Chapter 11 Invasion of basic rocks by the granite-magma

In a comprehensive study of the varied suite of intrusive igneous rocks in Skye no feature is more remarkable than the frequent association of different rock-types in intimate and peculiar relations. This is shown in two ways, which, however, are often illustrated by the same occurrences, and are obviously so connected that any general consideration of the subject must take account of both together. We find firstly a strong tendency for different rock-types to be closely and regularly associated, so as to constitute what is in effect one composite rock-body; and secondly the frequent inclusion of partially digested debris (xenoliths) of one igneous rock in another. Such relations are found to exist in many instances between two rocks of widely diverse composition, such as gabbro and granite or basalt and granophyre, and there are also some curious cases in which more than two kinds of rock are involved. The phenomena have sufficient novelty to warrant more than a passing notice, and they will be described at some length and their bearings to some extent discussed. It appears from numerous scattered notices in the geological literature both of the Inner Hebrides and of the northeastern counties of Ireland, as well as from an examination of specimens collected by the late Director-General in several of the islands, that the peculiar relations in question are in some degree characteristic of the Tertiary intrusions of the British province as a whole.

The probable significance of the phenomena will be pointed out as they are described, and such general considerations of a theoretical kind as are admissible in this memoir will be properly deferred to a later stage; but one remark may be made at the outset. There are good reasons, as will appear below, for believing that, when two different igneous rocks are *intimately and systematically associated,* whether as members of a composite intrusive body or as xenoliths and enclosing matrix, they are also closely related as regards source and origin; and further that, when such peculiarly intimate relations subsist between two igneous rocks of definitely intrusive habit, these have been separated by no great interval as regards the epochs of their intrusion. Petrographical phenomena to be described below can scarcely be explained except on the supposition that the first rock was still hot, and even in some cases its consolidation was not yet perfectly completed, when the second rock was intruded in juxtaposition with it. An essential distinction is thus to be drawn between the systematic and regular association of different rocks to form composite stocks, laccolites, sheets, or dykes and the merely fortuitous conjunctions, which also occur but are not usually attended by peculiarities of a petrographical kind. Equally must we recognise an essential distinction between the regular and abundant inclusions of one igneous rock, A, in another, B, repeated again and again through the country with the same remarkable circumstances, and the merely accidental inclusion of foreign rock-fragments (igneous or otherwise) which occur locally in these as in many other intrusive rocks.

In the large plutonic intrusions, which will be first noticed, the close association of basic and acid rocks does not assume the same regularity and symmetry as in the composite sills and dykes to be described in the next chapter. In several places, however, and especially on Marsco, gabbro and granite (including granophyre) are found with very remarkable mutual relations, the significance of which cannot be overlooked. Taking a broader view, the mere juxtaposition of the two rocks, recurring at a number of distinct centres, can scarcely be a coincidence without meaning. The great gabbro laccolite of the Cuillins has a great granite laccolite intruded beneath and partly into it; and the gabbro boss of Broadford has a granite boss intruded beside and partly through it. In the Carlingford district, in Arran, in Mull, in Ardnamurchan, in Rum, and so far away as in St. Kilda, occur other considerable masses of Tertiary gabbro, and in each of these places that rock has granite (including granophyre) for its intimate associate. Further, according to Sir Archibald Geikie, the sequence in time of the two rocks is everywhere the same, and the acid intrusion often intersects the basic one. The mutual relations of the two rocks have been described in the case of Carlingford by Professor Sollas,<ref>*Trans. Roy. Ir. Acad.,* vol. xxx., pp. 477–512, P1. XXVI., XXVII: 1894. See also Prof. Busz on an occurrence in Ardnamurchan, *Geol. Mag.,* 1900, pp. 436–441.</ref> whose account affords interesting material for comparison with some of the facts recorded below. Another district available for comparison, as regards the mutual relations of gabbro and granophyre, is Carrock Fell in Cumberland,<ref>Harker, *Quart. Journ. Geol. Soc.,* vol. 1., pp. 311–336, Pl. XVI., XVII.: 1894; vol. li., pp. 125–147, Pl. IV.: 1895.</ref> where, in default of direct geological evidence, the possible Tertiary age of the rocks is suggested by petrographical analogies.

We have first to describe some interesting phenomena which demonstrate that in certain places the gabbro has been partially fused in the vicinity of the invading granite magma, and to trace the effects which have resulted from reactions between the two rocks under these conditions.

Effects of this kind are to be observed on a small scale on the eastern and north-eastern borders of the eastern Red Hills, where we have already noticed a permeation of the basic rock by the acid. Microscopic examination shows clearly that this permeation has been attended, and doubtless facilitated, by a *local and partial refusion of the gabbro.* With the fused basic material has been mingled a small proportion of the acid magma, and the result has been, after consolidation, a rock of somewhat less basic composition than the normal gabbro, and differing from it in mineralogical constitution. Two specimens will suffice to illustrate this reaction. The first is from Creag Strollamus, and forms part of the gabbro close to the granite, which sends veins into it. It is a rather dark rock of fairly coarse texture, with some tendency to a separation in patches of the darker and lighter elements. A thin slice (S8048) [NG 608 262] shows it to consist chiefly of green hornblende and felspar, with some brown mica, relics of augite, and a little magnetite in irregular grains. The hornblende is often fibrous, and both it and the mica are to be regarded as formed at the expense of augite, though not merely as pseudomorphs. The felspar is partly labradorite, with albite and carlsbad twinning, partly a variety giving low extinction-angles, probably andesine-oligoclase. The latter is in clear crystals, often untwinned, closely associated with fibrous hornblende or actinolite, and sometimes enclosing the same as a multitude of fine needles. The other specimen is a rock of rather finer texture from the slope east of Allt a' Choire, near Coirechatachan, and was cut to show fine veins of granite traversing the gabbro (S8047) [NG 617 235]. The latter has been converted into an aggregate of green hornblende and felspar with little imperfect octahedra and granules of magnetite. Some of the felspar is labradorite, but most of it gives very low extinction-angles, and seems to be oligoclase. The granite-veins, of coarser texture than the modified gabbro, are not very sharply divided from it under the microscope. They consist of turbid felspar, both orthoclase and oligoclase, and quartz, with green hornblende and a little magnetite. The hornblende is perhaps a little more abundant than is usual in the granites, but not very noticeably so.

It seems beyond doubt that at junctions like these the gabbro has been in some measure enriched in silica and alkalies derived from the acid magma. This was apparently effected in the main by the fusion or solution of part of the labradorite by the acid magma and crystallisation therefrom of a more acid variety of plagioclase. In some cases part of the augitic constituent of the gabbro seems also to have passed into solution in the acid magma, giving rise on recrystallisation to hornblende or (in consequence of the accession of alkali) to biotite. Concurrently with the acidification of the gabbro there has been in some cases an evident modification of the acid rock in the opposite sense. Two examples of granophyre veins traversing and altering the gabbro give specific gravities 2.68 and 2.71, and are obviously of more basic nature than the main mass from which they are offshoots. This reciprocal modification of the granite or granophyre is, however, not always apparent, as we have seen in the case just described. If the reaction was quite local, the small amount of basic material taken up from the gabbro might be distributed by diffusion through a considerable volume of the acid magma. It is important to remark that in places where acid veins injected into the gabbro assume a fine texture, as if in consequence of rapid cooling, no perceptible effects of the kind in question are found. These reactions seem to have been dependent upon the injection of the acid magma into a mass of gabbro which was still hot.

Phenomena of the kind described, evincing reactions between granite and gabbro, are to be observed in many places along the outer borders of the large acid intrusions, where these are in contact with the earlier intrusions of gabbro. At these, which we may term *external,* junctions of the two rocks the effects are not on an extended scale or of a conspicuous kind. Reactions of a like kind, but of a more far-reaching scope and productive of much more striking peculiarities, have operated in certain localities at what may be distinguished as *internal* junctions; *i.e.* where portions of gabbro have been involved in the heart of a granite mass. The most remarkable relations are observed where continuous bodies of the earlier basic rock have thus been enveloped by the later acid magma; but we shall first describe the effects of the inclusion in the acid magma of a large amount of gabbro xenoliths.

The rocks which illustrate this type of intermixture most strikingly are the *xenolithic granophyres of Kilchrist,* in the broad strath leading up from Broadford towards Torran. These are crowded throughout with partially digested gabbro xenoliths. The mode of occurrence and probable geological relations of these rocks have already been discussed (*see* (Figure 4), above). They are in contact partly with the Cambrian limestones, chiefly with the agglomerate of the great volcanic vent: nevertheless, they contain no xenoliths of limestone; and fragments of metamorphosed basalt and grit which may be referred to the volcanic agglomerate are found only sparingly, chiefly in the fine-textured felsitic rock which in places forms the margin of the mass. The relics of gabbro, which are distributed in such profusion through the granophyre, are derived therefore from some unseen source. It is not impossible that a gabbro sheet underlies the granophyre, and has been disrupted by it; but this is entirely hypothetical, and there is nothing in the appearance of the gabbro debris to suggest their origin by the shattering of a solid sheet of rock. For reasons which will be discussed in connection with other xenolithic rocks in the district, we incline to the opinion that this gabbro has come directly from some primitive reservoir rather than from any intruded rock-body.

A description, illustrated by microscopical figures, of these rocks has already been published, and the following account is taken partly from that source.<ref>Harker, *Quart. bourn. Geol. Soc.,* vol. lii., pp. 320–328, P1. XIII., XIV.: 1896.</ref>

Compared with what may be called the normal granophyres of the neighbouring Red Hills, these rocks are darker and manifestly richer in the iron-bearing minerals. Examination shows, too, that they are decidedly denser: ten specimens gave specific gravities ranging from 2.56 to 2.73, with a mean of 2.66, while twenty specimens of the normal granophyres of the district gave from 2.51 to 2.66, with a mean of 2.58. Closer inspection often reveals a mottled appearance, due to the dark minerals tending to cluster in vaguely defined patches, and in places these patches become more distinct and are seen to represent enclosed fragments of some basic rock. In other respects — for example, in the prevalence of the micrographic structure, in the drusy character of the more coarse-textured type, etc. — these rocks show a close correspondence with the normal granophyres of the district. It cannot, of course, be asserted that they agree precisely with the latter as regards the composition of the original magma, but it will be shown that the differences which now exist are certainly due, atleast in the main, to the taking up and partial dissolution of gabbro material.

The xenoliths are, as a rule, less than an inch in diameter, though exceptionally larger. In a hand-specimen they are visible as dark blotches, often closely clustered together, with vague shadowy outlines which sufficiently indicate that the enclosed debris has suffered deeply from the caustic action of the magma. This becomes more evident in thin slices, where obvious xenoliths are not often recognisable as such, though unmistakably foreign material is universally distributed. Some constituents of the gabbro have suffered more or less complete fusion or solution in the acid magma; while other constituents, which resisted such action, have been set free, and now figure as xenocrysts, either intact or more or less perfectly transformed into other substances. At the same time the material absorbed has modified the composition of the magma, in the general sense of rendering it less acid, and this is of course expressed in the products of the final consolidation of the granophyre. In order to present in systematic form the observations made, it will be convenient to begin by enquiring what has befallen each of the chief constituents of the gabbro.

