scot.* Appendix to 'The Geology of Eastern Fife' 1902, pp. 392-93.

⁵ 'Summary of Progress of the Geological Survey for 1905' 1906, pp. 74 & 75.

⁶ A. Harker, in *Mem. Geol. Surv. Scot.* 'Geology of Northern Arran, &c.' 1903, pp. 112-14.

⁷ T. H. Cope & J. Lomas, *Rep. Brit. Assoc. (Southport)* 1903, pp. 664-65.

I am greatly indebted to Dr. Flett for drawing my attention to some of the foregoing references.

⁸ 'Petrology for Students' 4th ed. (1908) p. 147.

granulitic and in large idiomorphic crystals, is abundant. The rock at the spot numbered 55 (Pl. LII, fig. 2) is similar but rather finer-grained, showing some approach to the structure of a basalt. The felspar and augite (which is almost entirely 'granulitic') are very fresh; and the olivine, which is very abundant and evenly distributed, is completely serpentinized. A few well-terminated and slightly ophitic augite-crystals occur.

As the northern margin of the intrusion is approached, a doleritic type very rich in olivine is again met with, as at (38). At (39) a beautiful type occurs, in which fresh augite forms about half the bulk of the rock: this is one of the coarsest types met with, the plagioclase-phenocrysts, which have a maximum extinction-angle of 35° , reaching a length of 2 millimetres. At the base of the quarry near the northern margin, where the boundary of the dyke dips in below the altered Old Red, is a green type of dolerite (34) rich in ilmenite. In all these sections, the felspar is in laths showing twinning on the Carlsbad and albite-types, with maximum extinction-angles of about 35 to 40° : it is probably a basic labradorite.

(B) The Basalts.

By far the largest portion of the dyke is formed by a fine-grained basaltic rock which shows but little variation in a hand-specimen, being a black, compact, usually fresh basalt of uniform grain, with small felspars and dark augites figuring prominently in it.

A series of sections was examined, taken at intervals across the whole thickness of the basalt, and showed the rock to be very uniform in character except for the presence or absence of olivine.

Four sections, two (11) from the actual junction with the principal southern mass of dolerite, and the others (12 & 13) from a distance of 2 and 3 inches respectively from the junction, all agree as to the character of the ground-mass, which consists of little plagioclase-needles associated with augite and magnetite-grains, both minerals occurring in great abundance. All these sections also agree in the character of the felspars, which form laths having an average length of $\cdot 5$ to $\cdot 75$ millimetre, and giving extinction-angles that suggest labradorite of a less basic type than in the dolerite. The augite, however, varies considerably in the different slides. In sections 11 (Pl. LII, fig. 4) and 12 the augite is almost entirely in the form of fair-sized crystals with irregular, sometimes indistinct, and often corroded margins, and presenting a peculiar speckled appearance owing to the separation of magnetite. Some of the augite, however, occurs in fresh, idiomorphic, well-cleaved crystals with no separation of magnetite. This type of augite is the only one represented in section 13. The sections (11 & 12) cut from the marginal 2 inches of the basalt are quite devoid of olivine; section 13, however, contains abundant olivine, some of it serpentinized, some of it wholly or partly replaced by a fibrous, noticeably-pleochroic, and brilliantly-polarizing mineral, which appears to agree closely with a mineral observed under

similar conditions by Dr. Flett in the case of the Spalefield rock,¹ and with the pseudomorphs described and figured by Dr. H. H. Arnold-Bemrose² from Potluck (north-west of Tideswell). Dr. Arnold-Bemrose, who kindly examined one of my slides, agrees that the resemblance to the Potluck pseudomorphs is very close, and considers that the replacing substance is a mica-like mineral.

