Inverted Metamorphism across the Main Central Thrust constrained by metamorphic P-T condition, western Himalaya, India

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Evolutionary signatures of active mountain building tectonic process as a consequence of collision between Indian plate and Tibetan plate are well preserved in the Himalayan metamorphic rocks. Southward thrusting of high grade metamorphic rocks (amphibolite to granulite facies) of Greater Himalayan Sequence (GHS) over low grade (greenschist facies) Lesser Himalayan Sequence (LHS) cause an inverted metamorphic field gradient across Main Central Thrust (MCT) (Arita, 1983; Vannay and Hodges, 1996). A geological map of the study area along Madhmaheswar Ganga valley, Rudraprayag district, Uttarakhand, India is prepared. In order to understand the inverted metamorphism in the study area, it is important to analyze how *P-T* conditions inferred from the phengite chemistry and garnet zoning pattern change with increasing structural level across the MCT. In this study area, hangingwall block of north-easterly dipping MCT mainly consists of paragneiss with intrusive body of leucogranite within the lower GHS (~1.5 km thickness) and footwall is generally termed as MCT Zone (~4 km thickness) comprised of augen gneiss and micaceous quartzite with some intercalations of amphibolites. An inverted Barrovian sequence is persistent from biotite zone through garnet zone upto kyanite zone where garnet-in isograd lies just beneath the MCT.

In this study, chemical analysis including garnet line profile and elemental map for major elements such as Ca, Fe, Mn, Mg and composition of matrix minerals is carried out by electronprobe microanalyser. Further, we have employed average *P-T* method (Holland & Powell, 1994) by using Thermocalc program (ver. 3.36) for thermobarometry. Garnets from uppermost MCTZ and lowermost GHS are characterized by growth zoning with consistently decreasing X_{Mn} content (from core to rim) suggesting the grain growth during burial with increasing *P* and *T* (Spear *et al.*, 1990). On the other hand, most of the garnet porphyroblasts in the lower GHS exhibit flat profile of X_{Mn} with little increase of it at rim. So, this kind of diffusional zoning profile signify retrograde reaction during exhumation and cooling of the lower GHS rocks (Florence & Spear, 1991). Higher rate of diffusion of major elements at higher elevated temperature than that of growth zoning cause homogeneous distribution of these elements. Tschermak substitution $[(Mg, Fe2+)^{vi}, Si^{iv}=Al^{vi}, Al^{iv}]$, between solid solution end members of dioctahedral micas is good indicator of metamorphic condition (Guidotti, 1984). In low grade metamorphic rocks, phengite composition changes from celadonite-rich mica towards idealized muscovite composition with increasing temperature (Guidotti and Sassi, 2002). Decrease of octahedral Fe+Mg content with increasing tetrahedral Al content in the order of 1 a.p.f.u. (11 oxygen basis), towards structural high, indicate the extent of tschermak substitution from biotite zone to kyanite zone. However, there is an abrupt decrease of Fe+Mg and Si content at the base and top of the MCTZ which could support the presence of Munsiari thrust and MCT, respectively. Peak *P-T* condition of 594 ±19 ˚C and 9.4 ±1 kbar is estimated from garnet + quartz + chlorite + plagioclase + biotite + muscovite ±ilmenite assemblage in uppermost MCTZ rocks. In contrast, lowermost GHS experienced peak *P-T* condition of 687 ±31 ˚C and 11.9 ±1.2 kbar attained by the peak metamorphic assemblage of garnet + quartz + plagioclase + muscovite + biotite ±kyanite ±ilmenite ± rutile. Thus, it is estimated that a steep inverted pressure gradient of 16.4 ±1.3 kbar km^{-1} persist between uppermost MCTZ sample and lowermost GHS sample which could suggest that MCT activity exhumed GHS from deeper level than MCTZ rocks. Further, it has to be determined whether very low Si

concentration in phengites in direct proximity to the major thrusts correlate with the effect of low-*P* or high-*T*.

Keywords: Himalayan metamorphic rocks, Main Central Thrust, Inverted metamorphism, Tschermak substitution, Peak P-T conditions

