Chapter 7 Gabbros: field relations

For purposes of description we shall include under the name gabbro, not only the typical rocks so styled by petrographers, but also varietal forms which may be regarded as derived from that type by modifications either mineralogical or structural. Thus, variations in the relative proportions of the constituent minerals give, though only very locally and exceptionally, anorthosites, pyroxenites, troctolites, and picrites. Textural and structural modifications are more frequent and widespread, and give rocks which, taken apart from their actual associations and classed according to petrographical characters alone, might be named diabases, pyroxene-granulites, gabbro-aplites, and gabbro-pegmatites. All these are so intimately associated on the ground with the gabbros proper that no separation has been found practicable in the course of the mapping.

Gabbro, understood in this comprehensive sense, is a rock of great importance in the geological constitution of central Skye, and especially of the loftiest and most rugged mountains of the district. Its distribution, as shown on the map, may be summarised as follows. It forms the "country" rock of the whole of the *Cuillins* proper, and extends thence across the Camasunary valley at Loch na Creitheach, and so in a N.N.E. direction to form the *Blaven range,* viz. Blaven (Blath-bheinn<ref>Although the older place-names in Skye, whether of the more prominent physical features or of settlements, are of Norse origin, the majority of names are Gaelic, and for these we follow in general the Gaelic spelling, as given on the Ordnance maps. A few names, however, are current in anglicised form, roughly transliterated, and some are so given on the maps, *e.g.* Coruisk and Quiraing. In some cases Norse names have been disguised in a Gaelic dress. If, as is probable, this is the case with "Blath-bheinn" (Blaaval, blue mountain), the English spelling of the guide-books is to be preferred to the Gaelic which appears on the map.</ref>) itself, Garbh-bheinn, and part of Belig. This main gabbro tract measures about 8½ miles from east to west and 6 miles from north to south, being, however, encroached upon from the north-east by the granite of the Red Hills. The isolated occurrences of the rock are not numerous. The largest of them is a patch about two miles long and one mile broad lying to the north-west of Broadford, where it is associated with the Cambrian Limestones and Torridon Sandstone. Some small patches occur on the north-west slopes of Belig, near the boundary of the main area, and a little boss about 150 yards in extent is seen on the moorland west of Glamaig, not far from the high-road. To these may be added a few very small patches near the south coast of Scalpay and the whole of Guillamon, a rocky islet about ¼ mile long to the north-west of Broadford Bay.<ref>A rock intrusive in Jurassic strata between Allt Leth Slighe and Glen Boreraig, in the neighbourhood of Loch Slapin, is petrographically a gabbro, but probably belongs to a much later group of intrusions. It will be considered below (Chapter 21).</ref>

It remains to be said, however, that numerous patches and strips of gabbro occur enclosed in the later granitic intrusions, indicating that the rock in question has had originally a somewhat wider distribution. These relics of destroyed gabbro are in places highly metamorphosed and otherwise modified, and will be described below. The most interesting is the broken series of narrow strips which runs from Glen Sligachan to Coire na Seilg along the flanks of Marsco. The northern half of Beinn na Cro is formed by a large patch of the bedded basaltic lavas, traversed by thick irregular sheets of gabbro, the whole enveloped in the main granite mass of the Red Hills. Small patches of gabbro are entangled in the granite at the north-west base of Blaven and the eastern base of Belig, on the moorland north of Beinn na Caillich, and in other localities.

The actual forms assumed by the gabbro intrusions, and their relations to the bedded and other rocks among which they have been intruded, are subjects which necessitate a few remarks of a general kind, and these remarks will be in great measure applicable also to the granite intrusions to be described later. Concerning the true shapes and essential geological relations of large bodies of plutonic rocks geologists have been to some extent divided. The tendency of general opinion at the present time is to regard these large masses as not differing essentially, but only in their greater magnitude and less perfect regularity, from smaller intrusive rock-bodies which are easily recognised as sheets and laccolites, dykes and "plugs" With this view the results of a survey of the gabbro and granite areas of Skye are wholly in accord. We may say further that the more extensive bodies of plutonic rocks are generally of the nature of sheets or laccolites rather than plugs or bosses, and this remark also is probably one of wide application. Indeed, the only alternative would require us to suppose that the igneous magma has not merely displaced but replaced (by actually

incorporating) the rocks into which it has been forced; and, although we have in Skye itself abundant evidence of such action on a limited scale, its general application is negatived by chemical and other considerations sufficiently conclusive.<ref>The argument has been very cogently stated by Brogger in the second part of his *Eruptivgesteine des Kristianiagebietes (Vidensk. Skrifter, Math.* nature. *Klasse,* 1895, No. 7, pp. 116–153).</ref>

Confining our attention then to Skye, we find that the plutonic rock-bodies, whether of gabbro or of granite, fall under two heads. Firstly there are those which have, allowing for minor irregularities, the general habit of *sheets or laccolites,* inclined at no high angle to the horizon, overlying older rocks and overlain (where erosion has not removed the covering) by other older rocks. Such plutonic masses are the analogues of the smaller sheet-like or sill-like and laccolitio intrusions, composed usually of hypabyssal rocks, which may be directly observed as such in this and other districts. The only difference is that the large bodies are usually too extensive for their true forms and relations to be displayed in any one view, while the irregularity of their boundaries on a small scale often renders any single section inconclusive or misleading. The second category of plutonic masses is that which includes *stocks or bosses,* which break abruptly through the bedded or other rocks into which they have been intruded. Their analogues among minor intrusions are found in certain plug-like masses, or again (when there is a tendency to linear extension and straight boundaries) in dykes.

Corresponding in a general sense with the two kinds of habit just discriminated, there are two contrasted types of junction between the plutonic rock and contiguous rocks. The first type is usually gently inclined or quasi-horizontal, the igneous rock underlying or overlying that with which it is in contact at a low angle, and, if the latter be a bedded rock, cutting across it only gradually and obliquely or preserving a general parallelism with it. The second type of junction is usually approximately vertical and always clearly transgressive, the igneous rock cutting sharply across its neighbour, and, if the latter be a bedded rock, truncating the beds abruptly. Among minor intrusions of hypabyssal and volcanic rocks the sheet-like habit is almost always associated very regularly with the quasi-conformable type of junction and the plug-like and dyke forms with the transgressive junction, but in the case of the plutonic masses this correspondence is less complete. It may happen that a large body of gabbro or granite which from its general behaviour is clearly to be referred to the first mode of occurrence exhibits for some distance along its border a junction of the second type, while the converse case is also to be noted, though less frequently. In this way arise the irregularities which disguise in some degree the true nature of these large intrusive masses, and especially of those having a general sheet-like or laccolitic shape; and it follows that the true form and relations of such masses are to be made out, not from the examination of single sections, but from the boundary as laid down on a contoured map. It should be remarked, moreover, that we may have intrusive bodies of plutonic rock of the two different habits in direct continuity with one another, and such seems to be the case at more than one place in the district. The relation here indicated is doubtless that which among minor intrusions is often shown to subsist between a sill and the dyke which represents its feeder.

Certain other characteristic features seem to belong to the two modes of occurrence of the plutonic rocks, respectively, or, *again,* to the two different types of junction; and although these distinctions are more marked with the granites than with the gabbros, they may be briefly mentioned in this place. Along a junction of the gently inclined type the plutonic rock is frequently found to assume a finer texture and to develope porphyritic or spherulitic structure or some other modification, and at the same time there may be very little metamorphism produced in the adjacent rocks. Along a junction of the transgressive type, on the other hand, there is rarely any modification of the plutonic rock of a kind indicative of rapid cooling, while the metamorphism of the adjacent rocks may be very intense. In the latter case too the plutonic rock often encloses material derived from its bounding wall, and may even be considerably altered in bulk composition from this cause; a phenomenon not usually observable at the borders of sheet-like or laccolitic intrusions. To this rule there are, however, important exceptions.