In these Kilchrist rocks, as in the similar ones to be described on Marsco, apatite needles are constantly present and rather abundant, though, as usual with this mineral, somewhat capriciously distributed. Doubtless any apatite contained in the gabbro would survive as such in the modified granophyre, but we know that the Skye gabbros are usually deficient or very poor in this mineral. It does not seem possible to distinguish apatite needles derived from the gabbro from those proper to the granophyre itself.

It is the augite that affords the most conclusive proof of the extraneous origin of the xenocrysts, and this is due to the characteristic basal striation of the gabbro-augite, a feature not found in the augite of the normal granophyres. In the recognisable enclosed fragments of gabbro (S6704) [NG 607 208] the augite shows no change except a conversion to brownish-green, rather fibrous hornblende at the edge of the crystal, a transformation very common in the ordinary gabbros of the district. In the isolated xenocrysts the conversion to hornblende is usually far advanced, and in these rocks in general this mineral predominates over augite. It is yellowish to brownish-green or sometimes greenish-brown in colour, and of compact (as contrasted with fibrous) structure. Very often there is a core of unchanged augite with the basal striation that indicates its derivation from gabbro, and the traces of this structure are sometimes seen even when the conversion to hornblende has been complete. Failing this evidence, the derivation of the hornblende can often be inferred from the irregular shape of its crystals, or from its enclosing abundant shapeless grains of magnetite. On the other hand, there is usually some hornblende presenting the crystal outlines proper to that mineral, and this must certainly have crystallised out from the modified granophyre-magma. In some slides it is very plentiful. It does not differ materially in colour and pleochroism from the pseudomorphic hornblende. It may be remarked that, when the latter encloses a core of unchanged augite, the two minerals have the usual crystallographic relation, the b and c axes being common to both: in a clinopinacoidal section the extinction-angle of the augite is 39°, and of the hornblende 18°, on the same side of the vertical (S2674) [NG 617 200]. In addition to the augite plainly derived from gabbro, several of the slides contain rather rounded grains of augite showing neither basal striation nor partial conversion to hornblende. These are to be regarded as crystallised directly from the granophyre magma. Two slides (S2674) [NG 617 200], (S6703) [NG 607 208] contain altered xenocrysts of rhombic pyroxene, a mineral which we have noted as an occasional constituent of the gabbros of the district. There is a partial conversion to hornblende at the margin, while the interior is usually serpentinised.

Occasionally pseudomorphs after olivine, apparently of "pilitic" amphibole, are seen enclosed in the relics of striated augite (S6704) [NG 607 208], or isolated in the granophyre-matrix (S6703) [NG 607 208].

Magnetite-grains of irregular shape are embedded in many of the augite-xenocrysts and the hornblende-pseudomorphs after them, and these do not differ from the grains in the original gabbro. Most of the abundant magnetite in the slices is, however, of a different kind, building perfect or imperfect octahedra. Though partly representing in substance iron-ore absorbed from gabbro-debris, it is evidently a new crystallisation from the modified granophyre-magma.

Distinct xenocrysts of gabbro-felspar are rare in the specimens sliced, but they are occasionally found, especially in the neighbourhood of actual gabbro-xenoliths. One suitably oriented crystal gave extinction-angles 35° and 36° in alternate and is presumably labradorite like the common felspar in the gabbros of the district. It has a marginal intergrowth of a more acid felspar, and, like the felspar-phenocrysts in all these granophyres, has served as nucleus for a growth of micropegmatite (S6704) [NG 607 208]. It is clear that most of the felspar of the enclosed gabbro-fragments has been completely absorbed by the enveloping magma. The result is seen in a great preponderance of soda-lime- over potash-felspar in the rock as finally consolidated, compared with the normal granophyres of the district. This dominant felspar seems, however, to be chiefly oligoclase, with quite low extinction-angles.

Apart from the peculiarities described, the rocks here dealt with present a general similarity to the normal granophyres. There are, however, one or two special points worth noting. Several writers, in describing the phenomena of xenoliths of acid rocks in basalts and diabases, have remarked a tendency to the formation of hollow spaces, usually filled by later products. Indications of the same tendency are not wanting in the present converse case, though the circumstances are different. In one example are seen ring-like aggregates, about 1/10 inch in diameter, of hornblende crystals, surrounding areas of clear quartz (S6705) [NG 607 216]. Quartz is frequently seen moulded upon hornblende-crystals, and, in several slides, penetrated by actinolitic needles. Such patches of quartz are quite different from the quasi-porphyritic grains common in the granophyres, and they seem to be of late formation — not necessarily secondary in the usual sense. They probably occupy what have once been vacant spaces formed in connection with the destruction of xenoliths, and are quite distinct from ordinary druses. The latter are also found here just as in the normal granophyres, and are commonly filled by calcite and quartz (S6707) [NG 596 210]. In places it can be seen that the calcite-crystals project into the quartz, which again indicates that some of the latter mineral belongs to *a* very late stage in the history of the rock.

In addition to the relics of gabbro in these granophyres there are occasional traces of inclusions of other rocks. In particular there are granular aggregates consisting largely of hornblende and magnetite and presenting angular outlines to the surrounding matrix (S6709) [NG 585 201]. These, no doubt, represent small fragments of basalt in an advanced stage of dissolution, and are merely accidental xenoliths picked up from the volcanic agglomerate. They are of the same nature as the fragments enclosed in the felsitic rock already mentioned as forming the marginal part of the acid intrusion in certain places. These latter are much less altered from their original state, and often preserve sub-angular outlines.

We pass on to consider the more remarkable phenomena displayed on Marsco and about Glamaig, where the basic rocks involved in the acid intrusions are not merely detached small xenoliths from some subterranean source but large bodies of dyke-like and sheet-like form. Here the relations are of a very peculiar kind, being complicated by the intervention of a third rock in addition to the gabbro and the granophyre. Since this is unlike any type included in systematic classifications and nomenclatures, we shall for convenience refer to it under the provisional name "*marscoite*". This is done merely to avoid repeated periphrases, and it is not intended to establish a new rock-type: the rock indeed is certainly a hybrid one, and therefore not entitled to systematic rank or formal designation. In this place it is sufficient to state that it is a conspicuously porphyritic rock, with large crystals of labradorite, and, though of generally basic composition, contains quartz, usually in visible grains. On Marsco gabbro, marscoite, and the dominant acid rocks are associated in a peculiarly intimate fashion; while in the neighbourhood of Glamaig the marscoite is again found associated with granophyre, the gabbro being here scarcely represented. We shall describe the rocks of these two areas in turn, noting in each case first the relations of the rocks as seen in the field and then the more interesting petrographical details. These lead to results which have in some respects more than a local interest.

At the north-western base of *Marsco* the tourist-track up Glen Sligachan crosses a boggy slope, which is conspicuous at a distance as a bright green delta-like area, and is due to a mass of red sand or loam washed down from a deep gully in the hillside (Plate 8). On examining the gully, it is seen that this material is derived from a gabbro-like rock which, unlike most of the Skye gabbros, is deeply decayed, and by its decomposition has determined the line of the gully. The rock has been affected by spheroidal weathering, with exfoliation, and the large spheroids themselves are sometimes decayed to the core; so that what looks at first sight like solid gabbro may be seen traversed by numerous rabbit-burrows. This strip of basic rock is usually less than 50 yards wide, though considerably expanded at the lower end, where it is covered by the delta of sand. It runs eastward, with some departures from the straight course, for nearly ¾ mile (*see* sketch-map, (Figure 36)); and the way in which it crosses ridge and hollow without deviation, as well as the nature of the boundaries when visible, shows that it is a large dyke-like body with a small inclination to the vertical (Figure 35). While the greater part of it consists of gabbro (including gabbro partly acidified by impregnation), the northern border is of the rock which we have styled marscoite. On both sides the strip of basic rocks has been attacked by the acid magma and mutual changes have been produced. The acid rocks on the south and north sides seem to belong to distinct intrusions, for the one is granitoid or coarsely granophyric, while the other is fine-textured and porphyritic.

Since an examination of the exposures in this gully illustrates several points of interest in the behaviour of the four rocks involved, we give a transverse section across it in the accompanying figure (35). Beginning on the south side, we find little indication of any abnormality in the acid rock at A. It is a pale granite, often coarsely granophyric, and the exposures give very little evidence of modification due to the absorption of basic material. The actual boundary against the gabbro, where such evidence might be more confidently expected, is not easily examined. The gabbro, however, is very decidedly affected in the fashion already described elsewhere.

Even so far away as in the crags overlooking the burn there is a notable degree of acidification, the specific gravity at B being only 2.84. The gabbro in the burn at C and that with spheroidal structure in the slope C D are not very different from the normal type, and have a specific gravity 2.91. Between D and E the rock shows no evidence of acidification; but here it begins to assume something of a pophyritic aspect by the occurrence of prominent glassy-looking crystals of labradorite. These become more conspicuous, while the rock otherwise becomes progessively finer in grain. There is thus a general resemblance in appearance to the marscoite of other parts of the hill; but the quartz-grains are so far wanting, and even at F, where the porphyritic structure is well pronounced, the rock is thoroughly basic in composition, its specific gravity here being 2.98. Before reaching G, however, quartz-grains have appeared in considerable abundance, and the specific gravity has fallen to 2.86. The rock which forms what must be regarded as the border of the basic strip is a characteristic marscoite. Between this and the porphyritic felsite at H no sharp boundary can be drawn. There is an intermediate zone, a few feet in width, of a hybrid rock resulting from the intermixture of the marscoite and the felsite. The rock of this zone is of grey colour, with a rather fine-grained ground enclosing porphyritic felspars and quartz-grains. Its heterogeneous origin is manifest to the eye in a curiously patchy appearance, darker and lighter portions being in some places rather sharply separated and in other places shading into one another. The darker and ligher patches, which may be well displayed in a hand-specimen, represent the marscoite and the felsite respectively; but, even where they are most distinct, it is certain that the one has been partly acidified and the other partly basified. Admixture has thus taken place both by bodily intermingling and by diffusion, and it can scarcely be doubted that the two rocks represented were in a partially fluid state at the same time. The relations between the marscoite and the felsite on the north side of the gully thus differ in some respects from those between the gabbro and the granite on the south side.

Following the strip of basic rock eastward from the head of the gully, we find that the marscoite on the northern border is not to be traced continuously. After disappearing, however, it reappears near the eastern end of the strip, being here at some little distance from the edge of the gabbro and wholly enveloped in the acid rock, as shown in the sketch-map (Figure 36). This is enough to show, what is elsewhere sufficiently evident, that the marscoite is not merely a modification *in situ* of the gabbro, but represents a distinct act of intrusion. We shall see that this rock is everywhere younger than the gabbro, but older than the acid rocks. The only place where it has been observed clearly to graduate into the gabbro is in the gully already described, and there we must suppose that the marscoite was intruded along the edge of the gabbro while that rock was still in a fluid condition. In other places the two have been divided by a more decided, though probably only a short, interval. In the eastern portion of the gabbro strip the relations of this rock to the granite are well seen. The acid rock sends numerous veins into the gabbro, as well as impregnating it on a minute scale. Moreover the rock bordering the gabbro on its south side is for some distance rich in xenoliths and xenocrysts derived from the gabbro and in process of dissolution. It is here rather a granophyre than a granite, but evidently richer than is normal in the ferro-magnesian elements.

