Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 678

Noble Gases in Alpine-Type Peridotites from the Horoman Ultramafic Complex, Northern Japan

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Elemental and isotopic compositions of noble gases in the mantle provide important information regarding the kind and nature of earth's geochemical reservoirs and their differentiation histories. The alpine-type peridotites might be a suitable kind of samples for noble gas investigation, as they represent a larger portion of the mantle section (~kilometres) which is well greater than the scale inferred by xenolith samples (~centimetres). The Horoman peridotite complex, northern Japan, is one of the freshest orogenic peridotite complexes in the world. It consists of the Main Harzburgite-Lherzolites suite (MHL), with a subordinate spinel-rich dunite-wehrlite suite (SDW) and a minor banded dunite harzburgite suite. Noble gas elemental and isotopic compositions are determined for olivine separates or whole rock samples of these ultramafic rocks (so far six harzburgites and one dunite) for gases released either by step-heating or by crushing.

Our preliminary results revealed that the samples have a restricted range of $^{3}He/^{4}He$ ratios from 8.0 to 9.2 Ra (Ra = atmospheric $^{3}He/^{4}He$ ratio of 1.4×10^{-6}), while the abundance of helium varies by more than three orders of magnitude among the samples. The observed $^{3}He/^{4}He$ ratios are clearly of mantle origin, and agreed well with the values reported for samples from mid-oceanic-ridge environments. The ratios measured by crushing and by step-heating gas extractions agreed well each other, indicating that the mantle-derived helium is a component trapped in fluid inclusions. It should also be noted that $^{4}He/^{40}Ar^{*}$ ratios (1.5 ~ 3.1; $^{40}Ar^{*}$ = amount of radiogenic ^{40}Ar after subtracting atmospheric contamination) of the Horoman samples are quite consistent with the ratio predicted from a time-integrated production under the mantle K/U+Th ratio of 12700. Note that the most of reported $^{4}He/^{40}Ar^{*}$ ratios for MORBs showed generally elevated ratios (1 ~ 100) correlated with the amounts of ^{4}He, suggesting some elemental fractionation process favouring helium over argon. Only exception is the popping rock (i.e. MORB with extremely high vesicularity) which showed the $^{4}He/^{40}Ar^{*}$ ratios consistent with the production ratio.

It was suggested from the major and trace elemental and isotopic chemistry of the Horoman ultramafics that the complex was the MORB source mantle experienced variable melt extraction events at around 800 Ma ago (Yoshikawa & Nakamura, 2000). However, provided that fluid inclusions are clearly of secondary origin, and that the noble gases are highly incompatible upon melting, the MORB-like noble gas component now observed in the samples are not likely to be a simple residue of this earlier melt extraction at the ridge environment. Rather, fluid inclusions and associated noble gases should have been trapped by some fluid fluxing through mantle wall rocks. One possible process of noble gas acquisition by the samples would be so-called "regassing (Anderson, 1998)" of shallow upper mantle. At the active mid-oceanic ridges, volatiles exsolved from erupting magmas may have been partially trapped as fluid-filled inclusions and vugs in the shallow mantle and carry with them the $^{3}He/^{4}He$ ratios of the mantle source. The observed unfractionated $^{4}He/^{40}Ar^{*}$ ratios in fluid inclusions indicate that the Horoman mantle had acquired their noble gases at earlier stage of volatile exsolution from the MOR-magmas under ridge crest, as an evolved magma should have experienced volatile loss which would result in a significant enrichment in He over Ar as observed in many erupted MORBs (Moreira & Sarda, 2000). Another possible mechanism would be a metasomatic addition of noble gases by a slab-derived component when the Horoman complex was at the arc-setting (~23 Ma). Metasomatic addition of volatiles and a LREE-enriched component accompanied by formation of phlogopite veins has been recorded in the Horoman complex. However, unlike the common observations from currently active subduction settings, there is no evidence of relatively more radiogenic $^{3}He/^{4}He$ ratios than MORBs in the present set of samples. Noble gas analyses on samples with phlogopite vein or vein itself need to be carried out for further understanding the origin of noble gases in the Horoman ultramafics.

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