Tectonothermal evolution of the Greater Himalayan Series, Sutlej Valley, NW India

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The metamorphic core of the Himalayan orogen comprises medium- to high-grade rocks of the Greater Himalayan Series (GHS). GHS rocks in the Sutlej Valley, NW India, are exposed in an ~16 km thick panel, bounded below by the Main Central thrust (MCT) and above by the Sangla Detachment, a local strand of the South Tibetan Detachment system (STDS) of normal faults. Unlike other exposures of the GHS where pressure at peak temperature increases up structural section, in the Sutlej Valley the GHS displays a nearly isobaric inverted metamorphic temperature gradient. Here peak metamorphic temperatures range from ~610 ºC at the level of the MCT to ~750 ºC at the level of the STDS. Peak temperatures were all attained at ~7–9 kbar (cf. Vannay et al., 1999). To date a single *P–T* path has been extracted from a migmatite at high structural levels that indicated a period of nearly isobaric heating to ~750 ºC that was followed by cooling during decompression (Vannay et al., 1998). This path generally differs from others obtained at similar structural levels where a period of isothermal decompression is inferred to immediately follow attainment of peak temperature.

In this contribution we present new microstructural and petrologic data combined with thermodynamic modelling from the lowest structural levels of the GHS in the Sutlej Valley (within ~1200 m of the MCT). These rocks preserve a remarkably complete record of the microstructural and thermobaric evolution of the GHS and bear directly on the tectonothermal history of rocks incorporated into the MCT zone during mylonitization.

The earliest deformation event recognized in the Sutlej GHS at the level of the MCT is recorded by straight to sigmoidal (S1) inclusion trails of quartz + ilmenite in the cores of large garnet porphyroblasts. S1 is often observed at high angles to the matrix foliation (S2), and is truncated at inclusion-poor garnet rims. Thermodynamic modelling indicates these garnets began growing at ~500 ºC and 5 kbar. Where inclusions are preserved at the interface of garnet cores and rims they are invariably at high angles to S1. This textural relationship indicates either: i) a hiatus in garnet growth along the prograde path while the matrix fabric was reorganized; or ii) minor garnet resorption along the prograde path, or possibly a combination of both. The interpretation of a hiatus during garnet growth is supported by a sharp chemical discontinuity between garnet core and rim compositions. The abruptness of the observed chemical 'unconformity' indicates that this hiatus was relatively short-lived since diffusional relaxation of fast-diffusing major elements (e.g., Mn) was limited.

Microstructures observed in pelitic rocks collected at ~1000 m up structural section reveal a similar microstructural evolution. These rocks reached higher peak temperatures (~675 ºC and 8.4 kbar), and thus do not allow retrieval of conditions at the garnet-in reaction, but a clockwise *P–T* loop is inferred based on microstructures and thermodynamic modelling. The *P–T* paths of both rocks selected for thermodynamic modelling overlap on the cooling path at ~ 600 ºC and 7 kbar suggesting that rocks within ~1000 m of the MCT were coupled soon after the structurally lowest rocks attained peak metamorphic conditions. We also infer that exhumation of rocks at this structural level was rapid due to the preservation of pristine primary growth zoning even though peak temperatures >600 ºC were attained. Preservation of such a detailed record of punctuated porphyroblast growth and microstructural evolution is rare along the length of the Himalaya. These new data support an interpretation whereby the locus of mylonitization in the MCT zone propagated southward into progressively cooler crustal material. Rocks progressively incorporated into the deforming MCT zone were continually juxtaposed against hotter rocks in the hanging wall. As the MCT propagated southward, rocks in the hanging wall were cooled and rapidly exhumed toward the synorogenic topographic surface.

References

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