Minor intrusions - geochemistry - St. Kilda: an illustrated account of the geology

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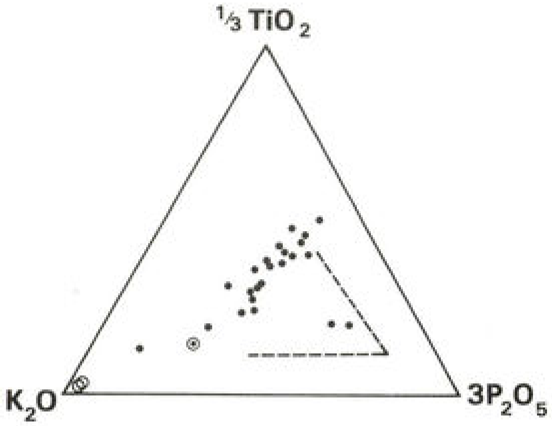

Figure 28 TiO2–K2O–P2O5 diagram showing range in K2O values at relatively constant Ti:P ratios. Broken line denotes closed system fractionation at Skaergaard (Thompson, 1982a). Solid circles are basalts and basaltic andesites; open circles are microgranite and porphyritic pitchstone

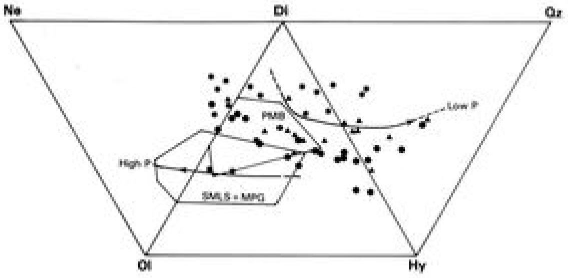

Figure 29 Normative nepheline-olivine-diopside-hypersthene-quartz diagram with values for St Kilda rocks (circles), non-porphyritic central magmas in other Tertiary centres (triangles), Blackstones rocks (stars), and the indicated fields for Skye Main Lava Series (SMLS), Mull Plateau Group (MPG) and Preshal Mhor Basalts (PMB). Fractionation trends at low and high pressure are shown (based on Thompson, 1982a).

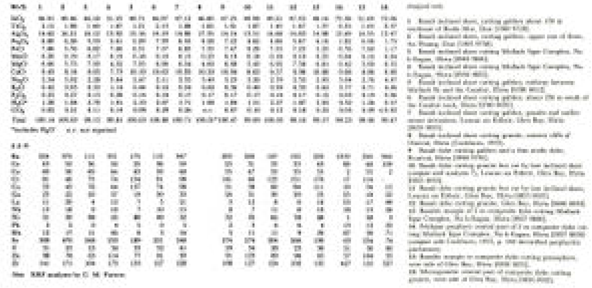

Table 29 Analyses of inclined sheets and dykes from Hirta, and Dun, St Kilda.

Chapter 16 Minor intrusions. Geochemistry

Keywords: chemical analysis, magma mixing and differentiation

Chemical analyses of 24 minor intrusive rocks from St Kilda were carried out; 16, representing the range, are given in (Table 29). A chemical classification of the rocks is based on the scheme of Irvine and Baragar (1971) and uses normative values recalculated after the manner of Thompson and others (1972) in which the values for Fe_2O_3 are adjusted to 1.5% or 2% depending on the alkali content of the rock. This scheme shows that a range of basaltic compositions is present, with most being classified as olivine + hypersthene normative tholeiites and only a small number being quartz normative. Only a few sheets are strongly quartz normative basaltic andesite, although one cuts the Mullach Sgar Complex at the northern end of Na h-Eagan [NM 0937 9850], and is comparable with some mafic pillows (Phase 3) within the Mullach Sgar Complex itself. The composition of the inclined sheet is probably a mixture of basaltic magma and granitic or sedimentary material as a partially resorbed quartz xenocryst can be seen in thin section. Cockburn (1935) recorded partially resorbed quartz crystals in another inclined sheet below Mullach Bi (Figure 27B). Some olivine + hypersthene normative basalts fall in the alkaline field of a Ne′Ol′Q′ triangular diagram (Irvine and Baragar, 1971) and the compositions of two late sheets are nepheline normative. The analysis of one marked R in (Figure 24B), is given in (Table 29), col. 7, and the other, which cuts the granite on Oiseval, appears in col. 8.