A little farther south is another but smaller strip of basic rock, running S.S.E. along the west side of Coire nan Laogh. Its eastern side is a dyke-like strip of marscoite, up to 50 feet in width; and in contact with this on its west side is gabbro, which, however, is of irregular width, and does not extend to the northern extremity of the strip. This illustrates a point which is elsewhere noticeable on Marsco, viz. that, except in the gully first noticed, the gabbro has been more readily attacked by the acid magma than the marscoite; so that, where the latter rock intervenes, it has to some extent protected the former. Another small enclosed strip of basic rock occurs further west, near the precipice named Fiaclan Dearg. This is for the most part of gabbro, much modified by the acid magma and having in places a rather ill-defined boundary. Northward, however, a dyke-like strip of marscoite comes on on the western or lower side of the gabbro, and continues beyond it, as shown in the sketch-map (Figure 36). The boundary of the marscoite is sharply marked, and without close examination it might pass for a dyke cutting the granite.

The largest of the enclosed strips of gabbro is that which takes a curved course, more than 1½ mile in length, to the east of the summit, and may be traced as far as the burn in Coire na Seilg. Here again the acid rocks to the north and south are different, the one being fine-textured and porphyritic, the other coarse and granophyric to granitoid in structure. This seems to indicate that the basic rock has not been enveloped by a single acid intrusion but caught between two distinct intrusions. The northern part of the strip is irregularly expanded, and terminates northward at a burn which runs down to Allt Mam a' Phobuill, the gabbro being bordered here by a dyke-like strip of marscoite. Following the strip of gabbro where it turns south-eastward, we find marscoite again on the south-western border; but this dies out after about 300 yards, leaving the gabbro in contact with the drusy coarse granophyre, which assumes a dark colour near the junction. This relation continues eastward, as the gabbro strip, with a width usually of 30 or 40 yards, runs up to Druim Eadar da, Choire and over to Coire na Seilg. Throughout this stretch the coarse granophyre to the south is manifestly modified by basic material taken up from the gabbro, but the porphyritic felsite to the north shows little sign of such modification. The rock which, for the purpose of describing the field-relations, we are calling gabbro, is in this part very different from a normal gabbro, and increasingly so eastward. It has here become so impregnated with the acid magma as to approach petrographically rather to a granite, and a specimen from the ridge of Druim Eadar da Choire gives a specific gravity only 2.75. Here, as in the locality first described, the rock is in great part decomposed to a reddish sand, and the spheroidal weathering formerly noted also reappears at several places on the line of this long strip.

These long narrow strips of gabbro seem to have had, prior to the invasion of the acid magma, the general nature of large dykes intersecting rocks of which no trace is now to be seen. We have alluded to them in a former chapter as probably representing some of the feeders of the large gabbro laccolite of the Cuillins. This latter has, in this immediate neighbourhood, been removed by erosion; but a relic of it seems to be represented by another patch of gabbro situated on the main ridge of Marsco itself, to the southeast of the summit (Figure 27) and (Figure 36), and having evidently the sheet-like, not the dyke-like, habit. There is no rock of the marscoite type in this place. The gabbro has very evidently been attacked and partially corroded by the acid magma, and for some distance below it on all sides the coarse drusy granophyre is enriched in the darker and more basic elements, isolated xenoliths of gabbro in an advanced stage of dissolution being detected in places for at least 500 yards farther along the south-east ridge. This outlying sheet of modified gabbro on the summit-ridge of Marsco may with much probability be taken to represent the base of the great laccolite. Prolonged for about a mile southward it would just miss the top of the lower granite hill Ruadh Stac (*see* (Figure 27)), and it is worthy of note that on the eastern shoulder of this hill the granite contains abundant little half-digested xenoliths of gabbro. On the north-western slope of Ruadh Stac a small patch of gabbro has been mapped, which by its low specific gravity (2.82) gives evidence of a certain degree of acidification, and others, not more closely examined, occur at two or three places in the granite of this part of the district.

Summarily, the chief igneous rocks of Marsco fall under three heads, the gabbro, the marscoite, and the acid rocks; and these were intruded in order as named. The gabbro was the earliest, and existed in the form of large dyke-like bodies, doubtless more continuous than at present and of greater and more constant width. The marscoite was intruded along the border of the gabbro in numerous places, and this also had the dyke-habit. Further, it is not improbable that the acid rocks were also intruded in the first place after the fashion of dykes, following still the old channels; but the overwhelming volume of the acid magma which was eventually forced up has obliterated the evidence on this point, and further has left only much corroded relics of the older basic rocks. The nature of the mutual reactions which have taken place among the several rocks indicates that they were intruded in somewhat rapid succession, and even in certain places that one was not completely solidified before it was invaded by another. Finally, if the several rocks were forced up along the same channels, with only brief intervals of time, we may infer that they were very closely connected in origin. Further light is thrown on some of these considerations by the petrographical study of the rocks.

Taking these peculiar rocks of Marsco in order, we shall note first the petrographical evidence of the *impregnation and internal fusion of the gabbro by the acid magma.* A good example of an early stage of the process comes from the south-eastern ridge of the hill, at about 600 yards from the summit-cairn. It is a dark crystalline rock very like many examples of the medium-grained normal gabbros of the Cuillins. The only suggestive feature on the hand-specimen is the presence of a few flakes of brown mica, a mineral rarely if ever found in our gabbros save in connection with reactions between them and other igneous rocks. The specific gravity is 2.92. A thin slice (S8965) [NG 512 250] shows nevertheless some noteworthy points. The felspar is a labradorite, giving extinction-angles up to 30° in sections perpendicular to the albite-lamella. Except that it is unusually clear, a common incident of thermal metamorphism, it resembles the felspar of the normal gabbros. The pale augite is also quite normal, but has been converted in small part into a light-green hornblende. There are also the usual irregular grains of opaque iron-ore, and little hexagonal prisms of apatite are locally present. There are, however, other constituents not proper to the gabbros; viz. some interstitial quartz, little crystals of brown hornblende, and flakes of deep-brown mica, the last chiefly surrounding the iron-ore grains. The brown silicate-minerals are partly idiomorphic, but in places their relation to the quartz is such as to prove that they belong to the same stage as that mineral. It cannot be doubted that these three are the results of reactions consequent upon a certain permeation of the gabbro by the acid magma.

Rocks similar to that just described occur at other spots on the ridge and in the gully on the north-west face of the hill. The next specimen, taken from the last-named place, illustrates a further stage of modification of the gabbro. To the eye it looks very like the preceding, though perhaps a little richer in the felspathic constituent. A slice ((Plate 20)., Fig. 1) shows some points of difference. Apatite is rather plentiful — a characteristic of these Marsco gabbros as compared with the generality of those in the district. Some of the original augite, very pale brown in colour, still remains, but the plates seem to be breaking up, and most of the augite in the slide is in pale greenish grains similar to those in the acid rocks. The brown hornblende and brown mica are more abundant than before, and so too is the interstitial quartz, which has become quite an important constituent. Further, the felspars show a considerable difference. Some large crystals indeed remain, with all the characters of the ordinary felspar, though clarified, but most of the felspar is in smaller crystals evidently of new formation. They are in the main oligoclase-andesine, but they are strongly zoned, and the outermost zones are of a thoroughly acid variety. The magnetite is in small crystal-grains, and its relation to the new-formed augite proves that it is recrystallised.

The extreme result of the invasion of the gabbro by the acid magma is well illustrated by the eastern part of the longest enclosed strip, where it crosses Druim Eadar da Choire. It is pretty sharply distinguished from the granophyre on either side of it, especially by its deeply weathered condition, which causes a marked dip in the ridge and a deep gully on each slope. Its geological relations, and its continuity with undoubted gabbro to the west, prove clearly that it represents an enclosed strip of that rock; but, taken by itself, there is nothing in its petrographical characters that would suggest referring it to the gabbro family, and it corresponds in composition much more nearly with a granite. Like these hybrid rocks in general, it does not fall under any normal rock-type. Mineralogically, it has too little quartz for a granite and too much of the ferro-magnesian minerals for a quartz-syenite, while the nature of the felspathic elements separates it from the quartz-diorites. A fresh specimen is a medium-grained crystalline rock of specific gravity 2.75. It has a mottled black and white aspect suggestive in itself of admixture. A slice (S7133) [NG 528 241] shows that the dominant coloured mineral is a green hornblende, but much of this is clearly derived from a pale augite, kernels of which still remain. Brown mica occurs in subordinate amount, partly intergrown with the augite. There are grains of magnetite and a few little prisms of apatite, while a more unexpected constituent is zircon in small pyramids and prisms. The felspar is mostly an oligoclase with very low extinction-angles; but there is also orthoclase, which shows some degree of zonary banding between crossed nicols. There is no micrographic structure here, the quartz being simply the latest product of crystallisation.

Such rocks as the specimen just described illustrate in a striking way the extent to which interchange of material may be carried between an enclosed strip of gabbro and an enveloping granitic magma without notably impairing the individuality of the former as a rock-body with well-defined boundaries. The same thing is constantly observable as between xenoliths and their matrix, even when viewed microscopically. Such facts go far to negative the assumption made by some petrologists that the viscosity of rock-magmas must be a serious check upon diffusion. In the case of our rocks it is clear that diffusion proceeded with great freedom when intermixture by flowing was not possible, and when dense inclusions were not able to sink in a lighter medium. A rock comparable in acidity and in density with that last described might be made by fusing together about one part of gabbro with two of granite, but it is not likely that the actual composition of the rock can be represented in this crude fashion. There has been free diffusion, and, as we shall see in the case of the xenolithic granophyres to be described next, the several constituents of the rocks involved did not diffuse with equal facility. If in the laboratory we fuse together two rocks of known composition in known proportions, we can calculate the composition of the resulting product; but the conditions which make this possible — viz., the isolation of the materials in a crucible and the reduction to a homogenous condition of everything within that circumscribed space — are conditions not realised in nature. The processes which have operated in the cases of the Kilchrist and Marsco rocks were of a less simple kind, mere admixture being supplemented by diffusion. The resulting hybrid rocks in such a case are thus only in a general sense intermediate in composition between the two parent rocks, and may be abnormal in comparison with any ordinary igneous rocks formed from a single magma. In other words, the series consisting of two extreme rock-types and the various hybrid rocks which they have generated will not in general be a "linear" series as regards chemical composition.

