Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SGC55-P06 Room:Convention Hall Time:May 23 15:30-17:00

Redox condition in subduction system elucidated from Os in Cr-spinel from Bonin Island beachsands

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The Os isotopic system is a potential tracer of a recycled crustal component in mantle or volcanic rocks because of the significant contrast between Os isotope ratios of crust and mantle. It is because, fractionation between Re and Os during mantle partial melting leads to a significant contrast in ($^{187}Os/^{188}Os$ between high values ($^{187}Os/^{188}Os > 0.5$) in crustal rocks and low values (($^{187}Os/^{188}Os < 0.13$) in mantle rocks. For instance, a recycled ancient crustal component with high ($^{187}Os/^{188}Os$ is involved in the production of hotspot volcanic rocks in Polynesia (Hofmann, 1997). However, the potential for crustal contamination overprinting this possible signal has hampered the utility of Os isotopic ratios.

We explored the use of Os isotopes in chromian spinel (Cr-spinel) as a discriminator of primitive magma Os compositions in the Izu-Bonin arc, using beach sands as composite samples of the boninite and tholeiite magmas in three different islands. Cr-spinel is an early-stage crystal that7 preserves its isotopic composition even during later crustal contamination of the bulk rock. We found highly unradiogenic Os isotopic compositions in Cr-spinels from boninites, suggesting that they represent primitive magmas with slight or no Os contribution from the subducting slab during the generation of boninites in the infant arc stage (48-46 Ma). Conversely, the radiogenic Os isotopic ratios in Cr-spinels from tholeiites most likely reflect the contribution from a slab-derived component, because more oxidative conditions in the subarc mantle probably allowed Os to mobilize from the subducting slab during the transitional arc stage (45-41 Ma). Although shallow-level assimilation of crustal components with radiogenic Os may overprint the original Os signature of tholeiite magma during its ascent, Cr-spinel allows us to compensate such possibilities.

Possible mechanism for the difference in Os transfer from the subducted slab between the early stage and transitional stage of the Izu-Bonin arc system is redox condition in the wedge mantle. We suggest that during boninite formation in the infant arc stage, the mantle beneath the Izu-Bonin arc was not strongly oxidized, resulting in less mobile Os in the subduction system. This leads to minimal input of radiogenic Os derived from the subducting slab to the primitive boninite magma. During formation of the Mukoojima tholeiites, the mantle was well oxidized by continuous input of slab-derived fluid and/or melt, providing mobile Os to the source mantle. This may account for the oxidative chemical compositions of Cr-spinel and the elevated Os isotopic compositions in the mantle source of the Mukoojima tholeiites.

Keywords: osmium isotope, Cr-spinel, Bonin Islands, redox condition