The range of normative values is shown in (Figure 29), and this distribution of the compositions is consistent with that of a series of rocks which have undergone fractionation at low pressure, suggesting that the St Kilda rocks were derived from a high level magma chamber. These were possibly developed within the continental basement since crustal contamination of the basalts can be demonstrated on a TiO_2 –K_2O–P_2O_5 diagram (Figure 28). The St Kildan basalts become increasingly potassic at a fairly constant ratio of Ti:P and follow a similar trend to basalts from Ardnamurchan which only differ in lying closer to the P_2O_5 apex. Thompson (1982a) has demonstrated that such enrichment in potash in the Ardnamurchan cone sheets cannot be due to closed system fractionation and is therefore due to contamination by sialic crust. However two rocks, one from a sheet cutting gabbro at Ruaival, the other from a sheet cutting gabbro at An Fhaing, Dun, are enriched in phosphorus and lie close to the trend for closed system fractionation. High values for other trace elements in these two rocks with corresponding low values for Ni and Cr are a further indication that fractionation has occurred. Geochemically the basic minor intrusives are similar to basalts from other Tertiary centres in that they possess low trace element abundances relative to typical continental tholeiitic rocks, but differ in respect of the proportions of these trace elements. In addition to differences in Ti–K–P proportions noted above, the St Kildan rocks have higher yttrium : zirconium ratios (0.15–0.27) than most basalts in the British Tertiary Volcanic Province, these ratios being exceeded only in sheets cutting the submarine Blackstones igneous complex WSW of Mull (Durant, unpublished data).

Analyses of both basic and acid components of two composite dykes are given in columns 13–16 of (Table 29). In both intrusions the outer part is basaltic and the inner is granitic. Both granitic components differ petrographically but have a similar SiO_2 content of 72%, which, along' with Ca, Mg and Fe values, lies between those for the Glen Bay Granite (69%) and the Conachair Granite (76%).

Post magmatic alteration of the minor intrusions is indicated by high Fe_2O_3:FeO ratios. This is consistent with the presence of abundant hydrous minerals, zeolites, calcite and epidote in some rocks and suggest that there has been considerable local hydrothermal alteration.

Analysed rocks

1. Basalt inclined sheet, cutting gabbro about 150 m southeast of Bioda Mor, Dun [NM 1060 9728].
2. Basalt inclined sheet, cutting gabbro, upper one of three, An Fhaing, Dun [NM 1005 9758].
3. Basalt inclined sheet cutting Mullach Sgar Complex, Na h-Eagan, Hirta [NM 0940 9840].
4. Basalt inclined sheet cutting Mullach Sgar Complex, Na h-Eagan, Hirta [NM 0930 9832].
5. Basalt inclined sheet cutting gabbro, midway between Mullach Bi and the Cambir, Hirta [NM 0780 0012].
6. Basalt inclined sheet cutting gabbro, about 250 m south of the Cambir neck, Hirta [NM 0780 0035].
7. Basalt inclined sheet cutting gabbro, granite and earlier minor intrusions, Leacan an Eitheir, Glen Bay, Hirta [NM 0855 0035].
8. Basalt inclined sheet cutting granite, eastern cliffs of Oiseval, Hirta (Cockburn, 1935).
9. Basalt dyke cutting gabbro and a thin acidic dyke, Ruaival, Hirta [NM 0948 9795].
10. Basalt dyke cutting granite but cut by late inclined sheet *(compare with* analysis 7), Leacan an Eitheir, Glen Bay, Hirta [NM 0855 0035].
11. Basalt dyke cutting granite but cut by late inclined sheet, Leacan an Eitheir, Glen Bay, Hirta [NM 0855 0035].
12. Basalt dyke cutting granite, Glen Bay, Hirta [NM 0840 0030].
13. Basaltic margin of 2 m composite dyke cutting Mullach Sgar Complex, Na h-Eagan, Hirta [NM 0937 9830].
14. Feldspar porphyry central part of 2 m composite dyke cutting Mullach Sgar Complex, Na h-Eagan, Hirta [NM 0937 9830] *(compare with* Cockburn, 1935, p. 542 devitrified porphyritic pitchstone).
15. Basaltic margin to composite dyke cutting granophyre, west side of Glen Bay, Hirta [NM 0836 0032].
16. Microgranitic central part of composite dyke cutting granite, west side of Glen Bay, Hirta [NM 0836 0032].

