

*A differentiated boss of alkali dolerite from Cnoc
Rhaonastil, Islay.*

(With Plates VII and VIII.)

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[Read 29 January 1959.]

Summary. An elongated boss of alkali dolerite is described having a NW. trend and measuring 800 m. by 250 m. Two main rock-types occur, an ophitic feldspar-rich analcime-olivine-dolerite or leucodolerite and a teschenite with subhedral pyroxene. The second type is intrusive into the first but the two are associated in vertical veins. Both show local banding and analcime-nepheline-syenite forms a differentiate of both. Finer grained olivine-rich dolerite resembling the crinanites of Jura occurs at the NW. extremity of the boss and probably represents the original magma. All four types have been analysed and are thought to be the products of normal crystal fractionation with slight absolute iron enrichment. The boss was apparently headed not far above the existing exposures and is considered to be of Tertiary age. The pyroxene and olivine of the leucodolerite have been separated and analysed.

THE Tertiary NW. dykes of Islay and Jura form a well-marked swarm continuing across the Mull of Kintyre into Arran. They increase in number to the NW., and Richey (1939, p. 393) has suggested that their focus lies under the Atlantic in that direction. Petrographically they range between olivine-dolerite and crinanite *sensu stricto*, but the much broader boss of Cnoc Rhaonastil, 5 miles ENE. of Port Ellen, is an exception in its petrographic as well as in its physical characteristics. This was early recognized by Wilkinson (1907, p. 64) who drew attention to its striking appearance and abnormal mineralogy. Yet the present communication represents the first petrographic description. It was written by the first author, but the field work was shared and three of the main rock-types were analysed by the second author.

Field Characters.

Cnoc Rhaonastil is a conspicuous grassy hill only 300 feet high but standing out boldly from the rather featureless Dalradian landscape of southern Islay. It is composed almost entirely of alkali dolerite forming an elongated boss of NW. trend measuring 800 m. by 250 m. This

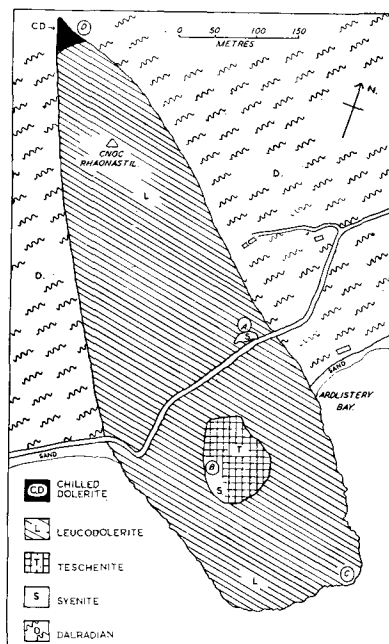


FIG. 1. Sketch map of the Cnoc Rhaonastil boss.

stretches down to the sea where it extends as a promontory separating Loch a' Chnuic from Ardlistry Bay. The National Grid reference of the summit is 434486.

Exposures along the shore section are almost continuous but the SW. side of the promontory is littered with large angular blocks which may have moved slightly from their source during severe storms. Apart from two abandoned quarries (A and B in fig. 1) exposures from shore to summit are scanty but behind the summit a series of rocky terraces falls abruptly to level arable ground where the boss wedges out rapidly to the NW. Air photographs suggest a similar submarine wedging to the SE. At no point is the contact exposed but the clear-cut terminations and moderate contact metamorphism of adjacent epidiorite sills indicate

its proximity. No chilling of the boss is seen except at the NW. where a small exposure of finer-grained olivine-rich dolerite is thought to represent the chill phase of the original magma (D in fig. 1).

The bulk of the intrusion consists of a fresh coarse-grained and highly ophitic olivine dolerite, light grey in colour and obviously very feldspathic. Irregular black clumps of pyroxene cause pustular weathering, especially round the summit, while green olivine is less prominent.