The two contrasted modes of occurrence of plutonic rocks are well exemplified by the two principal gabbro masses of Skye, respectively. The large mass which builds *the Cuillins and Blaven,* considered as a whole (*i.e.* disregarding for the present its highly complex constitution), is of the nature of a *great sheet or laccolite.* and its junction with adjacent older rocks is in most places a gently inclined one. The laccolitic nature of the mass was recognised many years ago by J. D. Forbes in a paper which deserves to be better known. Writing in 1846, he points out that the gabbro clearly overlies the basaltic lavas in visible sections, and remarks in conclusion. "The whole phenomena of junctions and superpositions… . leads us to consider the hypersthene [gabbro] as a *vast bed,* thinning out both ways, and inclined at a moderate angle

towards the S.E., or parallel to Loch Coruisk"<ref>*Edin. New Phil. Mag.,* vol. xl., p. 86: 1846.</ref>

The detailed mapping of the ground entirely confirms Forbes' statements, but the inclination of the base of the laccolite is only roughly expressed in the words quoted. As we follow round the outer boundary of the gabbro, we find that the dip is almost always inward, towards the mountains. To this rule there are, however, exceptions, the inclination in some places being nearly parallel to the boundary, but never outward. The altitude of the base of the laccolite varies from about 2500 feet above the sea to below sea-level. By taking points along the boundary corresponding with certain heights above sea-level (say at intervals of 500 feet), and drawing lines in the direction of local strike of the gabbro base, we obtain portions of contour-lines on the lower surface of the laccolite. These lines may be prolonged and connected up conjecturally, taking account of the obvious condition that neither inside nor outside the gabbro area must they cross the corresponding contour-lines of the surface of the ground. The large and deep interior valleys make this a much more determinate problem than might be expected, and the result given in the accompanying sketch-map (Figure 15) must represent the general shape of the lower surface of the gabbro with a rough accuracy quite sufficient for our purpose.

It will be seen that a sharp anticline occurs at the northern or north-western border, about Bruach na Frithe, and to the southwest of the axis of this a broad shallow syncline. The north-eastern part of the area is occupied by a very marked anticline corresponding with the later intrusion of granite, and the axis of this is prolonged in a S.S.W. direction to Sgùrr na Stri, overlooking Loch Scavaig. Between this anticline and the other one lies a syncline coinciding with the valley of the Sligachan River; while the south-eastern and almost detached portion of the gabbro, which builds the Blaven range, has also a sharply synclinal arrangement. There is a very evident relation between the form of the laccolite as thus roughly defined and the present surface-relief of the ground, and this will be referred to more fully below (Chap 26). One point very clearly illustrated by the sketch-map is that over considerable stretches in the interior the base of the gabbro must be at no great distance beneath the surface. This is true not only of low-lying portions of the surface such as Glen Sligachan and Harta Corrie, Coruisk, and the lower part of the Camasunary valley, but also for the more elevated Druim an Eidhne and Coire Riabhach and for portions of the northern mountains. Although only partially true, as Forbes believed, of the western range, it is true of the northern Cuillins and of the Blaven ridge, that much of their elevation is due not to the thickness of the gabbro but to the underlying rocks.

Although the shape of the base of the laccolite is in the main original and connected with the circumstances of the intrusion, some features of it must be ascribed to subsequent deformation. This is notably the case with what we have styled the Marsco anticline, which seems to be related to the intrusion of the granite beneath.

Concerning the shape and position of the top of the great laccolite the data directly observable are very scanty, the overlying rocks having escaped the effects of erosion only in a few small patches, if at all. The highest rocks in the Cuillins, forming the summits of the peaks known to climbers as Sgùrr Alaisdair, Sgùrr Tearlach, and Sgùrr Mhic Choinnich, to the east of Coire Labain, are not gabbro but basaltic lavas with some breccias. They are highly metamorphosed, and penetrated by tongues from the underlying gabbro. These rocks may possibly be only a patch of the volcanic group caught in the gabbro, like others at lower altitudes; but from their position and extent it seems very probable that they mark approximately the original summit of the gabbro mass. If so, the thickness of the laccolite in this place would be not far short of 3000 feet, and in the centre might perhaps be as much as 3500 feet, or about one-tenth of the probable average diameter. This kind of proportion is not unlike that observed in laccolitic intrusions in other parts of the world. The classical examples in the Henry Mountains of Utah have on the average a maximum thickness one-seventh of the diameter, and for more basic rocks, consolidated doubtless from a less viscous magma, a lower ratio is to be expected. Such a laccolite, indeed, may with equal propriety be regarded as a thick sheet tapering to the edge. From this point of view it is reasonable to suppose that the vanished upper surface corresponded in general form with the lower surface, the shape of which we have examined; and this would be the case whether the form is due to irregularity of intrusion or to subsequent disturbance.

The base of the gabbro does not correspond with a defined geological horizon. Approximately, however, the great laccolite occurs not far from the base of the volcanic series. This is true at least on the southern and eastern sides, where the thickness of basaltic lavas below is never great, and in one place the gabbro rests on Jurassic strata. Again, the agglomerate along which the gabbro is intruded at Loch na Creitheach and Druim an Eidhne is probably, like that of Coire Coinnich and Belig, at the very base of the volcanic rocks. On the western and north-western sides the gabbro is at

a somewhat higher horizon, though here. too, the thickness of basalt beneath need not be very great.

We have hitherto treated the gabbro laccolite as a single body of rock; but this is far from representing adequately its actual constitution. What we have styled for convenience of reference the gabbro mountains consist in fact of a great complexity of basic igneous rocks, of which gabbro is the most prevalent. A glance at the geological map shows that there are entangled and enveloped in the gabbro a great number of patches of older rocks, viz. basic lavas and agglomerates; and further that the gabbro and the patches enclosed in it are alike traversed by innumerable dykes and sheets of later rocks, also of basic composition, But the complexity now specially referred to is of a different kind, arising from the heterogeneous constitution of the gabbro itself, which consists of very *many separate intrusions,* often of different petrographical varieties. This composite structure is not indicated on the map, the small size of many of the component masses and their intricate relations to one another rendering this impossible. In very many parts of the mountains different types of gabbros, coarse and fine, granular and diabasic, paler and darker, are seen to succeed one another or alternate, the nature of their junctions often being such as to demonstrate that they represent distinct intrusions. As a rule they are associated together with some approach to a parallel disposition in stratiform masses or sheets; but this regularity often breaks down, and the various masses are seen to undulate, to wedge out or fringe out, or to intersect one another obliquely. In other cases it is not possible to distinguish separate masses from variations, which undoubtedly occur, in individual masses. It is to be supposed that successive intrusions often took place through the same fissures, and further that intrusions from different fissures invaded and interlaced with one another. It is not difficult to understand how, in such conditions, the tendency to form rough sheets parallel with the general extension of the whole complex would be modified by many circumstances tending to introduce irregularities. The several intrusions clearly differed much in bulk. Some, especially the typical coarse gabbros in the interior of the area, are found to extend for many hundreds of feet across their strike while others, usually of more aberrant varieties, are only a few feet thick.

