Crustal maturation through chemical weathering and crustal recycling revealed by Hf-O-B isotopes

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Juvenile continental crust is dominantly formed at intra-oceanic arcs via subduction zone magmatism. However, it remains unclear how basaltic oceanic arcs convert to granodioritic continental compositions. Here we present zircon U-Pb and Hf-O isotope data, whole-rock B isotope compositions, combined with a synthesis of over 1200 geochemical analyses from magmatic rocks that span a wide range of emplacement ages (~450 – 270 Ma), from the Junggar intra-oceanic arc of the southern Central Asian Orogenic Belt (CAOB). Geochemical data show that the Junggar evolved from a juvenile oceanic arc composition to one closer to continental crust at ca. 300 Ma. All samples show very high and uniform Hf isotope ratios with εHf(t) values from +10.6 to +14.4. Zircon $\delta^{18}O$ values and whole-rock δ11B values, however, are highly variable. The Silurian – Carboniferous (pre-300 Ma) rocks have distinctly lower zircon $\delta^{18}O$ values ranging from 4.80 to 7.20‰ with an average of 5.90‰, and the higher $\delta^{11}B$ values (-7.5 – +12.2‰), suggesting that they were derived from the asthenospheric mantle wedge, which supports the genesis of primitive intra-oceanic crust during that time interval. In contrast, the Early Permian (post-300 Ma) rocks reveal much higher zircon $\delta^{18}O$ values (8.24 to 10.29‰) and lower δ11B values (-9.0 to -12.2‰), which requires a source component comprising young, weathered, volcanogenic sediments from the Carboniferous Junggar intra-oceanic arc. Our study highlights that an intra-oceanic arc's own chemical weathering history promotes its transformation into continental crust during collisional events and clarifies the relationship between continental crust formation and intra-oceanic arcs through time.