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Petrological evidence for arc-metasomatized peridotites beneath mid-ocean ridges

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Here we report for the first time petrological evidence of recycled subduction-modified mantle materials beneath the Mid-Ocean Ridge. We conducted several cruises with submersible SHINKAI 6500 dives and dredges in the south end of the Central Indian Ridges (Phenix knoll). We recovered orthopyroxene-rich lithologies coupled with peridotites and gabbros from a small knoll along the present mid-ocean ridge. The orthopyroxene-rich lithologies can be formed by magmatic processes beneath the present mid-ocean ridges by crystallization from ultra-depleted primary melts (Sobolev and Shimizu, 1993, Nature) in the Mid-Ocean ridge system. Orthopyroxene-rich peridotites are also commonly observed in peridotite bodies of suprasubduction ophiolites (e.g., Morishita et al., 2011 Lithos) as well as in several sub-arc xenoliths (McInnes et al., 2001 EPSL; Arai and Kida, 2000 Island Arc; Arai et al., 2004 J. Petrol; Shimizu et al., 2004 Trans. Royal Soc. London; Ishimaru et al., 2007 J. Petrol). It is also well known that 30% of continental upper mantle samples are enriched in OPX/olivine relative to residual peridotite from partial melting of the primitive mantle (e.g., Boyd, 1989 EPSL; Kelemen et al., 1998 EPSL). Silica-enrichment in the uppermost mantle section under island-arcs is explained by infiltration of silica-rich hydrous fluids/melts derived from subducting slabs. The Re-Os system also supports subduction-metasomatized peridotite origins for orthopyroxene-rich lithologies. The Re-Os isotope system is used for a tracer of recycled crustal materials because oceanic/continental crust possess high Re/Os (parent/daughter) ratios, and develop radiogenic Os isotope compositions over time, which can be readily traced as recycled material if mixed back into the convective mantle. We examined the Os-isotopic compositions of the representative samples: dunite, one harzburgite and one olivine-orthopyroxenite, without signs of petrological and chemical modifications caused by the formation of gabbroic veins. The orthopyroxenite is characterized by a distinctively high in radiogenic Os (187Os/188Os) isotope signatures (0.1475-0.1499) with relatively high in Re contents (382-402 ppt) whereas the Os isotope of the harzburgite is slightly lower than the present-day depleted MORB mantle (0.123-0.126). High 187Os/188Os ratio coupled with high Os and Re contents of the olivine-orthopyroxenite cannot be accounted for by in situ 187Re decay after interaction between MORBs and peridotites for a million years. Radiogenic Os isotope compositions have been reported for MORB glass, and attributed to the presence of recycled oceanic crust in the upper mantle. Mixing of depleted mantle with exotic component that have an isotopic component with high 187Os/188Os ratios, i.e., radiogenic Os components, are required for the sample. We evaluate the effect of metasomatism of mantle by slab-derived fluids or melts on Os systematics observed in the samples. We conclude that ancient subduction-modified mantle domains, probably formed at continental margin of the Gondwanaland, now exists beneath the Central Indian Ridge.

Keywords: Mid-Ocean Ridge, Mantle, Peridotite, arc, recycling