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

BPT25-10 Room:201A Time:May 24 12:00-12:15

# Pb isotope evolution of the HIMU reservoir; implications to recycling of U and Th in the mantle

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Geochemical heterogeneity in ocean island basalts and mid-ocean ridge basalts documents the presence of several mantle reservoirs. HIMU is one such mantle reservoir that has been considered to be formed by subduction and accumulation of ancient oceanic crust in the deep mantle. Consequently, basalts with the HIMU signature may record the processes that act on the oceanic crust some billion years ago, such as formation of oceanic crust, subsequent hydrothermal alteration and subduction modification.

The 'extreme' HIMU basalts occur in limited localities at St. Helena in the Atlantic and Cook-Austral Islands in the south Pacific. These lavas exhibit remarkably similar isotopic compositions with very high 206Pb/204Pb and 208Pb/204Pb, depleted Sr isotope, and enriched Nd and Hf isotopes, suggesting uniform geochemical compositions of the HIMU reservoir that exist at different places in the mantle. However, significant difference in 207Pb/204Pb is confirmed by isotope analyses with both whole-rock and clinopyroxene; the St. Helena lavas show systematically higher 207Pb/204Pb for a given 206Pb/204Pb than the Cook-Austral lavas. This is explained by various formation age of the reservoir. The Pb isotope evolution model demonstrates that portions of the HIMU reservoir for St. Helena and Australs were formed at approximately 2.2 Ga and 1.8 Ga, respectively.

The relationship between 206Pb/204Pb and 208Pb/204Pb reflects time-integrated Th/U (or kappa = 232Th/238U) of the source. Both St. Helena and Austral lavas demonstrate that time-integrated Th/U of the HIMU reservoir is approximately 3.7, which is close to the chondritic Th/U (4.0) and is much higher than Th/U of the present-day MORB and depleted mantle (2.6). This indicates that the ancient oceanic crust, that is the precursor of the HIMU reservoir, had different Th/U from the modern MORB. Indeed, sub-seafloor alteration and subduction dehydration would decrease and increase Th/U in oceanic crust, respectively, but the net effect would be reduction of Th/U ($< 2$) in the subducted oceanic crust (Becker et al., 2000). Consequently, the depleted upper mantle at the time when the HIMU reservoir was formed (1.8-2.2 Ga) must have had higher Th/U than at present. This is consistent with the model in which the Archean and early Proterozoic depleted mantle had chondritic Th/U and then the value decreased to the present due to selective recycling of U, relative to Th, from continent back into the mantle (Elliott et al., 1999). Slightly lower Th/U in the HIMU reservoir (3.7) than the chondritic (or Archean depleted mantle) value (4.0) suggests either that the HIMU reservoir was formed by subduction of both fresh and altered parts of oceanic crust, that it was formed by hybridization of subducted oceanic crust with primitive mantle, or that the hydrothermal alteration did not lower Th/U so drastically under less-oxidized condition in the Archean (and possibly early Proterozoic) hydrosphere.

Becker et al., Chem. Geol. 163, 65-99 (2000)
Elliott et al., Earth Planet. Sci. Lett. 169, 129-145 (1999)

Keywords: HIMU, mantle recycling, U and Th, ancient mantle