We proceed to notice the *modification experienced by the granophyre* near the gabbro strips of Marsco in consequence of the *incorporation of basic material* in its substance. As seen in the field, the rocks vary from the normal drusy granophyre of the district (S8967) [NG 515 246], or in places a granitoid variety, to an extremely dark type, obviously much enriched in the ferro-magnesian minerals. Specimens but little modified show evident xenoliths in the form of little patches, rarely an inch in diameter, not very sharply defined against their matrix. These little patches are evidently richer in hornblende and other dark minerals than the surrounding matrix, and the felspar in them usually appears dead-white instead of the yellowish tint common in the granophyres. The indications of xenoliths are often less apparent in specimens of the darker, more modified rocks, but there is still a certain mottled aspect due to ill-defined patches of darker and lighter tints, respectively richer and poorer in the dark constituents.

In the thin slices prepared from various examples it is found that none of the principal constituents of the gabbro can be recognised as surviving: the xenoliths, though preserving sufficient individuality to indicate their approximate outlines, are represented entirely, or almost entirely, by new-formed minerals. The change is not a mere metamorphic one, but one of substance, for the new minerals include alkali-felspars and quartz. The xenoliths are in fact pseudomorphed by a relatively basic granophyre, and there must have been both addition and subtraction of material.

The only original mineral of the gabbro which has possibly survived is the apatite, with perhaps some part of the iron-ore. Apatite is constantly found in the rocks, and sometimes rather abundantly; but to what extent it is derived from destroyed gabbro it is not easy to decide. In some part, however, the apatite in these rocks must have belonged to the gabbro. One specimen sliced (S7554) [NG 511 252] shows dark patches about ½ inch in diameter enclosed, without a very sharp boundary, in rock with the characters of a normal granite. These patches are not only much richer in hornblende, relatively to felspars and quartz, than the matrix, but contain also abundant apatite and magnetite, which are wanting outside the patches.

As regards the ferro-magnesian minerals, it is very noticeable that augite, which is usually well represented and often predominant among the normal granophyres of the district, is here subordinate or entirely absent. Green hornblende is constantly the dominant mineral of this group, both within the altered xenoliths and in the interspaces between them, and it is sometimes accompanied by brown biotite ((Plate 20), Fig. 3). Much of the hornblende is idiomorphic, though without good crystal-forms, and it has clearly crystallised as such from fusion. In addition there may be patchy aggregates of hornblende, and perhaps biotite, with finely granular magnetite, which seem to replace augite (S8694) [NG 513 249]; and indeed the gradual conversion of augite to green hornblende with magnetite granules can sometimes be observed in various stages (S7553) [NG 511 253]. The hornblende thus arises in two distinct ways, and the same is true of the magnetite. Indeed this latter mineral is perhaps of three kinds, for in addition to little octahedra evidently crystallised from the basified granophyre magma and clusters of granules formed at the expense of augite, there are sometimes larger irregular grains which may be derived almost intact from the gabbro.

Both plagioclase and orthoclase are always present, but the former predominates, at least in those rocks which are much modified from the normal granophyre type. It is oligoclase; but occasionally there are also a few crystals which give higher extinction-angles, and seem to be andesine. Quartz is always well represented, though usually in notably less amount than in the normal granophyres. It builds irregular grains or enters into micrographic intergrowths, the structure of the rocks (granitoid or more commonly granophyric) presenting in this respect no peculiarity.

It is interesting to enquire what proportion of gabbro substance has actually been taken up by the acid magma. The crowded dark patches seen in some of the rocks give, no doubt, an exaggerated impression of the amount of foreign material present, for these patches have not the composition of gabbro. They have been permeated by the acid magma, and the basic material abstracted from them may have been diffused through a considerably larger volume than that of the visibly xenolithic rock. A specimen (S8694) [NG 513 249] from the south-east ridge of Marsco was examined by Dr Pollard, who found it to contain 64.72 per cent. of silica and 2.98 per cent. of lime. This was an average example of the dark basified granophyres. We may compare it with a mixture of 23.5 per cent of gabbro and 76.5 of granophyre, taking the figures for these from analyses already given:

	Silica	Lime	Sp. grav.
Gabbro	46.39	15.29	2.85
Granophyre	70.34	1.24	2.66
Calculated mixture	64.71	4.54	2.70
Dark granophyre (found)	64.72	2.98	2.73

The discrepancy here as regards lime can scarcely be accounted for by the variable composition of the gabbro and granophyre of the district, and we must suppose that the different constituents (such as silica and lime) diffuse through the magma in different degrees. We may, however, conclude that the acid magma has in some places taken up something like one-third of its mass of material derived from the gabbro. Some of these dark basified granophyres, indeed, cannot be much less basic than the extreme results of acidification in those rocks which are, from the point of view of their geological relations, included above as acidified gabbros.

A remark should be made concerning the drusy structure of the modified granophyres of Marsco. This structure, of very general occurrence in most parts of the Red Hills, is especially well displayed on Marsco; and in those granophyres which enclose evident xenoliths, or preserve the outlines of destroyed xenoliths, the druses often seem to stand in relation to the xenoliths. It may be supposed that the druses in this case have been rather of the nature of gas-and steam-cavities, and that the solid or quasi-solid fragments distributed through the magma have served as starting-points for the growth of bubbles. The association of druses of various kinds, usually of small size, with xenoliths is a very general phenomenon, as appears clearly in the literature of the subject.

Before leaving the acid rocks of Marsco, it should be remarked that in several places pegmatoid veins and streaks traverse the gabbro or the marscoite for a short distance from the junction with the granophyre. These are well seen in the gabbro about 750 or 800 yards east of the summit, and again at the base of the gabbro-sheet in a little ravine running down towards Coire nan Bruadaran. At both these places large crystals of bronzy-looking mica are conspicuous. Pegmatite-veins with a marked gneissic banding intersect the gabbro of the gully on the north-west slope. All these rocks are of very coarse texture, the individual crystals of quartz, orthoclase, and oligoclase, which make up the bulk of the veins, ranging up to an inch in diameter, and the flakes of brown mica being sometimes nearly as large. Lustrous black crystals of hornblende, brown and strongly pleochroic in a thin slice, are of smaller dimensions, and have good crystal-forms, with the customary habit. A few prisms of apatite are also present (S8052) [NG 513 251]. There is little or no approach to graphic intergrowth in these pegmatite veins. Another feature is that they do not, like the granophyre itself, take up any appreciable amount of extraneous material.

Lastly we have to notice the characters of the peculiar rock which we have for convenience named *marscoite.* We have seen that it holds an intermediate place, as regards epoch of intrusion as well as in actual situation, between the gabbro and the granite. It is intermediate between them also to some extent in composition, but no analysis has been made of it.

The usual type is a dark finely crystalline rock, enclosing glassy-looking crystals of finely striated felspar, ¼ to ½ inch long. Small grains of quartz are visible in places. There also occur, more sparingly and less uniformly distributed, dull white xenocrysts of felspar, contrasting with the fresh phenocrysts, and exceptionally little aggregates of felspar crystals and quartz which may be regarded as partially digested xenoliths. An average specimen of the rock gave the specific gravity 2.82. In a slice (S7858) [NG 505 258] the felspar phenocrysts are quite clear. They have a markedly tabular habit parallel to the brachypinacoid, with a breadth of sometimes less than 1/50 inch, and there is a certain degree of rounding of the angles. These crystals are of medium labradorite (extinction-angle 38°), with carlsbad, albite, and pericline twinning. The quartz-grains, which occur plentifully, are about 1/20 inch in diameter. They show in various stages the rounding and corrosion and the border of granular augite, or usually hornblende, which indicate their extraneous origin. The derived felspars, partly orthoclase, are also somewhat corroded and otherwise altered by the basic magma in which they have been enveloped.

The general mass of the rock consists chiefly of greenish brown hornblende and felspar. The hornblende is partly in crystal-grains, partly in elongated narrow prisms enclosing granular magnetite. In the latter form it seems to be derived from augite, some of which mineral still remains, and the process of conversion is seen in some places in the slice ((Plate 21), Fig 2). Besides the finely granular magnetite, there are little octahedra, doubtless crystallised from fusion. The felspar is partly in little striated prisms, partly in rather shapeless grains, some untwinned. Oligoclase is certainly present, in addition to a more basic plagioqlase, and some of the grains may be of orthoclase. Further there is a certain amount of quartz in clear interstitial grains. A striking feature of the rock is the immense number of minute needles of apatite which it contains.

It appears from this description that the marscoite represents a basic magma which has taken up granitic material, and, by the partial absorption of this, become in some measure acidified. The quartz and acid felspars have not been derived directly from the contiguous acid rocks, or at least this cannot be the general explanation of their presence; but it is none the less noticeable in some occurrences that these quasi-foreign elements become more abundant on the side neighbouring the acid rock. A like peculiarity will be observed below in the marscoite of the Glamaig neighbourhood. The section in the deep gully (Figure 35) exemplifies this fact. A specimen from this place, but taken towards the gabbro, shows on the other hand the transition from marscoite to gabbro which we have already pointed out. It is notably denser than the ordinary marscoite, having a specific gravity 2.94. A slice (S7859) [NG 505 258] shows that quartz-grains occur more sparingly than before, and are more corroded, having always a relatively broad border composed of augite-grains with some hornblende. Of the two coloured silicates the pale yellowish brown augite is in this slice the dominant one, though the greenish-brown hornblende also occurs. They build larger crystal-grains than before, and the same is true of the felspar, which shows albite and carlsbad, and rarely peticline, twinning. From its extinction-angles it seems to be an acid labradorite or andesine-labradorite. Interstitial grains of quartz are still found, though in somewhat less amount than before. In other respects, including the great profusion of fine apatite-needles, this slide resembles the other. The close resemblance between the labradorite phenocrysts in the marscoite and the crystals of the same mineral in the gabbro suggests a like origin for both; but further light is thrown upon this question by the phenomena, which we next proceed to describe, in the neighbourhood of Glamaig.

The peculiar rocks now to be discussed are exposed on *Glamaig* itself; in the burn, named Allt Daraich, to the south-west, which drains Coire na Sgaìrde; and at the termination of the ridge Druim na Ruaige on the opposite side of the corrie. This ridge is a spur from Beinn Dearg Alheadhonach, and consists of the ordinary granite, often granophyric, which forms so much of the Red Hills. At its northern end, however, the smooth flowing outline of the ridge is broken by a wart-like excrescence named Sròn a' Bhealain, which is a prominent object in the view from Sligachan. The prominence is caused by a sheet-like mass of marscoite, 200 to 250 feet thick, with a northerly dip of about 20°, which covers the northern face of the ridge and rises into a knoll nearly 1500 feet above sea-level (Figure 37). The base of the sheet is invaded by the underlying coarse granophyre, which sends little tongues obliquely into the marscoite; and the sheet 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 the marscoite, usually from half an inch to two or three inches in diameter and of ovoid shape. These dark spots in a lighter matrix give the rock a very striking appearance, and we shall speak of it for convenience as the "spotted granophyre" (*see* (Figure 41), below). In places the little dark patches become merged in their matrix, so that their outlines are almost or quite obliterated, and we have merely a very dark partly basified granophyre, representing the admixture of marscoite with the normal acid rock.

