Finding a Pulse: Melt Formation and Timing in the Garhwal Himalaya

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Motivation for this study

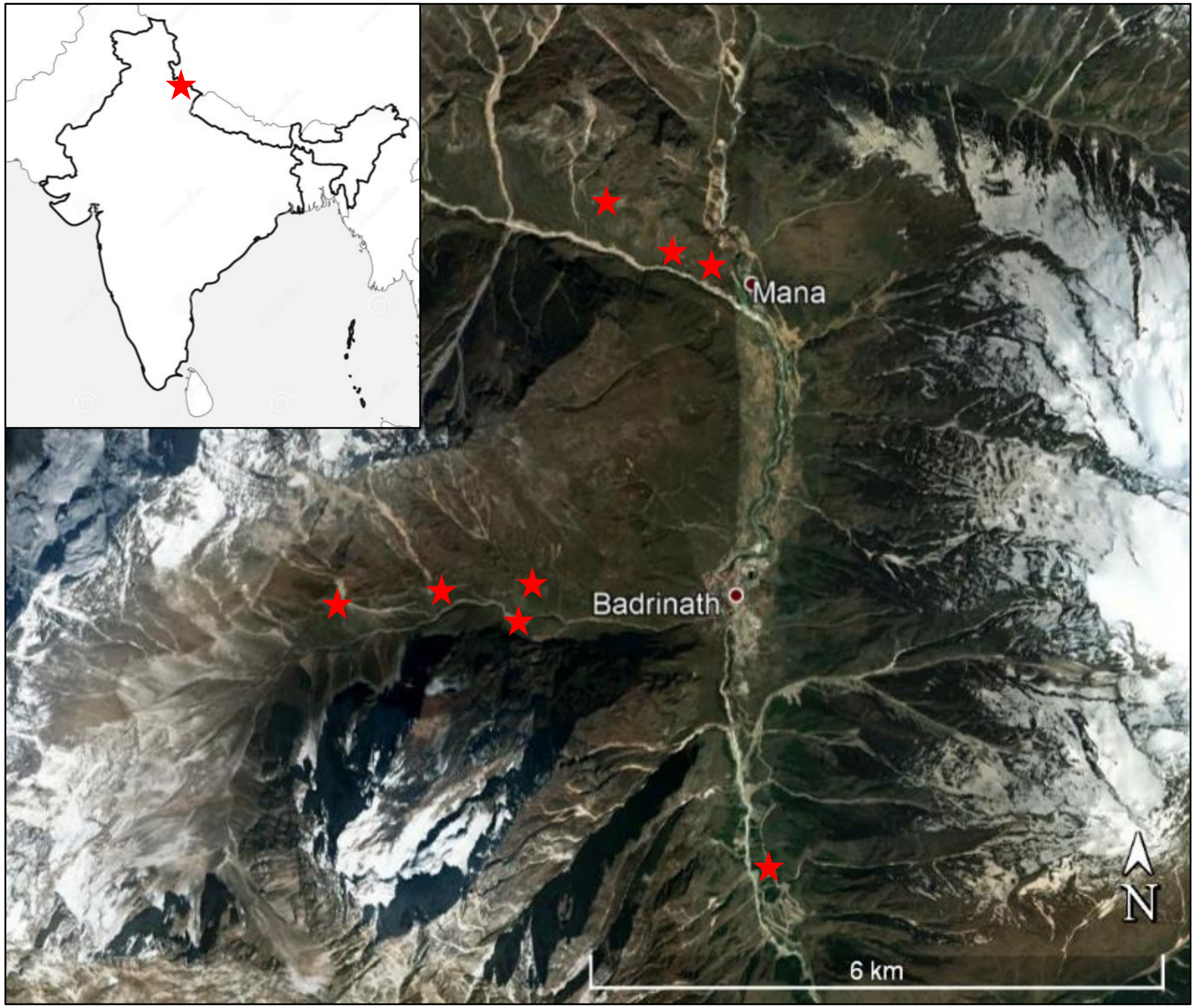
- Partial melting of metapelitic rocks has occurred throughout the high-structural levels of the Himalayan orogen
- The presence of melt impairs local mechanical strength and may be the driving force behind the mid- to deep-crustal exhumation
- Analysis of mineral chemistry in structurally related rocks of various melt fraction, we can gain a better understanding of this process
- In this study, we use a suite of geochemical signatures in zircon from leucogranites, migmatites, and host metapelites to inform us of specific interactions occurring at the time of crystallisation