Very different material is seen in quarries A and B (fig. 1). In quarry A the ophitic dolerite is the main type but it has decomposed to light brown friable rubble from which knobs and veins of fresh rock project. Both knobs and veins consist partly of the ophitic dolerite and partly of two non-ophitic types. One is mafic and of troctolitic appearance, greasy grey in colour with well-defined dark spots of olivine and pyroxene. The second is a greyish-white coarse and drusy syenite of which the main constituent is alkali feldspar often showing sub-parallelism. Sub-ordinate biotite and barkevikite in conspicuous black needles are visible in the hand specimen. The syenite is associated with the other two types in veins up to 60 cm. wide, generally vertical and showing marked banding (pl. VII, fig. 2), and in nests up to 2 m. in diameter.

Quarry B, now overgrown, is in a tree-clad knoll that forms a prominent physical feature probably representing a later intrusion. It consists almost entirely of the troctolite-looking rock but loose blocks show local gradation into syenite as well as rude banding into dark and light layers.

Similar banding is seen in the ophitic dolerite in places; near the summit it is rudimentary but at the end of the promontory (C in fig. 1) it becomes conspicuous. The bands are up to 5 cm. wide and have a seaward dip of 32° . At this point prominent platy jointing is developed parallel to the banding and to an 8 cm. felsic layer. Both here and NW. of the summit the disposition of banding and platy jointing indicate that the boss had a rounded head only a short distance above the existing exposures. A few thin ramifying veins of felsic material and some irregular patches of ophitic dolerite pegmatite occur below the banded dolerite at C.

Microscopic petrology.

Microscopic examination confirms that four principal rock-types¹ occur in the boss: ophitic analcime-olivine-dolerite or 'leucodolerite';

¹ In the remainder of this paper the names here in inverted commas will be used for brevity.

teschenite with troctolitic appearance or 'teschenite'; analcime-nepheline-syenite or 'syenite'; and fine-grained dolerite rich in Mg-olivine or 'chilled dolerite'. Some indication of the distribution of these types is shown in fig. 1 while tables I-IV and pl. VIII deal with their mineralogy, chemistry, and texture. Only diagnostic features are dealt with in the text below.

Leucodolerite. The main features of this unique dolerite are: abnormally high plagioclase content; poverty in pyroxene; extreme ophitic texture of pyroxene, 'nesophitic' of Walker (1957, p. 2); sub-ophitic to ophitic habit of Mg-Fe-olivine; and abundance of zeolites and widespread analcimization of plagioclase.

A variety of the leucodolerite with still less pyroxene but abundant ophitic olivine occurs on the shore section near the east end of the beach at the head of Loch a' Chnuic (4, table I).

Teschenite. This gabbroic rock is similar to some of the less ophitic teschenites of the Midland Valley (Walker, 1923) but differs from them in the following respects: absence of potash feldspar; presence of unaltered Mg-Fe-olivine; and very extensive development of zeolites and analcimization giving a greasy grey appearance megascopically.

Syenite. This drusy rock bears a marked resemblance to the greyish-white segregations of analcime-syenite of a sill in the Shiant Isles (Walker, 1930, p. 385), but shows the following minor differences: greater variation of mafic minerals, which in all cases bulk less than in the Shiant rock; slightly more abundant and better preserved nepheline; more complete zeolitization of feldspar; more calcic plagioclase (An_{20}); relative poverty in apatite.

Chilled dolerite. The rock is of smaller grain-size than the leucodolerite and closely resembles the type crinanite dykes of Jura in chemical composition, mineralogy and fabric with the following minor differences: curious habit of large Mg-olivines, which occur in elongated groups of welded grains up to 5 cm. in length and enclosing small plagioclase laths; and absence of vesicles.

Minor Types of restricted distribution are: Pegmatitic patches in leucodolerite at C (fig. 1), which contain much zeolitized labradorite, ophitic titanite in clumps up to 1 cm. across, and analcime as main constituents; ilmenite and soda-orthoclase are subordinate and olivine absent; a few pseudomorphs may represent nepheline. And anorthositic bands in leucodolerite, which occur sparingly at C; the constituent minerals are these of the leucodolerite but the mafic minerals are even scarcer.

TABLE I. Modes (volume %) of Cnoc Rhaonastil rocks compared with one from Jura. Also optical properties of the olivine and pyroxene.