Farther north, in the bed of Allt Daraich, we find some relics of marscoite and a considerable quantity of the spotted and dark granophyres, the whole probably representing the prolongation of the Sròn a' Bhealain sheet (*see* (Figure 38)). Corning to Glamaig itself, we cross two sheets of marscoite on the ascent from Bealach na Sgaìrde to the summit. Each of these in turn for some distance separates the granophyre of the lower part of Marsco from the overlying basaltic lavas, the boundary between granophyre and basalt ascending by steps, each of which corresponds with a sheet of marscoite. These sheets, however, continue as sills in the basalt, and may also be traced for some distance in the granophyre, by which they have been attacked and corroded. These relations are illustrated in (Figure 38) and (Figure 39). Another sheet of marscoite is seen for 300 or 400 yards on the west slope of the hill, in this case at the lower boundary of the granophyre against the basalts. In all cases the granophyre near its junction with the marscoite has taken up abundant debris of that rock, and when a sheet of marscoite comes to an end in the granophyre, its course can still be traced for some distance by a band of xenolithic and basified rocks.

The interpretation of these relations is, to a certain point, sufficiently evident. The marscoite, apart from subsequent modifications due to the acid magma, represents a distinct rock, which was intruded in the form of sills at several horizons in the basaltic lavas. An invasion of acid magma, of much greater volume, has followed, and this has at first found its easiest channel along the surfaces of the sills of marscoite. Where guided by these, it has often kept for some distance to one horizon, but elsewhere it has broken across irregularly. On the south-western slope of Glamaig, as shown on the map and in (Figure 39), it has broken across by successive steps from one sill to another. This irregularity of behaviour was doubtless facilitated by the destructive action which the acid magma exercised upon the basic sills, disintegrating and partially dissolving their substance. Such action was most effective when the acid magma had access to both the upper and the lower surfaces of a marscoite sill; and so a sill, once enveloped by the granophyre, soon comes to an end, at least as a continuous body. The sill of Sròn a' Bhealain, which has probably been completely enveloped, owes its preservation to its exceptional thickness. We proceed to discuss the petrographical characters of the various associated rock-types.

The *marscoite* of these sill-formed intrusions is in all essentials closely comparable with that which forms the dyke-like bodies on Marsco. It is on the whole more modified in the sense of acidification, but it varies in this respect in the several sheets and in different parts of the same sheet. There are abundant phenocrysts of labradorite, usually fresh and glassy-looking, up to ½ inch or more in length. Very abundant also are the rounded quartz-grains, always with a border of imperfect crystals and grains of green hornblende, or of augite in process of transformation to hornblende. These hornblende-crystals often project for a short distance into the quartz-grain, proving that the marginal portion of the latter is of new formation. The rocks also enclose occasional xenocrysts of orthoclase, turbid and altered, and exceptionally groups of these, with some quartz, which may perhaps be regarded as little xenoliths of granite in an advanced stage of dissolution.

In the ground-mass the relative proportions of brownish-green hornblende and pale augite vary considerably; but, since some part of the hornblende is certainly pseudomorphic after augite, this difference is perhaps not significant. The felspar, in little imperfect prisms or in irregular crystal-grains, is mostly of a striated variety with low extinction-angles, but some is untwinned. Apparently the dominant kind is near oligoclase or oligoclase-andesine in composition, but orthoclase sometimes occurs in addition. There is a variable and sometimes considerable amount of interstitial quartz. Magnetite and little needles of apatite occur abundantly.

The marscoite, as stated, shows a certain range of composition; and this is most easily studied in the thick sheet of Sròn a' Bhealain. Two specimens from the upper part of the sheet (as exposed) gave specific gravities 2.80 and 2.81, and two from the lower part 2.73 and 2.74. Comparison of thin slices (S7546) [NG 508 273], (S7547) [NG 508 273], (S7549) [NG 508 273] shows that the latter rocks are decidedly more acid than the former, being richer in enclosed quartz-grains and in interstitial quartz. It appears then that, although the derived acid material in the marscoite cannot be ascribed, at least in the main, to the contiguous acid rock, this sheet does grow more acid towards its junction with the granophyre. A comparison between the marscoites of Marsco and those of the neighbourhood of Glamaig is suggestive in the same connection. The latter, which are much more intimately invaded by the granophyre, are also as a whole decidedly more acid, the variety which prevails in the Marsco occurrences being found here only in the interior of the thick sheet of Sròn a' Bhealain. The fact that even in this case the rock contains not only interstitial quartz, but quartz-grains and xenocrysts of acid felspars, shows, nevertheless, that the marscoite had, in the main, acquired its peculiar characters prior to its intrusion.

We conclude then that the marscoite as intruded represented an originally basic magma modified by the inclusion of granitic material, relics of which still remain as xenocrysts. This process, while prior to the intrusion, was probably posterior to the epoch of the labradorite phenocrysts: it is at least difficult to conceive these crystallising from the partially acidified magma, and they never enclose any of the derived elements. If some portion of the magma had been intruded prior to the absorption of granitic material which converted it to marscoite, it would presumably have given rise to ordinary basic rocks containing phenocrysts of labradorite. It is not improbable that such intrusions are actually represented in the neighbourhood. On the moorland near the west base of Glamaig two or three sills occur in the basalts, coming down to the high-road about ½ mile N.E. of Sligachan (*see* (Figure 39)). We shall see later that the innumerable basic sills of the plateau country, which are of later age than the plutonic intrusions, never approach so near to the granite, and we are thus led to separate these Sligachan sills from the great group and to refer them to an earlier epoch. They are also separated petrographically from the plateau sills by the occurrence in them of abundant large phenocrysts of labradorite, like those in the marscoite. They are thoroughly basic rocks, with a considerable amount of olivine represented by pseudomorphs. Being found in such close proximity to the marscoite sheets of Glamaig, and unknown elsewhere, these porphyritic sills may not improbably represent an early intrusion of that basic magma which was subsequently converted to marscoite by taking up acid material.

Another point worthy of notice is the possible significance of the large crystals of labradorite in the marscoite. At one place on Marsco we remarked an unusually intimate association of gabbro and marscoite, with no sharp division between them, and we pointed out in that connection the resemblance between the labradorite crystals in the two rocks which there graduate into one another. Gabbro is not represented by distinct intrusions among the rocks of Glamaig; but in one place it is found in the form of irregular patches enveloped in the marscoite. This occurrence is in the bed of Allt Daraich, and the relations at this place are shown in (Figure 40). The locality is at a considerable distance from the main area of gabbro; but it is noteworthy, and perhaps significant, that a small patch of that rock is intruded among the lavas to the west of Glamaig in actual contact with the largest of the porphyritic basalt sills mentioned in the preceding paragraph. The gabbro enclosed in the marscoite of Allt Daraich is seen at a point about 150 yards below the infall of Allt Bealach na Sgaìrde. The largest patch, in so far as it is exposed, is about 20 feet across and of very irregular outline. It is intimately penetrated by tongues and veins of the surrounding marscoite, and there are detached portions of gabbro in the latter, one large enough to be shown in the accompanying ground-plan. Two small patches of gabbro lower down in the stream have probably also been enclosed in the marscoite, though they are now surrounded by dark basified granophyre of the spotted or xenolithic kind. The gabbro contains no quartz, and is of quite normal characters, though, like the Marsco gabbros, somewhat richer in apatite than is usual in rocks of this family in Skye. The point to which we would direct special attention is that in the marscoite surrounding the gabbro patches the labradorite phenocrysts show a tendency to aggregate in clusters. So marked is this tendency in places that, on the smooth channel of the burn, little areas, a few inches across, crowded with crystals, appear sharply defined against the neighbouring rock, which contains the crystals only sparingly. It is impossible on the ground to draw any absolute distinction between these portions rich in crystals of labradorite and undoubted xenoliths detached from the neighbouring large patch of gabbro; and the conclusion seems to be forced upon us that the labradorite crystals in the marscoite are derived from the gabbro.

If this last conclusion is to be applied to the marscoites of Marsco and Glamaig as a whole, it is not, however, to be supposed that the labradorite crystals in these rocks have in general come from the disintegration of solid gabbro. Rather should we suppose that, after the intrusion of the gabbros of the Cuillins, crystallisation began under intratelluric conditions in an unexhausted portion of the gabbro-magma, and labradorite was formed, a subsequent modification of the residual magma due to the addition of granitic material giving rise to the marscoite. If in places intratelluric crystallisation had already proceeded so far as to form actual gabbro, clots or patches of this might be caught up in the marscoite and so intruded with it; but this seems to have been exceptional.

We have still to describe the modification in the granophyre of Glamaig due to the inclusion of marscoite xenoliths in the magma. Everywhere in the vicinity of the marscoite sills effects of this kind are shown in various stages in the acid rocks. The only exception is presented by certain pegmatite veins and strings which traverse the lower portion of the Sròn a' Bhealain sheet. These, like the similar occurrences on Marsco, show occasionally a banded or gneissic structure. They are very coarse-grained, consisting essentially of crystals of orthoclase, sometimes two or three inches long, enclosing quartz crystals up to ¾ inch in diameter. There is no graphic structure on a large scale, but a thin slice shows a delicate micropegmatite fringe surrounding each crystal of quartz, the quartz and felspar of this fringe being continuous with the adjacent crystals of those minerals, respectively. These veins have never taken up basic material.

The *granophyres with partially digested xenoliths of marscoite* are well seen beneath the sheet of the latter rock on Sròn a' Bhealain, and occupy a considerable area on the south-western slopes of Glamaig, but they are perhaps most easily studied in the little patches exnosed in the bed of Allt Daraich some 200 yards below the infall of Allt Bealach na Sgàirde. There, with progressive destruction of the enclosed debris, every stage is exhibited down to a dark, almost homogeneous basified granophyre in which the outlines of the xenoliths are lost.

The most usual type is a rock presenting crowded dark patches or spots, of ovoid shape and usually less than an inch in diameter, in a lighter grey matrix (Figure 41). The phenocrysts of labradorite seem to have resisted the caustic action of the acid magma more successfully than the rest of the marscoite, for they are sometimes seen, with angles but little rounded, projecting from the dark spots into the surrounding matrix. Occasionally they are found quite detached; and this also happens, though it is less easily verified in hand-specimens, with the corroded quartz-grains and sporadic xenocrysts of turbid alkali-felspar. These minerals, which were xenocrysts in the basic rock, thus became what may be styled xenocrysts of the second order, *i.e.* twice derived, in the granophyre. An average specimen of the spotted rock gave the specific gravity 2.76, while a part of one of the dark spots, separated from the matrix, gave 2.806.

In thin slices (S7551) [NG 508 289], etc. the xenoliths of marscoite in these rocks resemble generally the marscoite of the sills. They have, however, a larger proportion of quartz and alkali-felspar in the ground-mass, or at least they are comparable in this respect with the most acid portions of the marscoite sills in immediate proximity to the granophyre. This is doubtless due to injection of the xenoliths by the granophyre magma. It is worthy of note that here, as in the sills, the quartz and alkali-felspar do not assume the form of micropegmatite. There is, as before, an abundance of brownish-green hornblende, often partly idiomorphic, octahedra of magnetite, and little needles of apatite ((Plate 21)., Fig. 1). One peculiarity is that the large crystals of labradorite are often cracked and shattered, as if by the heat of the granophyre magma. The paler matrix in which the dark xenoliths are enclosed requires no detailed description, being merely a granophyre richer in hornblende and magnetite than the normal kind.

