Platinum-group element and osmium isotope evidence for the origin of Scourie Dykes

L.R. Frick
D.D. Lambert
Victorian Institute of Earth and Planetary Sciences, Department of Earth Sciences, Monash University, Wellington Road, Clayton, Victoria 3168, Australia.

S.J. Reeves
Victorian Institute of Earth and Planetary Sciences, School of Earth Sciences, University of Melbourne, Parkville, Victoria 3052, Australia.

L.M. Heaman
Department of Geology, Royal Ontario Museum, Toronto, Ontario M5S 2C6, Canada.

Introduction

The Scourie Dyke Suite is a series of mafic dykes which have intruded the Archaean (2.9 Ga) Lewisian Complex of northwest Scotland. Four distinct dyke types have been identified (Weaver and Tarney, 1981): (1) a quartz-dolerite suite, which make up over 90% of the swarm; (2) a suite of bronzite picrite dykes; (3) an olivine gabbro suite; and (4) a tholeiitic/noritic group. It is the last three groups which are of most interest. U-Pb baddeleyite (ZrO_2) dates for the dykes (Heaman and Tarney, 1989) give ages of 2418 ± 7 Ma for the bronzite picrite Beannach Dyke, and an age of 1992 ± 3 Ma for the olivine gabbro Strathan dyke, which is interpreted to be the emplacement age of the dyke. A norite dyke from Badcall bay was dated but the data were inconclusive due to the overprinting of the age by the 1.7 Ga Laxfordian metamorphic event. Sm-Nd data (Waters *et al.*, 1990) for the dykes give ages which are indistinguishable from the baddeleyite ages. A regression of combined Sm-Nd data for all the dykes yields an isochron age of 3.05 ± 0.27 Ga. Waters *et al.*, (1990) interpreted the data to indicate the contamination of the source for the dykes with small volume basaltic melts derived from the Lewisian crust. These melts are proposed to have provided the enrichment of LIL elements which characterise the geochemistry of the dykes. The study could not uniquely define the source of the dyke magmas, suggesting that they were derived from either the crustal or the mantle part of the lithosphere.

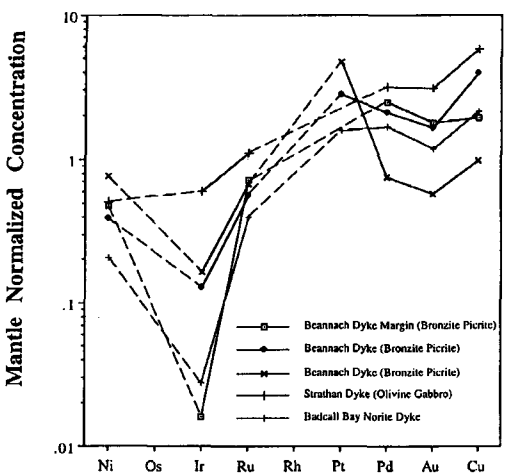

FIG. 1. Mantle normalized metal diagram for the Scourie Dykes.

Methods

Platinum-group element (PGE) data for the Beannach and Strathan dykes and the norite dyke at Badcall Bay are obtained by nickel sulphide fire assay preconcentration of PGE followed by radiochemical neutron activation analysis. Rhenium-osmium isotopic data are obtained by firstly a low blank acid digestion of the samples in a sealed Carius tube at 240°C followed by double distillation for osmium, and column chemistry for rhenium. Isotopic compositions are obtained by negative thermal ionisation mass spectrometry.

Results and discussion

Concentrations of PGE range between 3.2–13.6 ppb for Pd and 0.07–2.6ppb for Ir. The olivine gabbro Strathan Dyke recorded the highest PGE concentrations of all of the dykes, yielding values similar to estimated mantle concentrations (Barnes *et al.*, 1988). Mantle normalized metal diagrams for the three dykes (Fig. 1) have sloping patterns similar to the patterns obtained for high

magnesian basalts (Barnes *et al.*, 1988). The high PGE levels suggest that the source of the dyke magmas was enriched in the PGE, and is therefore likely to be the subcontinental lithospheric mantle, rather than the lower crust. Preliminary Re-Os data have been obtained for the PGE enriched olivine gabbro Strathan Dyke. Correction for the radiogenic growth of ^{187}Os from ^{187}Re using the measured $^{187}Re/^{188}Os$ ratio, and the baddeleyite age of the dyke of 1992 Ma result in an initial osmium isotopic composition less radiogenic that the CHUR model, yielding a large negative γ_{Os}. This preliminary finding suggests that the dyke was derived from a source which has experienced a long term depletion in rhenium as compared to the undepleted mantle. The evidence of depletion implies that the source has undergone two episodes of melting, the first which depleted the mantle in incompatible elements including rhenium, and the second which produced the PGE enriched high Mg dyke magmas.

Waters *et al.* (1990) suggested that the source for the dyke magmas was either the crustal or the mantle part of the subcontinental lithosphere. Due to the affinity of rhenium for crust, the subcontinental lithospheric crust will show evidence of radiogenic growth of osmium in the source (a positive γ_{Os}). The nonradiogenic nature of the source osmium defines the source of the olivine gabbro to be the depleted lithospheric mantle rather than the subcontinental crust. Further Re-Os data for the bronzite picrite and norite dykes will be presented to constrain the age of the rhenium depletion event.

References

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