Laser-Ablation Split-Stream Petrochronology of Kangmar and Mabja North Himalayan Gneiss Domes

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North Himalayan gneiss domes are an important part of the Himalayan orogen providing windows into structural levels beneath the Tethyan Himalaya and may afford an opportunity to examine processes "farther upstream" from the Greater Himalayan Sequence. We used laser-ablation split-stream (LASS) ICP mass spectrometry to measure U/Th-Pb ages and compositions of monazite from garnet + aluminumsilicate ± staurolite pelites in the Kangmar and Mabja domes. Most of the monazites are situated in biotite, but rare grains are included in garnet. Textures indicate that the monazite-producing reaction in the rock matrix was apatite + biotite → muscovite + monazite. The monazites are typically ~100 microns in diameter in Mabja and <20 microns in Kangmar.

Previous work shows that mid-crustal rocks exposed in **Mabja Dome** record peak Barrovian P-T conditions around 8 kbar and 650–700°C coeval with vertical thinning and N–S stretching [Lee et al., 2004]. Zircon rims from two migmatitic gneisses deep in the section range from 35 to 21 Ma, and were interpreted to reflect distinct (re)crystallization events at 35 and 22 Ma [Lee and Whitehouse, 2007]. Extension-related, late-tectonic pegmatite dikes intruded from 28–23 Ma and post-tectonic granites crystallized from 16–10 Ma [Schärer et al., 1986; Zhang et al., 2004; Lee et al., 2006; Lee and Whitehouse, 2007; King et al., 2011]. Muscovite $^{40}Ar/^{39}Ar$ ages are 17 to 14 Ma [Lee et al., 2006] and biotites are 14 to 11 Ma [King et al., 2011].

Our LASS measurements show that staurolite- and sillimanite-bearing samples, typically with homogeneous garnet, have monazite with equivalent $^{208}Pb/^{232}Th$ and $^{206}Pb/^{238}U$ ages ranging from 29 Ma down to 20 Ma. The bulk of the ages are between 29 and 25 Ma, and spot ages <25 Ma are exclusively from samples with partially resorbed garnets that have homogeneous major-element compositions. All monazites have negative Eu/Eu*, but variable HREE + Y contents. Other measured elements—e.g., LREE—show minor differences among grains. Spot ages older than ~25 Ma show a wide range of Y and HREE concentrations, whereas spot ages younger than ~25 Ma are correlated with progressively higher Y and HREE contents. These garnet features, monazite trace-element signatures, and monazite ages suggest that prograde metamorphism was still underway at 29 Ma, but that decompression or cooling was occurring by 25 Ma, consistent with the interpretation that peak metamorphism and mid-crustal ductile extension began at ~35 Ma, was ongoing at ~23 Ma, and had ceased by ~16 Ma [Lee and Whitehouse, 2007]. One sample with prograde-zoned garnet, the coldest peak metamorphic temperature (620°C), and a muscovite $^{40}Ar/^{39}Ar$ age of 15 Ma has monazites as young as 17–14 Ma that may be related to the final post-tectonic stages of magmatism.

Previous work shows that mid-crustal rocks in **Kangmar Dome** were colder than in Mabja, reaching peak conditions of 8.5 kbar and 625°C prior to and during ductile N–S extension [Lee et al., 2000]. $^{40}Ar/^{39}Ar$ muscovite and biotite ages are similar to Mabja, but decrease up section from 16 to 11 Ma [Lee et al., 2000].

Our LASS measurements show that Kangmar monazites have negative Eu anomalies and mild Y+HREE suppression produced by the presence of? cogenetic plagioclase and garnet like those from Mabja, but they are not zoned in Y and show markedly less variation in composition. Monazite from three kyanite-grade pelites and one garnet-grade pelite are 20 to 16 Ma—similar to the youngest monazite from Mabja. No grains older than 20 Ma were found. These monazite trace-element signatures and ages suggest that prograde metamorphism at Kangmar was later than in Mabja, but of similar duration—or, perhaps because of their small size—closed after prograde metamorphism.

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