Art. XLVII.—*On a Doleritic Dyke at Dyer's Pass.*

By R. Speight, M.A.

[*Read before the Philosophical Institute of Canterbury, 4th October, 1893.*]

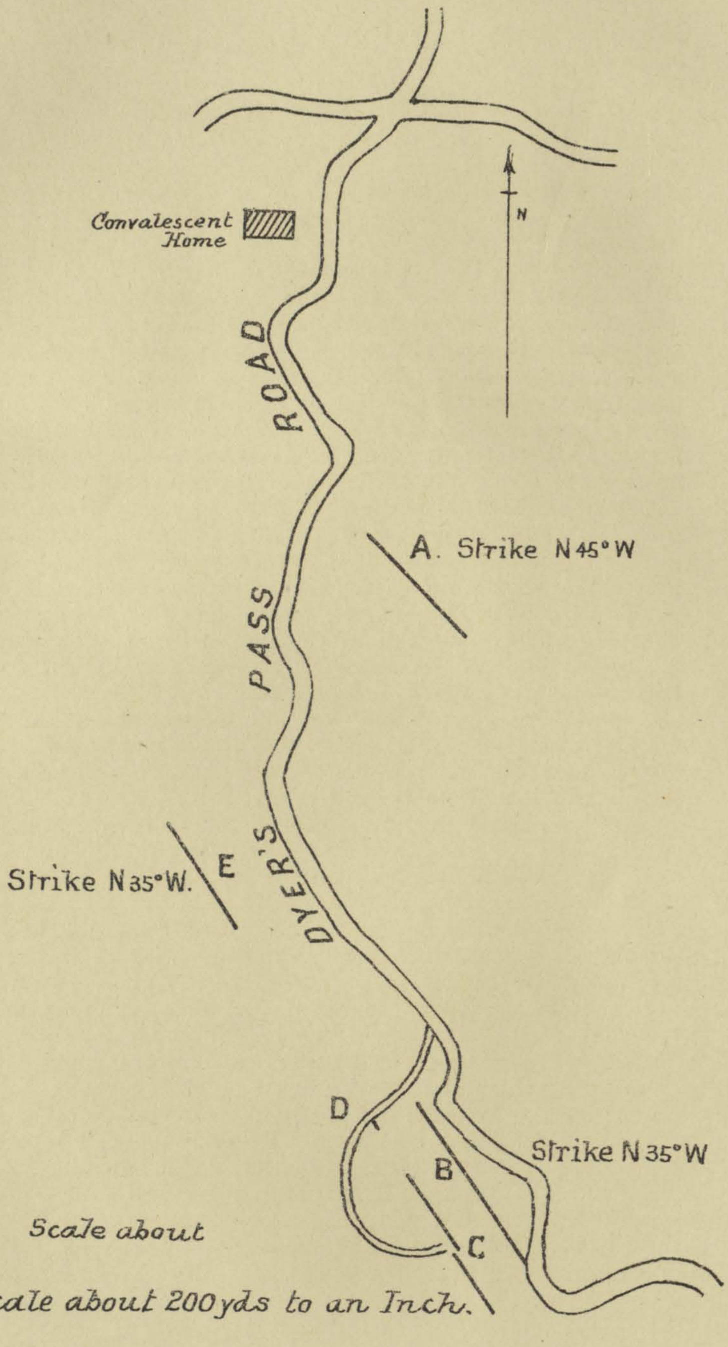
Plates XLIX.–L.

Locality.

On the Dyer's Pass Road, over the Port Hills to Governor's Bay, there occur several dykes. One of them (Pl. L., a), just above the Convalescent Home, runs north-west and south-east. It has been quarried for some distance, and is about 6ft. broad, and nearly vertical. It is probably classified as an andesite, but the deep weathering has rendered an accurate determination difficult. It seems to be composed of an interlacing network of feldspar microliths and augite grains, in which are porphyritic crystals of feldspar. This is probably labradorite, since the extinction-angles between twin lamellæ are greater than 37°, but not greater than 63°; also, a crystal in a section which shows no twinning, and is therefore probably parallel to the brachypinacoid, gave an optic axis out of the field, and a revolving axial shadow. There is no other porphyritic mineral. Probably augite is present, but only one large crystal was noticed, and that was greatly altered. The feldspar of the ground-mass is probably oligoclase, as the extinction is nearly parallel to the length of the microliths, and never greater than 5°; but the determination from the extinction of twin lamellæ did not give satisfactory results on account of undulose extinction. The augite of the ground-mass is greatly altered, forming brown grains of limonite.