The rock at (46), from near the junction of the dolerite and basalt at the southern border, exhibits an interesting intermingling of the two rock-types, as, while mainly basaltic, it shows many included patches of doleritic material, passing with irregular ill-defined boundaries into the basalt. Mr. Harker suggests a comparison with the 'glomero-porphyrific structure' of Prof. Judd.³ The same feature is shown in the rock at the spot numbered 62. The rock from (46) differs from all the others, in the fact that the abundant olivine is in the main perfectly fresh (Pl. LII, fig. 3). The rock at (41) contains no olivine, and the augite shows separation of magnetite as in (11).

At the spot numbered 47, a beautiful rock-type of medium coarseness occurs. Abundant serpentinized olivine, showing good crystal-outlines, is present; and the augite, although forming a few phenocrysts, is mainly in the form of small and very fresh grains filling the interstices between the feldspars.

Sections from the spots (54) and (16) near the middle of the dyke and from (17)—a point near (16), although its precise position was not recorded, agree in the fact that the augite, which is very abundant, shows as a rule corrosion of its borders and much separation of magnetite; but, while at (54) and (17) no olivine is present, at (16) it is abundant.

At a spot very close to (17) a rock occurs, having a specific gravity of only 2.69, and is to be grouped rather with the augite-andesites than with the basalts.

A section from (61), a point approaching the northern border, shows an undulating line of junction between two sharply-defined rock-types, basaltic and doleritic. The feldspar-laths of the basalt tend to accumulate along the line of junction with the dolerite and to be arranged with their long axes parallel to the edge. The character of the junction makes it clear, not only that the basalt was a later intrusion than the dolerite, but that the dolerite was completely consolidated before the intrusion of the basalt. An interesting section comes from (19), a point at a distance of 6 feet from the northern edge of the dyke. It consists in the main of basalt, showing the usual augite with corroded borders and separation of magnetite; but the basalt includes patches of dolerite and also a number of glassy patches which are dark, nearly isotropic, and imperfectly variolitic.

The occurrence of basaltic as well as doleritic material in the immediate neighbourhood of the northern margin is shown by the presence of a fine-grained basalt devoid of olivine at the points (31)

¹ Appendix to 'The Geology of Eastern Fife' Mem. Geol. Surv. Scot. 1902, p. 392.

² Quart. Journ. Geol. Soc. vol. 1 (1894) p. 613 & pl. xxiv, fig. 3.

³ *Ibid.* vol. xlii (1886) p. 71.

and (34), where, as seen in the diagram (p. 504), the dyke passes in below the Old Red. The rock from (31) resembles that from (61) in showing sharply-defined junctions between doleritic and basaltic material (Pl. LII, fig. 5), many small patches of dolerite being enclosed in the basalt.

The following silica-percentages and specific gravities, some of which have been already referred to in the foregoing account, were determined in the chemical laboratory at University College, Bristol, by Mr. J. H. Sturgess:—

<i>Position in quarry-face.</i>	<i>Character of rock.</i>	<i>Sp. gr.</i>	<i>Silica-percentage.</i>
6	Dolerite, greenish variety from near the southern margin	2·65	45·45
9	Olivine-analcime-dolerite (teschenite).....	2·84	—
10	Olivine-analcime-dolerite (teschenite).....	2·88	43·03
11	Basalt	2·93	—
54	Basalt	2·84	45·60
17	Basalt	2·93	48·26

The characters of the various rock-types which have now been described may be summarized as follows:—

Dolerites.—The prevailing type is a heavy olivine-analcime-dolerite or teschenite, formed of olivine generally serpentinized, labradorite, fresh non-pleochroic and non-ophitic augite, iron-ores, analcime, and apatite. But the rocks of the prevalent type may vary as regards the amount of olivine, the relative abundance of the granulitic and well-crystallized types of augite, the nature of the iron-ore, and the presence or absence of analcime.

Near the southern margin is a lighter, somewhat green, finer-grained type generally free from olivine (which, if present, is represented by pseudomorphs in carbonate), and further containing labradorite, augite sometimes fresh (but as a rule altered into a yellow, probably serpentinous mineral), apatite, and occasionally a little biotite.

