Chapter 5 Basalt and mugearite lavas: introduction

Lava succession

With the exception of a few relatively recent rhyolitic flows to be considered in Chapter 15, the lavas of Mull are basalts with a few mugearites. The latter (lettered W on the one-inch Map) are largely confined to a particular horizon, where, though subordinate in bulk, they constitute a distinctive unit within Sir Archibald Geikie's well-known Pale Group of Ben More.

The basalts fall into two main divisions, the one rich in olivine, the other poor. In general, both divisions are lettered B on the one-inch Map, though special types, as will be explained presently, are distinguished as B■ and fB respectively. The olivine-rich basalts are classed together as Plateau Types since they constitute practically the whole of the lava-pile as preserved to us in the peripheral plateau regions of Mull except in the south-west corner of the island mostly included in Sheet 43 beyond the limits of (Plate 3). They also continue into the central mountainous region—and as a matter of fact reach to the summit of Ben More—, but in central Mull they are abundantly associated with olivine-poor varieties for which the designation Central Types has been reserved.

The petrology of the lavas is dealt with in Chapter 10. It is sufficient here to mention that the mugearites are often characterized in the field by their pale weathering and marked fluxion; the Plateau Basalts by their olivine, fresh or decomposed as the case may be, and their non-porphyritic crystalline aspect; the Central Basalts by their porphyritic felspars or—where non-porphyritic—by their extremely compact texture. A minor, but interesting, feature of a few among the Plateau Basalt Lavas is the occurrence of contemporaneous segregation leading: to inconspicuous pegmatitic veins. The phenomenon is widespread, and has received special attention during the mapping of Sheet 43 (Chapter 7, also p. 138).

The distribution of the various types is blocked out in (Plate 3). It was impossible in the time at our disposal to attempt a detailed separation of the Plateau and Central Types, but the boundaries adopted may be regarded as very, fair approximations based upon field-diagnosis and supported by extensive microscopic investigation. The degree of accuracy attained may be gathered from an inspection of the Table on p. 93. Here one sees that 96% of specimens collected from outcrops ornamented as Central in (Plate 3). are of Central Types, while 93% from the Plateau outcrops are of Plateau Types. These figures do not include a particularly strongly marked variety of Central Type separately shown in (Plate 3) as Big-Felspar Basalt (f B of one-inch Map). Several examples of this type have been mapped, and as they all fall distinctly within the Plateau outcrops they serve as a useful index of a definite, though restricted, interdigitation of Central and Plateau Types. Another example of this interdigitation is afforded by the prevalence of a compact, non-porphyritic, olivine-poor basalt, described in the sequel (p. 145) as Staffa Type, among the earlier, often columnar, lavas of south-west Mull (mostly restricted to Sheet 43).

The age-relationships of the various types so far alluded to can be summarized as follows:

The main mugearite-development, that of Ben- More, is quite clearly an episode in the latter half of the Plateau Basalt period.

Where comparison is possible-the big-felspar basalts are in some cases slightly older, in some cases slightly younger, than the Ben More Mugearites (Areas 6, 7, and 8 of Sheet 44, shown in Index to (Plate 3)). All that is definitely certain in Area 5 is that the big-felspar basalts are high up in the Plateau Basalt Group.

The main mass of Central Types succeeds the main mass of Plateau Types. For this statement the distribution of the two types in relation to observed dips and the form of the ground in Areas 6 and 7 ((Plate 3) cf. also (Plate 5)) may be taken as sufficient justification. Equally significant perhaps is the fact that, except in south-west Mull where the Staffa sub-group is developed, one cannot point to direct superposition of Central Types on the Pre-Tertiary platform; in fact, close approach, or contact, of the two occurs only very exceptionally, and is almost certainly a result of faulting.

In Area 2, the Plateau Group has been subdivided by Sir Archibald Geikie into a Dark Group below, and a Pale Group Above. Where this separation has been effected, the basalts of the pale Group are lettered B■ on the one-inch Map. The age-relations of these two subordinate groups is self-evident in the field.

It is appropriate to refer here to the conspicuous columnar jointing which, as hinted at above, characterizes several of the basalt-lavas in the lower part of the Plateau Group of south-west Mull. The feature is almost confined to Sheet 43, where Staffa furnishes a famous illustration. The columnar lavas of Sheet 43 continue some little distance into Area 1 of Sheet 44 and the contiguous portion of Sheet 36, and are there finely exposed in the cliffs west of Carsaig. An isolated occurrence is also known at Bloody Bay, Sheet 52. Most of these, early columnar lavas, though referred to the Plateau Group on the score of geographical and chronological convenience, are petrologically of Central rather than of Plateau Type, and are treated under a special heading in Chapter 10. Several interesting aspects of their wonderful jointing are dealt with more particularly in Chapter 7.