	1.	2.	3.	4.	5.	6.	7.
Olivine . . .	—	—	8.6	19.3	4.1	23.8	22.3
Pyroxene . . .	2.4	1.2	9.3	6.6	25.2	19.9	14.9
Plagioclase } .	71.0	78.6	70.4	67.6	54.1	46.2	54.6
K-feldspar } .			—	—	—	—	—
Nepheline . . .	5.2	2.8	—	—	—	—	—
Zeolites . . .	13.1	12.2	7.5	3.1	6.7	1.9	3.6
Amphibole . . .	5.4	0.8	—	—	1.2	—	—
Biotite . . .	0.3	1.7	—	—	0.9	—	—
Iron ore . . .	2.1	1.9	4.0	3.2	7.2	8.0	4.4
Apatite . . .	0.5	0.8	0.2	0.2	0.6	0.2	0.2
<i>Olivine:</i>							
β	—	—	1.750	1.752	1.752	1.710	—
2V	—	—	75°	73°	73°	89°	—
<i>Pyroxene:</i>							
β	—	—	1.706	1.706	1.708	1.704	—
2V	—	—	50-54°	52°	50°	50°	—

1. Analcime-nepheline-syenite, nest in middle of quarry A (fig. 1), Cnoc Rhaonastil. Analysed rock, 1, table III.
2. Ditto from nest at SE. end of quarry A.
3. Leucodolerite from summit of Cnoc Rhaonastil. Analysed rock, 2, table IV.
4. Ditto with ophitic olivine, shore near N. end of Loch a' Chnuic.
5. Teschenite, S. end of quarry B (fig. 1), Cnoc Rhaonastil. Analysed rock, 3, table III.
6. Olivine-rich dolerite, NW. extremity of Cnoc Rhaonastil boss. Analysed rock, 4, table III.
7. Olivine-rich dolerite dyke, 300 m. N. of Faolin Ferry, Jura.

Mineralogy.

The properties of some of the chief minerals are given in table I. The olivine and pyroxene of the leucodolerite are of greater interest than the others for they represent the chief mafic constituents of an intermediate alkaline differentiate of unique character. They were therefore isolated and analysed. The pyroxene is a normal titanaugite lying slightly above Murray's curves for the pyroxene of the Garbh Eilean sill in the Shiant Isles (1954). The $100(\text{Fe}_2\text{O}_3 + \text{FeO})/(\text{Fe}_2\text{O}_3 + \text{FeO} + \text{MgO})$ ratios for the pyroxene (45), the rock (72), and the olivine (60) indicate a considerable degree of differentiation. It was not found possible to obtain the olivine completely free from feldspathic inclusions but when a slight correction for plagioclase and magnetite dust has been made the analysis (2, table II) yields a reasonable formula. The olivine and pyroxene of the teschenite have similar properties and compositions though the proportions are different. Zoning is not conspicuous in either but the specific

gravities and refractive indices indicate a limited range in composition. Refractive indices were determined by the immersion method (± 0.003) and 2V measured by the Vincent stage (Vincent, 1954).

TABLE II. Analyses of olivine and pyroxene from leucodolerite, Cnoc Rhaonastil.

<i>Olivine.</i>					<i>Pyroxene.</i>				
	Weight %.	Weight % corrected.		Atomic ratios to 4 oxygens.		Weight %.		Atomic ratios to 6 (O,OH)	
SiO ₂	34.46	34.58	Si	0.978	SiO ₂	49.14	Si	1.811	} 2.00
Al ₂ O ₃	1.24	—			Al ₂ O ₃	3.53	Al	0.153	
TiO ₂	0.07	0.07	Ti	0.001	TiO ₂	1.88	Ti	0.052 { 0.036 0.016	
Fe ₂ O ₃	1.81	—			Fe ₂ O ₃	2.27	Fe ⁺⁺⁺	0.063	} 2.028
FeO	35.84	37.76	Fe ⁺⁺	0.893	FeO	8.05	Fe ⁺⁺	0.248	
MnO	0.72	0.76	Mn	0.018	MnO	0.26	Mn	0.008	
MgO	24.95	26.83	Mg	1.130	MgO	12.53	Mg	0.688	
CaO	0.53	—			CaO	21.54	Ca	0.850	
Na ₂ O	0.28	—			Na ₂ O	0.52	Na	0.037	
H ₂ O	0.15	—			H ₂ O	0.48	OH	0.118	
	100.05	100.00				100.20			
	γ 1.767	(Mg,Fe,Mn) ₂ SiO ₄			γ 1.722	Ca ₄₅ Mg ₃₈ Fe ₁₄			
	β 1.750	Fo ₉₈ Fa ₂			β 1.706	Violet-brown			
	α 1.725	Sp. gr. 3.69–3.87			α 1.698	Sp. gr. 3.39–3.47			
	γ - α 0.042	Pale brown 2V – 75°			γ - α 0.024	2V + 50 to 54°, + 44°			

Analyst: W. H. Herdsman

Chemistry.

