Controls on and timing of metamorphism in the Himalaya

C. I. Prince
D. Vance
N. B. W. Harris
Dept. of Earth Sciences, Open University, Walton Hall, Milton Keynes, MK7 6AA

F. Oberli
D-ERDW, ETH Zentrum, CH-8092 Zürich, Switzerland

Since collision between the Indian and Eurasian plates at 55-65Ma, some 2500-3000km of shortening has occurred, resulting in major deformation and thermal disturbances in the collisional zone. The metamorphic belt is now represented by the High Himalayan Crystallines (HHC) and the Main Central Thrust Zone (MCTZ), a thick sequence of metamorphic rocks thrust over low grade Lesser Himalayan (LH) rocks to the South and bound to the North by the Tethyan sedimentary series. Here we summarise garnet Sm-Nd, P-T, and mica Rb-Sr data from the Garhwal and Zanskar Himalaya which directly constrain movements within the HHC in the period 37-23Ma. These data, in conjunction with other chronological data from across the Himalaya, unravel the major controls on Himalayan metamorphism and confirm a simple, foreland-propagating thrust model.

Regional setting

The Garhwal and Zanskar Himalaya of India expose a complete section from the LH through the HHC and into the overlying Tethyan sediments in several river valleys. The metamorphic rocks in both areas vary from chlorite zone to sillimanite zone gneisses. Leucogranites were formed by crustal melting of the HHC at around 20Ma and was followed by rapid cooling (Metcalfe, 1993; Noble and Searle, 1995).

Thermochronological data

Garnet dates from both Garhwal and Zanskar indicate that the upper structural levels of the HHC had thermally equilibrated around 35Ma while growth continued until 23 Ma at lower levels near the MCT. Core temperatures and pressures for both Garhwal and Zanskar are ~550°C and 3–7 kbar and for garnet rims are ~650°C and 7–10 kbar indicating that growth occurred during rapid burial; clearly linking the metamorphism with thrusting to the north of the HHC. The thermal response times recorded in the garnets suggest that this faulting was probably situated along the STDS, which is now a normal fault and was probably responsible for the rapid cooling at 20Ma (Fig. 1.).

In the lower grade MCTZ Rb-Sr dating of mica fabrics formed around feldspar augen yield ages as young as 8.3 Ma. This is in agreement with the youngest K-Ar and Ar-Ar ages from the Garhwal region (Oliver *et al.* 1995; Metcalfe, 1993). The similarity of the K-Ar, Ar-Ar and Rb-Sr ages, and the fact that the rocks appear never to have reached temperatures above the closure temperature for Rb-Sr in white mica, both suggest that the Rb-Sr ages are due to deformation-induced recrystalisation. Together with Ar-Ar cooling ages of 11–23 Ma for the HHC above the MCTZ these data confirm the forward propogation of exhumation and deformation.

However a garnet from ortho-gneisses near the top of the HHC gives an age of 534Ma. This confirms the presence of a widely recognised metamorphic event at 550Ma based on Rb-Sr whole rock scatter-chrons (e.g. Inger and Harris, 1993). This is the first time in

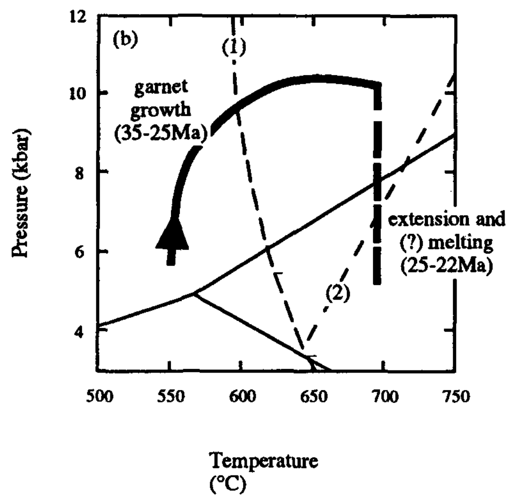

FIG. 1. Representative PTt path for the HHC from the Zanskar Himalaya.

the Himalaya that a pre-tertiary age has been obtained from a metamorphic mineral from which P-T data are commonly calculated. This finding suggest that care should be exercised, in the Himalaya as well as elsewhere, in assigning P-T data to any specific orogeny in the absence of chronological data.

Conclusions

These data in association with the 49Ma age obtained for eclogites in Pakistan (Tomarini *et al.*, 1993), the less than 6 Ma age for garnet growth beneath the MCT of Nepal (Harrison *et al.*, 1997) and cooling histories obtained from Garhwal suggest that a simple forward propagation model of thrusting since collision, although not necessarily contemporaneous along the entire chain, may be applicable along the whole length of the Himalaya. In addition the fact that burial appears to continue until ~25-23Ma implies that the HHC were not being unloaded until orogenic collapse in the early Miocene which resulted in rapid exhumation.

References

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