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Tracing carbonatite metasomatism in the source of arc magmatism using Li–Mg–Zn isotopes: implications for deep carbon cycling

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The subduction of carbonate-bearing components into Earth's interior is a key part of the deep carbon cycle. However, the mechanisms of carbon transfer from the subducted slab to the sub-arc mantle remain unclear. Here we present a novel study using the Li–Mg–Zn isotopic systematics of Early Cretaceous olivine websterites from the northeastern North China Craton, China, to investigate cryptic carbonatite metasomatism. Clinopyroxene in the websterites has high Ca/Al and $(La/Yb)_N$ ratios, indicating their derivation from fluxed melting of a carbonated mantle peridotite. The samples exhibit lighter Li ($\delta^7Li_{L\text{-}SVEC}$ = –4.42‰ to 3.68‰) and Mg ($\delta^{26}Mg_{DSM3}$ = –0.40‰ to –0.36‰) isotopic compositions compared with the mantle, but similar Zn ($\delta^{66}Zn_{JMC\text{–}Lyon}$ = 0.25‰–0.29‰) isotopic compositions, suggesting the source was modified by ~14% dehydrated altered oceanic crust and ~6% carbonate-bearing silicate sediments. We propose that arc magmatism lacking high-δ^7Li and -δ^{66}Zn signatures does not necessarily indicate the absence of carbonates in the source. The combination of clinopyroxene and Li–Mg–Zn isotopic analyses can provide an improved understanding of deep carbon cycling. This work was financially supported by the National Key Research and Development Project of China (2023YFF0804102), and the Natural Science Foundation of China (42372063, 41722204).