The chemical analyses of the main basic types of the boss in table III bring out clearly its Thulean affinities with characteristically low potash:soda ratios. This is also a feature of the chilled dolerite which resembles closely in its chemistry the type crinanite of Jura (Guppy, 1931, p. 86). Olivine-rich crinanites and dolerites are very common in the Islay-Jura dyke swarm to which the boss belongs petrologically as well as petrographically.

The composition of the leucodolerite, though reflecting accurately its mineral content, is peculiar, for extremely high alumina is combined with low magnesia and iron. The only analogue is the analysis of a felsic vein in the crinanite sill of Clauchlands Point, Arran, which has however somewhat different mineralogy. Furthermore the host crinanite itself differs in chemical and mineralogical composition from any of the analysed types in the boss.

The teschenite analysis is unlike that of the only other Tertiary example, the calc-teschenite of Northern Trotternish (Walker, 1932, p. 249), which is considerably higher in lime and lower in alkalis. It is

TABLE III. New chemical analyses and norms of Cnoc Rhaonastil rocks.

<i>Chemical analyses.</i>					<i>C.I.P.W. norms.</i>				
	1.	2.	3.	4.		1.	2.	3.	4.
SiO ₂	55.18	49.28	47.85	44.68	or	25.6	3.3	3.9	3.9
Al ₂ O ₃	20.66	21.07	15.48	15.99	ab	42.4	33.8	32.8	15.7
Fe ₂ O ₃	2.21	1.80	2.90	2.88	ne	8.8	1.3	2.1	1.1
FeO	2.02	6.27	9.69	9.23	an	10.3	36.7	20.9	32.3
MgO	1.09	3.09	4.15	12.48	C	0.9	—	—	—
CaO	2.37	9.64	9.26	9.46	di	wo	—	4.3	8.9
Na ₂ O	6.96	4.25	4.36	2.13		en	—	2.1	4.0
K ₂ O	4.26	0.56	0.72	0.68	ol	fs	—	2.1	4.9
H ₂ O +	3.45	1.52	1.76	1.26		fo	1.9	3.9	4.5
H ₂ O —	1.12	1.09	1.14	0.09	mt	fa	1.2	4.8	5.9
TiO ₂	0.15	1.11	1.94	0.96			3.3	2.6	4.2
P ₂ O ₅	0.08	0.06	0.46	0.06	il	0.3	2.1	3.7	1.8
MnO	0.05	0.13	0.17	0.21	ap	0.3	0.3	1.3	0.3
CO ₂	0.10	nil	tr.	nil	cc	0.2	—	—	—
	99.70	99.87	99.88	100.11	H ₂ O	4.6	2.6	2.9	1.4
Sp. gr.	2.50	2.75	2.81	3.07		99.8	99.9	100.0	100.2

1. Syenite nest in quarry A (fig. 1), Cnoc Rhaonastil. New analysis. Analyst: E. M. Patterson.
2. Leucodolerite, summit of Cnoc Rhaonastil. New analysis. Analyst: E. M. Patterson.
3. Teschenite, S. end of quarry B (fig. 1), Cnoc Rhaonastil. New analysis. Analyst: E. M. Patterson.
4. Olivine-rich dolerite. NW. extremity of Cnoc Rhaonastil boss. New analysis. Analyst: W. H. Herdsman.

much closer in composition to the Carbo-Permian teschenites of the Midland Valley though differing from them in its lower K₂O/(Na₂O + K₂O) ratio, 0.14 against 0.29 for the average of six Survey analyses (Guppy, 1931, pp. 92–93).

