Trace element and Sr, Nd, and Os isotopic systmatics of mafic granulite xenoliths from the Kerguelen Islands

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The Kerguelen hotspot became active at least 115 Ma ago, after the break-up of Gondwanaland. The Kerguelen mantle plume is responsible for extensive volcanism in the Indian Ocean basin, including the Ninetyeast Ridge, Broken Ridge and the Kerguelen Plateau, in the southern Indian Ocean (see references in, and Hassler and Shimizu, 1998 for a synopsis). The southern Kerguelen Plateau is one of the earliest known products of the Kerguelen plume (115 Ma), and the Ninetyeast Ridge tracks the northward migration of India, from >83 Ma to 43 Ma. Broken Ridge and its conjugate, the northern Kerguelen Plateau, erupted from 88 Ma until 43 Ma, when rifting was initiated along the Southeast Indian Ridge (SEIR). At this time, the plume was beneath the SEIR, but the northward migration of the SEIR left the plume in its present Antarctic intra-plate tectonic setting. The Kerguelen Islands, located on the northern Kerguelen Plateau, are the most recent of the Kerguelen plume volcanism (39 Ma to 0.4 Ma).

Xenoliths from the Kerguelen Islands, which occur in young alkaline dikes that cross-cut the Plateau lavas, can give information about the geodynamic evolution of the Kerguelen plume and its relationship to the formation of the Kerguelen Plateau. For example, discrete pieces of subcontinental lithospheric mantle were found in the northern Kerguelen Plateau lithosphere, determined on the basis of the Os isotopic composition of peridotite xenoliths from the Courbet peninsula, in the northeastern part of the Islands (Hassler and Shimizu, 1998). However, the geochemical characteristics of basalts from the Kerguelen Islands show no evidence of the involvement of continental material in their petrogenesis (Yang *et al*, 1998). The presence of mafic granulite-facies xenoliths from the Islands, a rare occurrence in oceanic environments, provides an opportunity to study the inaccessible lower crust of the Plateau. To this end we have undertaken a trace element and isotopic study of the granulites from the Courbet Peninsula. The goal of this work is to test if the granulites are cumulates from melts related to the SEIR mid-ocean ridge basalts (MORB), the Kerguelen plume, or a mixture of the two, and to determine if a continental geochemical signature is evident in these rocks.

Protoliths of the granulite xenoliths are gabbroic at varying stages of differentiation. Ilmenite-rich rocks appear to have a ferro-gabbroic precursor and are enriched in trace elements (*REE* > 10× C1 chondrites), in contrast to ilmenite-poor 'early-stage' rocks (*REE* <10× C1). Estimated trace element compositions of liquids in equilibrium with the granulite protoliths are variably *LREE* enriched, indicating that they may not be co-magmatic. These granulite-equilibrated liquids are within the ranges of trace element variations of basalts erupted on the Islands, indicating the possibility that the granulites are related to Kerguelen plume rather than MORB volcanism.

Whole rock $^{87}Sr/^{86}Sr$ ranges from 0.704464 ± 15 to 0.705144 ± 13 and $^{143}Nd/^{144}Nd$ from 0.512475 ± 8 to 0.512847 ± 9, also within the field of basalts erupted on the Kerguelen Islands. The dike that brought these xenoliths to the surface has $^{87}Sr/^{86}Sr = 0.706391 \pm 13$ and $^{143}Nd/^{144}Nd = 0.512428 \pm 5$, extending the enriched range of isotopic compositions of Kerguelen Islands basalts. Garnet-bearing granulite xenoliths from the Southeastern Peninsula have a slightly greater Sr and Nd isotopic range than the Courbet granulites ($^{87}Sr/^{86}Sr = 0.704222$ to 0.705234 and $^{143}Nd/^{144}Nd = 0.512540$ to 0.512883; Mattielli, 1996), also within the range of the isotopic variations of Kerguelen Islands basalts. Blank corrected $^{187}Os/^{188}Os$ of these samples range from 0.1285"3 to 0.1361"4 with Re/Os of 0.04 to 0.73 for ilmenite-poor samples, and 0.1340 ± 2, 0.1787 ± 4, and 0.1795 ± 16 with Re/Os of 1, 10 and 338 for the

Fe-Ti rich samples. Age correction of the granulites for isotopic ingrowth to 26 Ma, the age of Plateau basalts from the Courbet Peninsula, only significantly affects the most radiogenic sample, giving $^{187}Os/^{188}Os = 0.1601$.

On the basis of Rb-Sr, Sm-Nd, and Re-Os systematics, these rocks appear to be unrelated to Southeast Indian MORB and are more likely to have crystallized from Kerguelen plume related melts. The Os isotopic compositions of some of these granulites are as radiogenic as Kerguelen Islands basalts (to $^{187}Os/^{188}Os = 0.1727$; Yang *et al.*, 1998). In detail however, most of the Os isotopic compositions in granulites are significantly less radiogenic than Kerguelen Island basalts and are closer in composition to recent basalts erupted on Heard Island (e.g. $^{187}Os/^{188}Os = 0.1340$; Barling *et al.*, 1997). We interpret this as an indication that the Os isotopic composition of the Kerguelen plume is heterogeneous. Furthermore, the Sr and Nd isotopic signatures of the granulites show the strong EMI mantle signature of the Kerguelen plume, indicating that the Os isotopic composition of the EMI mantle end member could generally be heterogeneous. This heterogeneity reflects the varying contributions of recycled subcontinental lithosphere on small spatial and temporal scales.

References

Barling, J. *et al.* (1997) *Seventh Annual V.M. Goldschmidt Conference* **LPI Cont. 921**, 17–18.

Hassler, D.R. and Shimizu, N. (1998) *Science,* in press.

Mattielli, N. (1996) *Thesis*, Université Libre de Bruxelles.

Yang, H.-J. *et al.* (1998) *J. Petrol.* in press.