Higher up on the road, on the south side, there is another dyke (b), running also north-west and south-east. It has not been quarried, and so it was very difficult to get satisfactory sections. It is about 10ft. wide, and shows a rudely columnar structure perpendicular to the sides of the dyke. The ends of the columns are easily seen, as on the lower side it appears as a wall about 12ft. high. This is probably basaltic, as sections show olivine to be present, though in all I obtained it is altered to limonite.

Below this dyke occurs an old quarry in a corner of a small gully (c). This has not been worked for some time, but quantities of stone lie about. This has been derived from a large dyke about 15ft. broad. The dyke runs generally in a north-westerly direction, but where the quarry occurs it has been bent, so that the two lines make an angle of about 15°. The dip of the eastern branch is about 75°, while the western is



Scale about 200yds to an Inch.

To illustrate paper by Mr. R Speight

nearly vertical. There are other outcrops up the western side of the gully, and at a road on the other side of the spur (D), and again on an adjoining spur (E), where it has been quarried. The country rock is an olivine-andesite, but in the neighbourhood beds of laterite occur, produced by the weathering of the andesitic and basaltic flows, and by the subsequent pouring over them of hot lava streams. In no place were the beds observed to overlie the dyke, so it is most probably of later origin. The country rock has been altered near the edge of the dyke into a black rock in which crystals of feldspar appear, while a little further away it has become a laterite.

The dyke is composed of a dark-grey rock on fresh exposure, but near the edge it becomes black. It is more crystalline in the middle, but contains vesicles throughout. These are not filled with infiltration products. Near the edge occurs a band of steam-holes, with their long diameters parallel to the edge of the dyke. There is not any well-marked columnar structure such as occurs in the dyke above.

Specific Gravity.

By weighing pieces of the rock in water a specific gravity of 2·77 was obtained, but on grinding to a fine powder, and using a specific-gravity bottle, a result of 2·86 was obtained. This is what we should expect from the vesicular nature of the rock. The further examination of the rock was carried on—(1) By a quantitative chemical analysis; (2) by a microscopical determination by means of thin sections.

I. *Chemical Analysis.*

The following result was obtained:—

Loss on ignition	1·78
SiO_2	48·60
Al_2O_3	17·87
Fe_2O_3	6·20
FeO	5·76
CaO	9·11
MgO	4·32
K_2O	2·06
Na_2O	4·66
	100·36

This corresponds fairly closely with a dolerite of Hailstone Hill, Rowley, with the exception of the absence of TiO_2. (Teall's "British Petrography," p. 213.) It is well within the basic series, as is shown by the percentage of SiO_2. The large proportion of CaO may be accounted for by the presence of anorthite as the porphyritic feldspar. This was never large enough to be analysed separately.

II. *Microscopical Examination.*

A microscopical examination of the rock shows it to be composed of a holocrystalline ground-mass, in which crystals of feldspar, augite, olivine, and magnetite are porphyritically distributed.

Porphyritic Minerals: Feldspar.—The feldspar is the most important porphyritic mineral. It occurs in lath-shaped and rounded forms up to $\frac{1}{16}$in. in length. The species of feldspar as determined by the extinction of twin lamellæ proved to be anorthite, as the angle of extinction was noticed in several cases to be 70°, and slightly over. However, the determination was rendered inexact and difficult by the frequent occurrence of undulose extinction. As no cleavage-flakes could be obtained, no reliable determination could be made with convergent light; but the examination of sections which showed no twinning, and would therefore probably be parallel to the brachypinacoid, gave a revolving axial shadow and an optic axis just outside the field of view. This would make it bytownite or anorthite. So the conclusion to be come to is that it is probably anorthite, a species of feldspar álmost typical of basic rock.

Inclusions of magnetite are common, and on examination with higher powers there appeared numerous small acicular inclusions. These did not show straight extinction nor pleochroism, so they cannot be apatite. Many of the crystals show traces of alteration, and in some cases the crystals are completely honeycombed. These alteration products are often confined to the interior of the crystal, or arranged in zones, while the outside is altogether free from them.

