Tale of two migmatites and leucogranite generation within the Himalayan Collisional Zone: Evidences from SHRIMP U-Pb zircon ages from Higher Himalayan Metamorphic Belt and Trans-Himalayan Karakoram Metamorphic Belt, India

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Continental collisional tectonics in the Himalaya has been caused due to interaction between the Indian and the Eurasian Plates and has resulted in coalescing of these plates in the Himalayan and Karakoram mountains. One of the phenomena characterizing these regions is the presence of collisional-related magmatism, both within the Indian as well as Eurasian Plates. This collisional-related magmatism represents (i) crustal anatectic melting due to fluid migration during intracontinental thrusting, (ii) decompressional-controlled dehydration melting or (iii) vapour-absent muscovite dehydration melting of metamorphic rocks. These bodies are characterized by tourmaline-beraing leucogranite (TBL) and have been emplaced in a very short span between 24 and 19 Ma, as evident from the Higher Himalayan Crystallines of the western sector in Zanskar to Nepal and Bhutan. Their crystallization ages are much younger than the peak Himalayan metamorphism in Zanskar (37-28 Ma), Garhwal (44-26 Ma), Annapurna in Nepal (36 Ma), the Everest region in Nepal (32-23 Ma) and Bhutan (36-34 Ma). This gap between the timing of Eocene-Oligocene Himalayan metamorphism and generation of the Himalayan leucogranite ~20 has remained unexplained.

Both the Higher Himalayan Metamorphic Belt and Karakoram Metamorphic Belt are marked by intense migmatization, partial melting, *in situ* emplacement of various granitoids within sillimanite – K-feldspar bearing metapelite. The Higher Himalayan Metamorphic Belt has evolved in a 15-20 km thick, southwest-vergent ductile shear zone. Along the Bhagirathi valley, western Garhwal these are made up of two distinct packages. The lower package of the Bhatwari Group is separated from the upper Harsil Group by the Vaikrita Thrust and is thrust over the Lesser Himalayan sedimentary zone along the Main central Thrust (MCT). In the middle of the Harsil Group, sillimanite-kyanite-mica schist and gneiss pass gradually into stromatic- and diatexite-type migmatites. These have a melt fraction ranging from 20% to more than 50%, with clear presence of leucosome containing a few garnet porphyroblasts. The rocks that develop in migmatite are mica schist and gneisses and contain biotite, muscovite, quartz, k-feldspar, garnet, kyanite and a small amount of sillimanite. No post-tectonic garnet is observed. Biotite predominates over muscovite, which occurs in negligible amounts. Kyanite is well developed along the main foliation with mica, although a few kyanite and large muscovite crystals have grown across the main foliation, indicating their post-tectonic growth to the main deformation. Kyanite undergoes extensive retrogression to muscovite. Sillimanite needles are developed along the main foliation, as well as along the extensional foliation, and also along garnet margins. The presence of kyanite-garnet- oligoclase-biotite-sillimanite-muscovite assemblage and absence of staurolite in mica schist suggest that the HMB has undergone sillimanite-muscovite grade of middle amphibolite facies metamorphism. P-T calculations using garnet-biotite-muscovite-plagioclase-sillimanite/kyanite-quartz assemblage give 757±8°C for garnet core and 700±10°C and 8.9 to 10.7kb for garnet rim confirming sillimanite- muscovite grade metamorphism. Evidence for this is also provided by near-flat normal Mn and Fe garnet zoning. Garnet rims from samples above the Vaikrita Thrust, along the valley, give lower temperatures and pressures of 640±13°C and 8.7kb, indicating cooling during exhumation. P-T conditions of the surrounding country rocks indicate that they were in the kyanite zone, close to the dehydration-melting curve of muscovite and biotite.

The Karakoram Metamorphic Complex (KMC) represents deformation and extensive metamorphism of the southern edge of Eurasian Plate. It is characterized by intense penetrative ductile shearing as the most prominent deformation phenomenon, having top-to-SW sense of displacement, as has been deciphered from numerous shear criteria. It is superposed by an extensive phase of extensional tectonics, associated with the exhumed Karakoram metamorphics. The northwestern margin of the KMC is marked by the Tangste Shear Zone and characterized by structures indicating dextral transpressional regime. Metamorphism varies from biotite grade in the north to middle greenschist to sillimanite-muscovite grade of middle amphibolite facies condition towards south. In the middle amphibolite facies zone, mica gneiss has undergone prolofic migmatization and melting which led to the generation of *in situ* and injection granite – the Pangong Injection Complex. The P-T data from this belt indicates that upper greenschist facies rocks have undergone temperature- pressure of about 450-500°C and 6.00 kb, whereas in the highest sillimanite-muscovite grade of middle amphibolite facies in the zone of migmatization and melting, this belt seems to have reached a maximum temperature and pressure of about 700°C and 8.6kb.

U-Pb SHRIMP dating of zircons along with cathodo-luminescence (CL) imaging of metasediments, migmatites, biotite granite and *in situ* melt of collisional-related tourmaline-bearing leucogranite (TBL) have been performed along the Bhagirathi valley (Indian Plate) and Tangtse Gorge (Eurasian Plate). Zircons from these rocks are of varied shape varying from few tens of μm to ~400 μm. CL patterns of zircon grains reveal a distinctive core of apparent igneous origin and metamorphic overgrowth with faint oscillatory zoning related to the Himalayan orogeny. Zircons from *in situ* melt of the TBL along the Bhagirathi valley indicate three distinct patterns: clear rims, spongy middle portions and older cores. U-Pb zircon age data from the Bhagirathi valley indicate that the intrusion of felsic TBL tookplace at the peak metamorphism of the Himalayan orogeny with an episodic influx of fluid between 46 Ma and 20 Ma causing the growth zircons. However, data from Tangtse Gorge indicate an age of 19 Ma from the zircon rim and contemporaneous plug of the 20 Ma Darbuk Granite. U-Pb age data from both the sectors indicate that intrusion of felsic collision-related TBL are contemporary with each other and have formed at the peak metamorphism of the Himalayan orogeny.