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A global perspective on heavy Mg isotopic compositions of arc basalts

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Subduction zones are major sites of material transport between shallow and deep earth. Understanding subduction zone geochemical cycles has important implications for the evolution of both the mantle and the continental crust over geologic timescale. Mg isotope studies are emerging as a tool for understanding crustal recycling. Arc basalts appear to have isotopically heavier Mg compared to the normal mantle values. Subduction of marine sediments and oceanic crust may contribute to this, but minimally owing to their low Mg contents relative to that of the mantle. Serpentinites, which may occur in both the forearc mantle or subducting lithosphere mantle, potentially may have greater influence for their high water and Mg contents. Subduction zone thermal structure may exert strong control over the effectiveness of heavy Mg transport from slab to arc, as hotter subducting slabs can facilitate more thorough dehydration of serpentinites.

We report Mg isotope compositions of Quaternary basalt to basaltic andesite lava. δ^{26}Mg values of South Sandwich Island arc (-0.21±0.02 to -0.07±0.04 ‰), Central America Volcanic arc (-0.31±0.05 to -0.04 ±0.01 ‰), and Central-East Aleutian arc (-0.20±0.01 to -0.03±0.06 ‰) fall in similar ranges compared to previously published arc basalts. Additionally, we compile existing literature data from Kamchatka, Lesser Antilles, Mariana, North Chilean Andes, and North Cascadia. Our results demonstrate that while most subduction zones produce arc lavas ~ 0.1‰ heavier than the mantle, exceptionally cold (e.g. Kamchatka) and hot (e.g. Cascades) subduction zones show ranges of δ^{26}Mg largely overlapping the normal mantle range. This suggest the potential of a thermal ‘sweet spot’ for effective Mg mobilization where the onset of serpentinite dehydration is not too early nor too late. In hot subduction zones, the shallow slab may release heavy Mg from serpentinites to arc both at forearc depths and over a more dispersed section, whereas in cold subduction zones, the slab serpentinites may not reach antigorite breakdown P-T condition at arc depth.