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Identification of the nature of recycled carbonates in the mantle: Insights from the Mo-Mg isotopic pair

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Abstract

It is generally accepted that carbon from Earth's surface can be recycled into the mantle during oceanic subduction, thereby playing an important role in the global carbon cycle. However, evidence as to whether the mantle contains recycled carbonates, and of which types, remains ambiguous. Here, we present Mo-Mg isotopic data for two distinct mafic rock types in the Lhasa terrane, southern Tibet: the Taruocuo gabbros and Zhongba basalts. These units were formed in response to Neo-Tethys oceanic subduction at the sub-arc and post-arc depths of the mantle, respectively. Our results, combined with existing data, show that the Late Cretaceous (ca. 90 Ma) Taruocuo gabbros with arc-like geochemical characteristics (e.g., Nb-Ta depletions) have high $\delta^{98/95}$Mo (0.19 to 0.61‰) and mantle-like δ^{26}Mg (−0.29 to −0.22‰) values. In contrast, the Early Cenozoic (ca. 52 Ma) Zhongba basalts with ocean island basalt-like geochemical signatures (e.g., Nb-Ta enrichments) have low $\delta^{98/95}$Mo (−0.66 to −0.24‰) and δ^{26}Mg (−0.38 to −0.30‰) values. Neither shallow processes (e.g., alteration, crustal contamination, and fractional crystallization) nor partial melting can explain the Mo-Mg isotopic features of the Taruocuo gabbros and Zhongba basalts. Thus, we infer that those features may well reflect their source characteristics. We argue that the Taruocuo gabbros were derived from a mantle source that contained recycled Ca-rich carbonates at the sub-arc depths. In contrast, the Zhongba basalts appear to have been derived from a mantle source containing recycled Mg-rich carbonates and some oceanic crust in the form of eclogite at the post-arc depths. Our findings suggest that recycled carbonate sediments at the sub-arc depths of the mantle may increase their $\delta^{98/95}$Mo values without significantly affecting δ^{26}Mg values, whereas recycled carbonate sediments at the post-arc depths of the mantle would decrease both $\delta^{98/95}$Mo and δ^{26}Mg values. Therefore, the Mo-Mg isotopic pair may be a unique tool for determining whether the mantle contains recycled carbonates and for identifying the types of carbonates involved during oceanic subduction.

Keywords: Mafic rocks, carbonates, oceanic subduction, Mo isotopes, Mg isotopes, Southern Tibet