The numerous *patches of basaltic lavas and agglomerates, mostly of lenticular form, enclosed* in the compound laceolite are in general not enveloped by individual gabbro intrusions, but caught between distinct intrusions. In accordance with this they have almost always an inclination more or less inward, *i.e.* towards the interior of the gabbro area, corresponding with the general structure of the composite laccolite itself. In some places not far from the boundary of the gabbro on the map occur patches of the volcanic rocks which were probably not wholly surrounded by gabbro, but have become isolated as the result of erosion. The gabbro mass fringing out into a number of sheets has intercepted wedge-like portions of the lavas, which, prior to the denudation of the district, were continuous with the main body beyond. This is especially the case on Gars-bheinn, as illustrated by the section (Figure 16), and on the north ridge of Bruach na Frithe and its vicinity. It is in accordance with the general stratiform arrangement of the gabbro mass, as a whole and in its component elements, that it sometimes passes at the edge into sheets, but never gives off dykes. These sheet-like apophyses, however, are not a very general feature, and never extend for any great distance. It is especially noticeable that the base of the laccolite is usually an unbroken surface. The map shows that the outcrop of the base is, round the greater part of the circumference, a continuous line. The only important exceptions to this, on a large scale, are seen above the upper part of Glen Brittle and on and about the northern ridge of Bruach na Frithe.

The gabbro laccolite, being formed by numerous distinct intrusions, is therefore not all exactly of one age, and it is of interest to inquire whether any law is apparent in the sequence of its component parts. Did successive intrusions spread out beneath those already injected, as at a later time the granite magma forced its way under a part of the whole gabbro laccolite ? Or was the composite laccolite built up from below upward, the newer portions breaking through the older and spreading above them? These two alternatives are, of course, not exhaustive: we might conceive, for instance, that the highest and lowest portions represent the first intrusions, later ones having forced their way between and among the earlier. We have not been able to arrive at any conclusion on this point from actual observations demonstrating the priority of one component sheet to another, but other considerations may perhaps afford some clue. It is noteworthy that the gabbro magma has effected much more serious inroads upon the upper than upon the lower surface of the large pre-existing laccolite of peridotite. The only apparent explanation of this is that the peridotite was still at a high temperature when the overlying gabbro was intruded, but had cooled before the intrusion of the underlying. This would indicate that here the upper portion of the gabbro is older than the lower portion. If such be the general rule, it removes a difficulty which is otherwise pressing, viz. the fact that the conduits by which the higher portions of the gabbro mass were supplied are rarely to be detected.

The gabbro of the Cuillins and the Blaven range is not only complex as consisting of many distinct intrusions; the rocks of these individual intrusions themselves are often not of uniform characters. In many localities *patches and streaks* are seen, which differ mineralogically or in texture from the surrounding rock, but are not distinctly separable from it. They are not to be confused with the inclusion of actual xenoliths of one type in a matrix of another type, but are clearly referable either to segregation in place or to the magma being heterogeneous at the time of its intrusion. Only occasionally is there any great petrographical difference between the patches or streaks and the general body of the rock: in some cases the former are unusually rich in augite or in iron-ores.<ref>Probably of this nature was the lump of magnetite found loose by Heddle on Druim nan Ramh. "It consisted of interlocked crystals, about the size of peas, and might have weighed forty pounds or more". *Trans. Roy. Soc. Edin.,* vol. xxx., p. 453: 1882.</ref>

Usually the patches are more or less drawn out into narrow lenticles or bands, with a general parallelism at any given spot, and this may be carried so far that a very conspicuous *banded or ribboned structure* results. Banded gabbros are intercalcated among and between rocks of the more normal massive kind, or in places occupy alone considerable stretches of ground. They are especially well developed round Loch Coruisk and from there north-eastward to Druim an Eidhne (Figure 17), and it is in the latter place that the most remarkable exhibition of banding in the gabbros is found. The rocks here have been described by Sir A. Geikie and Mr Teall,<ref>Quart. *Journ. Geol. Soc.,* vol. 1., pp. 645–659, Pl. XXVI -XXVIII: 1894. See also Plate XIII. in the same volume.</ref> and their appearance in the field is well shown in the accompanying (Plate 5). and (Plate 6).

It appears from the small sketch-map appended that, disregarding a few local irregularities, the inclination of the banding follows a general law, the structure dipping inwards towards the interior of the gabbro area. More accurately, it dips towards a point situated somewhat to the north-east of the centre and where a portion of the gabbro laccolite is wanting owing to the subsequent invasion of granite. The angle of dip is usually between 30° and 70°.

The significance of the banded structure will be more properly discussed in connection with the petrographical characteristics of the banded rocks. It may be remarked here, however, that the phenomenon is doubtless, as Sir A. Geikie and Mr Teall have indeed proved, of the nature of an original flow-structure, and has a special interest with reference to the origin of some banded gneisses of much greater geological antiquity. The bands have thus a general parallelism with the upper and lower surfaces of the individual sheets of gabbro which exhibit the structure; but it does not follow, and it is evidently not the fact, that the banding is parallel to the lower surface of the complex laccolite as a whole. This appears from a consideration of the dips as recorded, and is very clear in what may be regarded as the typical locality, viz. the strip of gabbro on the border of the area at Druim an Eidhne (Figure 18).

The bands, though usually straight and preserving a common direction in any given exposure, are seen in places to be winding or puckered (Plate 6), and the finer seams are sometimes bent sharply upon themselves at an acute angle.

An interesting question refers to the *channels by which the gabbro magma ascended* before spreading laterally in the form of sheets. Analogy would lead us to expect that the molten material rose through more or less vertical fissures, which, filled by the latest uprising magma consolidating in them, are to be looked for in the form of dykes. That this was the case we have abundant evidence. The exposures of the base of the laccolitic mass belong in most places to its peripheral parts; but the north-eastern portion of the laccolite has been removed, partly by erosion, partly by the destructive agency of the granitic intrusion, and here we are able to obtain a glimpse of the mechanism by which the uprise of the gabbro magma was effected. On Druim an Eidhne a number of irregular dyke-like intrusions of gabbro are seen intersecting the volcanic agglomerate which there underlies the laccolite, and some of them are visibly continuous with the latter. The fissures which they fill are not straight nor of a uniform width: they suggest rather that the rocks on which the laccolite rests in its central part were at the time of the intrusion broken by a plexus of irregular curved and branching crevices, through which the successive bursts of molten magma ascended. Another place where a series of curving and in places bifurcating dykes can be traced is along a line from Glen Sligachan to the head of Coire na Seilg, passing over Marsco. This case has a peculiar interest, since the dyke-like strips of gabbro are enclosed in, and partially destroyed by, the granite: their remarkable features will be described in Chapter 11.

If the higher sheets of the gabbro laccolite were in any case intruded after the lower, their fissures of supply must have intersected these, and we should expect to find gabbro dykes cutting the gabbro mass itself. Not many instances of this

have been detected. One such dyke runs along the western slope of Bruach na Frithe, where it may be followed by its dark colour contrasting with the somewhat paler rocks which it intersects. Two large dykes are conspicuous objects on the western slope of Gars-bheinn as seen from Coire nan Laogh. There they traverse one of the large enclosed patches of volcanic rocks, and their actual connection, if any, with the overlying gabbro is concealed by screes. In the tract immediately bordering the gabbro of the mountains gabbro dykes are seen in several places. Near the termination of the Blaven range, to the east and south of Loch na Creitheach, they are visibly continuous with the main body of gabbro.<ref>The relation is further emphasised in one case by both the dyke and the contiguous portion of the laccolite enclosing quartz-pebbles, probably picked up by the dyke from a conglomerate a little lower down.</ref> Some of these have the irregular branching form of the Druim an Eidhne dykes, but others run in straight lines for a certain distance, with the N.W.–S.E. direction common to most of the dykes of the district, both earlier and later than the gabbro. It will be pointed out in a subsequent chapter that there are in Skye certain dykes of coarse diabase often indistinguishable from gabbro in the field, but belonging to an epoch long posterior. Where a dyke of gabbro-like aspect is not in visible continuity with the gabbro laccolite there may thus exist a doubt, only to be solved by more minute study of the rock. The dyke which crosses the Blath-bheinn ridge itself in this neighbourhood, at about 1100 feet altitude, is, on petrographical grounds, to be referred to the later set, and the same is perhaps true of other large dykes on An Stac and Slat-bheinn. Those, however, which are seen, to the number of five or six, on the coast south of Sgùrr na Stri, though they have not been examined microscopically, we place here, for at least one of them can be traced up into continuity with the great gabbro mass.

