Spatial deuterium excess patterns in high-elevation Asian precipitation

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Stable water isotope (δD and $\delta^{18}O$) and deuterium excess ($d=\delta D-8*\delta^{18}O$) data from precipitation collected in mountain ranges (Himalaya, Tien Shan, and Altai) surrounding the Tibetan Plateau display spatial patterns related to moisture source and transport. In the Himalaya (Mt. Everest and Xixibangma regions), summer monsoon fresh snow *d* values are higher in glacier regions (5100-6500 masl; 15.3‰) vs. lower elevation sites (4300 masl; 4.1‰). The magnitude of the *d* difference between the two sites, coupled with synoptic observations, indicates that different moisture sources are likely involved (Bay of Bengal and the Indian Ocean). Snowpit stable isotope records of >1-year accumulation from Mt. Everest have an average *d* value of 11.1‰. This value is comparable to the mean *d* value (10.7‰) from a 20m firn core recovered from the Altai Mountains (4100 masl), and is also close to the global meteoric *d* value (10‰). Synoptic weather patterns indicate that a significant portion of the moisture reaching the Altai comes from the North Atlantic, which has lower sea surface temperatures than the Indian Ocean. Therefore, the long distance moisture transport from the North Atlantic and continental location of the Altai may be responsible for creating precipitation *d* values similar to those observed in the Himalaya. In contrast, the mean *d* value of an 18m firn core from the Inilchek Glacier (5300 masl), central Tien Shan, is 22.6‰, suggesting a significantly different precipitation regime from the Altai. Our hypothesis is that moisture from the Caspian Sea, and reevaporation over the Ustyurt Plateau, is responsible for the high d values in the Tien Shan. Moreover, there is a strong seasonal *d* signal (higher *d* values in winter) in Tien Shan snow that is not observed in the Himalaya or Altai regions, and which is consistent with the Caspian source hypothesis. Several ice cores of >100m have now been recovered from the Everest, Tien Shan, and Altai regions. We will discuss and present 1 and 2-D isotope modelling results that are being used to interpret down-core δD, $\delta^{18}O$, and *d* records.

Where is geochronology going? Migmatite petrology and isotope transport

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Geochronology may provide constraints on a number of important issues in metamorphic and magmatic petrology, which have a bearing on our understanding of large-scale geodynamic processes. Some of these issues are: (1) coupling of petrogenetic indicators (thermobarometry; trace element distributions; oxygen isotopes) with time constraints; (2) the time-scale of pro- and retrograde processes in migmatites; (3) melt extraction rates; (4) rates of processes in general.

Migmatite petrology is exemplified as a research field where an increased input from geochronology is required. A new migmatization model (Kriegsman 2001) incorporates four sequential processes: (i) partial melting producing restite (mesosome) and melt; (ii) melt segregation and extraction; (iii) back reaction between melt and restite producing leucosome and biotite- or hornblende-rich melanosome; (iv) crystallization of remaining melt at its solidus.

One of the implications of this model is that incompatible elements that entered the liquid phase during partial melting may re-enter restitic layers upon cooling. Zircon resorpton followed by zircon growth in migmatites (Schaltegger et al. 1999) may be explained in a similar way. Zircon and monazite morphologies may therefore be strongly correlated to trace element (re)distribution at leucosome-melanosome-mesosome interfaces. The model is now being tested by trace element zoning and oxygen isotope distributions in garnet, zircon and monazite (EPMA, LA-ICP-MS, NORDSIM).

A next step is to constrain the rates of these processes, either through an assessment of the heating and cooling rates of the terrain (i); or by inferring the melt extraction rates from physical models for melt escape and melt percolation (ii) and the degree of (dis)equilibrium reached between melt and source rocks (iii). The first method is restricted by the current time resolution of isotopic techniques (commonly U-Pb) and therefore generally yields time scales > 1 Ma. Results from the other two approaches depend heavily on assumptions, but suggest rapid melt segregation (< 100 years).

Progress in this field requires a method that combines high spatial resolution (10 microns or less) with high time resolution (< 1 Ma) and is valid in minerals having low concentrations of relevant isotopes (e.g., U-Pb in garnet). This would open up possible applications such as deriving cooling paths directly from U-Pb zoning patterns in garnet.

References

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