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Metamorphic P-T profile and P-T path discontinuity of the Main Central Thrust in far-eastern Nepal

Takeshi Imayama[1*], Toru Takeshita[2], Kazunori Arita[3]

[1]Center Chr. Res. Nagoya Univ., [2]Dept. Natural Hist. Sci., Hokkaido Univ., [3]Hokkaido. Mus., Hokkaido Univ.

The channelized flow of weak mid-crustal material is an appealing explanation for the thermal-mechanical evolution of the Tibet-Himalayan system (e.g. Beaumont et al., 2004), but still controversial. Far-eastern Nepal Himalaya is a well-characterized example of an inverted metamorphic zonation that generally shows much higher temperature with increasing structural level. In this paper, we examine the spatial distributions of P-T conditions and P-T paths across the Main Central Thrust (MCT), which juxtaposes the high-grade Higher Himalayan Crystalline Sequences (HHCS) over the low-grade Lesser Himalaya Sequences (LHS), based on the average P-T method (THERMOCALC; Powell et al., 1998), growth zoning of garnet with the Gibbs method (Spear & Selverstone, 1983), and the pseudosection using perplex_X07 (Connolly, 2009). Finally, we compare the P-T results with those inferred from recent channel flow models (Jamieson et al., 2004, 2006), and discuss the thermal evolution of the orogen.
Thermobarometric data and compositional zoning of garnet show the discontinuities of both metamorphic pressure conditions at peak-T and P-T paths across the MCT. Maximum recorded pressure conditions occur just above the MCT (c. 11 kbar), and decrease southward to ~6 kbar in the garnet zone and northward to c. 7 kbar in the kyanite + staurolite zone. The inferred nearly isothermal loading path for the LHS in the staurolite zone may have resulted from the underthrusting of the LHS beneath the HHCS. In contrast, the increasing temperature path during both loading and decompression (i.e. clockwise path) from the lowermost HHCS in the staurolite to kyanite + staurolite transitional zone indicates that the rocks were fairly rapidly buried and exhumed. Exhumation of the lowermost HHCS from deeper crustal depths than the flanking regions, recording a high field pressure gradient (c. 1.2-1.6 kbar/km) near the MCT, is perhaps caused by ductile extrusion along the MCT, not the emplacement along a single thrust, resulting in the P-T path discontinuities. These observations are consistent with the overall scheme of the model of channel flow, in which the outward flowing HHCS and inward flowing LHS are juxtaposed against each other and are rapidly extruded together along the MCT. A rapid exhumation by channel flow in this area is also suggested by a nearly isobaric decompression path inferred from cordierite corona surrounding garnet in gneiss of the upper HHCS. On the other hand, peak metamorphic temperatures show a progressive increase of temperature structurally upward (c. 570 to 740 oC) near the MCT and roughly isothermal conditions (c. 710-815 oC) in the upper structural levels of the HHCS. The observed field temperature gradient is much lower than those predicted in channel flow models. However, the discrepancy could be resolved by taking into account heat advection by melt and/or fluid migration, as these can produce low or nearly no field temperature gradient in the exhumed midcrust, as observed in nature.

Keywords: Himalaya, channel flow, metamorphic rock, P-T path