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Diverse recycled Paleo-Asian oceanic materials control the formation of Cenozoic basalts from the western North China Craton

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Subduction of the Paleo-Asian oceanic slab was proposed to have significantly modified the deep lithosphere beneath the North China Craton (NCC). However, whether this slab contributes to the formation of widespread basaltic magmatism in the NCC remains highly controversial. Here, we examine mineral chemistry, whole-rock geochemical and Sr–Nd–Pb–Hf isotopic compositions of Cenozoic Liangcheng basalts from the western NCC, to investigate their source lithology, melting conditions and residual mineral assemblages, and to explore the potential contribution of the subducted Paleo-Asian oceanic materials on the source of these basalts. The Liangcheng basalts are mainly alkaline basalts with moderate SiO_2 (45.2–49.0 wt.%) and low CaO (6.70–9.36 wt.%) but high TiO_2 (1.77–2.60 wt.%), $(Fe_2O_3)_T$ (10.1–12.2 wt.%) contents. The low CaO, high Ni concentration and Fe/Mn, Zn/Fe ratios of olivine phenocrysts, together with the high whole-rock Fe/Mn ratio and FC3MS, FCKANTS values, suggest the silica-deficient pyroxenite as their source lithology. The partial melting is estimated to have occurred in the asthenosphere under an average temperature of ~1350 °C and pressure of ~2.5 GPa, with residual minerals of Ol ± Cpx ± Gt ± Rt. The variable isotopic compositions of these basalts are not a result of melt-rock interaction, magma mixing or fractionation during their ascending, as indicated by the poor-correlation between Dy/Yb and $^{143}Nd/^{144}Nd$, Ti/Eu ratios, but more reflect their source characters. The rocks with positive Nb, Ta anomalies and high Ce/Pb, Nb/U ratios along with their Sr, Nd, Hf, Pb isotopic compositions suggest the involvement of subducted oceanic slab, sediment and depleted mantle in the source. Isotopic simulation results reveal that the recycled components have ages mainly from 0.5 to 1.5 Ga, probably related to the subducted Paleo-Asian oceanic slab. The eruption of Liangcheng basalts is likely triggered by mantle upwelling and convection corresponding to the deep subducted (Paleo-) Pacific slab. Combined our data with regional published data, we suggest that both the subducted Paleo-Asian oceanic slab and sediment, have exert prominent effects on the formation of Cenozoic basalts from the western NCC. The geochemical variation of these intraplate basalts is mostly related to the variable amounts of recycled components in their source.