A typical garnet-tourmaline leucogranite

A diatexite migmatite

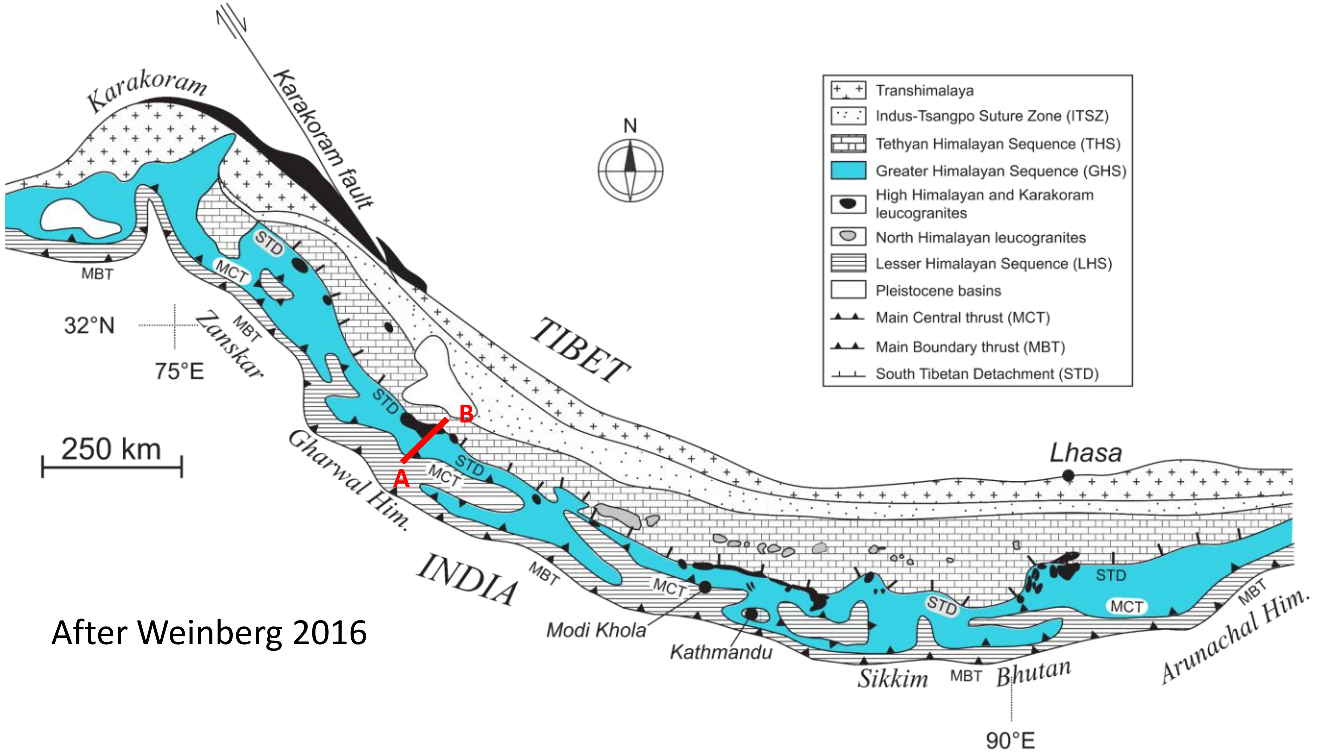
Sampling

- Leucogranites, migmatites, and host metasediments were collected as part of this study
- Sampling locations (marked in red) were mostly contained to the Rishi Ganga (Badrinath) and Alaknanda (Mana) valleys in the Garhwal region of the Indian Himalaya