Wt%	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SiO_2	46.91	49.46	46.18	51.25	49.71	46.97	47.12	46.80	47.25	49.94	49.21	47.32	48.16	72.38	51.69	72.06
TiO_2	2.15	1.98	1.40	1.87	1.21	2.13	1.88	1.85	1.81	1.87	1.45	1.47	1.37	0.25	1.63	0.37
$A1_2O_3$	14.62	16.21	16.12	13.92	15.16	14.19	14.80	17.35	14.16	13.51	14.68	14.83	14.98	13.69	14.35	13.47
Fe_2O_3	6.80	6.28	5.33	5.61	5.29	7.39	6.53	4.28	7.22	4.62	4.84	5.47	6.16	1.82	4.06	1.75
FeO	7.86	5.76	6.82	7.60	6.31	7.57	6.83	7.33	7.47	9.29	7.55	7.25	5.25	0.76	7.60	1.17
MnO	0.20	0.19	0.17	0.19	0.18	0.19	0.15	0.23	0.19	0.18	0.18	0.19	0.25	0.04	0.16	0.04
MgO	6.66	5.75	7.93	4.52	7.35	6.90	6.54	4.60	6.68	5.43	6.92	7.58	6.81	0.42	5.69	0.55
CaO	9.43	8.14	9.65	7.73	10.19	10.63	10.93	10.20	10.04	8.63	9.57	9.96	10.68	0.66	8.86	0.60
Na_2O	2.54	3.02	2.28	3.64	2.47	2.11	3.55	3.40	3.23	3.26	2.70	2.53	2.93	5.04	2.76	4.97
K_2O	0.42	0.95	0.33	1.14	0.44	0.16	0.24	0.60	0.36	0.49	0.39	0.33	0.62	3.77	0.71	4.06

P_2O_5	0.22	0.27	0.15	0.28	0.14	0.18	0.17	0.17	0.17	0.17	0.14	0.17	0.12	0.03	0.19	0.06
H_2O^+	1.28	1.84	2.70	1.91	2.10	2.07	1.71	1.80	1.84	1.51	2.27	1.87	2.02	0.32	1.26	0.57
CO_2	0.02	0.21	0.11	0.14	0.09	0.29	0.26	n.r.	0.07	0.10	0.12	0.18	0.22	0.05	0.09	<0.02
Total	100.14	100.83	99.15	99.81	100.63	100.80	100.71	100.01*	100.47	99.00	100.03	99.16	99.57	99.23	99.06	99.67
p.p.m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ba	224	375	111	331	175	113	347		203	260	167	152	220	1019	244	944
Ce	43	53	36	50	25	38	59		23	31	33	33	49	98	48	109
Co	60	50	69	44	63	59	48		55	47	53	55	55	2	55	2
Cr	81	40	73	74	154	91	98		141	46	125	151	170	17	114	
Cu	53	43	78	44	137	74	98		31	38	60	84	111	19	54	15
Ga	25	22	29	37	19	30	33		24	31	30	20	25	25	18	22
La	11	20	4	12	7	5	21		3	12	8	6	16	53	17	49
Nb	13	18	9	10	7	10	15		8	7	11	8	10	18	13	26
Ni	51	50	98	25	89	49	52		52	35	62	78	80	1	50	3
Pb	3	2	0	4	5	0	5		2	3	6	6	4	13	12	22
Rb	12	17	11	65	8	3	16		5	11	11	9	20	87	20	71
Sr	309	470	248	253	189	221	240		274	274	204	266	199	63	254	74
Y	31	25	23	34	33	32	61		29	34	28	25	36	51	30	60
Zn	98	78	63	114	77	81	93		91	123	89	96	65	57	104	55
Zr	141	171	104	173	133	127	228		108	127	124	102	135	427	155	527

* *includes H_2O^-
- n.r. not reported
- Note: XRF analyses by C. M. Farrow.

References

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