The few actual exposures of dykes continuous with the overlying gabbro mass may be taken to indicate that the fissures of supply are for the most part concealed beneath the interior portion of the laccolite, and the general inward dip of the component sheets of the laccolite is in harmony with this supposition. In one place at least in the interior of the area the connection of a sheet of gabbro with its dyke of supply is clearly visible. This is at Eas Mòr, on Allt Coire na Banachdich, the most considerable water-fall in this part of Skye. The ordinary coarse gabbro is here in a very decayed state; but in it occurs a sheet of finer gabbro (S8729) [NG 420 214] in a much sounder condition, and this, by its superior durability, has determined the fall. The sheet is of lenticular form, and probably does not extend far, though the thick cover of drift prevents the accurate tracing of it. For some distance it forms the upper part of the walls of the gorge below Eas Mòr (*see* (Figure 19), the coarse gabbro appearing beneath it. Nearly a hundred yards below the fall a broad dyke of fine-grained gabbro crosses the burn in a N.N.E. direction, intersecting the coarse gabbro, and this dyke is in visible continuity with the sheet above.

It remains to make a few remarks concerning the *nature of the junctions* between the gabbro of the great laccolite and the older rocks among which it was intruded. Excepting for a short distance to the south-east of Blath-bheinn, where it invades the Lias, and excepting also its junction with the granite, to be described in connection with the latter rock, the gabbro is everywhere in contact with members of the volcanic series. In these rocks it has produced metamorphism more or less intense, the phenomena of which have already been described. It should be remarked, however, that the effects are not everywhere equally extended, nor have they always attained the same degree at equal short distances from the gabbro. Perhaps one reason for this is connected with the fact that the gabbro mass, especially in its lower portion, is built up of successive sheet-like intrusions. If we may suppose that in some places a newer intrusion forced its way between an earlier one and the underlying rock, already metamorphosed, the latter would presumably be raised to a higher temperature, and might be so maintained for a prolonged time, and the effects might be expected to be correspondingly more pronounced.

The junction with the volcanic agglomerate is in general a clean-cut line. In some places, however, and especially in the case of some of the enclosed patches of that rock, the precise boundary is more difficult to draw. There is then room for a suspicion that the finely divided matrix of the agglomerate has been to some slight extent absorbed and incorporated in the gabbro magma. In such places there are often xenoliths of a somewhat different kind of gabbro enclosed in the prevalent type, which may perhaps represent fragments in the agglomerate set free in this fashion.

The junction with the basaltic lavas has a rather different character. If it departs, as it occasionally does, from the simple type of contact, it is usually by the gabbro sending small veins into the immediately adjacent basalt. These veins may be numerous and minute. This, however, is apparently not so common a feature with the gabbro as with the granite. It is seen in a few places in the Cuillins, and is well exhibited at the boundaries of the irregular sheet of gabbro which forms

the conspicuous buttresses at the north end of Beinn na Cro.

There are places where the relations between the basaltic lavas and the gabbro are of a more remarkable character, and there is little doubt that the former rocks have been to a limited extent actually fused and incorporated in the gabbro-magma. This is found at numerous localities on the western and south-western slopes of the Cuillins: *e.g.* in parts of Coire na Banachdich<ref>The pitted surface of these peculiar rocks when slightly weathered has probably given this corrie its name, signifying small-pox</ref> and Coire Labain and on the flanks of Sgùrr nan Eag and Gars-bheinn. An easily accessible place for study is a flat knoll in the lower part of Coire Labain, about 580 yards E.S.E. of Loch an Fhir-bhallaich.<ref>Following the usual track from Glen Brittle House, a conspicuous erratic of Matterhorn shape is seen close on the left: the knoll mentioned is then immediately on the right.</ref> The phenomena are found only in connection with patches of lava actually enveloped in the gabbro mass or caught between sheet-like prolongations of it. They are rarely observable in other parts of the Cuillins, *e.g.* at one or two spots on Druim nan Ramh. The eye is caught at once by conspicuous amygdules, comparable with those seen in the metamorphosed lavas, but here occurring in what has otherwise the appearance of a normal gabbro. Sometimes the amygdules stand out prominently, and are found to be of quartz, perhaps with a black border of hornblende; sometimes we see the dead white colour of felspar, representing metamorphosed zeolites. Where the amygdules have been formed in the main of more perishable minerals, they have weathered into little cavities, and impart a curiously pitted appearance to a surface on which they are numerous.

Thin slices confirm the statement that the enclosing rock has the character of an ordinary gabbro. They also make it certain that the amygdules are enclosed foreign bodies, not patches of secondary minerals occupying druses in the gabbro. Their shape is always rounded, and in the smaller amygdules spherical. The quartz, probably derived from chalcedony, has clearly crystallised under metamorphic influence, for it is penetrated by fine needles of actinolite, and encloses imperfect crystals of light-green actinolitic (fibrous) hornblende and sometimes crystal-grains of yellow epidote (S8700) [NG 456 191], (S8701) [NG 440 205]. Other amygdules consist of an aggregate of felspar precisely like that described in the metamorphosed amygdaloidal basalts. As a rule the amygdules are immediately surrounded by the gabbro matrix, the basalt to which they belonged having wholly disappeared; but this is not always the case. Thus an amygdule may be invested by a relatively fine-textured rock, which must be regarded as a metamorphosed basalt, the little felspars bordering the amygdule being set tangentially to it in the customary fashion: as seen in the slice, this basalt gives place rapidly, though not at a perfectly defined line, to the enveloping gabbro (S8699) [NG 462 185]. Here we have enclosed in the gabbro a small relic of basaltic lava, which itself encloses an amygdule.

Two alternative explanations are not inconsistent with the facts as so far stated. We might suppose that the amygdaloidal gabbro represents the extreme phase of metamorphism of amygdaloidal basalt, all the original characters of the rock except the amygdules having been obliterated; or, on the other hand, that the basalt has actually passed into a state of fusion and mingled with the gabbro magma, only the amygdules surviving. Further consideration, however, makes the former hypothesis scarcely tenable. The gabbro presents features (*e.g.* in some cases schiller-structures in the augite) which are highly distinctive of true plutonic rocks, and are not to be expected in any product of thermal metamorphism. Even more convincing is the fact that similar amygdules are locally found in the ultrabasic rocks already described, and present the same indications of a foreign origin. Since no metamorphism could convert a basaltic lava into a picrite or peridotite, it is clear that in that case at least the lava, with the exception of its amygdules, must have been fused, and moreover must have become sufficiently fluid to diffuse through the ultrabasic magma, mingling freely with it.

We conclude then that the amygdules in the gabbro are of the nature of xenoliths, set free from their original matrix by the complete fusion of the latter. There is no evidence that the process has operated on any extensive scale. The amygdaloidal gabbros occur in small patches or along bands rarely as much as 100 yards wide, and usually much less, always in the immediate neigbourhood of metamorphosed lavas. In strictness the zone of fusion must be supposed to stop at a definite line; but in actual mapping it is not always easy to divide sharply the amygdule-bearing gabbro from a highly-metamorphosed amygdaloidal basalt.