A transition from the distinctly spotted rocks to the uniformly dark granophyres is illustrated by specimens exhibiting a rather indistinct mottling on a small scale (S7548) [NG 508 273]. This appearance is. due to the breaking up of the ovoid xenoliths preparatory to their final dissolution. In a thin slice the darker parts are marked out by the abundance of hornblende and magnetite which they contain. Augite is scarcely found except in rings surrounding xenocrysts of quartz or minute xenoliths of orthoclase and quartz, which are still recognisable. A flake or two of biotite is also present. As regards the felspar and quartz of the ground-mass, there is no appreciable distinction between the darker and the lighter patches of the rock, both alike being now characterised by micropegmatite. Apatite-needles occur in both parts, but are both stouter and more numerous in the darker portions of the slice.

From such rocks as this there is a gradation (often in a very short space) to those in which no heterogeneity is apparent to the eye, and in which the microscope shows that the component elements are uniformly distributed (S7550) [NG 508 289]. They are simply granophyres unduly rich in hornblende, magnetite, and apatite. Part of the last-named mineral seems to have been derived directly from the marscoite, but no other simple xenocrysts of this kind are to be detected. The large crystals of labradorite, already shattered, have broken up as soon as they became isolated in the acid magma, and have been dissolved like the rest. The quartz-grains and crystals of turbid orthoclase, which were found as xenocrysts in the marscoite, remain undestroyed in these dark granophyres as xenocrysts of the second order. We may suppose that minerals proper to acid rocks found themselves in something like chemical equilibrium when again enclosed in an acid magma. The quartz-grains, however, have lost their border of augite or hornblende, and the orthoclase xenocrysts show certain interesting peculiarities. These, when enveloped in the basic magma, had sometimes undergone an incipient breaking up by minute fissures following the cleavages — an effect often noticed by Lacroix and other writers on xenocrysts —; and this rectangular system of fine fissures, not so pronounced as to impair the continuity of the crystal, has subsequently been occupied by newly formed quartz supplied from the granophyre magma.

Phenomena in any close degree comparable with those described about Sròn a' Bhealain and Glamaig have been observed in one other locality only — viz., on the north-eastern slope of Meall a Mhaoil, to the north of Loch Ainort. Here a narrow strip of basaltic lavas is enclosed in the granite, running steeply down towards the coast in an E.S.E. direction. On the southern edge of it a strip or sheet of a basic intrusive rock is interposed between the basalt and the granite, the last-named rock penetrating both the others in the form of small tongues and veins. The basic intrusion is of a rock somewhat similar to that of Sròn a' Bhealain, though of rather coarser grain. It might be matched more closely in the deep gully on Marsco. It has the same porphyritic crystals of labradorite as the typical marscoites, and like them is evidently a basic rock partially acidified; but the slice examined shows no recognisable xenocrysts, the quartz present being wholly of interstitial occurrence. The ferro-magnesian mineral is exclusively hornblende (S8980) [NG 560 304]. The rather fine-grained granophyre in contact with this rock is seen to be in places enriched in hornblende and magnetite, and to enclose little dark patches which must be interpreted as destroyed xenoliths of the marscoite (S8981) [NG 562 308]. This Meall a' Mhaoil occurrence thus reproduces in most essential particulars the peculiar phenomena described near Glamaig, but only on a small scale and with fewer complications.

It is to be observed that the Glamaig rocks are petrographically of more peculiar characters than those described in the earlier parts of this chapter. At Kilchrist and on Marsco hybrid rocks have been produced from gabbro and granite, and they are, as we have shown, essentially abnormal in chemical and mineralogical composition. On Glamaig, however, the intermingling has taken place between marscoite and granite, the former itself a hybrid rock of peculiar composition, and the results are correspondingly complicated. We have here to deal, in short, with hybridism of a second order. On Marsco effects of this kind are to be verified only exceptionally (for instance, between G and H in (Figure 35), the marscoite there not having entered, as a rule, into important reactions with the acid magma.

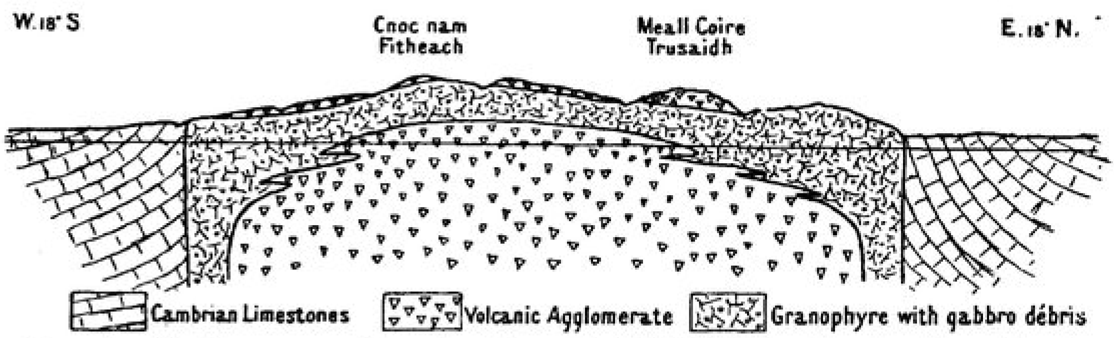
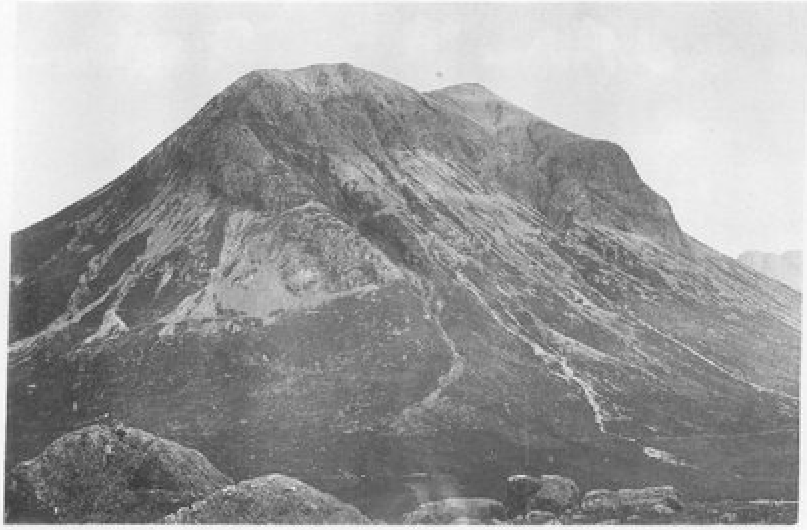


FIG. 4.—Section across the volcanic vent of Kilchrist; showing the volcanic agglomerate breaking through a sharp anticline of Cambrian limestone, and itself invaded by a later intrusion of a peculiar granophyre, full of débris of gabbro, to be described later. Scale, 1½ inch to a mile.

(Figure 4) Section across the volcanic vent of Kilchrist; showing the volcanic agglomerate breaking through a sharp anticline of Cambrian limestone, and itself invaded by a later intrusion of a peculiar granophyre, full of debris of gabbro, to be described later. Scale, 1½ inch to a mile.

Plate VIII.



Marsco, from the North-west.

(Plate 8) Marsco, from the North-west.

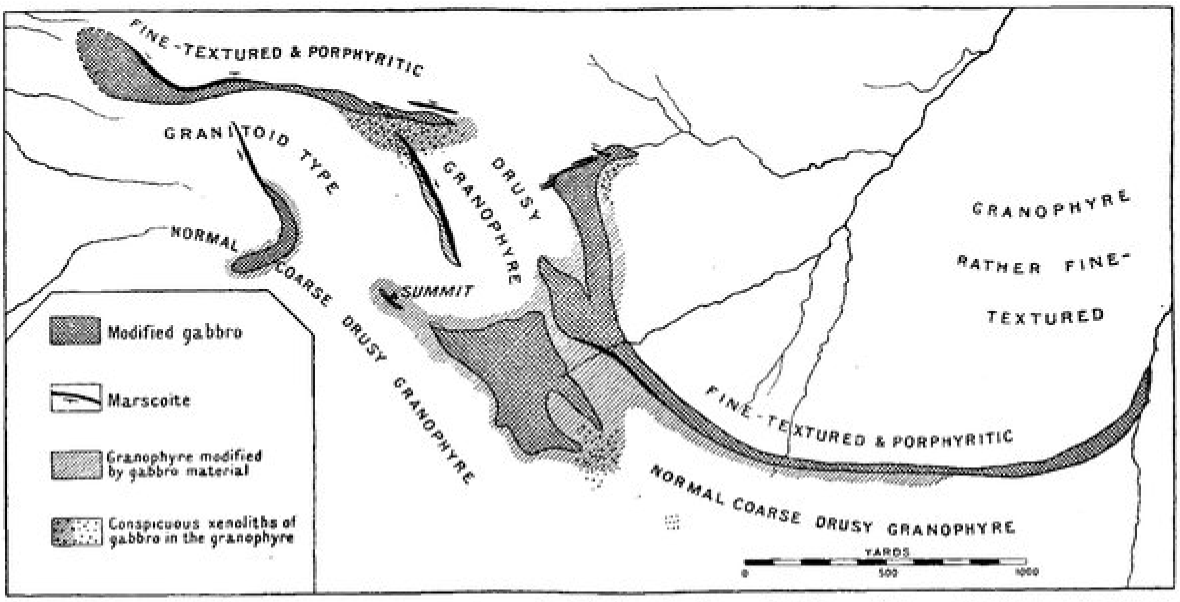


Fig. 36.—Sketch-map to illustrate the relations of the enclosed bodies of gabbro and of the rock here styled "marscoite" on the slopes of Marsco. Scale, 3 inches to a mile.

(Figure 36) Sketch-map to illustrate the relations of the enclosed bodies of gabbro and of the rock here styled "marscoite" on the slopes of Marsco. Scale, 3 inches to a mile.

