Observation of zircon internal structures toward elucidating the deformation and fluid activity history of leucogranites from the Bhutan Himalaya

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The Himalaya is an active continental collision zone between India and Asia, extending for more than 2,000 km from west to east, and represents a key natural laboratory for understanding orogenic processes. In the Himalayan orogen, the Greater Himalayan Sequence (GHS), composed of high-grade metamorphic rocks, is sandwiched between the South Tibetan Detachment System (STDS) and the Main Central Thrust (MCT). Structurally above the GHS lies the Tethyan Himalayan Sequence (THS), consisting of unmetamorphosed to weakly metamorphosed sediments, whereas the Lesser Himalayan Sequence (LHS), composed of low- to medium-grade metamorphic rocks, occurs structurally below the GHS. Leucogranites are widely distributed near the STDS. To explain these characteristic tectonometamorphic architectures, several orogenic models have been proposed, including the Channel Flow Model and the Critical Wedge Taper Model. In these models, the STDS, marking the boundary between the GHS and THS, plays a critical role, and intrusion ages of leucogranites are commonly used to constrain the timing of STDS activity [1].

In this study, we conducted detailed petrographic analyses of 15 leucogranite samples collected from four plutons intruding into different tectonic units in the Bhutan Himalaya: Jomolhari, Dolam Kencho, Dochu La, and Trashigang. Deformation microstructures of the samples and internal microstructures of zircon from each leucogranite are observed in detail. The Jomolhari leucogranite forms a sill intruding along the boundary between the THS and GHS [2]. The Dolam Kencho leucogranite is a pluton intruding the GHS that is the footwall of the STDl. The Dochu La leucogranite intrudes into the GHS, whereas the Trashigang leucogranite occurs within a THS klippe surrounded by the STDl.

As a result, quartz grains from all leucogranite bodies exhibit microstructures characterized by grain boundary migration (GBM) recrystallization, indicating that these leucogranite bodies underwent ductile deformation in the solid state after emplacement. According to the deformation regimes proposed by [3], the observed GBM textures suggest deformation under temperatures of approximately 500–600 °C. In addition, some samples from the Jomolhari and Dolam Kencho leucogranites contain sillimanite + muscovite mat filling the matrix grain boundaries, implying the presence of fluid activity under the sillimanite-stable *P-T* conditions.

Cathodoluminescence (CL) observations of zircon revealed that zircons from the Jomolhari, Dolam Kencho, and Trashigang leucogranites are euhedral and locally preserve oscillatory zoning; however, these primary textures are partly replaced by porous domains indicative of dissolution–reprecipitation processes. This suggests zircon recrystallization associated with fluid activity in these leucogranites. In contrast, zircons from the Dochu La leucogranite are euhedral and inclusion-rich and show well-preserved oscillatory zoning in CL images, consistent with their magmatic origin. Future geochronological analyses of these zircons will constrain the timing of leucogranite emplacement and subsequent deformation, providing new insights into the tectonic evolution of the Bhutan Himalaya.

References

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