The relations of the gabbro to the large peridotite laccolite which it envelopes have been described in the preceding chapter. Not only does the later rock penetrate the earlier in the form of an intricate system of dykes and veins extending for some distance from the boundary; but about Allt a' Chaoich and Meall na Cuilce and down to the shores of Lochs Coruisk and Scavaig the gabbro encloses abundant blocks and fragments of picrite and other rocks belonging to the

ultrabasic group. It is to be remarked that these enclosed fragments are of fairly angular shape, and there is little or no indication of the gabbro magma having absorbed material from the debris which it took up. Further, there is little clear indication of thermal metamorphism (at least as regards new minerals) in the enclosed blocks and fragments. The difference in these respects between the ultrabasic rocks and the basaltic lavas can only be attributed to the different petrographical natures of the two groups of rocks.

Turning now to the second considerable mass of gabbro in Skye, that exposed to the *north-rest of Broadford,* we find that it offers in every respect a remarkable contrast to the larger mass of the mountain tract, its form and habit being those of a *boss.* It occupies most of the ground to the north-east of the Beinn na Caillich granite as far as the high-road, where it and the rocks with which it is associated are cut off by a fault bringing on the Lias. It is intruded chiefly into the Cambrian Limestones (Balnakiel group); but this statement does not adequately express what is seen on the ground, for, excepting an area of about 1400 by 500 yards, much invaded by gabbro, the limestone is seen only in the form of small detached portions enclosed in the igneous rock (Figure 20). There are about fifty of these enclosed patches, varying in dimensions from 300 to 20 yards, besides others, down to 10 feet or less in diameter, which are too small to be mapped. In ground-plan they always present convex outlines to the gabbro, and the smallest ones are circular. The larger are of irregular outline, with sharp indentations occupied by processes of the gabbro; and where these latter completely intersect the limestone, we have two or more ovoid patches lying close together, representing the relics of one larger patch. They are easily recognised, even where no rock is visible, by a depression due to the more rapid weathering of the limestone, and by the bright green growth of bracken contrasting with the peaty or heather-clad surface of the gabbro. The junction of the two rocks is often well exhibited, and is found to be *everywhere a vertical one,* the gabbro standing up as a perpendicular wall a few feet higher than the surface of the limestone. This is true all along the sinuous outline of the larger limestone patches, and it is true of patches only a few yards in diameter.

The gabbro has cut sharply across the limestone, the latter being cut out as if it had been annihilated, saving that columnar portions of it have been left standing surrounded by the igneous rock. It is not possible to explain the phenomena by supposing that the enclosed patches of limestone seen are resting upon gabbro below, and there is no evidence that they have been disturbed by the intrusion. It is true that they show dips in various directions and sometimes at high angles, but this seems to be due to folding of a much earlier date, connected with the over-thrusting of the Torridon Sandstone. Similar dips are observed in the larger and more independent area of limestone mentioned above, the strata there being greatly disturbed and in places vertical, while outliers of Torridon Sandstone rest almost horizontally upon them. Along the exposed western boundary of this area, too, the limestone does not dip away from the gabbro, but towards it at high angles. It is curious to notice that the gabbro shows no tendency to force its way along the thrust-plane, though the later intrusion of granite has often done so.

It can scarcely be doubted that this remarkable behaviour of the gabbro, so totally at variance with what is seen in the Cuillins, is in some measure due to the fact that the country-rock here is a limestone. The circumstantial evidence for this hypothesis is at least very strong. All intrusive rocks in the district, whether basic or acid, which occur in limestones, have a strong tendency to assume the forms of bosses, plugs, or dykes, with vertical walls; arid the larger bodies exhibit curiously irregular and sinuous outlines in ground-plan. Intrusions which have been running as more or less regular sills or sheets in other "country" rocks, break abruptly across and lose all regularity as soon as they enter limestones. We shall have to revert to this matter in connection with the granites and minor intrusions of the district. At present it will suffice to note as a significant fact that this gabbro boss, at its north-western end, on Creag Strollamus, where it enters the Torridon Sandstone and basaltic lavas, at once takes the form of a sheet.

The mechanism of such an intrusion as the Broadford gabbro boss presents a physical problem of considerable difficulty. Where gabbro now appears on the map was once limestone, and this limestone has vanished as completely as if it had been annihilated. It can only have been removed either in blocks and fragments or in solution in the gabbro magma, and neither of these hypotheses, nor a combination of them, is easily applied. We may perhaps conceive the gabbro magma as forcing its way along joint-fissures of the limestone, detaching blocks and loose fragments of that rock, and floating them upwards; but, in view of the probably small difference in specific gravity between the limestone and the fluid magma, it is difficult to account on this supposition for the entire absence of detached pieces of limestone in the gabbro as now exposed. It is also necessary to assume that the intrusion has been prolonged upward with the same boss-like form through the once-overlying Torridon Sandstone, Cambrian quartzites, etc., an assumption not in itself probable.

Even if the chief bulk of the limestone can have been carried away in fragments, as suggested, the smooth rounded form of the junctions compels us apparently to admit a certain amount of solvent action. Any noteworthy amount of solution and absorption of this dolomitic limestone by the basic magma would betray itself in the chemical composition of the gabbro by an unusually high percentage of lime and magnesia, and such data as we have on this point do not afford any support to the supposition. The following figures are taken from analyses given in full below:

	silica	Lime
Gabbro of Cuillins (I)	46.39	15.29
Gabbro of Cuillins (II)	47.28	13.42
Gabbro of Cuillins (III)	48.12	15.43
Gabbro of Broadford boss (IV)	50.78	10.28
Offshoot of the same, traversing limestone (V)	47.18	11:59

It appears from these figures that the Broadford gabbros are not richer, but actually poorer, in lime than those of the Cuillins, intruded among basaltic lavas. This must of course be ascribed to different composition of the magma as intruded; but it is evident that in no case can any important absorption of lime be postulated. The figures in the last line refer to a dyke-like apophysis of the boss, cutting through the limestone, and they show it to be poorer in silica and rather richer in lime than the main body. This, however, if the two are really parts of one intrusion, only increases the difficulty; for it proves that any dissolved lime was not freely diffused through the magma, and free diffusion is essential to any explanation of the facts on the lines suggested. We are compelled, therefore, to leave the question unsolved.

Although the boundary of the gabbro boss is a highly sinuous one in ground-plan, and processes which might be called short dykes extend out from the main body, the junction is on the small scale a regular and clean-cut one. The gabbro does not send out veins into the limestone. The latter rock is highly metamorphosed, and is in the condition of a crystalline marble often carrying various silicates, etc. The metamorphism is quite of the same kind and degree as that produced by the Beinn an Dubhaich granite, two or three miles farther south, and we shall defer any detailed account of it until the latter is discussed (Chapter 9).

Where the gabbro is in contact with Torridon Sandstone, on Creag Strollamus, the junction is of a different type. The intrusive mass has here a more irregular boundary, in the sense of sending out small veins into the neighbouring rock. In places these veins are numerous, minute, and ramifying; and the sandstone, for a few inches from the general line of junction, has been injected or impregnated with the gabbro magma, which has even insinuated itself in narrower threads between the grains of the elastic rock.

The gabbro boss of Broadford differs from the great laccolite of the Cuillins not only in general shape but in detailed structure. We are not able to assert that it represents a single effort of intrusion, but it certainly shows no clear indication of the complex constitution of the laccolitic mass, and exhibits much less range of petrographical diversity, while the banded, xenolithic, and other special structures are not met with.

