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Metamorphic evolution and geochronological characterization of metapelitic granulites of the far-eastern Himalaya

TOKU OMEN ATTE[1], AMITAVA CHATTERJEE[1], DR. ROHIT PANDEY, PHD[2] AND BYUNG CHOON LEE[3]

[1]Pondicherry University
[2]Institute of Science, Banaras Hindu University, Varanasi
[3]Department of Earth and Environmental Sciences, Chonnam National University

The Himalayan range serves as a natural laboratory for investigating erstwhile subduction and ongoing subduction processes. These tectonic processes have profoundly affected the crust, particularly through metamorphism and deformation. The nature and intensity of these processes are well represented in the vicinity of the syntaxes, which can be linked with the style of subduction and collision. However, the eastern syntaxis within Indian territory, i.e., the North-eastern Arunachal Himalaya, remains relatively unexplored in terms of metamorphic and geochronological characterization. To address this gap, the present study focuses on the Tato-Monigong and Tato-Menchukha transects, proximal to the Namche Barwa Syntaxis (NBS) within the Lesser Himalayan Crystallines (LHC) and Greater Himalayan Sequence (GHS).

The mineral chemical data indicate the presence of silica-rich porphyroblastic garnet (Si a.p.f.u. 3.05–3.31) in metapelites. These porphyroblastic garnets contain quartz inclusions with kyanite and/or sillimanite in the matrix, suggesting high-pressure granulite-facies metamorphism. Conventional thermobarometry estimates peak conditions at ~9–12 kbar and ~735–810°C. From the presence of hydrous minerals, such as muscovite and biotite, adjacent to the peak metamorphic assemblage, the retrogressed *P–T* conditions are estimated as ~3.8–4.7 kbar and ~400–500°C. Additionally, the application of QuiG elastic barometry further refines metamorphic *P–T* conditions. Quartz inclusions in garnet systematically record decreasing pressure from core to rim. The cores formed at 8.9–9.7 kbar, whereas the rim and mantle were affected by retrograde metamorphism at 3.3–5.9 kbar. Considering the peak *P-T* estimation, these results provide the first evidence for high-pressure granulite-facies metamorphism in the Arunachal Himalaya, comparable to the well-established metamorphic evolution of the NBS.

U–Pb SHRIMP detrital zircon ages yielded the dominant Palaeoproterozoic-Neoproterozoic age populations, ranging from ~1800–900 Ma, with prominent age peaks at ~1840, 1300, 1100, and 900 Ma. Zircon grains exhibit weak oscillatory zoning, subhedral to euhedral, prismatic shape, and Th/U consistently >0.1, indicating their igneous origin. These age populations suggest that the detrital zircon grains in the LHC and GHS were likely derived from the Indian plate, which was extensively affected during the Columbia and Rodinia supercontinental cycles.