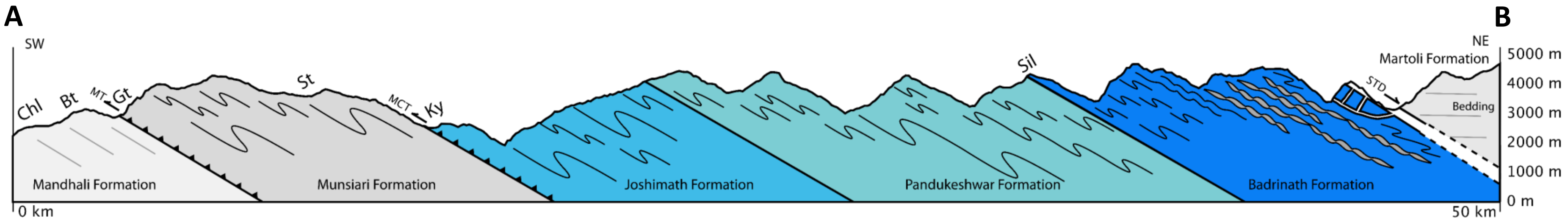


Geology of the Garhwal

- Valleys sampled are part of the Greater Himalayan Sequence (GHS) of crystalline metamorphic rocks, marked in blue, found right across the orogen
- Line A-B transects the GHS and is shown in cross-section below
- Extent of migmatization is greatest towards the north-east, with larger granitic bodies below the South Tibetan Detachment (STD)
- Sampling targeted the Badrinath Formation