The several *smaller masses of gabbro* in Skye do not call for particular notice. Both the stratiform and the boss-like modes of occurrence are represented among them. A small patch on the north-western spur of Belig is merely an outlier of the main laccolite, and the same is probably true for a patch on the main ridge of Marsco. The gabbro which runs with sheet-like habit along the west ridge of Beinn na Cro, and forms conspicuous buttresses at the northern end of the hill, may not impossibly represent the thin edge of the great laccolite, but the granite which has isolated this patch of basalt and gabbro has destroyed the evidence on this point. Some quite small sill-formed intrusions of gabbro on the southern and eastern slopes of the Blaven range, never far from the great laccolite but at lower horizons, belong probably to the same focus of intrusion. One or two other small masses seem to have the boss-like habit, *e.g.* one which breaks through the basaltic lavas on An Stac, about a mile east of Blath-bheinn.

We may mention also that Mr Clough has mapped two small bosses of gabbro in the Moine Schists of Sleat, about ½ mile N.W. of Knock. This is about 9 miles S.S.E. of the Broadford boss. He has also noted two small bosses on the other side of the Sound of Sleat, which aro possibly to be attached to the Skye group. One is a little south of Glenelg Pier and

the other farther south, near Sandaig.

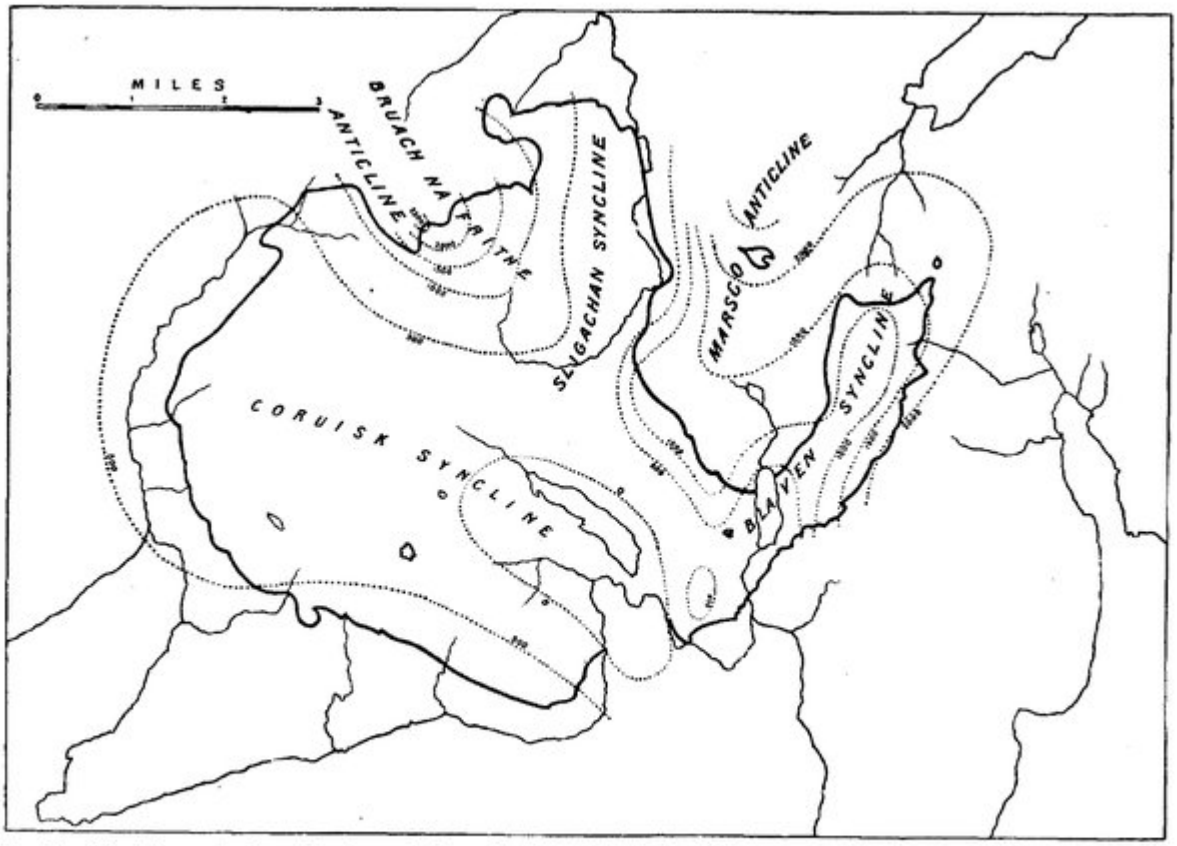


FIG. 15.—Sketch-map to show the shape of the gabbro laccolite of the Cuillins: scale, ½ inch to a mile. The boundary of the laccolite (omitting minor irregularities) is shown by the heavy line; the chief streams and lakes and the coast to the south by lighter lines. The dotted lines are intended to represent approximately the shape of the lower surface of the laccolite, being contour-lines of that surface at intervals of 500 feet, reckoned from sea-level.

(Figure 15) Sketch-map to show the shape of the gabbro laccolite of the Cuillins: scale, ½ inch to a mile. The boundary of the laccolite (omitting minor irregularities) is shown by the heavy line; the chief streams and lakes and the coast to the south by lighter lines. The dotted lines are intended to represent approximately the shape of the lower surface of the laccolite, being contour-lines of that surface at intervals of 500 feet, reckoned from sea-level.

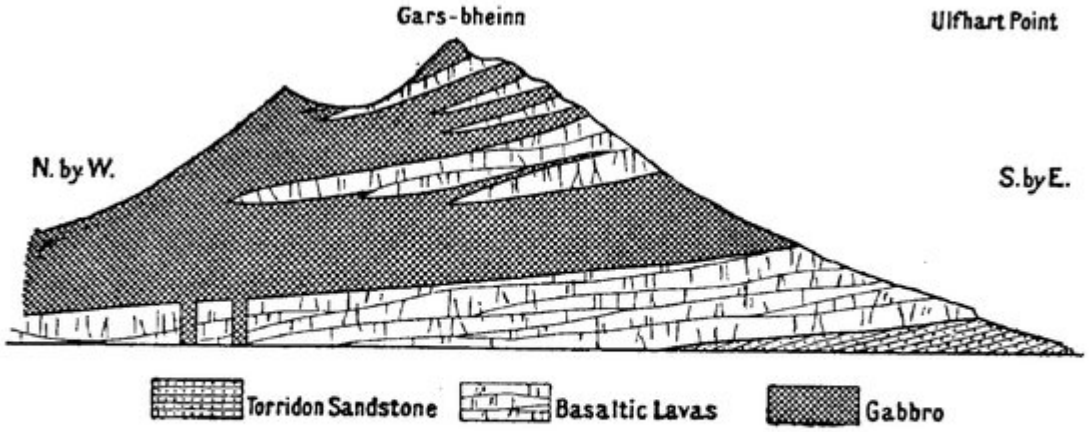


FIG. 16.—Section through Gars-bheinn, to illustrate alternations of basaltic lavas and gabbro, due to the successive intrusions of the latter rock having followed different bedding-planes in the lavas. Scale, 2 inches to a mile.

(Figure 16) Section through Gars-bheinn, to illustrate alternations of basaltic lavas and gabbro, due to the successive intrusions of the latter rock having followed different bedding-planes in the lavas. Scale, 2 inches to a mile.

