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Origin of enriched mantle component of the Cenozoic intraplate continental volcanism in Northeast Asia: Constraints from the Quaternary Hantan River Basalts, Central Korea

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Cenozoic intraplate continental volcanism in Northeast Asia is interpreted to have occurred above the Big Mantle Wedge (BMW), formed by westward subduction and stagnation of the Pacific Plate in the mantle transition zone. These volcanic rocks, mainly alkali basalts, display ocean island basalt (OIB)-like geochemical characteristics with variable contributions from an EM1-type enriched mantle component.

This study examines the origin of the enriched mantle component using petrochemical and isotopic data from the Quaternary Hantan River Basalts (HRB), central Korea. The HRB consists of massive lava flows erupted between 0.51 and 0.15 Ma that filled the NE–SW-trending Chugaryeong fault valley. The basalts range from alkali basalt to trachybasalt (SiO_2 = 47.5–49.7 wt.%; MgO = 8.1–10.3 wt.%) and exhibit OIB-like enrichment in light rare earth elements (LREE) and highly incompatible elements.

Sr ($^{87}Sr/^{86}Sr$ = 0.70443–0.70522), Nd ($^{143}Nd/^{144}Nd$ = 0.51255–0.51269), and Pb ($^{206}Pb/^{204}Pb$ = 17.629–17.869; $^{207}Pb/^{204}Pb$ = 15.515–15.568; $^{208}Pb/^{204}Pb$ = 38.312–38.619) isotopic ratios indicate the presence of an EM1-type mantle component, common in Cenozoic intraplate basalts of Northeast Asia. Major-element log-ratio analysis suggests that mafic lithologies contributed to the parental magma. The relatively low CaO/Al_2O_3 ratios (0.48–0.55) of the olivine-fractionation-corrected primary magma are consistent with melts derived from an EM1-like source, implying that the enriched mantle component originated from mafic lithologies.

Estimated melting conditions (1,451–1,488 °C and 2.4–2.9 GPa) indicate derivation from a heterogeneous upper mantle containing mafic components in the spinel-lherzolite stability field. These mafic components are interpreted to have originated from recycled crustal materials introduced by ancient subduction or lithospheric delamination during Paleozoic to Mesozoic crustal growth in Northeast Asia. Strong enrichment in K and Pb suggests that sediment-derived fluids released from the stagnant slab enhanced metasomatism and partial melting of mafic lithologies in the heterogeneous upper mantle. Wet plume upwelling above the stagnant slab likely intensified this process, producing the enriched mantle signature observed in Cenozoic intraplate volcanism above the BMW.