The genesis of high magnesium andesites and basalts from Shodoshima in the Setiuchi district, southwest Japan

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The genesis of high magnesium andesite (HMA) magmas in subduction zones is one of the most important issues of earth science. Results of high pressure melting experiments of peridotites demonstrated that two processes could form HMA magmas in the mantle, partial melting of hydrous peridotites at P ≥1GPa and partial melting of anhydrous peridotites at P ≤0.6 GPa (Kushiro, 1969, 1972, 1974, 1996; Falloon et al., 1988; Hirose and Kawamoto, 1995; Hirose, 1997; Wood and Turner, 2009) .
The Setouchi HMAs distributed Shodoshima in SW Japan is considered to be formed by a reaction between slab-derived felsic melts and the mantle, a type of flux melting of peridoties (Shimoda et al., 1998; Tatsumi, 2006). The mantle/melt reaction model, however, has an insolvable petrological problem. Results of high pressure melting experiments indicate that the model requires additional processes forming a temperature difference larger than 150 °C in the mantle at a given pressure to explain the genetic relationships between HMAs and basalts coexisting in Shodoshima (Shimoda et al, 1998). The additional process has not been proposed by researchers advocating the mantle/melt reaction model.
Addition to this petrological incongruity, the mantle/melt reaction model is not consistent with seismic and geologic background of Shodoshima. The model considers that hydrous felsic melts would have been derived from sediments on the subducting Shikoku Basin lithosphere. The deep seismic zone representing the subducting slab, however, is not clear beneath Shodoshima, which implies that the subducting slab would not extend there even at the present day. The Setouchi magmatism occurred at around 14 Ma, which is the post period of the Takachiho Orogeny (20 –15 Ma). During the orogeny, the Shimanto accretional belt was uplifted (Sakai, 1990), which indicates a strong mechanical coupling between the SW Japan lithosphere and the Shikoku Basin lithosphere at that time. Under such a strong mechanical coupling between lithospheres, sediments on the Shikoku Basin would not have subducted effectively in the mantle. Instead, sediments would have been accreted to the SW Japan lithosphere. Sediments on the Shikoku Basin therefore would not have been transported beneath Shodoshima if the subducting slab reached there at that time. These seismic and geologic incongruities erode the confidence of the mantle/melt reaction model for the genesis of the Setouchi HMA magmas in Shodoshima.
Instead, these petrologic, seismic and geologic features indicate that the association of basalts and HMA in Shodoshima would have been formed by multi-stage partial melting of relatively anhydrous source mantle. The basalt magmas would have segregated at P > 1GPa and the HMA magmas would have finally segregated at P = 0. 5 GPa. In the context of the multi-stage partial melting model, geochemical features of the HMAs attributed to subducting sediments would be a result of involvements of accretional oceanic sediments at the base of the crust in the source mantle. This is consistent with results of an integrated seismic experiment across Setouchi implying forearc accretional belts such as the Sambagawa belt and/or the Shimanto belt gwould extend to the base of the crust beneath Shodoshima (Ito et al., 2009).

Keywords: high magnesium andesite, basalt, multi-stage partial melting

