$^3He/^4He$ ratios in Kerguelen Archipelago basalts: new evidence for an undegassed mantle plume component

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Several submarine physiographic units including the Kerguelen Plateau–Broken Ridge (~85-115 Ma) and Ninetyeast Ridge (82–38 Ma) manifest the ~115 my eruption history of the Kerguelen Plume; however subaerial exposure of Kerguelen Plume lavas is limited to islands located on the Kerguelen Plateau such as the Kerguelen Archipelago and, perhaps, Heard Island. Lavas from Heard Island and the Kerguelen Archipelago range widely in Sr, Nd and Pb isotopic ratios, creating debate about the isotopic character of the Kerguelen Plume (Frey and Weis, 1996). Lavas from the Southeast Province of the Kerguelen Archipelago have Sr, Nd and Pb isotopic ratios that have been attributed previously to the Kerguelen Plume (Weis *et al.*, 1993). In an effort to evaluate alternative hypotheses, six olivine-rich basalts from the Southeast Province of the Kerguelen Archipelago have been analysed for helium concentration and isotopic ratio.

The Southeast Province includes basalts, trachyte and phonolites which range from 22–20 Ma and 10–7 Ma based on $^{40}Ar/^{39}Ar$ and K-Ar dating (Weis *et al.*, 1993; Nicolaysen *et al.*, 1996). Located 440 km southeast of the Kerguelen Archipelago, Heard Island has two Late Pleistocene to Holocene lava series which include a basanite to trachyte suite and a basanite– alkali basalt–trachybasalt suite. The Kerguelen Archipelago basalts chosen for this study contain porphyritic olivine and clinopyroxene crystals which commonly occur in cumulate clots. The olivine is subhedral to euhedral and generally 0.3–2 mm in diameter. Typically, olivine compositions range from $Fo_{88\text{-}53}$ and crystals generally contain few inclusions. Most olivines are normally zoned, but three samples contain reversely zoned olivine (cores $Fo_{\sim 60}$-rims $Fo_{\sim 83}$).

Helium data were determined on gases extracted by crushing olivine and pyroxene separates *in vacuo* (Kurz *et al.*, 1996). The $^3He/^4He$ ratios normalized to air (R_A) range from 7.4 ± 0.2 to 10.2 ± 0.1 for olivine separates; notably these values are lower and higher than the average value for mid-ocean ridge basalt (8.3 R_A). The pyroxene data show a similar, although slightly lower range (6.5 ± 0.3 to 9.8 ± 0.4 R_A). Samples with low ^4He content show the most isotopic variation (Fig. 1). Previous $^3He/^4He$ studies of Kerguelen Archipelago samples have been limited

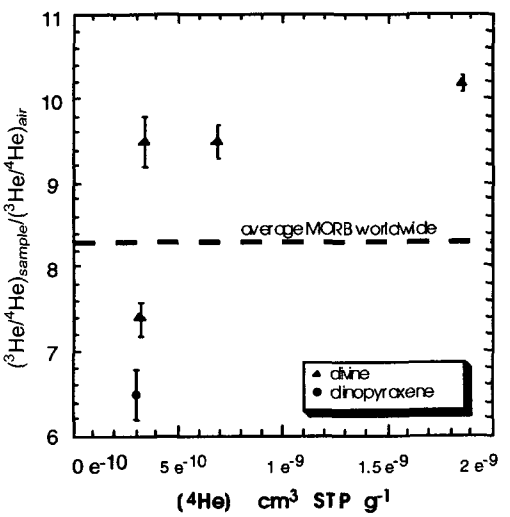

FIG. 1. Helium isotopic ratios *vs.* ^4He concentration. The error bars are 1 σ values.

to cpx from a single lava (R_A = 4.9) and xenoliths ranging from gabbro to dunite and harzburgite xenoliths (Valbracht *et al.*., 1996 and references therein). Helium results for crushed phases in these xenoliths are highly variable (R_A = 5.2 to 12.3) and encompass the range we find for basalt phenocrysts. Valbracht *et al.* (1996) concluded that Ne and He isotopic systematics of Kerguelen xenoliths "... preserve evidence for a primitive mantle component ...".

Some Kerguelen Archipelago and Heard Island basalts have helium isotopic ratios higher than MORB values, thereby indicating the presence of an undegassed source component. However, both island complexes have basalts also with He isotopic ratios less than average MORB (R_A = 8.3). Hilton *et al.* (1995) noted that complexly zoned phenocrysts from Heard have relatively low $^3He/^4He$ and conclude that these ratios were lowered by lithospheric assimilation. In contrast, reversely-zoned olivines from Kerguelen Archipelago basalts display the highest $^3He/^4He$ ratios. This suggests that a more mafic and relatively ^3He-rich magma, which is more representative of the plume, mixed with cumulate phenocrysts from evolved and largely degassed magma with low $^3He/^4He$.

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