Trachy-ophitic texture in Carboniferous basalts.

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Many Jedburgh-type olivine-basalts of Carboniferous age in Scotland are characterized by a sub-ophitic texture in their groundmass and a flow structure of their lathy felspar phenocrysts. These characteristics have been frequently reported in the writings of Geikie, Flett, Bailey, Tyrrell, MacGregor, and others and are recognized as important textural features. In the main, however, they have been described as independent features and have been regarded as unrelated phenomena. Tyrrell (1909) alone has remarked on parallel felspars enclosed in plates of augite, and since his description appeared at an early date and has been available to subsequent workers, the lack of further examples indicates either that his discovery has been overlooked or that the texture is very rare.

During an examination of the igneous rocks of the Langholm district, Dumfriesshire, a Jedburgh-type basalt was found possessing a combined flow and ophitic texture. It was originally described by Lady McRobert[1] as the Dinwoodie basalt which occurs as a sheet, roughly half a mile in diameter, capping Greena Hill, four miles south of Newcastleton in Liddesdale. A small quarry cut into the base of the sheet shows a fine, grey non-porphyritic rock with pronounced platy jointing and a lack of vesicles. At higher horizons the rock becomes coarser and decidedly doleritic; its colour turns dark-grey and it contains many slender felspar microphenocrysts with parallel orientation. From the presence of the fine-grained lower margin, the absence of vesicles, agglomeratic material, and iddingsite pseudomorphs after olivine, it is inferred that the sheet is not a lava-flow but a sill which has been intruded at the top of the Fell sandstone.

In thin section, the rock is a typical Jedburgh-type basalt composed of microphenocrysts of thin plagioclase crystals and altered olivines, in a matrix of felspar laths, augite, chlorite, calcite, and iron ores. The relative proportion of these constituents is shown by the mode from which it can be seen that the rock is not completely fresh (table I).

[1] R. W. McRobert, Igneous rocks of Teviot and Liddesdale. Trans. Edinburgh Geol. Soc., 1920, vol. 11, pp. 86–103. [M.A. 1-92.]

Of the phenocrysts, plagioclase is the more abundant and has a composition of $Ab_{40}An_{60}$, length: breadth ratio of 5:1, and an average length of 2 mm. In spite of their length, they are quite different in habit from the felspars of the macroporphyritic Markle-type basalt. The olivine pseudomorphs consist of patches of calcite and dense chlorite which can only be identified with certainty when they exhibit the typical shape of

FIG. 1. Trachy-ophitic texture in basalt, Dinwoodie, Dumfriesshire. ×24.

the replaced mineral. As a rule the patches are small and rarely exceed 0·4 mm. in diameter.

The groundmass is composed of small, flow-alined laths of labradorite, of an average length of 0·2 mm., in part intergrown with plates of purplish augite and in part with interstitial fibrous chlorite, calcite, alkali-felspar, and iron ores.

The optical data of the ingredients of the intergrowth is as follows: the plagioclase, as measured on the universal stage, shows complex twinning with (010) as the composition plane and gives an extinction angle of 31° perpendicular to (001), corresponding to a composition of $Ab_{42}An_{58}$. The augite has 2V 53°, α 1·692, and γ 1·716±0·001, indicating a composition $Fe_{20}Ca_{44}Mg_{36}$.

The interstitial felspar is not easy to determine qualitatively and almost impossible to measure quantitatively. It shows a shadowy complex twinning and has a refractive index below that of Canada balsam, from which data it is probably albite-oligoclase, while from a consideration of the chemical analysis it is likely that it also contains an appreciable quantity of potash (table I).

FIG. 2. Enlargement of portion of fig. 1. × 120.

TABLE I. Chemical analysis (of fine margin) and mode of the Dinwoodie basalt.

SiO_2	45·64	Na_2O	3·62	Felspar	55 %
TiO_2	2·48	K_2O	2·04	Olivine	6
Al_2O_3	18·15	$H_2O+105°$ C. ...	2·42	Augite	11
Fe_2O_3	4·67	$H_2O-105°$ C. ...	0·50	Chlorite	17
FeO	6·15	CO_2	2·68	Magnetite ...	9
MnO	0·19	P_2O_5	0·67	Calcite	2
MgO	2·82		——		
CaO	7·78		99·81		

The intergrowth between the labradorite laths and the purplish augite differs from the normal ophitic type, in which there is random or even divergent orientation of the felspars, by having the felspar laths in parallel orientation (figs. 1 and 2). These laths are mostly bounded by crystal faces and have irregular margins only when they are in close contact with other felspars. The enclosing augite plates are usually slightly elongated and have an average length of 0·4 mm. with a maximum of

1·7 mm. The plates have very irregular margins due to the many protruding felspars and in some examples they are so full of felspars that a single crystal appears as several apparently discrete triangular patches. Neglecting the flow-structure, this rock texture is clearly of 'sub-ophitic' rather than 'ophitic' character.

Interpretation of the structure.—Since the felspar laths are mostly euhedral and only show irregular margins when they are in close contact with one another it is evident that some growth took place after orientation and whilst the surrounding medium was still entirely fluid. The fact that the augite envelops these euhedral and orientated felspar crystals indicates that it formed after the formation of the felspar laths and after the production of their flow-structure. The sequence of events revealed by the texture is as follows: firstly the formation of the felspar laths, secondly the production of the flow-structure, and thirdly the crystallization of the augite.

Unlike the normal ophitic texture, which has been taken as evidence of simultaneous crystallization of felspar and augite,[1] this variety of the texture provides clear evidence that augite crystallized later than the felspar laths. The texture is not confined to the Carboniferous basalts, for, in addition to being recorded by Tyrrell,[2] it has been described by Krokström[3] in the Tertiary olivine-basalts of Greenland. In view of its distribution, its distinctive nature, and its petrogenetic significance, it seems that a precise term is required to distinguish it from ophitic, about which views conflict. I therefore suggest *trachy-ophitic*, as almost self-explanatory and introducing no new or unfamiliar adjectives.

[1] R. A. Daly and T. F. W. Barth, Dolerites associated with the Karroo system, South Africa. Geol. Mag., 1930, vol. 67, pp. 97–110.

[2] G. W. Tyrrell, The petrology of the Auchineden district, Kilpatrick Hills. Trans. Geol. Soc. Glasgow, 1909, vol. 13, pp. 337–343.

[3] T. Krokström, On the ophitic texture and order of crystallization in basaltic magma. Bull. Geol. Inst. Univ. Upsala, 1932, vol. 24, pp. 197–216.