Oceanic crust recycling and generation of Cenozoic basalts in the Trans-North China Orogen

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Cenozoic basalts from the Trans-North China Orogen (TNCO) are predominantly alkali basalts with small amounts of tholeiites. Compared to partial melts of mantle peridotite, the TNCO basalts have higher TiO_2, total Fe_2O_3, FC_3MS ($FeO/CaO-3*MgO/SiO_2$), Fe/Mn and Zn/Fe ratios and lower CaO contents. The olivine phenocrysts from the TNCO basalts have lower Ca and Mn and higher Ni and Fe/Mn than olivines crystallized from peridotite partial melts. These features indicate that the TNCO basalts may predominantly be derived from a mantle source of pyroxenite lithology. Combining Nb/Ta ratios with the CS-MS-A pseudo-ternary projections suggests that the residue mineralogy in the mantle source of alkali basalts with MgO > 7.5 wt% are mainly composed of clinopyroxene + garnet ± rutile, whereas those of the tholeiites with MgO > 6 wt% are composed of clinopyroxene + garnet ± orthopyroxene. The ocean island basalt (OIB)-like trace element distribution patterns and enriched Sr-Nd isotopic compositions of the TNCO basalts suggest that subducted oceanic crust was involved in the depleted mantle source.

The Cenozoic basalts in the TNCO evolved from alkali basalts of Late Eocene–Oligocene age to coexisting alkali and tholeiitic basalts of Late Miocene–Quaternary age. This temporal variation in basalt geochemistry was previously interpreted as reflecting progressive lithospheric thinning in the TNCO during the Cenozoic. However, this model of lithospheric thinning was based on the conventional assumption of peridotite melts. The estimated average melting depth of TNCO tholeiitic basalts was ~ 100 km, significantly deeper than those (< 60 km) based on a convectional assumption of a peridotite mantle source but in agreement with the present lithosphere thickness beneath the north region of the TNCO (~ 90-120 km). The geochemistry of these basalts varies symmetrically from the center to both the north and the south sides, suggesting that the recycled oceanic crust in the mantle of the TNCO is likely related to the southward subduction of the Paleo-Asian oceanic plate and/or the northward subduction of the Tethyan ocean plate.