Basalts.—The prevailing type has a fine-grained ground-mass, formed of felspar-needles with augite- and magnetite-grains, and includes phenocrysts of felspar (of a less basic type than in the dolerite), and of augite, the latter being very generally corroded and marked by the separation of magnetite.

Many of the basalts, however, contain olivine, either fresh or serpentinized.

Small areas of glass are frequent in the basalt, and in one case relatively-large imperfectly-variolitic areas were met with. Small areas of doleritic material are frequently included in the basalt, the boundaries between the two rocks being in some cases sharply defined, in other cases ill-defined.

V. CONCLUSION.

The rocks just described, though showing a large amount of variation, are all closely related; and the facts seem most readily explicable on the view that, in the Bartestree dyke, we have evidence of three successive injections of basic material. First, in all probability, came the green dolerite without fresh or serpentinized olivine, chiefly seen near the southern margin. Then followed the darker, coarser teschenite, which (judging from the sharply-defined junctions) was completely solidified before the intrusion of the basalt. This latter rock formed the central and major portion of the dyke, enclosing here and there patches of the teschenite, and further sending veins into the marginal portion. The basalt-magma brought up with it numbers of small ill-defined patches of coarser material, and here and there portions of the magma solidified in a glassy condition.

As regards the date of the intrusion, all that can be learnt from field-evidence is that it is later than the Old Red Sandstone. The strong resemblance of the dolerite to many of the other Midland dolerites, and especially to the Clee-Hill rock, suggests that it belongs to the same series, in which case it would not be earlier than very late Carboniferous.

Prof. Watts¹ remarks on the very close resemblance between some of the Midland dolerites and some of those of Scotland and the North of England, and suggests that the former group, like the latter, may really be of Tertiary age. The presence of analcime affords no indication as to whether the rocks are of Carboniferous or of Tertiary age, this mineral having been met with in British doleritic rocks of both these periods. In the non-pleochroic and almost entirely non-ophitic character of the augite, the Bartestree rock approaches more closely to the Carboniferous than to the Tertiary dolerites.

I wish to acknowledge my great indebtedness to Mr. Alfred Harker, F.R.S., both for help in examining my sections, and for the loan of sections of other analcime-bearing rocks.

EXPLANATION OF PLATE LII.

[The numerals in parentheses refer to the diagram, p. 504.]

Fig. 1. Teschenite (51), near the southern margin of the dyke: \times about 25.

The large, roughly-triangular, clear patch in the left half of the figure is analcime. The dark patch in the right-hand top corner consists partly of serpentinized olivine, partly of magnetite. The remainder of the section is occupied by labradorite-laths, apatite-needles, and augite-grains. (See p. 506.)

2. Olivine-dolerite (55), near the middle of the dyke: \times about 25.

This shows several completely-serpentinized olivines, with numerous labradorite-laths and augite-grains, the latter being best seen near the base of the figure. (See p. 507.)

¹ Proc. Geol. Assoc. vol. xv (1898-99) pp. 399-400, & *ibid.* vol. xix (1905-1906) pp. 178-80.

Fig. 3. Olivine-basalt (46), near the base of the southern margin of the dyke: \times about 25.

The whole or parts of three well-formed and very fresh olivine-crystals are seen. Grains of magnetite and of very fresh augite with feldspar-laths make up the rest of the section. (See p. 508.)

4. Basalt (11), near the southern margin of the dyke: \times about 15.

No olivine is present in this section, and the augite-crystals, which are not very clearly seen in the photograph, are characterized by the corrosion of their borders, and by the separation of magnetite, giving them a speckled appearance. (See p. 507.)

5. Basalt with doleritic patches (31), near the base of the northern margin of the dyke: \times about 15.

An irregularly-rounded patch of dolerite is seen enclosed in the basalt, much magnetite and augite being aggregated along the line of junction. (See p. 509.)

6. Altered Old Red Sandstone, close to the northern margin of the dyke: \times about 25. (See p. 502.)

The clear areas are patches of quartz with corroded borders. Numerous needles of recrystallized feldspar are also visible.