The Plateau Group as a whole must attain a thickness of some 3000 feet in Ben More, but it seems hardly possible that the group much exceeds 1500 feet along the shores of the Sound of Mull (Areas 5 and 9), or in the Croggan Peninsula (Area 6). The variation of thickness just alluded to cannot be established beyond doubt owing to difficulties of estimation; but within the limits of the Plateau Group the same kind of change is strongly suggested by other evidence. Thus it is quite probable that the Ben More and Derry-naculen mugearites are on approximately the same horizon, although at Ben More there are about 800 feet of Plateau Basalts above, while at Derrynaculen, 3 miles south-east of Ben More, there are scarcely any at all. The Derrynaculen development agrees closely with that near Glenbyre on Loch Buie.

The Central Group cannot be accurately measured, but locally it seems to be quite as thick as the Plateau Group at its maximum, while in the Coke Mar Syncline (pp. 98, 121) it fails altogether.

Pneumatolysis and trap-featuring

One of the many interesting features of the Mull lavas is the difference of their condition inside and outside the line drawn on (Plate 3) as the Limit of Pneumatolysis—a difference in keeping with what Dr. Lee has already pointed out in connexion with the Mesozoic and Tertiary sediments (p. 59).

Outside the limit, one notices that the Plateau Types of basalt are apt to weather with rusty red surfaces; some rot spheroidally to soft red loam; while others may develop pustular surfaces, crowded with little rounded eminences left by a wearing away of intervening less resistant matrix. It is an easy matter, too, to secure specimens which show glistening specks of olivine when examined with a lens. Inside the limit, weathering yields sombre grey and brown surfaces, smooth except for veins and amygdales; and fresh olivine is unprocurable. The results of microscopical examination tally with field-observation in this matter: of 336 olivine-basalts sliced from within the Pneumatolysis Limit, not one has retained a vestige of fresh olivine; while, of forty-four specimens examined from outside the limit, thirty-four carry this susceptible mineral more or less intact.

Another important characteristic of the pneumatolytic core of Mull is a widespread development of albite and epidote filling vesicles and cracks. In many parts of the district included within the Pneumatolytic Limit, the lavas have minute cracks running in all directions and now filled with epidotic veins. In such localities the tracery of the veins, upstanding on weathered surfaces, arrests attention; and so too does the resistance to weathering of amygdales which is a common feature of much of the central region of Mull.

Here one may notice a scenic distinction of the pneumatolitic core which happens to be the basis for very divergent interpretations. The lavas occurring within the Pneumatolytic Limit do not show step-, or trap-, featuring nearly so prominently as those outside. The change is not abrupt; for instance, much of Area 9 is strongly terraced. The explanation adopted here is that subsequent folding, shattering, and pneumatolysis (not to mention interruption by intrusions, and the development of contact-aureoles) are quite sufficient to account for the relatively amorphous weathering of central Mull lavas. In a district where individual amygdales and the contents of cracks weather as prominences, it is not surprising to find that vesicular bands weather at approximately the same rate as solid basalt. Dr. Harker, however, attributes the scenic contrast to an absence of more massive basaltic bands in central Mull, which he accounts for by supposing that the massive bands, responsible for scarps in the surrounding trap-country, have been excluded from central Mull by previous contact-alteration of the lavas of that region; and from this he deduces that the massive bands are sills. Dr. Harker happens to have described a part of the Carsaig cliffs in this sense, but his position is mainly based upon his wide experience of other Hebridean occurrences,<ref>Dr. Harker's position is stated by himself in the Geol. Survey Memoirs on Skye and the Small Isles, and The Sgùrr of Eigg; some comments on Mr. Bailey's Paper,' *Geol. Mag.,* 1914, p. 306.</ref> and is correspondingly difficult to criticize. At the same time the detailed examination of Mull has supplied the following data which have carried conviction to those employed on the research:

1. The normal massive bands of the trap-country are, as Sir Archibald Geikie and others have maintained, the central portions of lava-flows because they are usually inseparably associated with slag above and below, without any chilling at the mutual contact.<ref>It is often possible to recognize the line of junction of two lavas, since the top of the underlying lava may be weathered, or there may be some mineralogical difference. In such cases, the slaggy top is generally found to be much thicker than the slaggy base,. for which latter 6 inches is a common measurement. In other cases, it may be impossible, owing to the absence of chilling, to say where the one lava ends and the other begins.</ref> Our experience is that not 1 per cent. of the sheets we interpret as lavas, other than pillow-lavas, shows the smooth, compact, manifestly - chilled bottom almost universally met with among intrusions of comparable size and texture; and that none of them has a smooth, compact, chilled top. Dr. Harker in some measure recognizes this peculiarity, and interprets it as an indication of high temperature affecting the country-rock during the supposed period of sill-intrusion. It is noteworthy, however, that the Early Basic Cone-Sheets of Chapter 21, though commonly coarser in their interior crystallization than any of our lavas, everywhere show chilled margins, Another hypothesis connects the lack of chilling with the conductivity of the country-rock; but the objection, here, is that one can see innumerable transgressive intrusions chilling against the self-same country-rock that fails to chill the bands under discussion.