The characteristic twinning is of the albite type, but cases occur which show the cross-hatching due to twinning on both the pericline and albite types, while one case showed three sets of twin lamellæ, one inclined at an angle of 20°, and the other at an angle of 70°, to what seemed the ordinary twinning of the crystal. This was parallel to the length of the crystal, and could be traced passing through the others as if it had been of the latest formation (Pl. XLIX., fig. 1). This may show that the state of polysynthetic twinning is the more stable state for feldspars near the surface of the earth. The twin lamellæ were noticeable for the fact that they frequently died out, or occupied but a small portion of the crystal. Several cases were noticed in which an internal kernel was twinned, while the outside portion was untwinned, or twinned in a different direction. The twin lamellæ sometimes end abruptly at the edge of the core, but occasionally are prolonged faintly to the edge of the crystal. The most characteristic feature of the feldspar is the curious evidence of crystal growth. In many cases the crystal seems composed of a kernel round which new material has been deposited (Pl. XLIX., fig. 2, and Pl. XLIXA., fig. 3). In some cases this may be true zonal structure, but sometimes the wave of extinction passes outwards gradually, so that there are no zones at all. The kernel is at times rounded in form, and seemingly corroded, but the resultant shape is idiomorphic. In one case the gradual approximation to the crystallographic outlines could be traced. This structure is not peculiar to the feldspar, but belongs to the augite in a small degree, and appears faintly even in the olivine. There are several facts which show that this has been produced late in the history of the crystal:—

(1.) The kernel is usually irregular in shape, as if it had suffered injury from various solvents, &c.

(2.) The alteration products and inclusions are usually confined to the core, while the periphery is usually free.

(3.) Cracks in the core suddenly terminate at its edge; of course, many instances occur in which they are prolonged through the surrounding portion.

(4.) There is often a zone of alteration products at the edge of the core, as if the crystal had been weathered there and had commenced growing afterwards.

(5.) Twin lamellæ terminate at the edge of the core, though a few sections showed them prolonged further.

(6.) The periphery is often twinned in a different direction from the interior.

These observations seem to show conclusively that the crystals had suffered weathering before they were added to. If this is the case the rock must have been solid at the time, and the question is, Where has the new material come from? If the crystal had been enlarged while the rock was molten it would be easy to understand, but the appearance of weathering renders such an hypothesis improbable. This has been noticed before by Professor Judd (*Vide* "Quarterly Journal of the Geological Society," vol. xlv., page 175), but in that case the crystals which showed growth were in a glass, and he supposes they grew at its expense under altered conditions of temperature and pressure. It would be difficult, however, in this case to account for new growth in this way, since the ground-mass is holocrystalline, and shows no alteration in the neighbourhood of the anomalous crystals. These rocks, being from near the surface of a Tertiary volcano, cannot have been buried under subsequent lava-flows, or under sedimentary deposits, so the growing of the crystals cannot have been caused by the influence of changed conditions of temperature and pressure on a glassy ground-mass. Nor can the crystals have been added to by water saturated with feldspathic minerals, forming accretions round minerals resembling the matter in solution, since the temperature and pressure required for this would not be such as would occur in a dyke which reached the surface. We can hardly suppose that the dyke suffered alteration while it was cooling, owing to the presence of imprisoned hot water, but, if it were the case, then it would explain all the facts. The water saturated with mineral matter would have both a disintegrating and a restoring effect. It would account for the presence of alteration products, and the deposition round a corroded crystal would proceed as the water cooled. There would be no sensible alteration in the ground-mass, though some of the material might be drawn from it. It is usually the case that the ground-mass is more acidic than the porphyritic mineral, and so the new outside layers ought to be more in accordance with this than the kernel. The fact that the twinning extends faintly into the periphery would not be contrary to this hypothesis, as there is evidence that twinning is a structure impressed on minerals as they cool. This is perhaps a hazardous suggestion, but the case seems difficult to explain. It may be that these anomalous crystals were part of an old lava-flow which had suffered weathering near the surface, and then been buried under subsequent flows; and that, as the dyke penetrated it, parts of it had been caught up and the crystals afforded nuclei for crystallization, just as a piece of alum put into a solution of an alum begins to crystallize afresh. All the phenomena observed would be explained by this; but it is rather hard to conceive that the occurrence should be so general throughout the dyke if produced by this means alone.

