# Geochemistry of the major intrusions - St. Kilda: an illustrated account of the geology

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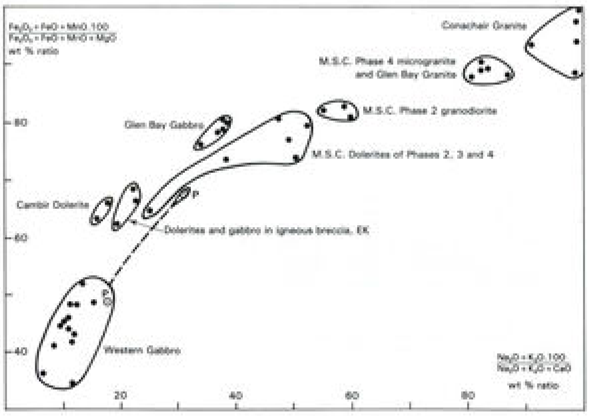


Figure 42 Iron-magnesium and alkali-calcium ratios of the major St Kilda intrusions

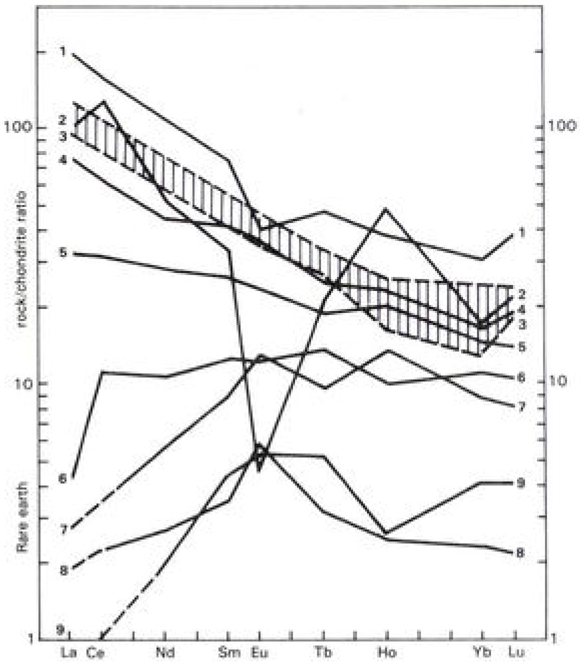


Figure 43A Chondrite normalised (Haskin and others, 1968, average of 9 chondrites) REE abundances versus atomic number for St Kilda rocks. 1 Glen Bay Granite, RR239. 2 Conachair Granite, RR322. 3 Dotted lines enclose an area representing dolerites, diorites and microdiorites of Phases 2, 3 and 4 in Mullach Sgar Complex, RR181C, 184, 185, 298A, 301A. 4 Glen Bay Gabbro, H7287. 5 Basaltic dolerite, Glacan Mor, RR311B. 6 Banded gabbro, Boreray, RR369B. 7 Cambir Dolerite, RR265. 8 Western Gabbro Type 2, H7640. 9 Western Gabbro Type 1, RR341B. Analyst: Dr S. J. Parry

Figure 43B Acicular red brown chevkinite 0.5 mm long in quartz and turbid alkali feldspar lies adjacent to amphibole and opaque grains. Glen Bay Granite, S67633, plane polarised light.

# Chapter 23 Geochemistry of the major intrusions

**Keywords: chemical ratios, major rock groups, rare earth element patterns**

This section attempts to explore some of the relationships of the St Kilda igneous rocks by plotting their chemical compositions on appropriate variation diagrams. In (Figure 42) the iron–magnesium ratio of each rock is plotted against its alkalis-calcium ratio. Each of these ratios is a measure of how well differentiated or how mixed a particular rock may be and although the ratios must be used cautiously they provide some measure of the relationships amongst a variety of rock types in one igneous centre. Analysed samples of the Western Gabbro occupy a field with the lowest iron ratio but is similar to the Cambir Dolerite field in its alkali–lime ratio. Likewise the Cambir Dolerite has iron ratios similar to both basalts in the breccia EK and to some Phase 3 dolerites in the Mullach Sgar Complex, but the different alkali ratios in these three groups of rocks suggest that they have arisen in different ways. Two pegmatites from the Western Gabbro (*P* in (Figure 42)) are perhaps the closest approximation to compositions of residual liquids resulting from solidification of the Gabbro. The alkali ratio of the upper pegmatite point (Figure 14A) is similar to ratios in the Glen Bay Gabbro but the iron ratios are different. The Glen Bay Gabbro crystallised from a tholeiitic magma with a composition assumed to be that of the chilled margin in east Glen Bay and produced pegmatitic residues richer in potassium, phosphorus and rare earth elements than the $E^w$ pegmatites. Such differences suggest that the Western Gabbro and Glen Bay Gabbros are genetically unrelated.