The syenite analysis shows no really close resemblance to any other of this type, whether in the Hebridean Tertiary or Midland Valley Carbo-Permian. The K₂O/(Na₂O + K₂O) ratio shows a marked rise to 0.38, potash evidently being concentrated in the late differentiates. The best match is with the syenite segregations of the Eilean Mhuire sill in the Shiant Isles (Walker, 1930, p. 387). The intrusion as a whole falls into the alkali-calcic division of Peacock (1931), the alkali index being 52.

Differentiation.

Initial magma. The olivine-rich dolerite at the NW. extremity of the boss seems to represent the initial undifferentiated magma. The mafic constituents and plagioclase are respectively more magnesian and more sodic than in the other varieties and the rock closely resembles the main

TABLE IV. Chemical analyses of Cnoc Rhaonastil rocks with others for comparison, calculated to 100 % water-free.

	1.	A.	2.	B.	3.	C.	4.	D.
SiO ₂	57.9	60.0	50.6	48.3	49.3	50.4	45.2	45.0
Al ₂ O ₃	21.7	16.3	21.7	24.1	15.9	15.5	16.2	14.5
Fe ₂ O ₃	2.3	5.1	1.8	3.6	3.0	2.9	2.9	2.0
FeO	2.1	2.6	6.5	4.8	10.0	7.2	9.3	12.0
MgO	1.1	0.6	3.2	2.6	4.3	5.9	12.6	10.8
CaO	2.5	2.1	9.9	9.9	9.6	8.7	9.6	9.2
Na ₂ O	7.4	7.7	4.4	4.7	4.6	4.0	2.2	2.8
K ₂ O	4.5	4.4	0.6	0.4	0.7	2.4	0.7	0.3
TiO ₂	0.2	0.5	1.1	1.3	2.0	2.2	1.0	2.6
etc.	0.3	0.7	0.2	0.3	0.6	0.8	0.3	0.8

1. Syenite nest in quarry A (fig. 1), Cnoc Rhaonastil. New analysis (table III, 1).
- A. Syenite segregation in Eilean Mhuire sill, Shiant Isles. Analyst: E. G. Radley (Walker, 1930, p. 355).
2. Leucodolerite, summit of Cnoc Rhaonastil. New analysis (table III, 2).
- B. Segregation vein in crinanite sill, Clauchland's Point, Arran. Analyst: W. H. Herdsman (Tyrrell, 1928, p. 121).
3. Teschenite, S. end of quarry B (fig. 1), Cnoc Rhaonastil. New analysis (table III, 3).
- C. Teschenite, below Craigens sill complex, Ayrshire. Analyst: E. G. Radley (Guppy, 1931, p. 92).
4. Olivine-rich dolerite, NW. extremity of Cnoc Rhaonastil boss. New analysis (table III, 4).
- D. Crinanite dyke. Inver Lodge, Jura. Analyst: E. G. Radley (Guppy, p. 86).

type of the Jura-Islay dyke swarm in which the boss is situated. Of medium grain, the rock is chilled only in the sense that the cooling process at the wedge-shaped termination was too rapid to permit significant differentiation. Its richness in Mg-olivine points to a magma intermediate in character between the Mull plateau type and the picritic liquids postulated by Drever (1952). Similar magnesia-rich lavas occur in Antrim (Patterson, 1952).

Gravitational differentiation. The leucodolerite on the other hand is a strongly differentiated type. Its relationship to the previous type is not seen but the iron-rich nature of its mafic minerals indicates that it is far advanced in the crystallization series. Furthermore, it is a highly felsic rock containing no less than 78 % of plagioclase and zeolites. The former evidence favours crystal fractionation and the latter gravitational settling of magnesian olivine and possibly, at a later stage, large ophitic aggregates of pyroxene and plagioclase or olivine and plagioclase (4, table I), which would sink by virtue of their bulk.

A subtraction diagram shows that the most basic material that can be subtracted from the chilled dolerite to produce the leucodolerite has

a normative composition including 27 % anorthite, 15 % pyroxene, and 47 % Mg-olivine. Both the nature and proportions of these minerals are in keeping with the hypothesis of gravitational differentiation suggested above. Complementary to the settling process there would be a concentration of the later residues in the upper part of the magma chamber and this again is in keeping with the high zeolite content of the leucodolerite. Lastly the observations of the first author on ophitic texture (Walker, 1957) agree with the suggested differentiation process.

