Geophysical Research Abstracts
Vol. 20, EGU2018-8903, 2018
EGU General Assembly 2018

The petrogenesis of kyanite-bearing leucogranites in Bhutan

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Dramatic exhumation of high-grade rocks from orogenic cores is commonly modelled as ‘channel flow’, and is triggered by abrupt weakening of the mid-crust by low degrees of partial melting. However, the evidence for such melts is typically sparse and cryptic, overwhelmed by later deformation, recrystallisation and decompression melting. This project is investigating crustal melts from the Himalaya and testing their potential role in the rapid exhumation of the crystalline Himalayan core.

Small-scale, kyanite-bearing leucogranites found throughout the Himalaya are thought to represent early crustal melts that formed in the mid-lower crust during the India-Asia continental collision. Such prograde melts would therefore pre-date the more voluminous and better-studied Miocene granites that formed through decompression melting. This implies that the formation of kyanite-bearing leucogranites weakened the mid-crust, and was thus the driver of the change from the burial of the Greater Himalayan Sequence to its rapid exhumation, as required by the ’channel flow‘ tectonic model.

A suite of deformed kyanite-bearing leucogranites and their host rocks was collected from Bhutan in Spring 2017. Field observations indicate the leucogranites are small-scale (cm-dcm sized) bodies of melt and segregations that formed in situ within kyanite-bearing schists. Thin section microstructures confirm these as melt-bearing rocks, while textures reveal evidence for both prograde and retrograde mineral reactions in the leucogranites. Within the same section kyanite is preserved both in textural equilibrium with other phases, and elsewhere shows breakdown to muscovite. Primary muscovite laths also appear to have broken down to quartz and plagioclase. These replacement textures are interpreted to represent localised back-reactions with the melt.

A recent study by Kendrick & Indares (2017) demonstrated how cathodoluminescence (CL) imaging of kyanite and EMPA and LA-ICP-MS analysis of kyanite trace element concentrations (Cr $\pm$ V, Ti, Fe & Ga) can distinguish prograde and retrograde growth, thus preserving the reaction history of the rocks. Kyanite from both our Himalayan host rocks and leucogranites, including both the reacting kyanite and the intact kyanite, will be investigated using similar methods. U-Pb isotopic data will also be acquired from accessory phases (zircon and monazite) to determine when the leucogranites crystallised. Understanding the reaction history of these rocks and constraining the timing of leucogranite petrogenesis will underpin future P-T-t modelling that will aid the investigation of this critical tipping point between burial and exhumation of the orogenic mid-crust.

Kendrick J, Indares A. The reaction history of kyanite in high-P aluminous granulites. J Metamorph Geol. 2017;00:1–22. https://doi.org/10.1111/jmg.12286