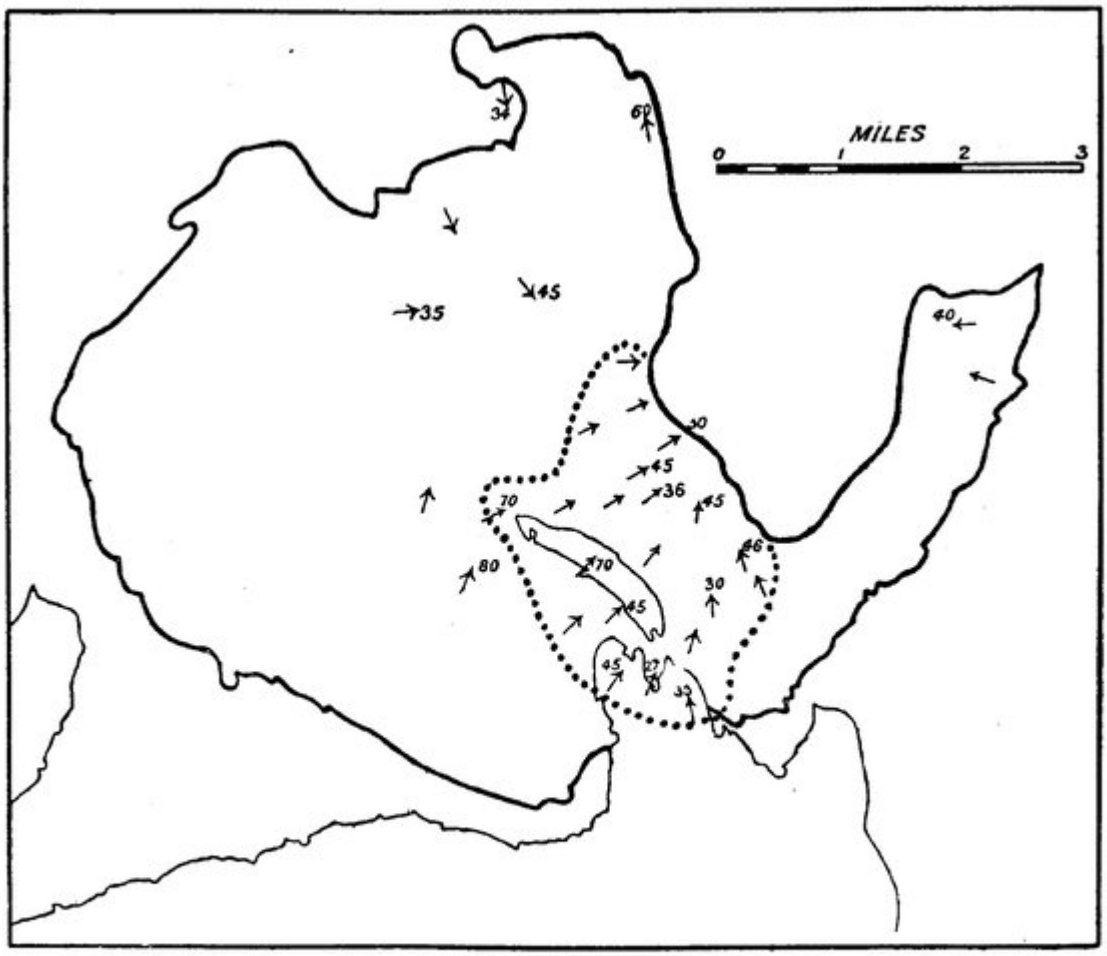


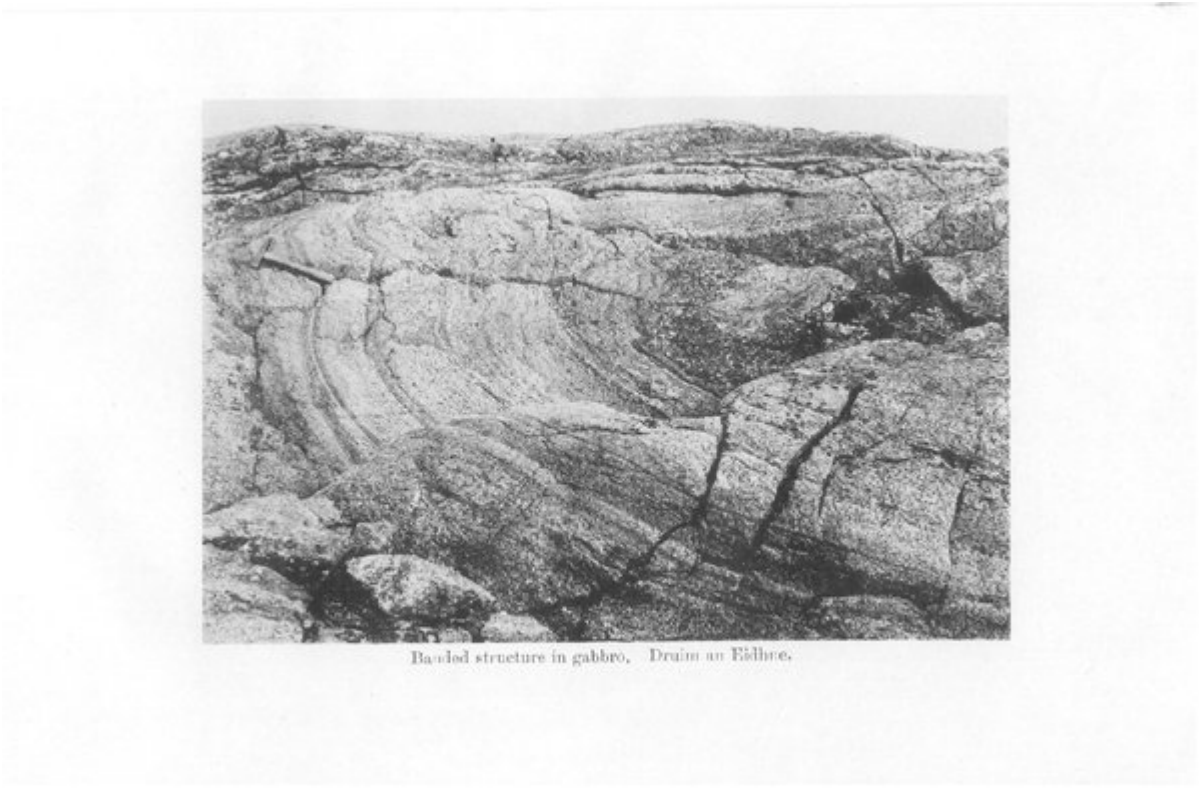
FIG. 17.—Sketch-map showing the distribution of banded structures in the gabbros of the Cuillins. The strong line indicates the boundary of the gabbro itself: the dotted line encloses the area within which banding is most prevalent. The dip of the banding is shown by arrows. Scale, ½ inch to a mile.

(Figure 17) Sketch-map showing the distribution of banded structures in the gabbros of the Cuillins. The strong line indicates the boundary of the gabbro itself: the dotted line encloses the area within which banding is most prevalent. The dip of the banding is shown by arrows. Scale, ½ inch to a mile.

PLATE V.

Strongly banded structure and felspathic veins in gabbro, Druim an Eidhne.

(Plate 5) Strongly banded structure and felspathic veins in gabbro, Druim an Eidhne.



Banded structure in gabbro, Druim an Eidhne.

(Plate 6) Banded structure in gabbro, Druim an Eidhne.

