Garnet: a key to unraveling Earth's dynamic lithosphere

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The Pamir-Himalaya-Tibet Orogen is the ultimate natural laboratory for the development and testing of models for the dynamics of collisional orogens. Significant achievements in various fields of geoscience have greatly advanced the knowledge on the Cenozoic evolution of the region. In spite of this, the most fundamental aspect to the development of the region – the India-Eurasia collision – is poorly understood and timed. Plate reconstructions indicate collision and slowing-down of convergence at 55-50 Ma. Deformation and thickening of the crust, however, cannot be traced back further than 35 Ma. The 15-20 million year hiatus is largely uncharacterized, impeding progress in the development of tectonic models. To address this issue, we performed Lu-Hf garnet dating on deep crustal rocks of Indian and Eurasian affinity exposed in Central Tibet and the Pamir, respectively.

Garnet from high-grade rocks now exposed in the North Himalayan Gneiss Domes in Central Tibet commenced in the early Eocene (54-49 Ma). This result is the first to confirm an 'old' age for the onset of crustal thickening and contraction in the Tibetan Himalaya. The result is identical to the age of collision as determined by plate reconstructions, erasing a decades-long controversy on India-Asia collision timing. Garnet dating and thermometry, and rutile U-Pb thermochronology on high-grade rocks in Pamir revealed a history of heating to 750-830 °C. This process commenced at 37 Ma in the South Pamir and occurred progressively later northward until 22 Ma, when the crust switched swtitched to wholesale collapse by orogen-parallel extension. The latter study advocates a causal link between Indian slab break-off to the south and progressive prograde heating and ductilification of the subduction hanging wall. Both studies demonstrate the ability of garnet to characterize the crucially important, yet typically difficult to constrain, early stages of crustal tectonics in orogenic cycles.