Migration of frontal thrusts in the Himalayas caused by cooling of the metamorphic nappe

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We present thermochronological data on the metamorphic nappe, from its root in Mount Everest to its southern end located 120 km to the south. The present data suggest that the metanorphic nappe extruded onto the ground at about 14.4 Ma and moved southward at 3-4 cm/yr, before the ermination of its movement at about 11 Ma, and gradually cooled douwn from its front at the rate of about 1 cm/yr towards the north; while the surface cooled rapidly down immediately after extrusion, temperatures of about 240 C were maintained in the interior up to 6-4 Ma before falling below 120 C by 3-0.8 Ma.

Our research results indicate that the metamorphic nappe underwent four major cooling events: (1)15-14 Ma, (2)11-10 Ma, (3) 5-3 Ma and (4) 1-0.8 Ma. Each event corresponds to a tectonic and sedimentary event reported in previous studies.

(1) 15-14 Ma: Our data indicate rapid cooling from 350 to 120 C on the surface of the metamorphic belt, interpreted as cooling accompanying extrusion of metamorphic rocks to the ground surface. This age is consistent with timing of changes in mineral assemblage of the Bengal Fan sediments at about 15 Ma, believed to reflect the onset of erosion of metamorphic terrains.

(2) 11-10 Ma: A deep-sea drilling study at the fringe of the Bengal Fan (ODP Leg 116, Site 717-719) revealed an abrupt tenfold increase in sedimentation rate at 10.9 Ma, which was attributed to the uplift of the Higher Himalaya and large-scale unroofing of metamorphic rocks in the Himalaya. This change coincides with termination of the southward advancement of metamorphic nappe. At about 10 Ma, a drastic change was observed in the Siwalik foreland basin sediments both its sedimentation rate and composition from lithic quartzose sandstone to immature micaceous sandstone containing metamorphic grains. It is ascribed to the termination of metamorphic nappe advancement behind the foreland at about 11 Ma and rapid supply of detritus from it. The Main Boundary Thrust appears to have been formed in front of the nappe margin where stress concentration occurred after termination of thrusting on the MCT.

(3) 5-3 Ma: During this period, the whole Lesser Himalayan metamorphic nappe and metamorphic core of the Higher Himalaya cooled down below 240+-50 C, which correspond to the temperature of ductile-brittle boundary. Thus, at this time, the entire Himalaya, except for a part of northern slope, started to behave as a rigid body, and this may have resulted in a southward migration of the deformation front of the Himalayan range from the MBT to the Main Dun Thrust (MDT) and the Main Frontal Thrust (MFT).

(4) 1-0.8 Ma: By the early Pleistocene, the whole Himalayan range cooled down below 120+-20 C and the Himalaya started its deformation under a brittle fracture field. At this time, the frontal range of the Himalaya including the Mahabharat range in Nepal and the Siwalik hill started to uplift rapidly. This uplifting must have caused strong weathering and erosion, which was recorded as a rapid increase of sedimentation rate in the Bengal Fan.