A model of low-pressure partial melting of the anhdyrous source mantle for the genesis of the Setouchi high magnesium andesites from Southwest Japan

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The Setouchi high magnesium andesites (HMAs) are regarded as evidence for the active mantle upwelling models, such as mantle plumes, for the Japan Sea opening. The mantle/melting model for the genesis of the Setouchi HMAs, which considered that the HMA magmas would have been formed by reactions with hydrous felsic melts derived from sediments on the subducting slab and the mantle wedg, leads us such an interpretation. The mantle/melt reaction model for the Setouchi HMAs, however, have critical weak points. (1) There is no successional and petrographical evidence indicating the HMA magmas would have been significantly hydrous. (2) The HMAs associate with basalts in some localities, such as Shodoshima. The mantle/melt reaction model requires an unrealistic temperature variation such as larger than 150 °C at 1GPa to explain the association of basalts and HMAs in Setouchi. (3) Geochemical features are considered to be strong evidence indicating contributions of sediments on the subducting slab to the HMA magma genesis. SW Japan, however, is composed of accretional prisms. Geochemistry could not distinguish which contributed to the HMA magma genesis, subducting sediments on the slab or accreted sediments at the deeper part of the crust. Therefore, Mashima (2009) proposed an alternative model for the HMA magma genesis that proposes HMA magmas would have been formed partial melting of relatively anhydrous mantle involving accreted sediments at low pressures such as 0.5 GPa. Accumulations of geological, geophysical and petrological observations support the low-pressure and anhydrous partial melting model for the Setouchi HMAs.

The Setouchi HMAs are distributed in the Nankai subduction zone where a young oceanic lithosphere, the Shikoku Basin meets the Eurasian Plate. Along the back arc coast, the late Miocene San' in folded zone is developed. Deep earthquakes representing the subducting slab are not observed beneath Shodoshima, which indicates that the slab would not extend there even at the present day. The slab would not also have extended there at 14 Ma. Geophysical observations along the Muroto, where the youngest part of Shioku Basin subducts, indicate that sediments on the slab would not subduct but accrete to the overriding plate at the present day. Since the slab at 14 Ma was younger and hence more buoyant than that at the present day, mechanical coupling between the plates would have been stronger than that at the present day. Sediments on the slab, therefore, could not have subducted into the mantle but have accreted to the overriding plate at that time. Seismic explorations indicate that the MTL striking northern margin of the Sambagawa Belt dips northward to extend to Shodoshima, which indicates that the deeper part of the Setouchi crust would be essentially composed of accreted oceanic materials such as sediments. This interpretation is confirmed by xenoliths of partial pelitic schists included in Setouchi volcanic rocks from Osaka.

As mentioned above, the HMAs from Shodoshima lack successional and petrographical evidence indicating that they would have been significantly hydrous. The body of evidence indicates that geochemical features of the HMAs, which were attributed to sediments on the subducting slab, would have been derived from accreted sediments at the deeper part of the crust. The normative olivine –quartz –Jd + CaTs compositions indicate that the HMA and the basalt would have been segregated at 0.7-0.5

GPa and 1.5 GPa from their source mantle. The San’in folded zone developed in the late Miocene indicates that the Setouchi crust at 14 Ma would have been thinner than that at the present day, which would have enabled the segregation of the HMA magmas at such a low pressure. The Setouchi basalt-HMA association would have been formed by multi-stage partial melting of the heterogeneous source mantle at pressures ranging from 1.5 to 0.5 GPa. The Setouchi HMAs therefore could not be regarded as evidence for the active mantle upwelling models, such as mantle plumes, for the Japan Sea opening.

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