7. Yes, I think in some cases only a small amount of magma is required, just sufficient to lubricate the crystal aggregate and allow it to intrude.

8. Only someone already prejudiced against the hypothesis of magmatic differentiation could conclude that the results given in my paper show " that a magmatic interpretation of the Scottish Caledonian complexes cannot be reconciled with the firmly established principles of phase-rule chemistry ". The facts brought forward in connection, more especially, with the light constituents indicate a most striking similarity of behaviour between these constituents in natural magmas and in experimentally determined melts. Is it an accident that the last residual liquids of natural magmas should lie on the ternary cotectic curve ? This affords a rational explanation of the composition of the aplites and their related lavas and explains why rocks of more extreme acid character are not found here or in other igneous rock series. The hypothesis of emanations does not explain this limitation of composition nor does it explain the fact that lavas and dyke rocks, belonging to the same suite, have the same chemical composition as plutonic rocks lying on the assumed liquid line of descent.

It is interesting to learn that Mr. McIntyre has been investigating the Loch Doon complex, but hardly surprising to find him concluding it has been formed by metasomatic replacement, in view of the address given at the bottom of his letter. I cannot feel this to be an argument against the hypothesis of magmatic differentiation.

In conclusion, it is gratifying to find an emanationist taking some interest in phase diagrams, even if in a rather naïve fashion. If only Mr. McIntyre can persuade his fellow emanationists to do likewise, there may come a day when the emanationist view of the origin of rocks can be discussed as a reasonable scientific hypothesis.

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CHILLED AND " BAKED " EDGES AS CRITERIA OF RELATIVE AGE

SIR,—In their recent letter to the *Geological Magazine*, Dr. Richey, Dr. Stewart, and Professor Wager record the fact that on Glamaig, on Sron a'Bhealain, and in Allt Daraich, in the Red Hills of Skye, they have found marscoite to be chilled against the granophyre with which it is in contact. They interpret this evidence as proof that the marscoite layer is younger than the adjacent granophyre. On equally good evidence, however, i.e. the inclusion of relics of marscoite within the granophyre of these localities, Harker (*Skye Memoir*, 1904,

https://doi.org/10.1017/S0016756800082285 Published online by Cambridge University Press

pp. 187–196) came to the opposite conclusion, deducing that the marscoite was older than the granophyre. The latter he considered to have replaced much of the basaltic rocks within which the marscoite originally formed layers.

When reliable observers disagree on what appears to be such a straightforward issue as the relative ages of adjacent igneous rocks, it is clear that the criteria on which the conclusions are based require re-examination, and that such further consideration may well lead to an important discovery. Since one of us (D.B.McI.) spent several weeks examining the rocks of Glamaig, Sron a'Bhealain, and Allt Daraich last spring, and since the other (D.L.R.) is investigating the Tertiary rocks of Slieve Gullion, where similar problems are presented, it is perhaps not out of place for us to make some of our observations available.

On Slieve Gullion thick layers of dolerite alternate with sheets of granophyre against which the dolerites develop fine-grained edges. At some localities these fine-grained edges have a variolitic texture, and are characterized by skeletal crystals of plagioclase similar to those found within the tachylytic selvedges of members of the younger dyke swarm. This evidence clearly indicates that the fine-grained edges of the dolerite layers are chilled edges. There is, however, another line of evidence suggesting that these fine-grained edges have been " baked ". Not only do the plagioclase crystals they contain exhibit " clouding ", of the type so commonly interpreted as indicative of contact alteration, but in places the texture of the margins is distinctly hornfelsic. In this case the pyroxene is crystalloblastic, occurring as granules or as more robust stellate forms to which Dr. Richey has applied the term " star aggregates " (*Proc. Geol. Assoc.*, 1937, p. 274). Such " baked " margins, however, still retain evidence that they originated as a result of chilling, for not only does the grain-size of the rock decrease as the contact with the granophyre is approached, but some of the larger plagioclase crystals within these hornfelsed margins still retain their original skeletal form. Paying attention to one set of criteria, Dr. Richey has interpreted these selvedges as " baked edges " (*Proc. Geol. Assoc.*, 1935, p. 488 ; 1937, p. 274), whilst one of us (D.L.R., *Proc. Geol. Assoc.*, 1937, p. 255), paying attention to the other set of criteria, has interpreted them as chilled edges. The only interpretation that will satisfy all the criteria, however, is that the edges are chilled edges that have been subsequently " baked ".