2. In many parts of Central Mull, for instance on the slopes of Ben More, the same type of interbanding of slag and solid can be detected in the field. In such cases, both slag and solid have suffered pneumatolytic change, and the trap-featuring of the succession is materially reduced. The statement that the interbanding of slag and solid is comparable in the trap and central districts, apart from differences referable to pneumatolysis, is based on field-observation and microscopic study. The massive bands of the trap country *are* represented profusely in Central Mull *in an altered condition.*

It should be added that Dr. Harker, in claiming the massive bands of the trap-islands as sills, emphasizes the fact that they sometimes show transgressive relations. It must be realized, however, that the authors of the present Memoir have also found transgressive sills, locally in great abundance, for instance, in southwest Mull ((Figure 42), p. 258), and have been impressed with their difference from the normal massive bands of the trap-succession. In regard to the latter, it may be mentioned that transgressive relations are sometimes quoted which seem to be of the type ascribed in Chapter 7 to auto-intrusion of a lava into itself. Such auto-intrusion must be a common phenomenon from the very nature of the case.

Having informed the reader of the interesting discussions which have arisen out of the scenic contrast on the two sides of the Pneumatolytic Limit drawn on (Plate 3), we may now pass to another aspect of the question, namely, the date of the pneumatolysis. There can be little doubt that the conditions giving rise to the change appeared and reappeared at widely different epochs, and it is hardly to be imagined that the whole central district was subjected simultaneously to vapour-action. Here it is sufficient to consider two instructive occurrences. Area 9 furnishes good examples of shattered epidotized lavas, which are freely cut by Early Basic Cone-Sheets (bI of one-inch Map) subsequent to the epidotic veins. The sheets are, it is true, altered, and only their most massive representative, that of Beinn Chreagach Mhòr, retains any fresh olivine; but they are not veined (p. 239): On the other hand, Area 10 supplies instances where the Early Basic Cone-Sheets are themselves altered and veined in the most conspicuous manner (p. 236).

The pneumatolysis-area contains several intrusions of plutonic rock, and these are surrounded by recognizable aureoles of contact-alteration (pp. 128, 151). In a number of cases it can be shown that pneumatolysis preceded contact-alteration, and the reverse relation has not yet been proved. The subject has not been fully investigated, but it would be natural to expect that products of contact-alteration, owing to their compact texture, should be relatively resistant to pneumatolysis just as they are to present-day weathering.

The Mull amygdales have yielded much of the information at present available in regard to the relations of pneumatolysis and contact-alteration. Another interesting feature of the Mull amygdale-assemblages is the rich development of scolecite in the Ben More district.

Conditions of accumulation

It is now convenient to touch upon the conditions which prevailed during the accumulation of the Mull lavas. The main conclusion of earlier workers, that the Mull basalts were poured out on dry land, has been accentuated by detailed study. The Cretaceous sea gave place to desert sands, and these to swamps and forests, amidst which great floods of lava made their appearance: One cannot speak of forests in connection with Mull geology, without thinking of the leaf-beds of Ardtun and Macculloch's upright tree often styled the 'fossil tree of Burgh' (Frontispiece).The latter is the most arresting single geological phenomenon in the island, a coniferous trunk forty feet high, submerged in lava, but still erect. All the same, two or three trees, rare leaf-beds and sporadic coal-seams, mostly restricted to south-west Mull, are not enough to furnish a complete picture of the conditions of the period. Of more general significance is the evidence of subaerial weathering afforded by reddened surfaces and thin red boles met with time after time in the Plateau Basalt succession; and there is also the well-nigh universal absence of sedimentary infillings of cavities in the lavas—only two cases of sandstone-filled cavities have been noted.

The red-weathered tops referred to above are abundantly displayed in many of the peripheral regions of Mull, but fail almost at once inside the Pneumatolysis Limit. Two explanations may be advanced, and both probably have an element of truth. The volcanic accumulation in the central region may have been more rapid than at the periphery, thus checking the accumulation of weathered products. Also the pneumatolysis of central Mull may have rendered the red tint of surface-weathering evanescent, as it certainly seems to have changed the colour of the basal mud-stone (p. 59).

Though red tops are not available, there is nothing in the greater part of the central pneumatolysis area to suggest that aqueous instead of terrestrial conditions prevailed during the lava-period. Everything continues normal until in one restricted tract (outlined as the more south-easterly of two calderas in Plates 3 and 5), evidence of an aqueous environment is abundantly displayed. It is afforded by widespread and repeated development of pillow-lavas within this caldera ((Plate 4) and (Figure 18), pp. 134, 133).