The *teschenite* intrusive probably represents the result of crystallization differentiation at depth without the thorough gravitational cleansing shown by the leucodolerite, for its mafic content is considerably higher. It is closely associated with both leucodolerite and syenite elsewhere and cannot be far removed in time from the main intrusive episode, though the mechanism of injection remains in doubt through lack of exposures.

Syenite occurs as thin partings in vertical veins of alkali-dolerite, as rounded patches or nests in the leucodolerite (A, fig. 1), and as schlieren in loose blocks of the teschenite (B, fig. 1). It is of variable mineralogy which may point to diversity of origin. There is, however, little doubt that the rounded masses so conspicuous in quarry A arose in the same way as the analcime-syenites of Ayrshire described by Tyrrell (1928), that is through enclosure by or injection into a hot crystal framework of aqueous and alkaline residual magma. Certainly they have no stratiform tendency but this may be explained by the difference in form between the Ayrshire sills and the Islay intrusion, which seems to represent the rounded head of an elongated boss. The local sub-parallelism of the alkali feldspar indicates that the syenite is a magmatic residue rather than a replacement deposit but the varied mineralogy and extensive zeolitization point to its highly aqueous and mobile nature.

The syenite bands and schlieren in the loose teschenite blocks of quarry B are too scanty to yield information as to their origin and the thin partings of the banded vertical veins of quarry A are dealt with below.

Dolerite pegmatite at C has a patchy habit like that of the same rock-type developed in tholeiitic intrusions described by the first author (Walker, 1953) and there is no need to postulate a different origin. Like those of syenitic nature they are thought to represent residual magma trapped in a growing crystal framework.

Banding. The rudimentary banding seen at a number of localities, notably behind the summit and at C (fig. 1), shows an inclination more or less in conformity with the surface topography and platy joint system. In sheet or dyke injections similar banding and jointing have been

recorded near and parallel to the margin and it is thought that the banded outcrops of the boss are not far from the upper contact now removed by erosion. If this is so the boss must have had a rounded upward termination.

The bands fail to show the more perfect segregation of light and dark minerals displayed by the great layered intrusions, nor is there any preferred orientation. The dark bands are thinner than the light and show more clearly on a weathered surface than in a large thin section. At C where the banding shows its most regular development individual layers do not exceed 8 cm. in thickness (pl. VII, fig. 4).

Somewhat similar banding has been observed by the first author in the Palisade sill, New Jersey, by Mr. H. G. Wright (priv. comm.) in a Skye sill, and by Mr. P. L. C. Grubb (priv. comm.) in dolerite sills in Bechuanaland. It appears to be a phenomenon of rhythmic crystallization rather than of convectional sorting and sedimentation. The mechanism proposed by Coats (1937) may possibly be applicable. Its investigation continues.

The thick vertical veins of quarry A show much more clear-cut banding but again there is no preferred orientation of any of the constituent minerals. On the other hand the thin syenite partings, less than 5 mm. wide (pl. VII, fig. 2), show a well-marked co-planar arrangement, parallel to the contacts, of long needles of alkali amphibole. The other elements of the bands consist of leucodolerite and teschenite with transitional types but containing the same minerals as occur in the massive rock.

These veins give proof of the contemporaneity of leucodolerite, teschenite, and syenite. They probably represent material filling and dilating rifts in a hot crystal framework near the upper contact. The infilling seems to have taken place in the order leucodolerite, teschenite, syenite. It is possible that the syenite partings are the result of replacement.

The four analysed rocks represent the liquid line of descent of an alkaline basaltic magma rich in olivine. The trend of differentiation is well shown on the MgO , $(\text{FeO} + \text{Fe}_2\text{O}_3)$, $(\text{Na}_2\text{O} + \text{K}_2\text{O})$ diagram of fig. 2. The suite exhibits absolute as well as relative iron enrichment, though the peak of the curve is much less high and sharp than in many tholeiitic provinces such as the Palisades (Walker, 1953, p. 53).

