Cooling and Exhumation Patterns associated with Tectonometamorphic Evolution of the Himalayan Metamorphic Belt in the Alaknanda and Dhauliganga valleys, Garhwal Himalaya, India

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Two distinct packages of inverted metamorphic sequence of the Himalayan Metamorphic Belt (HMB) along the Alaknanda and Dhauliganga valleys of the Garhwal Himalaya are characterized by a basal package (Munsiari Formation) ranging from chlorite to staurolite zone, whereas the overlying package (Vaikrita Group) ranges from staurolite-kyanite to sillimanite-K-feldspar and migmatite zone, along with generation of insitu melt in the higher structural level.

The rates of cooling and exhumation of the HMB have been constrained using muscovite-biotite co-genetic pairs of Rb-Sr whole-rock mica ages (muscovite: 500±50°C and biotite: 300±50°C). In the present study we considered a simplified one-dimensional frame with the assumption that 30±10°C/km steady-state geothermal gradient persisted over the calculated age. The calculated data show that the rate of cooling or exhumation is higher at the central part of the thrust sheet indicating a concave upward geotherm or a reversal of the geotherm. Near the Vaikrita Thrust, mineral cooling ages give a higher exhumation rate of about 1.36 mm/yr between 8.61 Ma and 2 Ma, which is followed by an exceedingly high rate between 2 Ma and the present time within Munsiari Formation. The high cooling rate is associated with the measured shallow geothermal gradient in this area, which is related to the exceedingly high erosion rate observed in the dynamic and rugged terrain.

A total of 27 samples of metasediments, migmatites and leucosomes of the HMB along with Tethyan sedimentary rocks were also analysed for Nd-isotopic calculation for ε_{Nd} at the present time along with the corresponding values of $^{87}Sr/^{86}Sr$ ratios. The average value of $\varepsilon_{Nd\,(0)}$ and present-day $^{87}Sr/^{86}Sr$ ratios for the Vaikrita Group is ~ -16 (ranging between -7.0 and -21.4) and 0.78759 (ranging between 0.75152 and 0.86479) respectively. The samples mainly of leucosome yield anomalous values of ε_{Nd} probably due to high Sm/Nd ratio in the rocks and the corresponding $^{87}Sr/^{86}Sr$ ratio also has very high values indicating a disequilibrium melting of the crustal rocks. However, the Munsiari Formation values are ~ -25 (ranging between -24.0 and -25.8) and 0.90528 (ranging between 0.99398 and 0.81658). The ε_{Nd} and $^{87}Sr/^{86}Sr$ ratio values indicate that the source of the Munsiari Formation seems to be different that of the Vaikrita Group, whereas they appear to be part of same thrust sheets with similar tectonometamorphic history.

The migmatite zone gives a maximum temperature of metamorphism of about 700°C and a significantly lower pressure ranging from ~5 to ~7 kbar, whereas the lower part of the upper package also gives maximum temperature of about 700°C and pressure of about 12 kbar. The upper part of the Vaikrita Group clearly indicates total decompression of about 5-7 kbar and maintains near–isothermal conditions at about 700°C. On the contrary, the basal Munsiari Formation is characterized by lower pressure and temperature of about 7 kbar and 520°C. Garnet zoning profiles also indicate that the basal part of the Vaikrita Group displays progressive metamorphism. Between the basal Munsiari Formation and the upper Vaikrita Group, a sharp discontinuity in pressure and temperature is present across the Vaikrita Thrust (VT) where the contact between the staurolite zone and the staurolite-kyanite zone has been observed. However, no structural break has been encountered between these two packages. Samples from the basal part of the Vaikrita Group do not show the effect of the isothermal decompression, but seem to be overprinted by more recent localized metamorphism of short duration possibly related to thrusting along the VT.

Cite as: Singh, S. and Singha, T.N.B., 2010, Cooling and Exhumation Patterns associated with Tectonometamorphic Evolution of the Himalayan Metamorphic Belt in the Alaknanda and Dhauliganga valleys, Garhwal Himalaya, India, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 1 p. [http://pubs.usgs.gov/of/2010/1099/singhsingha/].