That pillow-structure is confined to lavas poured out into water is a very generally accepted thesis, and has been strongly supported of late years by Dr. Tempest Anderson's observations at Matavanu. What seems to clinch the matter in the case of the Mull examples is a marked superficial chilling of the individual pillows ((Figure 21), pp. 132, 151)—and the same phenomenon has been recorded from many other well-known localities. Clearly a fluid must have been responsible for the chilling of these ellipsoidal surfaces, a fluid which has left no other trace of its presence. Air scarcely seems competent to chill the surfaces of incandescent pillows. Water seems the only agent available.

It is proper to state that a definite approach to pillow-structure has sometimes been noted outside the caldera-area, especially in south-western Mull (Sheet 43). It shows itself as a somewhat lenticular flow-structure, generally with pipe-amygdales springing from the base of each flow-band; and it is regarded (p. 114) as a subaerial counterpart of pillow-structure.

Microscopic evidence supports the contrast between the southeastern caldera and the surrounding country. It is well known that variolitic structure is a common microscopic associate of pillow-structure. In keeping with this, one finds that thirty-four per cent. of the basalt slides from Area 10 are variolitic as against two per cent. from the rest of Sheet 44. Another interesting microscopic peculiarity of the Mull pillow-lavas, as compared with their fellows, is the invasion of early-formed vesicles by froth ((Figure 21), p. 151).

The present-day restriction of pillow-structure to the southeastern caldera of central Mull appears to be sufficiently definite to call for interpretation. The basalts of the region are all of Central Types, and as they approach closely on the west to outcrops of Pre-Tertiary rocks, this in itself makes it tolerably certain that they occupy a region of marked subsidence (Chapter 13). The question naturally arises whether this subsidence is merely responsible for the preservation of the pillow-lavas, or whether it may not equally have been responsible for their development.

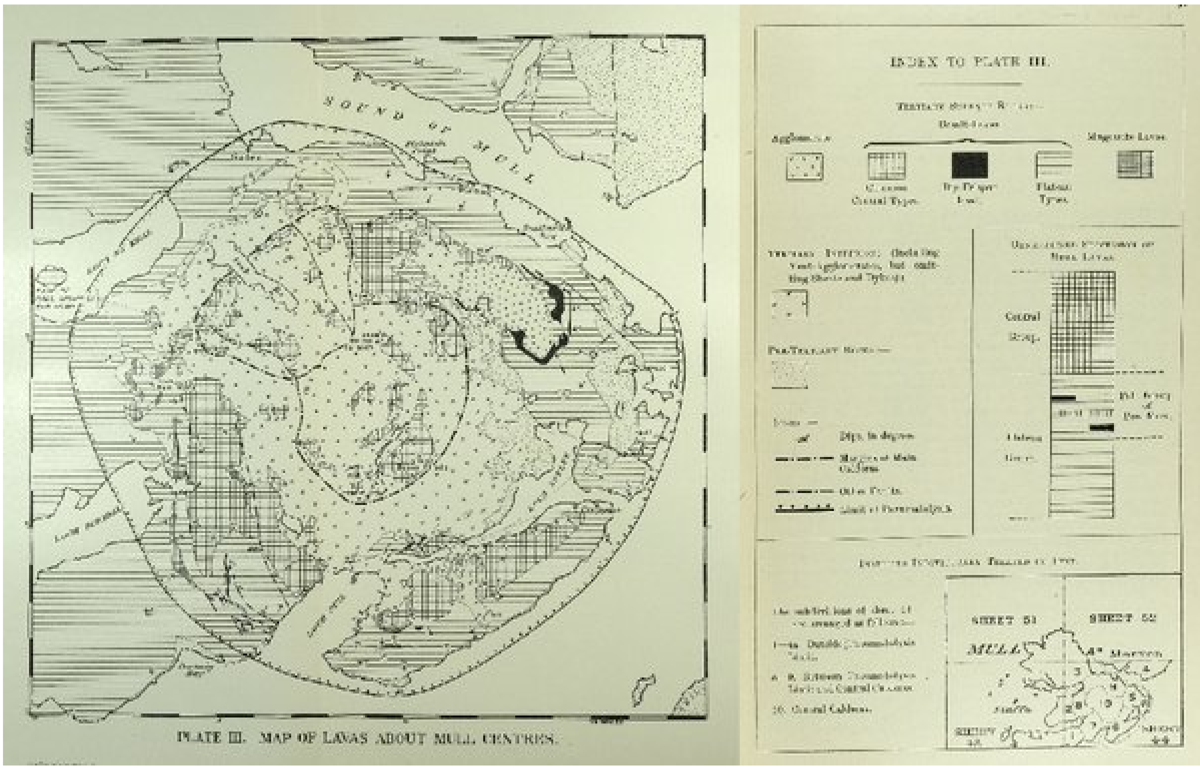
In the first place, it might be claimed that the pillow-lava suite, which on the local evidence is some few thousand feet thick, is a downthrown remnant of a once wide-spread formation. But two circumstances make this hypothesis difficult:

1. The lavas in question are shown by their relation to neighbouring intrusions to be of early date in Mull's igneous history. This, combined with their close petrological resemblance to other developments of Central Types in Mull, makes it probable that they belong to the same general period as these latter. Accordingly, if they mark a wide-spread and a long continued submergence of Mull as a whole, it is strange not to find their counterpart in the Coire Mòr and Loch Spelve Syncline where the Mull lavas are overlain by later agglomerate.

