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Garnet geochronology: improvements and application in studying India-Asia collision

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Garnet enables constraints on all parameters relevant to lithosphere studies: pressure, temperature, strain, and time. This aspect, in combination with its widespread occurrence in metamorphic rocks, make the mineral a prime target in research into the dynamics of mountain belts. Our ability to obtain and interpret precise age constraints from garnet Lu-Hf and Sm-Nd data has greatly improved over the years. This contribution highlights recent enhancements in garnet geochronology and demonstrates the versatility of this method in two case studies set in the India-Asia collision zone.

To enable a more effective use of garnet geochronology, we investigated the retentiveness of Lu-Hf and Sm-Nd isotope signatures in naturally metamorphosed garnet. A grain-size dependent Lu-Hf and Sm-Nd analysis of garnet was done on a sample of a slowly cooled Archean granulite from the Pikwitonei Granulite Domain, Canada. Comparison of the apparent ages to the known thermal history of this rock allowed constraints on chronometer systematics at high temperature. Diffusive re-equilibration is shown to occur to a small (Sm-Nd) to minor, if not insignificant (Lu-Hf), extent during high temperature metamorphism, thus firmly establishing the Lu-Hf and Sm-Nd chronometers as reliable, well-characterized dating tools.

Garnet Lu-Hf chronology was done to show that mid-crustal flow and ‘Barrovian-type’ metamorphism of rocks now exposed in the North Himalayan Gneiss Domes in Central Tibet commenced in the early Eocene. This result is the first to confirm that crustal thickening and contraction in the Tibetan Himalaya was broadly synchronous with the collision between Greater India and Eurasia. Garnet dating and thermometry, and rutile U-Pb thermochronology on granulites from the Pamir (an exposed segment of deep Asia) revealed a history of heating to 750-830 °C, commencing at 37 Ma in the South Pamir and occurring progressively later northward. The data advocate a causal link between Indian slab break-off to the south and progressive prograde heating of the Pamir hanging wall. Both studies demonstrate the ability of garnet to characterize crucial, yet typically difficult to constrain, early stages of mountain building.