Comparison with other British Tertiary bosses. Bosses and plugs of dolerite are common in the British Tertiary province but with few exceptions are confined to the lava regions, notably the Antrim plateau

(Patterson and Swaine, 1957). They consist mainly of undifferentiated rock and doubtless acted as feeders of flows now removed by erosion. Being conduits they have occasionally produced striking metamorphic

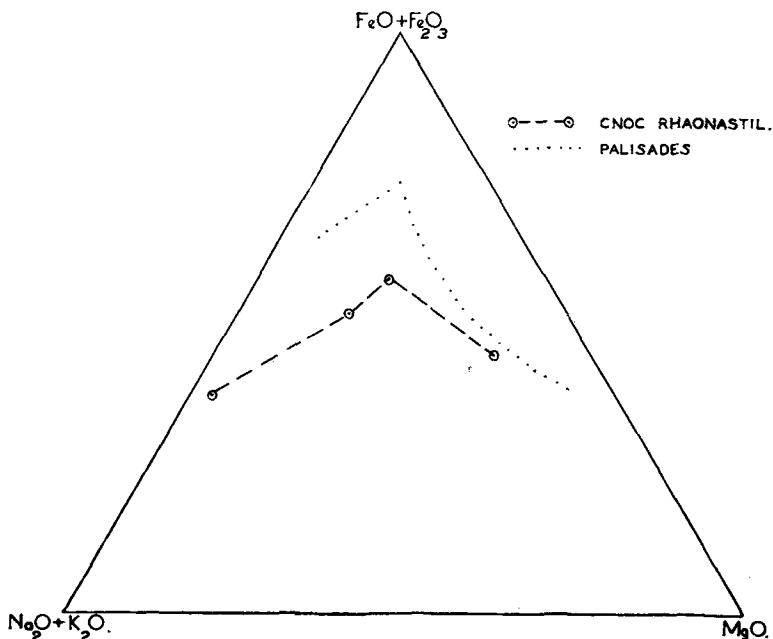


FIG. 2. Differentiation trends of the Cnoc Rhaonastil and Palisades (New Jersey) dolerites.

effects on the country rock (e.g. at Scawt Hill, Tilley and Harwood, 1931, and at Tievebullagh, Agrell and Langley, 1958). In the latter case inclination of the plug has resulted in accumulation of olivine on the foot wall to form a local development of picrodolerite.

The boss of Cnoc Rhaonastil is very different. The main rock-type is a highly differentiated leucodolerite and the contact metamorphism of the adjacent epidiorite sills is only slight. This is in keeping with a headed boss of static magma but not with a constantly replenished conduit. Furthermore, the outcrop of Cnoc Rhaonastil is lens-shaped with the major diameter parallel to the trend of the associated dyke-swarm and not circular or elliptical as in the pipes referred to.

The only Scottish intrusion at all comparable to Cnoc Rhaonastil is the elongated boss of Maiden Island near Oban (Walker, 1939), but

apart from a local marginal development of picrite and some residual veins and patches the latter is an undifferentiated olivine-dolerite; it lies just within the Mull dyke swarm, to which its trend is parallel, and only six miles from the nearest lavas of that island. Cnoc Rhaonastil on the other hand has no apparent connexion with any volcanic area and is unique in its high degree of differentiation.

Acknowledgements. The authors are grateful to Mr. H. C. G. Vincent of Cape Town University for separating the olivine and pyroxene of the leucodolerite and to Messrs. P. L. C. Grubb and H. G. Wright for assistance on the field. They also desire to express their indebtedness to the Council of the University of Cape Town for financial aid towards travel and chemical analysis.

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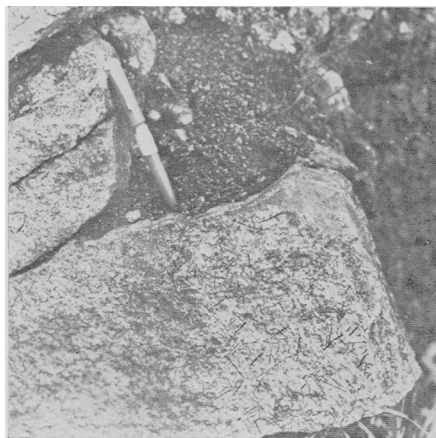
EXPLANATION OF PLATES VII AND VIII. Alkali dolerite from Cnoc Rhaonastil, Islay.

PLATE VII.