After Weinberg 2016



Spencer et al., 2012

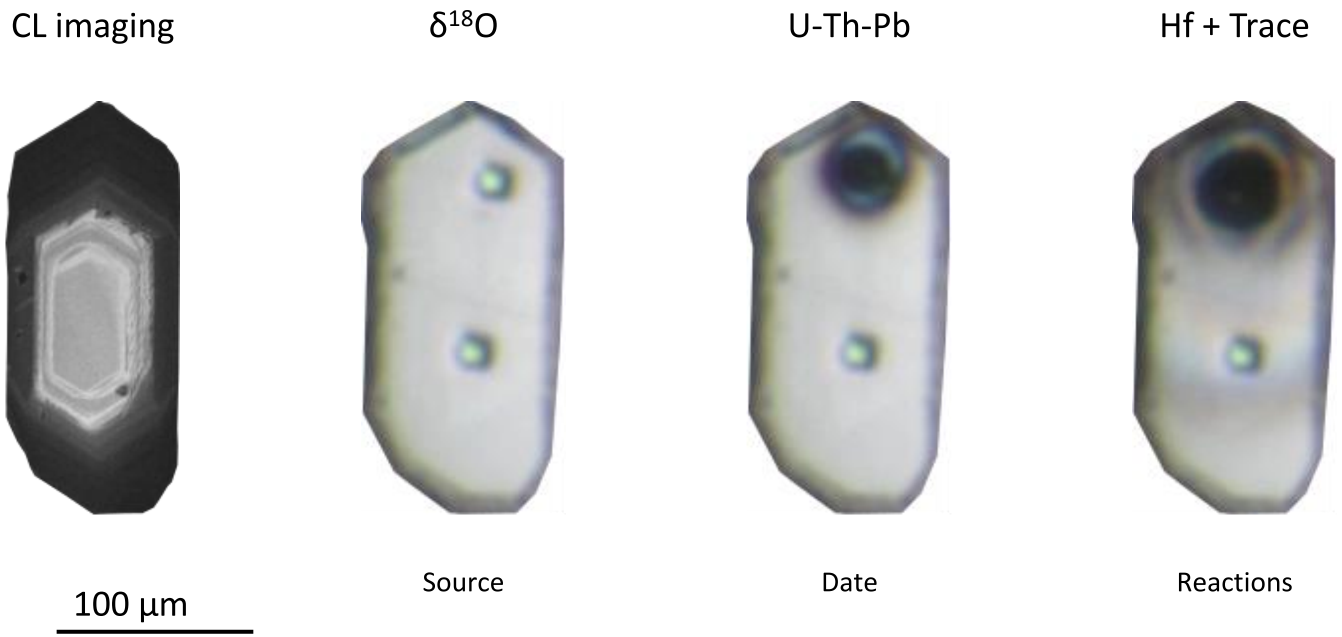
Analysis

- Analytical spots targeted the dark (high-U) outer growth rings typical of Himalayan-aged zircon

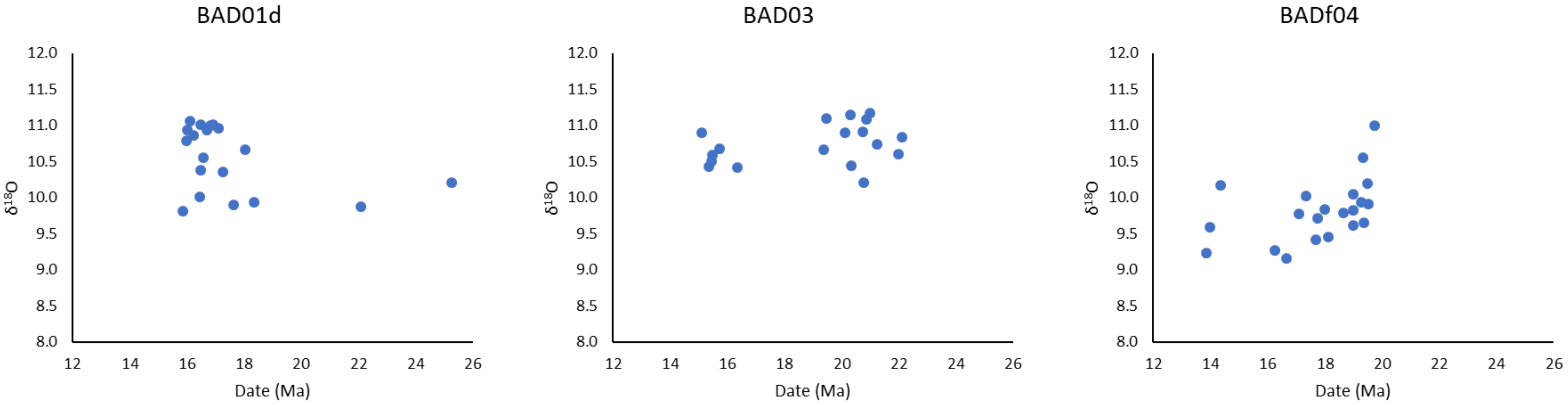
- Oxygen isotope ratio ($\delta^{18}O$), analysed with SIMS, is unaltered by anatexis and is inherited from the source rock
    - Measured at the Guangzhou Institute of Geochemistry

- U-Th-Pb analysis, using LA-ICP-MS, dates the crystallisation event
    - Measured at Curtin University

- Hf isotopic and trace element analysis (LA-ICP-MS) allow for the U-Pb dates to be linked to geological processes
    - Measured at Curtin University