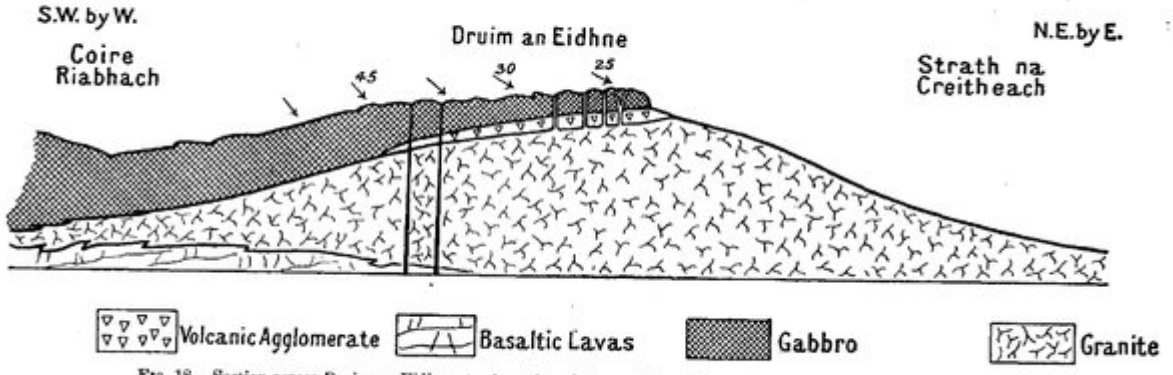


FIG. 18.—Section across Druim an Eidhne, to show the relations of the gabbro and granite: scale, 6 inches to a mile. The arrows mark the inclination of the banding in the gabbro at this place.

(Figure 18) Section across Druim an Eidhne, to show the relations of the gabbro and granite: scale, 6 inches to a mile. The arrows mark the inclination of the banding in the gabbro at this place.

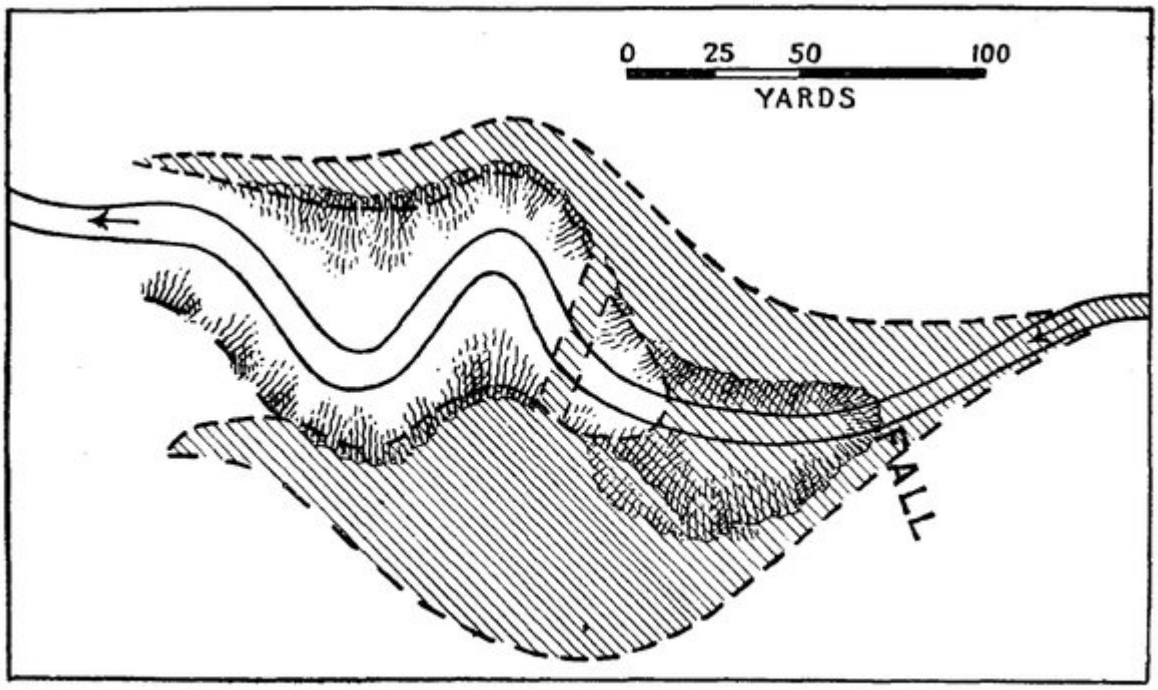


FIG. 19.—Ground-plan of a sheet of fine-grained gabbro and its dyke-feeder, at Eas Mòr, on Allt Coire na Banachdich. Scale, 24 inches to a mile.

(Figure 19) Ground-plan of a sheet of fine-grained gabbro and its dyke-feeder, at Eas Mòr, on Allt Coire na Banachdich. Scale, 24 inches to a mile.

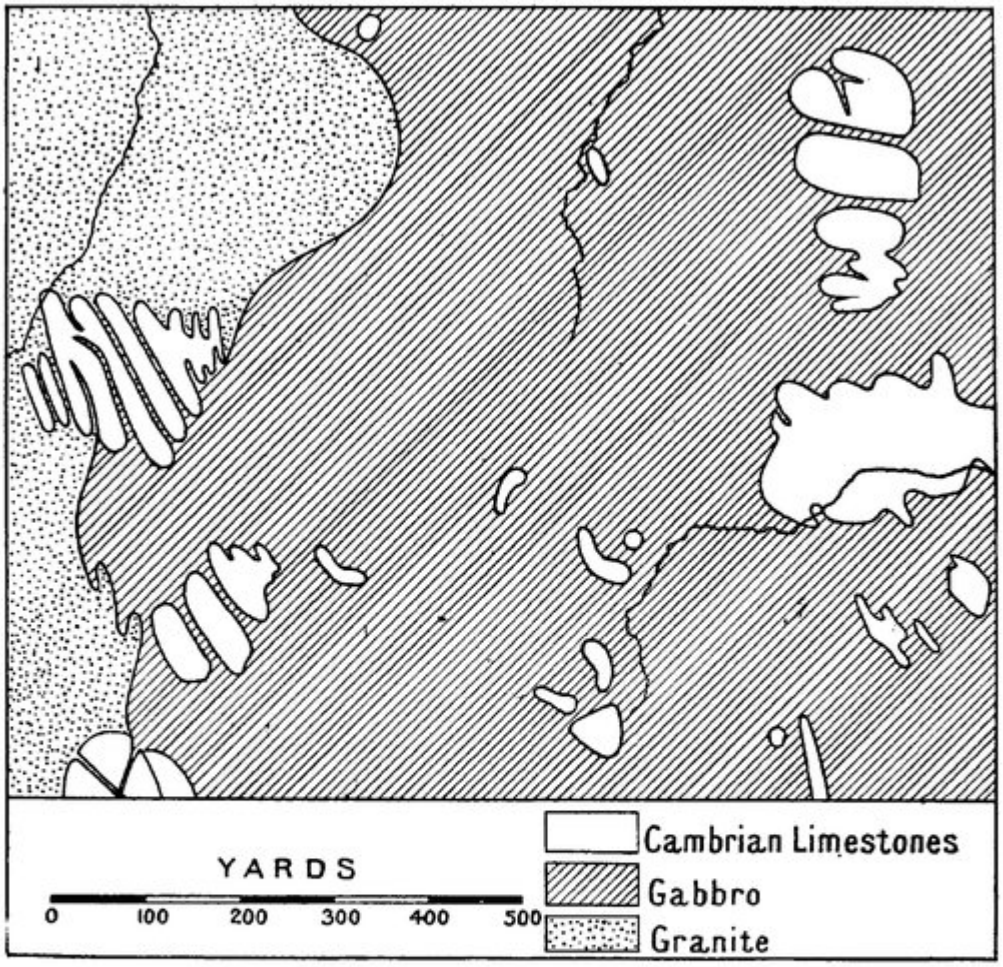


FIG. 20.—Map showing a part of the Broadford gabbro boss and a small part of the Beinn na Caillich granite, with patches of the Cambrian limestones enclosed in the igneous rock-masses.

The area shown lies immediately N.E. of Lochain Beinn na Caillich. For explanation, see text.

(Figure 20) Map showing a part of the Broadford gabbro boss and a small part of the Beinn na Caillich granite, with patches of the Cambrian limestones enclosed in the igneous rock-masses. The area shown lies immediately N.E. of Lochain Beinn na Caillich. For explanation, see text.