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Ultra-slow cooling of ultra-hot orogens

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The rate of cooling of metamorphic rocks provides a first-order constraint on the tectonic processes controlling heat flow and exhumation. For example, for small crustal terranes that were subducted to ultrahigh pressure conditions during the early stages of collisional orogenesis, exhumation is generally fast with rates similar to plate velocities, such that cooling is also rapid. Similarly, rates of cooling are commonly fast (generally ~20–30°C/Myr) during exhumation of metamorphic core complexes or due to transpression. By contrast, cooling in some granulite terranes can be slow and close-to-isobaric, leading to time-integrated cooling rates of <5°C/Myr. The implication of such slow rates of cooling is that these granulite terranes were close to isostatic equilibrium as a result of sustained high mantle heat flow that limited exhumation by erosion. However, constraining initial cooling rates in granulite terranes can be difficult, particularly where the rocks reached ultrahigh temperatures (>900 °C) that exceed the closure temperature of many geochronometers. In order to overcome this difficulty, we combine U–Pb zircon geochronology with Ti-in-zircon thermometry to investigate the thermal history of metapelitic rocks from the Eastern Ghats Province of eastern India. For the combined dataset of metamorphic zircon from the samples, concordant dates decrease continuously within 2σ uncertainty from around 950 Ma to 800 Ma, consistent with *c.* 150 Ma of zircon crystallization. Ti-in-zircon temperatures for each dated spot during this period decrease with age, corresponding to linear cooling rates ranging from 0.26 to 0.90°C/Myr. We propose that retention of heat producing elements in the lower crust of the Eastern Ghats Province and a low net erosion rate were responsible for *c*. 150 Myr of ultra-slow cooling. The location of the Eastern Ghats Province on the margin of the supercontinent Rodinia may have been a contributing factor enabling the region to remain relatively undisturbed until it was exhumed during the formation of Gondwana.