Augite.—Augite crystals occur abundantly as rounded grains, but occasionally in lath-shaped forms up to ¼in. in length. They are of a brownish colour in ordinary light, but at times they have a purplish tinge, and in these cases there is very faint pleochroism. They contain inclusions of magnetite, which are usually absent from the periphery. Their characteristic features are the zonal structure, which has been dealt with before, and a remarkably perfect cleavage. In some cases it approaches the perfection of that of diallage. In the sections which show this there is only one set of cleavage-planes, but in those which show two sets it is not so perfect by any means, and becomes mere irregular cracks. The sections which show one set of parallel cleavage-cracks will be parallel to the axis of *c*. In estimating the extinction-angles with these the maximum result recorded was 44°. The crystals which showed this were usually lath-shaped. Those which showed two sets were short and idiomorphic. In one of these latter the extinction was symmetrical to the cleavage-cracks, and also parallel to a twin lamella running through the crystal. The extinction-angle was 47°. The section would probably be parallel to OP. However, many crystals exhibited no cleavage-cracks at all. Crystals show both binary and polysynthetic twinning. In one case (Pl. XLIXA., fig. 4) a twinned band was observed to be faulted, but no disruption appeared in the crystal, the part which should have been occupied by the faulted lamella being occupied by the adjacent one. In one case a part of a crystal polysynthetically twinned was surrounded by a portion free from twinning.

Olivine.—Crystals of olivine occur throughout the rock. Occasionally they are unaltered, but in the great majority of cases cracks occur with alteration proceeding from them. The product of decomposition is limonite. In some cases the alteration has proceeded so far that only a pseudomorph of limonite remains.

Magnetite.—Grains of magnetite occur throughout the rock, both in the ground-mass and porphyritically, but they graduate into one another. In many cases they are included in the augite and olivine, thus showing it was the first mineral in order of production.

GROUND-MASS.—The ground-mass consists of a holocrystalline aggregate of feldspar microliths and augite and magnetite grains. The feldspar was difficult to determine, since the small crystals nearly always exhibited undulose extinction. By the method of extinction of twin lamellæ it proves to be labradorite or anorthite, since in most of the cases observed the angle was over 20°, and in some few over 40°. However, the method of extinction, with the length of the microliths, gave contradictory results, as nearly all extinguished in the length of the microlith, or at very small angles from it. This would point to oligoclase. This is not very uncommon in the ground-mass of a rock of the basic series, but the first method would probably be more reliable, and the conclusion to be arrived at is that it is probably labradorite or anorthite. The augite and magnetite showed no remarkable structure. There was no glass apparent.

GENERAL CONCLUSIONS.

The foregoing description shows that the rock must be classified as an olivine-dolerite, or, if olivine is to be considered as an essential mineral of the basalt group, it would be called simply a dolerite. The holocrystalline nature of the rock is probably due to slow cooling in a fissure at a slight depth beneath the surface, but not sufficient to allow large crystals to form.

EXPLANATION OF PLATES XLIX.–L.

Plate XLIX.

Micro-photographs.

Fig. 1 represents a feldspar crystal with three sets of twin bands. The third appears as fine lines parallel to length of crystal. The altered parts are in the middle. (Crossed nicols. Magnified 25 diameters.)

Fig 2. is an instance of a crystal with a kernel of earlier formation. The inside is twinned faintly, and the twin bands die out at its edge. One small part is twinned on the pericline type, but very indistinctly. The dark lines parallel to the corners represent an outward wave of extinction. There is a row of alteration products just outside the kernel. (Crossed nicols. Magnified 25 diameters.)

Plate XLIXa.

Fig. 3 is another crystal showing zonal structure. The inside is twinned, while the outside shows several waves of extinction moving outwards, but getting straighter in outline, till the form is idiomorphic. There is a zone of alteration just outside the core. The twin band is confined to the interior. (Crossed nicols. Magnified 30 diameters.)

Fig. 4 represents a twinned augite crystal. One of the bands is faulted. The fine parallel lines represent perfect cleavage. A large white crystal near the edge of the field is a crystal of feldspar greatly altered. (Crossed nicols. Magnified 25 diameters.)

Plate L.

Map of Dyer's Pass Road.

Art. XLVIII.—*Geology of Nelson.**

By W. F. Worley.

[*Read before the Nelson Philosophical Society, 12th June, 1893.*]

I am only about to attempt the barest outline of the geology of this district, and in doing so must acknowledge my indebtedness to the Geological Reports, issued by the Geological Department, and to the "Outline of New Zealand Geology," prepared by Sir James Hector, Director of the Geological Department.

To describe the geology of Nelson it will be necessary to say a few words about the geology of New Zealand as a whole. New Zealand, there are good reasons for believing, is but the remains of what was once an extensive continent. Soundings made by the "Challenger," on her famous expedition, brought to light the fact that a submerged plateau extends for many miles to the eastward of New Zealand. The depth of water over this plateau varies from 300 to 600 fathoms, while the water of the ocean beyond the plateau has a depth of 2,000 to

* The maps and diagrams referred to in this paper were enlargements of geological map and sections issued with "Outline of New Zealand Geology."