Melting of metasomatized lithospheric mantle by mantle plume: geochemical evidence from the Yokota alkali basalt province

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Trace element and Sr-Nd-Pb isotopic data suggests that Yokota alkali basalt lavas were derived from melting of metasomatized lithospheric mantle. The melting was induced by heat and melt fluxes from a mantle diapir. Yokota alkali basalt lavas have extremely high Sr and LREE contents and negative Nb-Ta anomalies. Nd-Sr isotope ratios of the lavas plot on a mixing line between MORB and Bulk Earth compositions. Conventional Pb isotope plots suggest mixing between a MORB-like endmember and an EMII-like component. However, due to the extremely high Sr contents (1000-3000 ppm), single-step fluid-fluxed melting cannot produce the Yokota lavas. Small degrees of melting of metasomatized mantle may be an appropriate solution. To test this, we examined a melting model at 30-40 kbar with 5% melting. Calculated trace element compositions of the mantle source suggest addition of 10% fluid to a moderately depleted MORB source mantle (5% MORB extracted). The trace element composition of the hypothetical fluid is very similar to that of carbonates in metasomatized mantle xenoliths (Ionov & Harmer, 2002), suggesting CO2 fluid metasomatism. Mixing calculations were applied using the Nd, Sr, and Pb isotopic compositions of Yokota lavas and estimated metasomatized mantle source. In this case, we found that EM I has the only suitable isotopic composition for the metasomatizing fluid. EM I isotopic signatures frequently occur in CO2-rich magmas in continents. Existence of such fluids beneath SW Japan is not surprising, because lithospheric mantle in this area has been in a continental margin environment for a lengthy period. The isotopic composition of the metasomatized mantle source remains intermediate between MORB and Bulk Earth. Further enrichment in the EM II component in Yokota lavas would have occurred by mixing of enriched alkali basalt. None of the fluids or sediment melts generated are appropriate for mixing endmembers, due to unrealistically high mixing rates which are not attainable in nature. EM II type alkali basalts were produced contemporaneously at Kannbe (1.7-0 Ma) near Yokota (2.4-1.0 Ma), and therefore the EM II alkali basalt mixing endmember assumed above is appropriate to generate the mixing curves found in Yokota lavas. A mantle diapir model seems to be a practical method of achieving the required mixing between lithospheric and EM II type alkali basalt melts. Melting of metasomatized lithosphere would have been induced by addition of conductive heat as well as by heat transfer by EM II type basalt dikes from the diapir. Both lithospheric and asthenospheric alkali basalt melts would have mixed, and were subsequently erupted to produce the Yokota alkali basalt province. Temporal-spatial expansion of eruption centers may reflect incubation and flattening of the EM II mantle diapir head at the base of the metasomatized lithosphere. The volcanological evidence also supports our conclusions.