2. The pillow-lava suite is very little interrupted by sediment.

It is reasonable to suppose, therefore, that the pillow-lava suite of Central Mull is the local equivalent of much of the Central Group found round about; and that it accumulated in a frequently renewed crater-lake. If, as analogy would suggest, the crater was placed centrally upon a flat lava-dome, the entry of external drainage would be prohibited, and sedimentation would thus be reduced to a minimum. The picture that rises before one's eyes is of the caldera-sink of Kilauea with its movable floor<ref>T. D. Dana, Characteristics of Volcanoes, 1890, p. 78.</ref>; only one must imagine a Kilauea with intermittent periods of repose during which the fires of Halemaumau give place to the waters of a lake.

The possible co-operation of normal fissure-eruptions in building up the lava-pile of Mull as a whole has already been discussed (p. 4). E.B.B. (as Editor).



(Plate 3) Map showing the distribution of lava-types and the limit of pneumatolysis

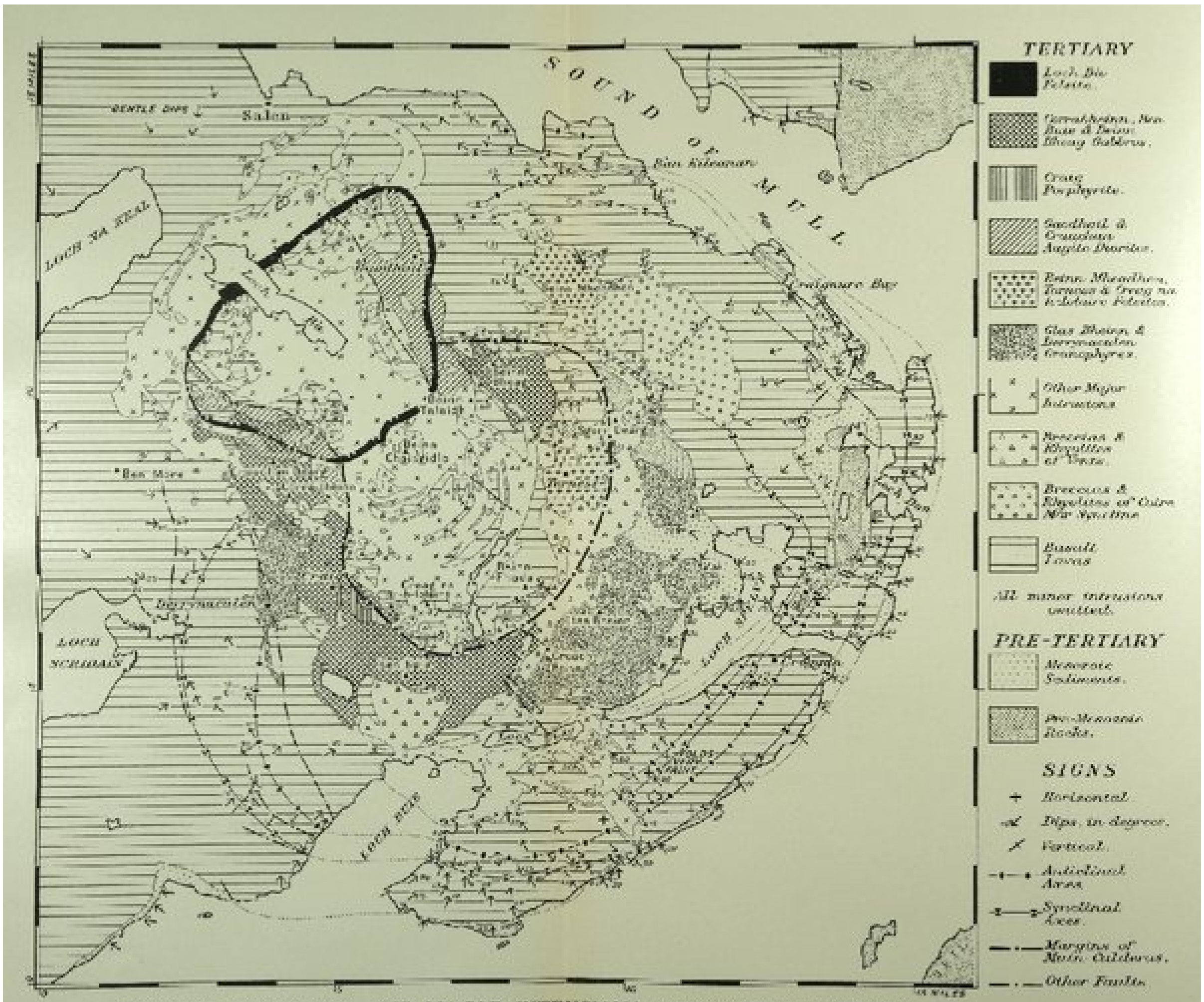
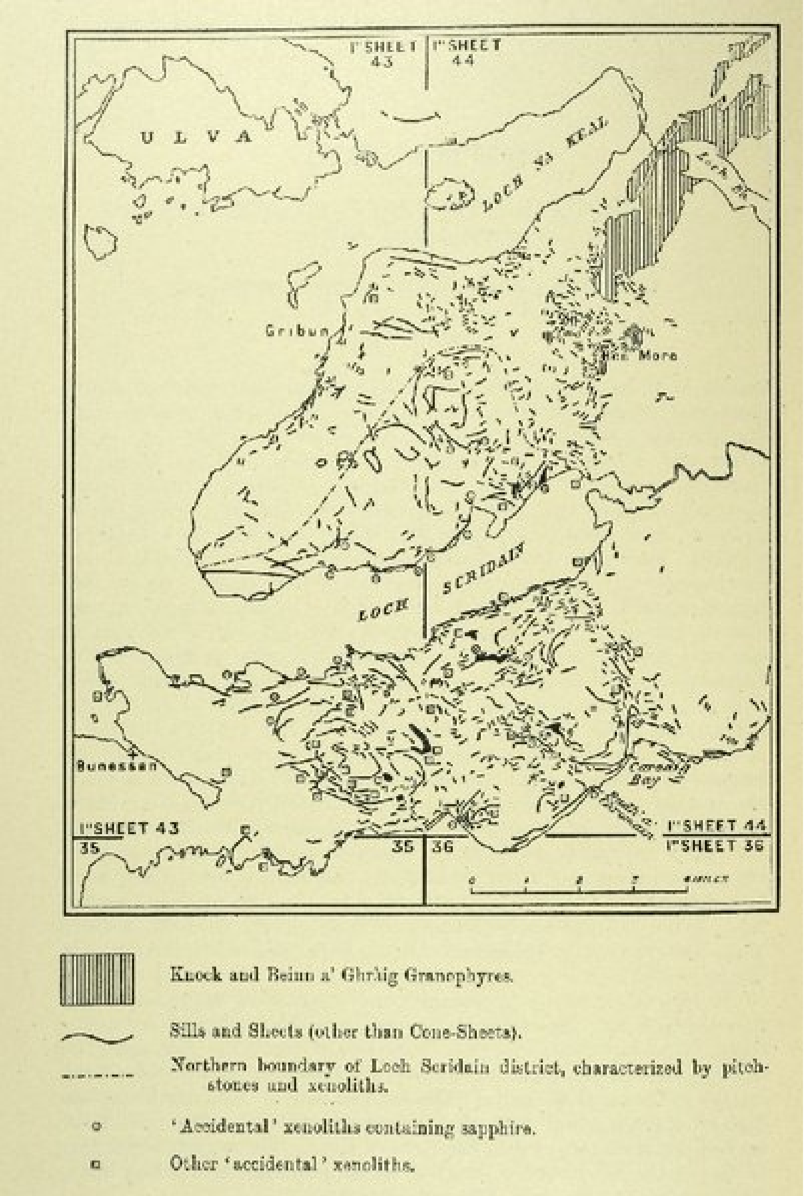


PLATE V. TECTONICS AND MAJOR INTRUSIONS ABOUT MULL CENTRES.

(Plate 5) Map showing calderas, major intrusions, and folds



(Figure 42) Map of South-West Mull, showing distribution of Sills and Sheets other than Cone-Sheets.

