

Geochemical connection between HIMU-FOZO-PREMA: link to chemical and water content variation in oceanic crust

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One of fundamental concepts of the geochemistry is an existence of mantle reservoirs. Namely, isotopic composition of the ocean island basalts (OIBs) are explained by mixing of distinct and isolated reservoirs in the Earth (White, 1985; Zindler and Hart, 1986; Hofmann, 1997; Stracke, 2012). In early research on the mantle reservoirs, the isotopic composition of OIBs was mainly explained by the mixing of depleted MORB mantle (DMM) and three enriched reservoirs, those are HIMU (high-u: $u = 238\text{U}/204\text{Pb}$) EM1 (Enriched Mantle 1) and EM2 (Enriched mantle 2) whose isotopic compositions are enriched extremes. In addition to these reservoirs, importance of reservoirs whose isotopic compositions are common and intermediate has been pointed out, these are, FOZO (Focal Zone, Hart et al., 1992), C (common component; Hanan and Graham, 1996), PREMA (Prevalent Mantle, Zindler and Hart, 1986) and PHEM (Primitive Helium Mantle, Farley et al., 1992). Although the existences of these intermediate reservoirs are still in debated, the isotopic compositions of these reservoirs, in particular FOZO, have been frequently used to describe the isotopic distribution of OIBs. Therefore, elucidating the origin of these reservoirs should be important from the perspective of production of mantle heterogeneity (e.g., Hofmann, 1997; Stracke et al. 2005; Stracke, 2012).

To evaluate the origin of high-u (HIMU), focal zone; (FOZO) and Prevalent Mantle (PREMA), geochemical modeling was conducted from the perspective of chemical fractionation at mid-ocean ridges and subduction zones. For the modeling, MORB compositions from the Mid-Atlantic ridge are compiled for seven trace elements (Rb, Sr, Nd, Sm, Pb, Th and U) and used as representatives of oceanic crust compositions. Effect of chemical fractionation at a mid-ocean ridge is estimated based on magnesium number and frequency distribution. The results suggest that the chemical fractionation at a mid-ocean ridge can produce moderately depleted isotopic compositions those are suitable for PREMA if the age of recycled MORBs is 1-2 Ga. It may follow that subduction modification is unnecessary for the production of PREMA, suggesting the importance of recycling of dry MORBs. Dehydration process at a subduction zone can produce FOZO isotopic signatures if degree of dehydration is high (4 %) that may represent maximum amount of dehydrated water. Thus, FOZO-PREMA isotopic array can be explained by mixing between recycled strongly dehydrated and dry MORBs. Consequently, PREMA-FOZO arrays could be produced by mixing between dry and dehydrated MORBs. For the production of HIMU, U and Th enrichment during crystal fractionation at mid-ocean ridge and Pb depletion owing to removal of sulfur during subduction is required in addition to FOZO production condition. As sulfur content in MORBs should be controlled by degassing process at a mid-ocean ridge, key processes that can differentiate HIMU from FOZO may be magma evolution process at mid-ocean ridge.

Keywords: HIMU, FOZO, PREMA, OIBs, recycling, mantle reservoirs