Now it is clear that these fine-grained selvedges of the dolerite layers cannot have been both chilled against the adjacent granophyre and " baked " by it. It has, however, already been shown (D.L.R., *Proc. Geol. Assoc.*, 1937) that the granophyre at one horizon on Slieve Gullion has been developed in situ from Caledonian granodiorite, and

https://doi.org/10.1017/S0016756800082285 Published online by Cambridge University Press

that the transformation has culminated in rheomorphism, as is witnessed by the veining of the dolerite by the granophyre. Thus, in their present forms, both the dolerite and granophyre layers are, so to speak, " metamorphic " rocks. The only logical interpretation, therefore, is that the dolerite layers were originally emplaced and chilled against the antecedents of the present-day granophyre layers, and that the whole rock suite was subsequently " baked ", this process accounting both for the hornfelsic texture of the dolerite and for the rheomorphism of the granophyre, that is, of the rock with the lower melting point. Such changes in the initial layered rocky pile are perhaps not surprising when it is realized that the rocks under discussion occupy the site of what may well have been a caldera within the area enclosed by the Tertiary ring-dyke of Slieve Gullion.

Although in a different milieu, such co-ordinated changes in diversified rock assemblages are comparable with those observed by Sederholm in the Pre-Cambrian rocks of Finland. After an initial granitization of the leptites of Svionian age, which resulted in the development of grey gneissic granite and its associated migmatites, a swarm of dolerite dykes was intruded. These dykes commonly show chilled edges against the older rocks. Subsequent changes led to the conversion of much of the grey gneissic granite and leptites, which formed the country rocks of the dolerite dykes, to the younger Hangö granite. Within the Hangö granite the dolerite dykes now occur as hornfelsed, amphibolitized, and veined relics, yet some of them still retain fine-grained margins which originated as chilled edges against the antecedents of the red Hangö granite.

Now it will be clear from the above discussion that the finding by Dr. Richey, Dr. Stewart, and Professor Wager that the marscoite has chilled edges against the granophyre can be accepted as a criterion of age only if it can also be shown that Harker's observation—that the same marscoite occurs as inclusions within the granophyre—is wrong. One of us (D.B.Mc.I.) was fortunate in visiting the localities in question during last May and June when the burns were exceptionally low, and not only was Harker's observation that inclusions of marscoite occur within the granophyre of Allt Daraich confirmed, but a complete set of specimens was collected, varying from marscoite through net-veined marscoite, " spotted granophyre " and dark granophyre, to relatively leucocratic granophyre, to illustrate all the stages of disappearance of the marscoite within the granophyre. The marscoite of this locality was found to be fine-grained where it is in contact with the granophyre, but equally fine-grained patches were also found well within the mass. The sheet-like body of marscoite outcropping on Sron a'Bhealain, of which, as Harker suggested, the exposure in the Allt Daraich probably forms a continuation, has a chilled margin as Dr. Richey, Dr. Stewart,

https://doi.org/10.1017/S0016756800082285 Published online by Cambridge University Press

and Professor Wager record ; the selvedge is, in fact, tachylytic. At the same time the following observations made by Harker—apparently inconsistent with the chilling—were confirmed : " the sheet [of marscoite] itself is seen to be two-fold, with a parting along which the acid magma has found access. Both in this parting and below the base of the sheet the acid rock is crowded with partially digested xenoliths of marscoite." Thus the Allt Daraich–Sron a'Bhealain sheet of marscoite is seen both to be chilled against the granophyre and to occur as inclusions within it. The analogy with the previously discussed examples from Northern Ireland and Finland will be obvious.

On Glamaig and Sron a'Bhealain and in Allt Daraich, Dr. Richey, Dr. Stewart, and Professor Wager distinguish an older biotite-hornblende-granite and a younger " spotted " granophyre. The reason for this distinction is not obvious. Locally the granophyre of the area under discussion is leucocratic, adjacent to marscoite it contains hornblende and biotite, and in places it is spotted with marscoite in association with which it may contain quartz xenocrysts derived therefrom. Moreover, in contact with the gabbro relics in the Allt Daraich it contains monoclinic pyroxene. Throughout its varietal facies, the granophyre exhibits a micropegmatitic texture.

Far from providing a simple interpretation of the age relations of the rocks of Glamaig, Sron a'Bhealain, and Allt Daraich, such as is proposed in the letter under discussion, the facts are actually more complicated than even Harker's descriptions would indicate. Further complications are that in the Allt Daraich and on the slopes of Glamaig the granophyre contains abundant inclusions of fine-grained granophyre ; other inclusions are pyroxene-bearing, whilst yet others appear to be of sedimentary origin. Some of the basalts near the granophyre contact on the summit of Glamaig contain patches, two or three feet across, with numerous plagioclase phenocrysts, and similar patches are found within and near the base of the marscoite sheet on Sron a'Bhealain. The porphyritic patches in the marscoite contain very peculiar sheaf-like aggregates of strongly coloured monoclinic pyroxene. This pyroxene is identical with that characterizing the gabbro of Allt Daraich. Moreover, patches of gabbro, additional to those recorded by Harker, were found in the granophyre, unassociated with marscoite. Another point of interest is that the marscoite contains small fine-grained basic inclusions which themselves contain rimmed quartz xenocrysts similar to those found in the marscoite.

The rocks of the marscoite areas evidently constitute a palimpsest, from which a complex succession of histories remains to be deciphered.

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19th December, 1946.

https://doi.org/10.1017/S0016756800082285 Published online by Cambridge University Press