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Carbon-recycling via carbonate dissolution in subduction zones revealed by molybdenum and boron isotopic systems

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Subduction zones are crucial sites for carbon recycling between the earth surface and interior, which modulate the global carbon budget and influence Earth's climate. However, how subducted carbon is released and transported to the surface is not well constrained, especially regarding the role of slab-derived fluids in the deep carbon cycle. Here we report Mo and B isotopic data for the Silurian normal arc andesites and adakitic andesites from the Chinese Tianshan, which represent partial melts of fluid-modified mantle wedge and dehydrated oceanic crust, respectively. The normal arc andesites yield δ^{98}Mo values (0.33–1.08‰) significantly higher than that (about –0.20‰) of the depleted mantle. Because their limited ranges of SiO_2 (53.8–55.3 wt.%) preclude differentiation as a cause for their variable δ^{98}Mo values and Mo isotopic fractionation solely by fluid mobilization is limited (≤ 0.3‰), the elevated δ^{98}Mo values could be ascribed to the incorporation of crustal materials with heavy Mo isotopes in the mantle source. Since marine carbonate is characterized by both heavy Mo and B isotopes and our normal arc andesites also show heavy δ^{11}B (–1.63 to +4.00‰) ratios, we consider that marine carbonate was possibly involved as a component of the subducted slab, which modified Mo–B isotopic compositions of the mantle source. The positive correlations between δ^{98}Mo and δ^{11}B and between δ^{98}Mo and Ba/Rb suggest transport of subducted carbonates to the overlying mantle wedge through slab fluids, thus providing robust evidence for transfer of subducted carbon to the overriding plate by carbonate dissolution. In contrast, the younger adakitic andesites have light δ^{98}Mo (–0.48 to –0.27‰) and δ^{11}B (–9.43 to –2.05‰) values, implying an isotopically Mo- and B-light source. Given the preferential transport of heavy ^{98}Mo and ^{11}B to the fluid phase during slab dehydration, their remarkably light δ^{98}Mo and δ^{11}B values support a dehydrated oceanic crust as their magma source. The contrasting Mo–B isotopes for such two kinds of andesites highlight that most carbonates could be removed from the subducted slab to the overriding lithosphere during oceanic subduction.