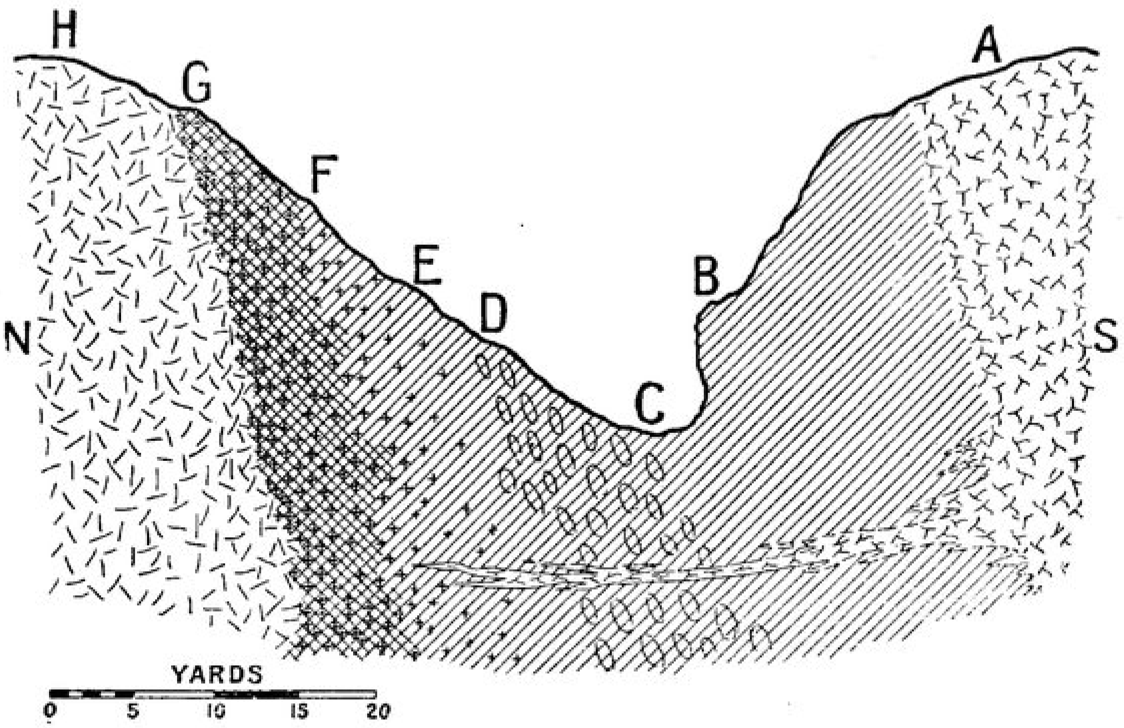


FIG. 35.—Section across the deep gully on the N.W. slope of Marsco. Explanation in the text. K is granite of pegmatoid and gneissic structure veining the gabbro as exposed in the bed of the stream a little lower down. Its connection with the granite to the south is only conjectural.

(Figure 35) Section across the deep gully on the N.W. slope of Marsco. Explanation in the text. K is granite of pegmatoid and gneissic structure veining the gabbro as exposed in the bed of the stream a little lower down. Its connection with the granite to the south is only conjectural.

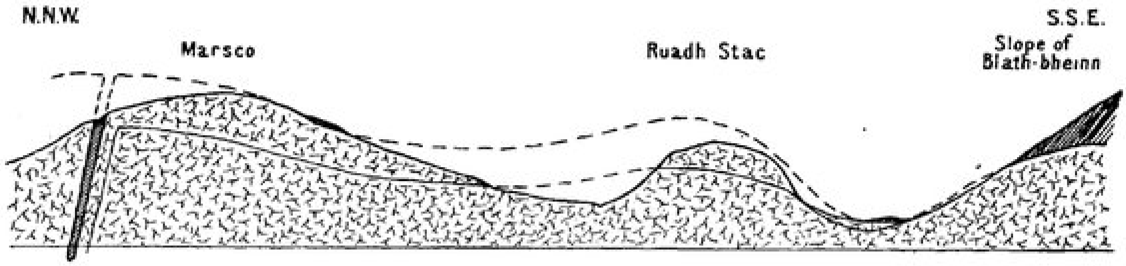
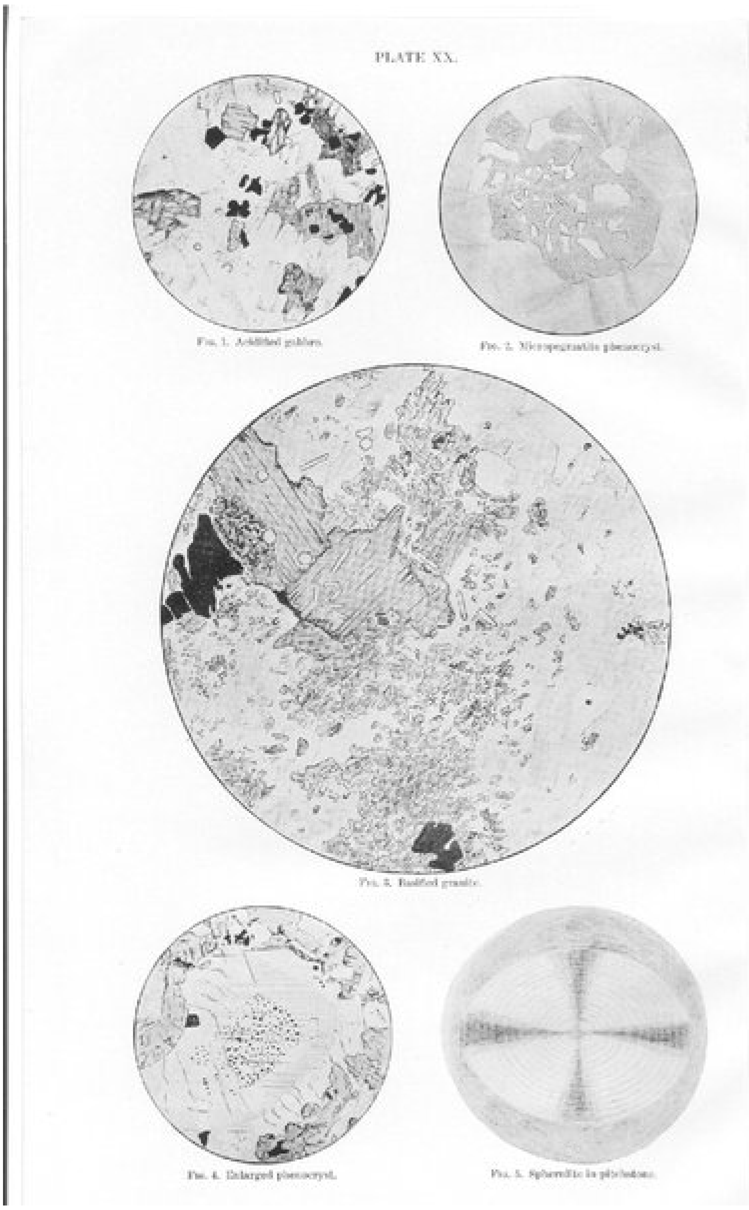
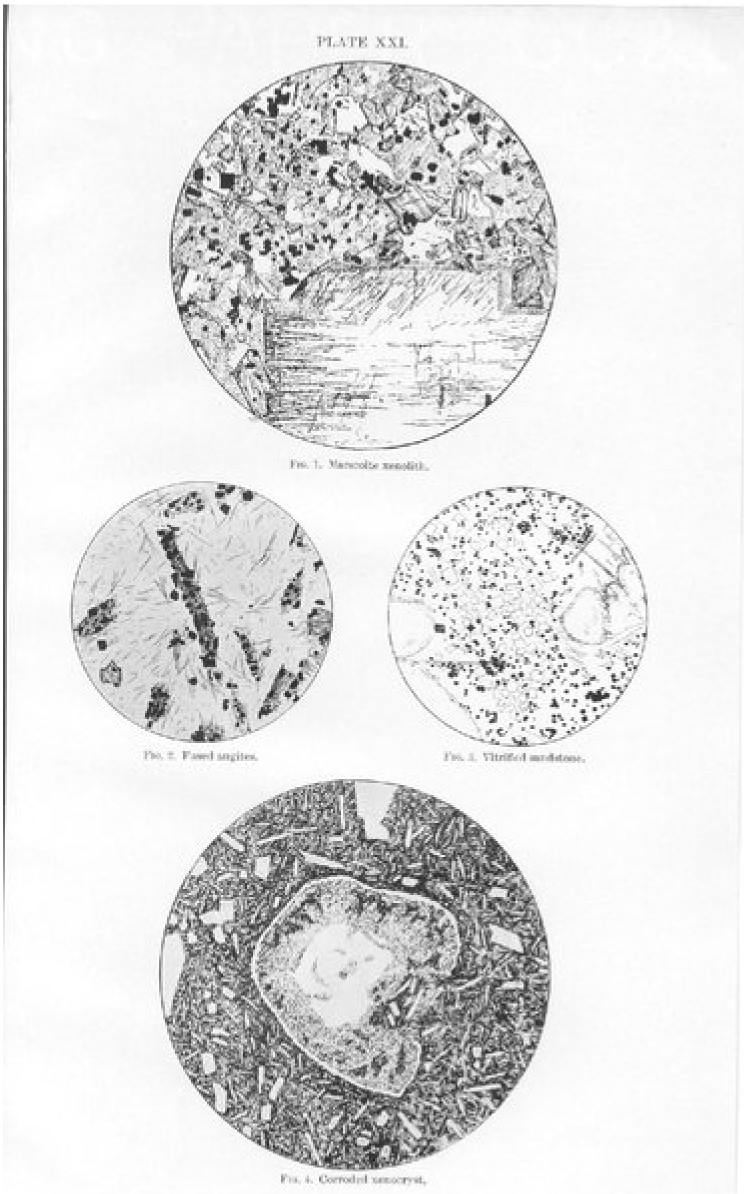


FIG. 27.—Section along a rather sinuous line through Marsco and Ruadh Stac, to illustrate the supposed manner of intrusion of the granite. Scale, 1½ inch to a mile.

(Figure 27) Section along a rather sinuous line through Marsco and Ruadh Stac, to illustrate the supposed manner of intrusion of the granite. Scale, ½ inch to a mile.



(Plate 20) Fig. 1. (S8962) [NG 500 258] × 20. Gabbro partially fused and injected by the granite magma, gully on the N.W. face of Marsco. The minerals shown are felspar, partially destroyed augite, greenish brown hornblende, magnetite, apatite, and some interstitial quartz. Of the original constituents of the gabbro there remain relics of augite and some of the large crystals of labradorite. See p. 182. Fig. 2. (S5344) [NG 490 230] × 30. Phenocryst of micropegmatite in spherulitic dyke, Druim an Eidhne. It has served as the starting-place for subsequent spherulitic growths. See p. 284. Fig. 3. (S8694) [NG 513 249] × 40. Granite modified by absorption of gabbro material, S.E. ridge of Marsco. The figure shows aggregates composed of greenish brown hornblende with little scales of biotite, larger flakes of biotite enclosing apatite, and irregular grains of magnetite. The rest is of quartz, oligoclase, and orthoclase. See p. 184. Fig. 4. (S8188) [NG 418 351] × 20. Porphyritic Olivine-Dolerite, dyke on Roineval, two miles N of Drynoch: showing a felspar phenocryst enlarged by a later growth with crystalline continuity. See p. 329. Fig. 5. (S8733) [NG 50 30] × 50, crossed nicols. Spherulite in pitchstone, W. face of Glamaig: showing a concentric shell structure. See p. 404.



