

Zircon U-Pb, Hf and O isotopic constraints on the pre-Himalayan crustal evolution: Insights from metasediment, orthogneiss and leucogranite in Garhwal, NW India

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Zircon U-Pb geochronology and Hf-O isotope geochemistry of metasediment, orthogneiss and leucogranite in Garhwal, NW India provide new insights into the pre-Himalayan crustal evolution. The Harsil Formation, the High Himalayan Crystalline Sequence (HHCS), and the Lesser Himalaya Sequence (LHS) in Garhwal are divided by the Jhala Normal Fault and Main Central Thrust (MCT) zone, respectively. Igneous zircon U-Pb ages from orthogneisses in the MCT zone revealed ca. 1865–1845 Ma felsic magmatism associated with the Columbia Supercontinent. Detrital zircons U-Pb ages from metasediments in the LHS and MCT zone yielded the age populations of ca. 2.73, 2.42, 2.33, 2.11, 1.94, and 1.89 Ga, with the youngest age peak of 1.84 Ga, indicating the Paleoproterozoic sedimentation. In contrast, those in the Harsil Formation yielded the age populations of ca. 3.14, 2.81, 2.51, 1.85, 1.73, 0.99, 0.70, and 0.63 Ga, indicating the Neoproterozoic sedimentation that characterize the HHCS. The Harsil Formation was intruded by ca. 496–492 Ma Bhagirathi leucogranites. Both the detrital zircons from the Paleoproterozoic and Neoproterozoic metasediments have various $\epsilon\text{Hf}(t)$ values from -18 to $+12$, suggesting a combination of depleted mantle and an older source. Some depleted mantle Hf model ages are as old as Meso-Paleo Archean (ca. 3.0–3.5 Ga), representing a reworked portion of an older crustal component. In contrast, the zircons from the Paleoproterozoic orthogneisses and Early Paleozoic leucogranites show only positive $\epsilon\text{Hf}(t)$ values from 0 to $+15$, showing juvenile mantle input. However, the zircon Hf model ages older than the U-Pb ages and the oxygen isotope (^{18}O : 7.74–8.91 ‰), significantly higher than zircons crystallized mantle derived magma, indicate large degrees of mixing and contamination of crust materials in both granitoids. The pre-Himalayan crustal evolution through the Paleoproterozoic to Neoproterozoic sedimentations and episodic granite generations, were developed over an extended period of time around the northern margin of the Indian crust.