In the Mullach Sgar Complex some dolerites of Phase 3 are relatively low in iron and alkalis but other Phase 3 dolerites and those of Phase 2 and 4 are higher and approach the ratios found in Phase 2 granodiorite, being distinguished chemically by lower $K_2O$ contents and petrographically by finer grain size. The latest granite phase (4) in the Complex has ratios quite separate from the granodiorite but they are indistinguishable from those of the Glen Bay Granite. This coincidence demonstrates that although the fields in (Figure 42) appear to indicate a correlation between chemical composition and sequence of intrusion, from oldest Western Gabbro to youngest Conachair Granite, in fact at the high alkali end the Glen Bay Granite is the earliest of the granitic intrusions predating those of the MSC, whereas at the low alkali end relatively magnesian dolerites were intruded quite late in the Mullach Sgar Complex.

A similar overall pattern of progressive variation in chemistry with age is also suggested by the rare-earth element (REE) contents plotted in (Figure 43A) as rock to chondritic meteorite ratios. Again however, in detail, such correlation is false since the earliest granite (Glen Bay) has the greatest enrichment of REE's with La being 200 times and Lu 40 times more abundant than the average chondrite. The younger Conachair Granite has only 100 times the chondrite La content and shows a pronounced negative Eu anomaly, distinctive among the REE patterns of St Kilda rocks. Its Eu content is the same as that of the Western Gabbro but here the rest of patterns 8 and 9 are almost mirror images of that of the Granite, with low enrichment (8) or even depletion (9) of the light REE's and 2 and 4 times chondrite content of the heavy REE's. The Cambir Dolerite pattern (7) is similar to that of $E^{w}$ with relative enrichment of heavy REE's but the two EK rocks (5 and 6) give almost flat patterns with equal enrichment (10–30 times) of light and heavy REE's. The Glen Bay Gabbro is significantly enriched in light REE's and its pattern is very similar to those of the Mullach Sgar Complex rocks. Close links between these intrusions are also indicated by their similar initial $^{87}Sr/^{86}Sr$ ratios (about 0.7041, (Figure 40)) and by the presence of rare-earth minerals. Three minerals with significant REE contents occur in pegmatites related to the Glen Bay Gabbro and also in the three main granites. Chevkinite has the highest content of REE's (41%), and is a common accessory mineral in the granites of Glen Bay (Figure 43B), Mullach Sgar and Conachair. It is very enriched in the light REE's and resembles allanite in this respect, although the latter is poorer in total RE contents (22%). Allanite occurs in the Mullach Sgar granites and in pegmatites of the Glen Bay Gabbro where it is associated with zirkelite (Figure 14C), a Zr–Y titanate relatively low in total RE content (7%) and displaying a significantly different REE pattern (Nd> Ce) from that of allanite. The differing mode of crystallisation of these three minerals appears to be reflected in the patterns 1, 2, 3 and 4 of (Figure 43A), forming a group of light REE-enriched rocks. Zirkelite crystallised in residual liquids derived from solidification of basic magma (pattern 4), one of which was perhaps already partially depleted in light REE's by crystal fractionation processes. Chevkinite and allanite crystallised from more granitic magma enriched in light REE's (patterns 1, 2 and 3). The similarity between patterns 1, 3 and 4 suggests that these rocks may be related through fractionation to a common parental magma. However the distinctly different pattern 2 of the Conachair Granite is not easily linked to the same fractionation event. It shows a strongly negative Eu anomaly which is only mirrored by the positive Eu anomaly displayed by the cumulates of the Western Gabbro, and it seems more likely that a separate fractionation process links these two intrusions.

The geochemical data corroborate field and petrographical evidence suggesting that the major intrusions on St Kilda fall into two major groups. The first, a group of mafic rocks, comprises the Western Gabbro, Cambir Dolerite and the rocks of Glacan Mor, Boreray and Soay. In (Figure 42) this group is characterised by low alkali–lime ratios and in (Figure 43A) by a lack of light REE enrichment. The second group range from mafic to granitic compositions and not only have higher alkali and iron ratios but also contain more K, P and REE's, relatively enriched in the light elements. Several members of this second group appear to be related through fractionation to a parental tholeiitic magma of the Glen Bay type. Relationships among the first group are less clear: if the Conachair Granite is related by fractionation to the Western Gabbro, this might explain the relative depletion of the latter in REE's and low alkali and iron ratios. Further sampling of the breccia EK may reveal rocks intermediate between these two groups, and indeed may indicate components from even more sources.

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