DISCUSSION.

The PRESIDENT thought that the explanation offered by the Author was correct; it was applicable to all the composite dykes that had come under his own observation.

Dr. HATCH congratulated the Author on having so well described an excellent example of a multiple dyke. Judging by the thin sections thrown on the screen, he thought that the micro-structure of the Bartestree rocks was comparable to that of some of the well-known types of Carboniferous dolerite occurring in the Midland Valley of Scotland. He asked the Author what was the distinction that he made between 'dolerite' and 'basalt' in the present case. He (the speaker) deprecated the application of the terms 'basalt' and 'andesite,' which should be reserved for basic and intermediate lava-types, to rocks of undoubted hypabyssal character (such as those of Bartestree), of which the proper equivalent designations were dolerite and porphyrite respectively.

Mr. J. V. ELSDEN said that he had been particularly interested in the Author's conclusion that the analcime recognized in some parts of this dyke was of primary origin. Most of the admitted occurrences of primary analcime had been in connexion with rocks consolidated under considerable pressure. As some of the Author's specimens contained glassy patches, he would like to ask whether the analcime might not be altered glass.

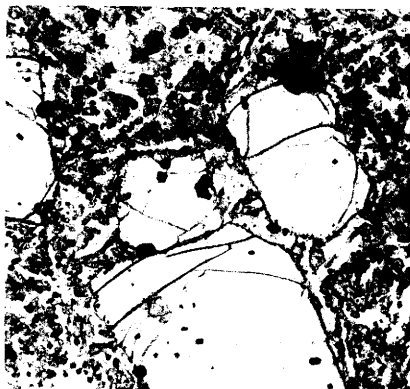
The AUTHOR said, in reply to Dr. Hatch, that he had used the term 'dolerite' to denote a relatively coarse-grained rock, and the term 'basalt' to denote one of relatively fine grain. In reply to Mr. Elsdén, he stated that the analcime was found in the freshest of the doleritic rocks; and, in reply to a question asked by the President, that ilmenite was present in certain parts of the dyke.



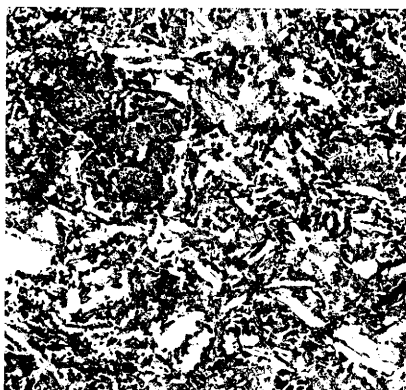
1



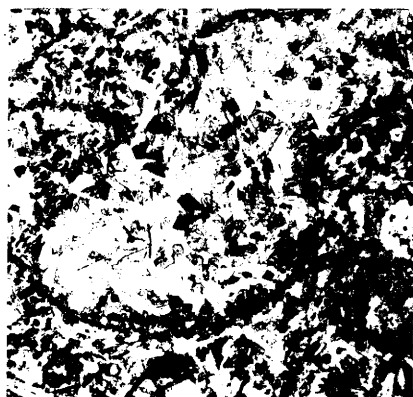
2



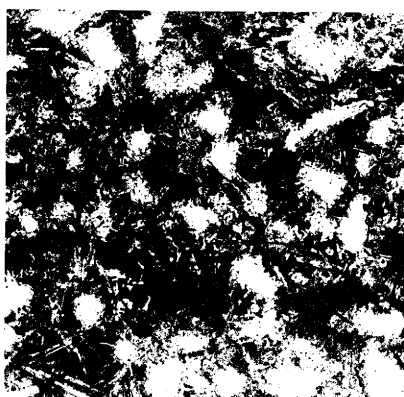
3



4



5



6

S. H. Reynolds, Photomicro.

Bemrose, Collo., Derby.

IGNEOUS AND ALTERED ROCKS FROM BARTESTREE.