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Deciphering the origin of a basanite-alkali basalt-tholeiite suite using Zn isotopes

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Basanite-alkali basalt-tholeiite suites have unique chemical and isotopic signatures associated with recycled crustal materials. However, the relative contribution of recycled carbonates and silicates is unclear owing to the inability of traditional isotopic approaches (e.g., Sr-Nd-Pb-O isotopes) to fully identify trace amounts of recycled crustal materials. On the other hand, the identification of the types of recycled components would help decipher origin of these magmatic suites. Since the zinc isotopes ($\delta^{66}Zn$) are distinct between marine carbonates and silicate reservoirs (e.g., mantle, oceanic mafic crust, and siliciclastic sediments), they could be used to identify the different source endmembers in magmatic rocks. In this work, we used the Zn and Sr-Nd isotopes of Cenozoic continental basalts from the Central North China Craton to identify the nature of the recycled materials present in the mantle source of these basanite-alkali basalt-tholeiite suite. We found that, basanites and alkali basalts have high $\delta^{66}Zn$ (ranging from 0.32‰ to 0.46‰), while tholeiites have low $\delta^{66}Zn$ (0.28 ± 0.04‰, 2sd) similar to mid-oceanic ridge basalts (MORB) ($\delta^{66}Zn$ = 0.27 ± 0.05‰, 2sd). Given the limited extent of Zn isotopic fractionation (<0.1‰) during crystallization and <20% partial melting, the elevated $\delta^{66}Zn$ observed in the basanites and alkali basalts reflect the involvement of recycled marine carbonates (which have an average $\delta^{66}Zn$ of ~0.91‰) in the mantle sources. Moreover, the $\delta^{66}Zn$ of these basalts show clear correlations with carbonate metasomatism indexes (such as, Ti/Eu and Zr/Hf). Mixing models for $\delta^{66}Zn$ vs. $^{87}Sr/^{86}Sr$ and $\varepsilon_{Nd(t)}$ demonstrate that the mantle sources of basanites, alkali basalts, and tholeiites were metasomatized by different proportions of carbonates and siliceous sediments. Furthermore, both isotopic and geochemical compositions exhibit symmetrical variations from the central zone towards the south and the north along the TNCO, that is, $\delta^{66}Zn$ and $^{143}Nd/^{144}Nd$ and Ce/Pb decrease, while SiO_2 contents and $^{87}Sr/^{86}Sr$ increase. We suggest that more carbonates and fewer siliceous sediments are released from the subducted slab, with an increase in the depth of subduction. We further propose that this process is one of the most important causes of compositional variations in the basanite alkali basalt-tholeiite suite.