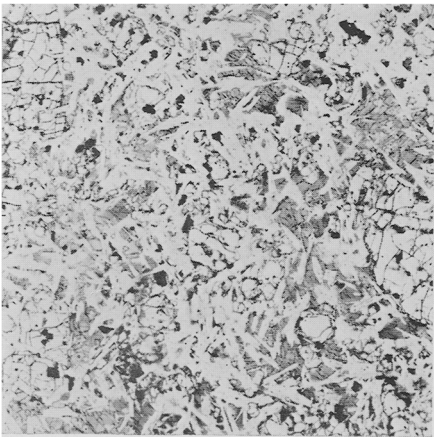
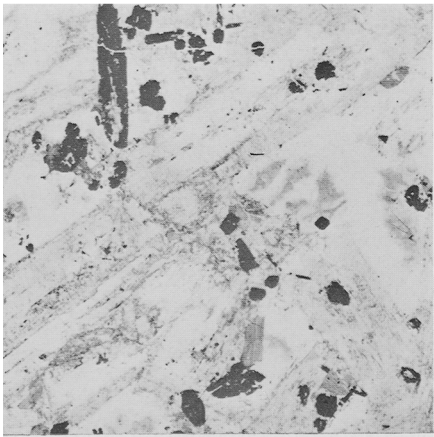
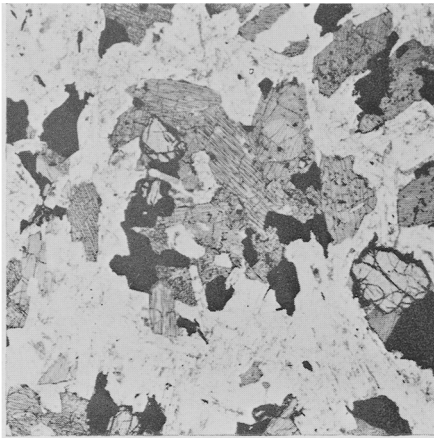
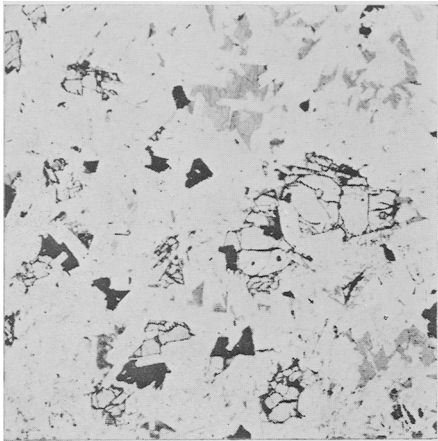
- FIG. 1. Quarry A showing 30 cm. vertical banded vein (left) and syenite nest (right) projecting from friable, weathered leucodolerite.
 FIG. 2. 30 cm. vertical vein in quarry A seen from side and showing banding and syenite parting with planar arrangement of barkevikite needles.
 FIG. 3. Pustular weathering and slab like jointing of leucodolerite at summit.
 FIG. 4. Banding and jointing of leucodolerite at C (fig. 1).

PLATE VIII.

- FIG. 1. Leucodolerite. Ordinary light. Showing sparse ophitic titanaugite and sub-ophitic olivine intergrown with abundant plagioclase An_{60} . Titanomagnetite and analcime are subordinate. $\times 8$.
- FIG. 2. Teschenite. Ordinary light. Euhedral to sub-ophitic titanaugite and pale brown olivine are embedded in plagioclase An_{60} . Subordinate analcime occurs in interspaces and replaces plagioclase. Titanomagnetite is prominent and sparse marginal growths of biotite and barkevikite are accessory. $\times 8$.
- FIG. 3. Syenite. Ordinary light. Large analcimized tables of anorthoclase and oligoclase are prominent while analcime and other zeolites fill interspaces. A dark prism of barkevikite is conspicuous near top and ægirine-augite is accessory. A rectangular pseudomorph after nepheline occurs near centre. $\times 8$.
- FIG. 4. Chilled dolerite. Ordinary light. Abundant Mg-olivine in large elongated aggregates of grains enclosing small plagioclases. Matrix consists of ophitic purple titanaugite and plagioclase An_{65} with subordinate iron-ore and analcime. $\times 8$.
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F. WALKER AND E. M. PATTERSON: ALKALI DOLERITE FROM ISLAY



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