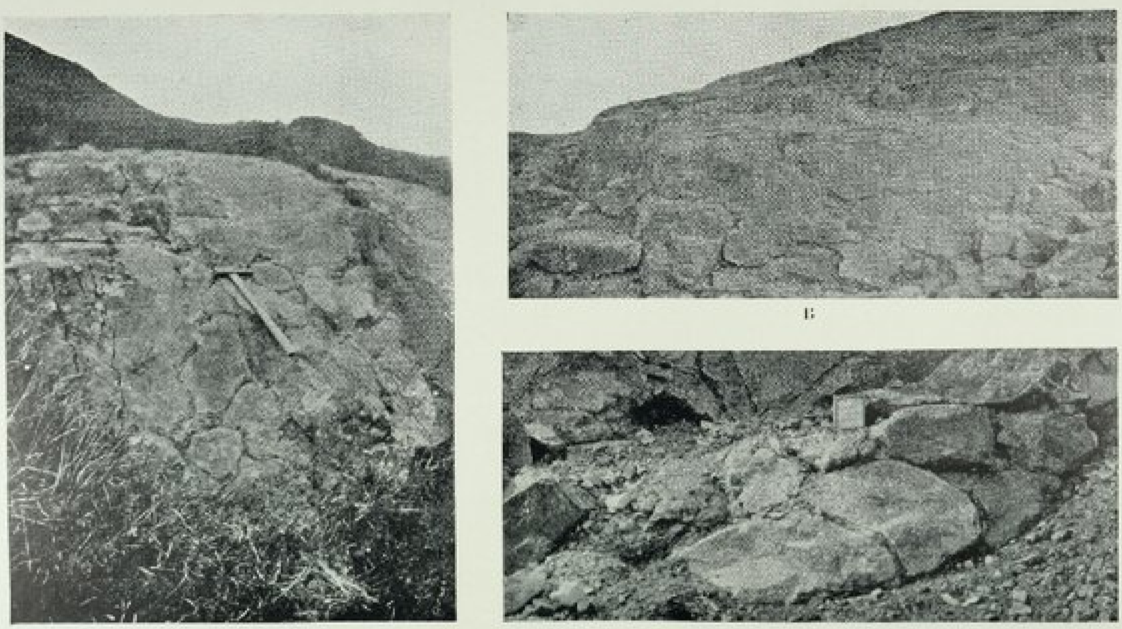


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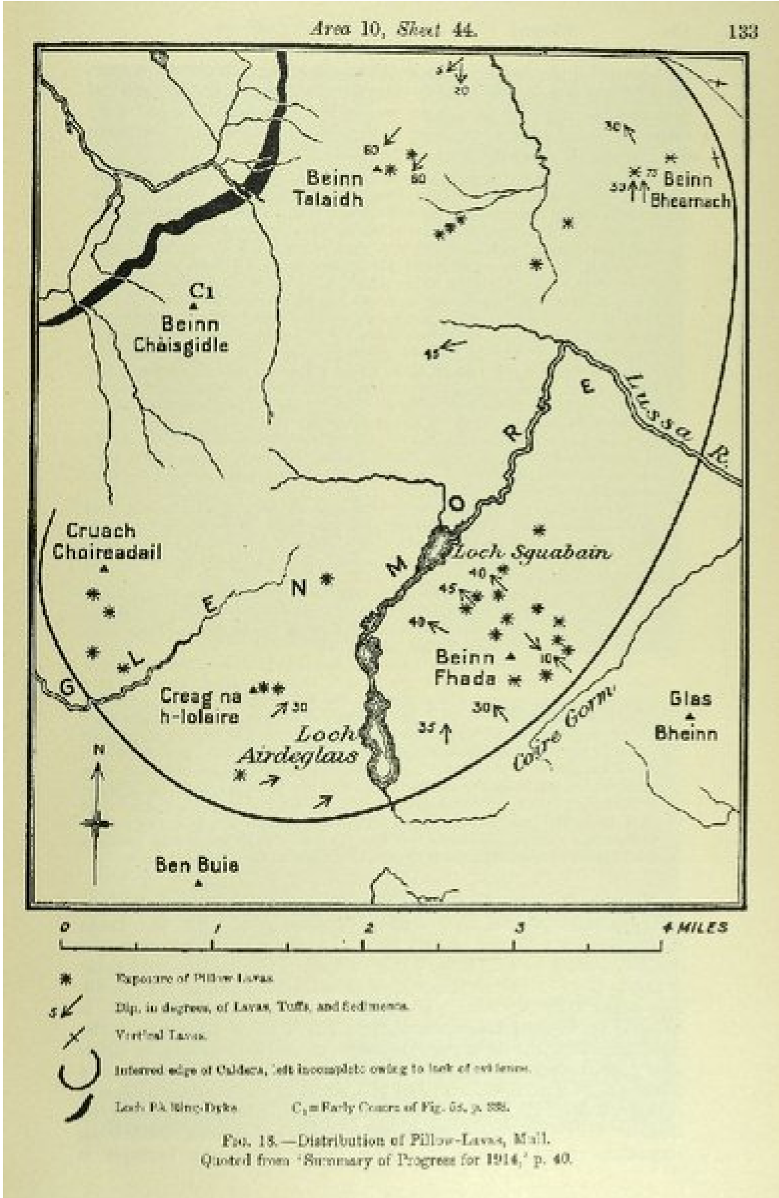
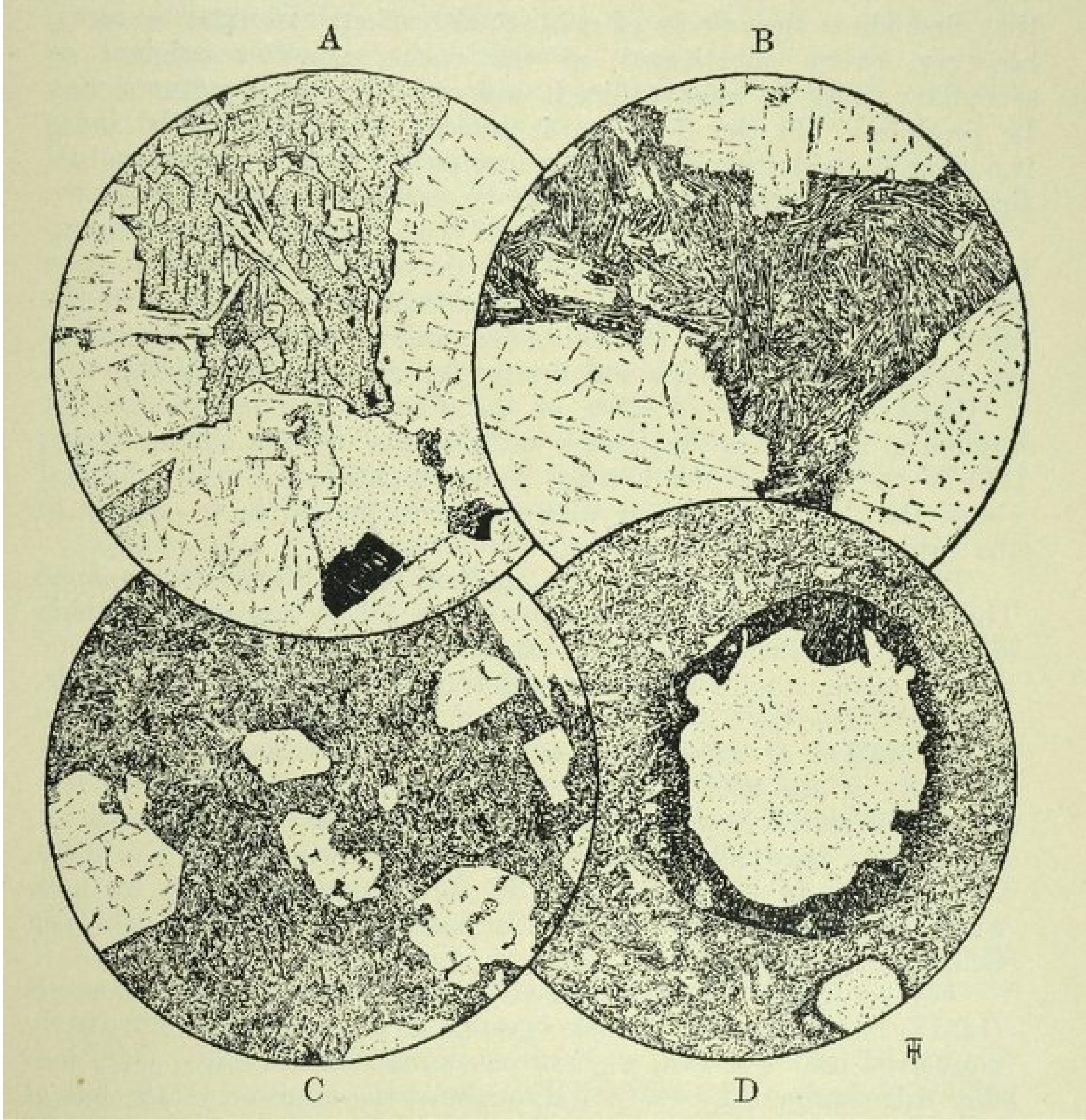
PLATE IV.—Pillow-Lavas of South-Eastern Caldera.

(Plate 4) Pillow-lavas of central Mull



(Figure 18) Distribution of Pillow-Lavas, Mull. Quoted from Summary of Progress for 1914, p. 40.



(Figure 21) A -C Pillow-Lava, Cruach Choireadail. D Beinn Fhada. A. (S17184) [NM 5932 2982] x 17. Interior of Pillow. Moderately coarse doleritic rock with the augite and felspar in ophitic relationship. B. (S17185) [NM 5940 3000] x 17. Exterior of Pillow. The felspar occurs in two generations as porphyritic crystals of bytownite-anorthite, and as slender laths, which, with elongated crystals of augite, impart a variolitic structure to the matrix (compare with (Figure 23a, p. 163). C. (S17186) [NM 5924 3011] x 17. Chilled Margin of Pillow. Porphyritic basic plagioclase, near anorthite in composition, in a fine-textured matrix. The ground-mass is composed of small, elongated crystals of felspar, augite and iron-ore, with a chloritized residuum probably representing glass (compare with Fig 23A, p. 163). D. (S18039) [NM 6437 2936] x 17. Beinn Fhada. Portion of the exterior of a pillow showing the characteristic invasion of vesicular cavities by mesostatic residual material which has subsequently frothed up in situ.