(Plate 21) Fig. 1. (S7551) [NG 508 289] × 30. Xenolith of marscoite from the "spotted" granophyre of Allt Daraich, near Sligachan. The figure shows one of the large labradorite crystals, much fissured, in a ground-mass of hornblende, oligoclase, orthoclase, quartz, magnetite, and apatite. There has been some impregnation by the surrounding acid magma. See p. 195. Fig. 2. (S7858) [NG 505 258] × 100. Augite crystals replaced by fibrous green hornblende and granules of magnetite, in marscoite from the gully on the N.W. face of Marsco. See p. 186. Fig. 3. (S9982) [NG 444 122] × 100. Vitrified Torridonian grit, in contact with a dolerite sill, S. coast of Soay. Some relics of quartz-grains remain in a corroded shape. The rest is a clear colourless glass enclosing minute crystals of cordierite, magnetite, and a pyroxenic mineral. See p. 246. Fig. 4. (S9371) [NG 645 249] × 30. Corroded xenocryst of oligoclase in small sill above the composite sill of Rudh' an Eireannaich, near Broadford. The crystal, except at its centre, is greatly affected by secondary inclusions. In one place corrosion has eaten away the crystal, forming an inlet occupied by the ground-mass with its small felspar crystals. See p. 229.

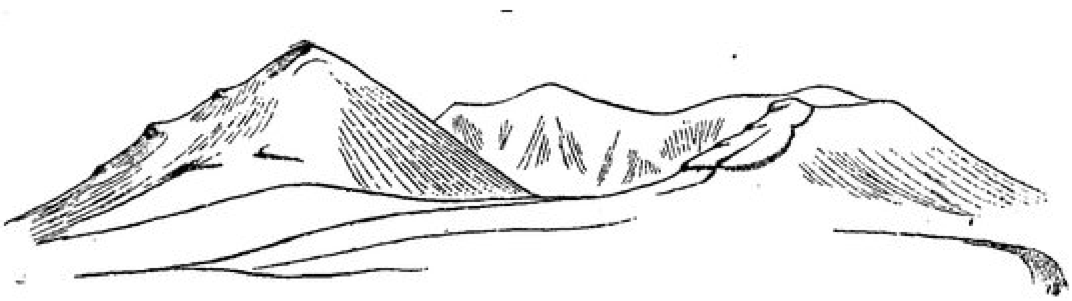


Fig. 37.—Outlines of Glamaig and Beinn Dearg, seen from the road a mile north of Sligachan. The broken north face of Glamaig, on the extreme left, consists largely of metamorphosed basaltic lavas. Beinn Dearg illustrates the characteristic rounded outlines of the granite hills; while, in strong contrast with this, the abrupt knoll of Sròn a' Bhealain is seen towards the right of the sketch.

(Figure 37) Outlines of Glamaig and Beinn Dearg, seen from the road a mile north of Sligachan. The broken north face of Glamaig, on the extreme left, consists largely of metamorphosed basaltic lavas. Beinn Dearg illustrates the characteristic rounded outlines of the granite hills; while, in strong contrast with this, the abrupt knoll of Sròn a' Bhealain is seen towards the right of the sketch.

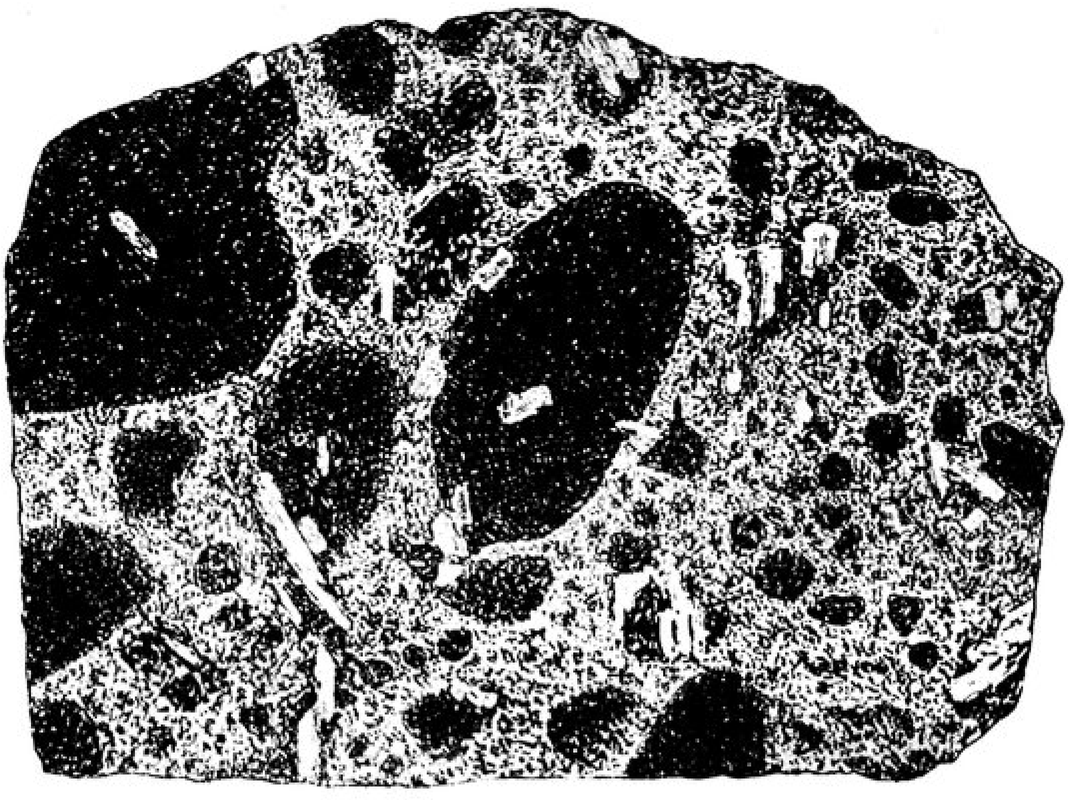


Fig. 41.—Granophyre crowded with xenoliths of marscoite and the débris of these, including released crystals of labradorite; specimen drawn of the natural size; from Allt Daraich, near Sligachan.

(Figure 41) Granophyre crowded with xenoliths of marscoite and the debris of these, including released crystals of labradorite; specimen drawn of the natural size; from Allt Daraich, near Sligachan.

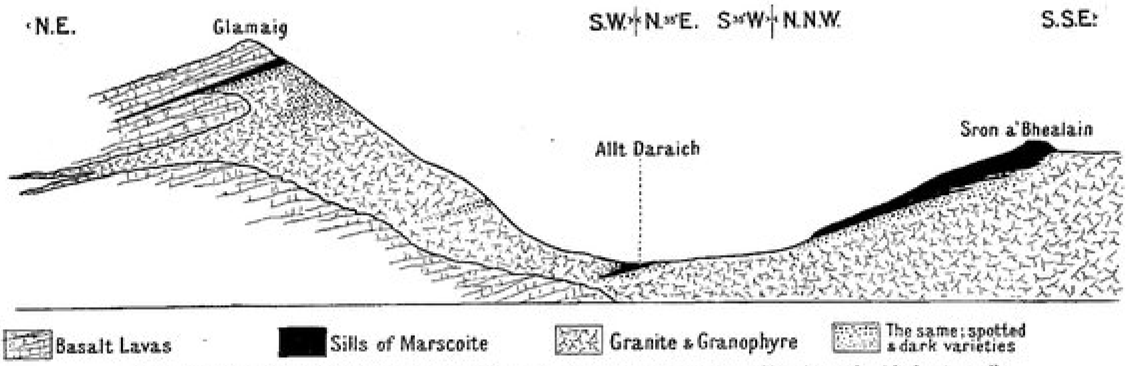


FIG. 38.—Section from Sròn a' Bhealain to Allt Daraich and thence to the summit of Glamaig; scale, 4 inches to a mile.

(Figure 38) Section from Sròn a' Bhealain to Allt Daraich and thence to the summit of Glamaig; scale, 4 inches to a mile.

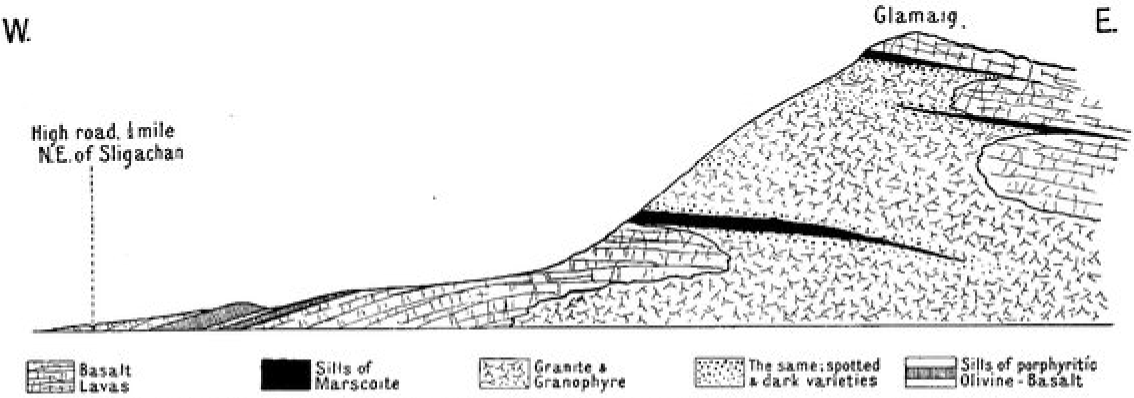


FIG. 39.—Section through the summit of Glamaig and westward to the Sligachan estuary; scale, 4 inches to a mile.

(Figure 39) Section through the summit of Glamaig and westward to the Sligachan estuary; scale, 4 inches to a mile.

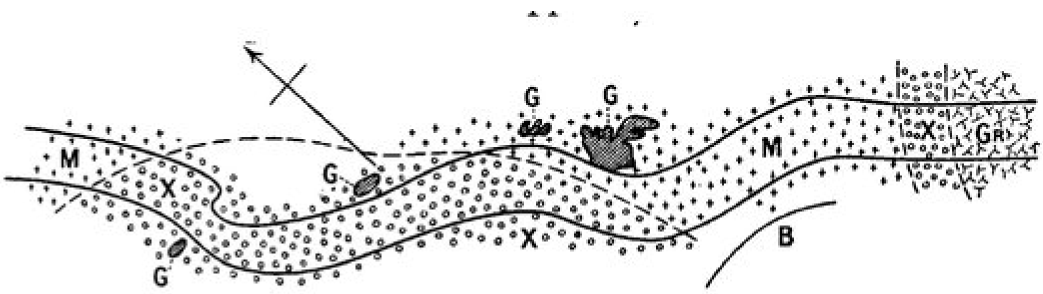


FIG. 40.—Ground-plan of part of Allt Daraich, near Sligachan.

GR. Coarse granophyre or granophyric granite of normal type.
M. Marscoite.
X. Xenolithic ("spotted") granophyre.
G. Gabbro, enclosed patches.
B. Amygdaloidal basalt (lava).

(Figure 40) Ground-plan of part of Allt Daraich, near Sligachan. Ga. Coarse granophyre or granophyric granite of normal type. M. Marscoite. X. Xenolithic ("spotted") granophyre. G. Gabbro, enclosed patches. B. Amygdaloidal basalt (lava).