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Grain-scale zircon Hf isotope heterogeneity inherited from sediment-metasomatized mantle: Geochemical and Nd-Hf-Pb-O isotopic constraints on Early Cretaceous intrusions in central Lhasa Terrane, Tibetan Plateau

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Abstract

Clarifying the mechanism of recycling of pre-existing continental crustal materials into the source of mantle-derived magma is a challenging effort that can be of great value to improving our understanding of mantle processes and continental crust growth. This study presents an integrated investigation of whole-rock and mineral geochemical and Nd-Hf-O-Pb isotopic data for dolerites and diorites intruded in the central Lhasa Terrane of Tibetan Plateau at ca. 120 Ma (zircon U-Pb ages). These intrusions have similar distributions of trace elements that are characterized by depletion in Nb-Ta relative to Th, Ba, and U, and moderately negative whole-rock $\varepsilon_{Nd}(t)$ (–5.0 to –1.7) values. Magmatic zircon shows dramatically variable $\varepsilon_{Hf}(t)$ values (from –5.0 to +13.7 in the same rock, including up to 12 epsilon unit variability in single grains). On the other hand, the zircon $\delta^{18}O$ values are relatively uniform (+6.0‰ to +7.7‰). The constant $^{208}Pb/^{206}Pb$ values of clinopyroxene crystallized at ca. 500–900 MPa suggest no contamination with lower continental crust. The lack of covariation between Hf and O isotopes from the same grains, and the lack of relationship between Hf isotopes and trace elements (e.g., Hf, Th/U, and Yb/Gd) in the magmatic zircons, together with the absence of ancient zircon xenocrysts, imply limited upper crustal contamination. In combination with high-whole-rock Th/La (>0.29) ratios, we interpret the zircon Hf isotope heterogeneity as inherited from a depleted asthenospheric mantle with the addition of 1–4% Hf from isotopically heterogeneous sediments. Our study therefore emphasizes the need for caution when using complex Hf isotopic zonation in zircon as an argument for intracrustal hybridization of two end-member magmas derived from distinct reservoirs. In addition, the high-Zr/Y ratios and no negative Zr-Hf anomalies of the Aruo intrusions imply a high surface temperature of the down going slab that was able to fully dissolve zircons in the subducted sediments. This requires a special geodynamic condition that was most likely related to the steepening of flatly subducted Neo-Tethyan lithosphere at ca. 120 Ma according to a synthesis of regional tectonic-magmatic-sedimentary records.

Keywords: Zircon Hf heterogeneity, sedimentary recycling, mantle metasomatism, magma mixing, Lhasa Terrane