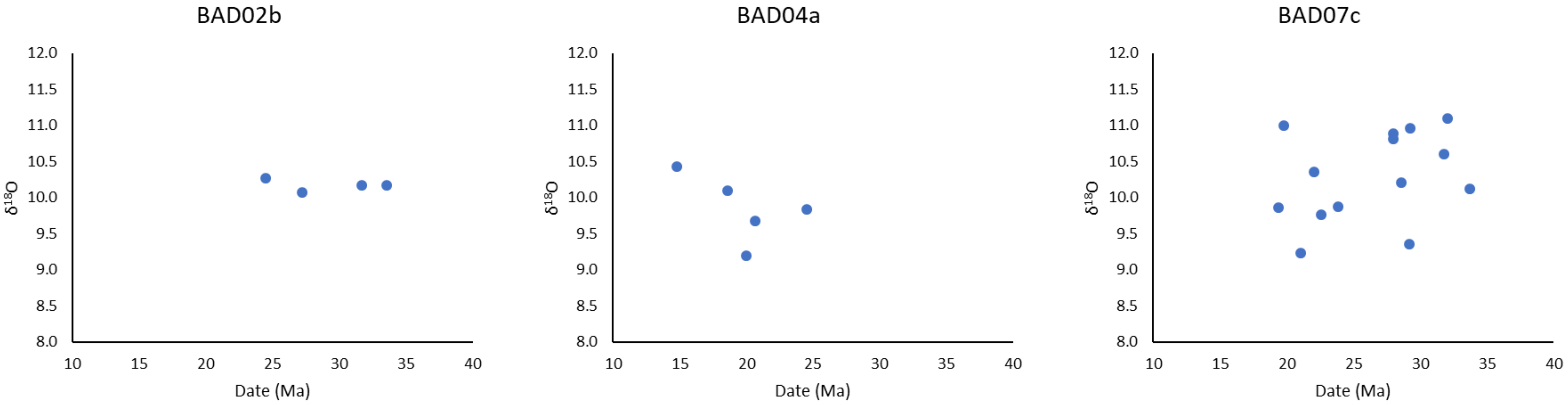


Leucogranite Date vs $\delta^{18}O$



- Here is a subset of leucogranites analysed, with date plotted against $\delta^{18}O$
- $\delta^{18}O$ varies by up to 2‰, which suggests a high degree of heterogeneity in the early melt
- All spot analyses fall within the expected $\delta^{18}O$ range of sedimentary origin
- Samples show periods of both continuous and punctuated zircon crystallisation

Migmatites Date vs $\delta^{18}O$



- Here is a subset of migmatites analysed, with date plotted against $\delta^{18}O$
- For many migmatites samples the extent of new zircon growth is low, resulting in a reduced dataset
- Again, all $\delta^{18}O$ values are within the sedimentary-derived range, with strong heterogeneity in both date and oxygen isotopes (BAD07c) or surprisingly homogeneity (BAD02b)
  - The later is likely due to the small sample size of zircons suitable for analysis

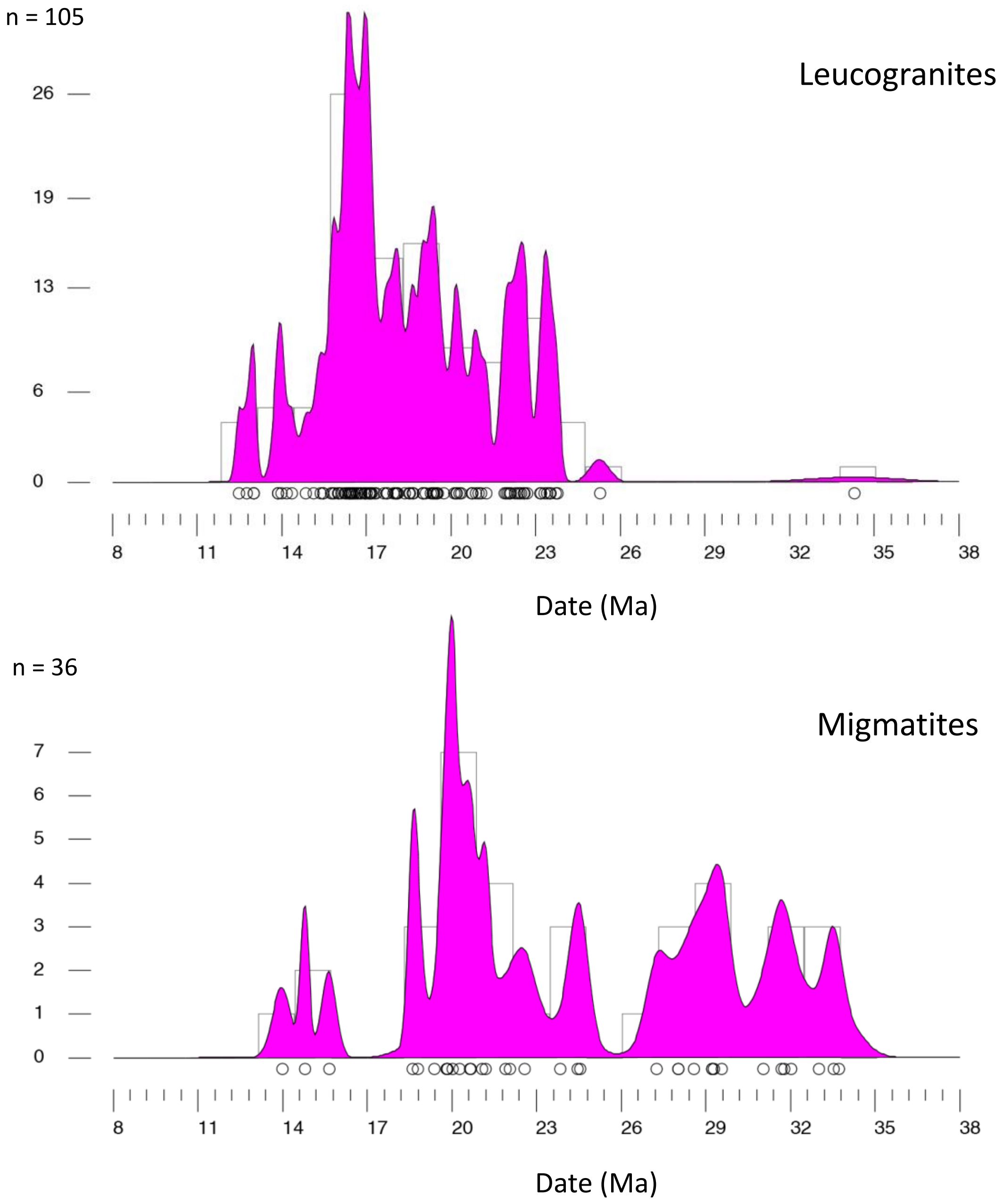
Probability Density Plots

- On the right are probability density plots of zircon U-Pb dates for both leucogranite and migmatite samples

- Leucogranite zircon crystallisation is concentrated between 12 and 24 Ma, with a prominent peak at 16.5 Ma

- Migmatite zircon dates can largely be split into two groups – those occurring before and those contemporaneous with the main body of leucogranite zircon

- Within this relative small area of the Himalaya, melt would have been present and repeatedly generated across a 20 Ma timespan



Conclusions

- Leucogranites show a variety of zircon populations:
    - Younger dates with restricted $\delta^{18}O$, shifting $\delta^{18}O$ ranges with increasing crystallisation, etc.
    - Continuous and punctuated episodes of crystallisation, with potentially varying sources
- Migmatite data is sparse, with huge variety between samples
    - Less zircon has crystallised in the migmatites than in the leucogranites, result skewed towards larger grains
- Zircon crystallisation events in leucogranites and migmatites are offset, with populations of migmatite-hosted zircon crystallising before and during leucogranite formation

Future work

- Integrating Hf isotope and trace element data
- In-situ petrographic analysis (EPMA, LA-ICP-MS)
- Additional analysis of a monazite
    - Specifically in migmatites to supplement the current data

References

Spencer, C. J., Harris, R. A., and Dorais, M. J. (2012), The metamorphism and exhumation of the Himalayan metamorphic core, eastern Garhwal region, India, *Tectonics*, 31, TC1007, doi:10.1029/2010TC002853.

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